Tacis

TRACECA : Central Asian Railways Restructuring Project Module E: Telecommunications

Final Report

March 1999

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Project title	TRACECA: TELECOMMUNICATIONS		
Project number	TNREG 9602		
Country	Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan		
	Local operator	EU Consultant	
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Introduction

This study on interconnection of telecommunications systems in TRACECA countries is part of the Central Asian Railways Restructuring study consisting of Module E.
This project is financed by Tacis/Traceca in collaboration with the European Bank for Reconstruction and Development (EBRD).

The results of the UIC feasibility study will enable the best target solution to be determined from a technico-economic point of view.

In order to speed up the renovation process of the Caucasian Railways, a **minimum pilot project** will also be presented.

This part is the executive summary.

Chapter one and two contains a survey of existing facilities.
Chapter three presents the European systems presentation seminar.
Chapter four includes general recommendations and the methodology used to draw up the detailed recommendations.
Chapter five and six presents the detailed recommendations with an economic study.

1 Project Synopsis

Project Title:	TRACECA-Central Asian Restructuring – Module E Feasibility Study Concerning Interconnection Possibilities between the Telecommunication Networks of the TRACECA countries
Project Number:	TNREG 9602
Countries:	Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan

Overall objective(s):	The development of the rail, maritime and road transport corridor linking the Georgian Black Sea harbours with the Caspian harbours and further to the Central Asian republics. The setting up of an efficient telecommunications network linking the various TRACECA countries.
Project Purpose (or Specific objective):	TRACECA railways have been assisted in making their choice for an adequate solution for interconnecting the telecommunication system (telecommunications, information technology) between themselves and with European railways
Anticipated Results	A diagnosis of telecommunications systems used. A seminar to present the systems used in Europe. An action and investment plan. A training seminar on the new systems (if an additional budget is allocated).
Project activities:	Preparation of questionnaires for the inventory. Inventory of existing systems in TRACECA countries. Analysis of existing telecommunications and IT-related reports on TRACECA countries. Organisation of a seminar to present European systems. Analysis of interconnection possibilities with European railways. Preparation of the action and the investment plan. Organisation of training (if an additional budget is allocated).
Target group(s):	Railways in TRACECA countries, in particular their IT and telecommunications managers.
Project start date :	06 August 1997
Project duration:	11+4 months

2 Executive Summary

2.1 Telecommunications Inventory

There was a time when telecommunications facilities at the Central Asian and Caucasian railways amply fulfilled railway operating requirements. This is no longer the case.

In general, switching equipment, dedicated lines and transmissions employ analog technology, while aerial lines and copper cables make up the tangible transmission media. The primary power source for the various installations is the public electricity grid, with the secondary power supply being provided by the railway.

Telecommunications installations comply with standards (GOST) and OSJD leaflets on railway applications. They are the result of mass production with little or no innovation on the general telecommunications front, but admittedly display certain simplifications authorised for private networks. All installations were supplied by the former Soviet Union and are thus uniform across the entire Caucasian railway network.

Today, production of this telecommunications equipment has been halted, making it difficult to maintain the worn-out installations in working order. Some were damaged during the civil war or through theft. In the absence of spare parts, some installations are dismantled to repair others. Given the slump in train numbers, the telecommunications facilities can still cope with the traffic volume, albeit with frequent train delays. At some stage, this deterioration in railway telecommunications will culminate in a crisis in general transport conditions on certain lines.

Over the past few years, some installations have been upgraded to digital technology. These had been shut down for the reasons listed above.
There is a need to train local teams prior to the use of new technology.
Attempts in Georgia to sling optical fibre cables between OHL masts clearly illustrates the need to train local teams prior to the use of new equipment.
In Central Asia, the railways' response to the insufficient transmission capacity has been to install Hertzian links or lease channels from public telecommunications services.

Upgrading programmes are undermined by the railways' lack of finance. The current tendency to replace faulty installations at minimum cost could result in a hotchpotch of different equipment and ruin all attempts to harmonise technology between the railways. Incompatibility would be the result. Help would be required to draw up a basis for technical harmonisation in the various telecommunications sectors.

2.2 Information Technology Inventory

2.2.1 Caucasus

On the whole, the railways in Caucasian countries - Armenia, Azerbaijan and Georgia - are poorly equipped with IT applications.

In the absence of any mainframes, IT facilities are limited to PCs and terminals, which are only available at headquarters and border stations.

There are no direct links between the railways, but all three are connected, each via a single terminal, to the railway computer centre in Moscow. The Moscow centre is the heart of the former USSR railway computer system and also covers the Traceca countries in Central Asia.

The information available from Moscow is adequate for freight management, however the system is more geared towards compensation between the different countries for wagon hire. The IT management system for international passengers has not been installed in these countries.
On the whole, the railways appear to be satisfied with the existing system although they did state that they would like to have a system which linked them more directly and was better tailored to their needs.
The main fault in the current system is the appalling state of the transmission lines between stations.

There is no electronic exchange of data with administrative bodies, for example customs or police.
There is no electronic exchange of data with customers.
Neither is there any electronic exchange of data with port authorities or shipping companies.
The railways have expressed a desire to improve on the above three points in order to be more competitive with road transport.

2.2.2 Central Asia

On the whole, IT facilities are quite well developed at the Central Asian railways - Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

These facilities rely on three computer centres fitted with a mainframe and located in Kazakhstan, Turkmenistan and Uzbekistan.
In addition, the railways have PCs and terminals, a large number of which are hooked up to the mainframes.
Most of the facilities are located at headquarters and border stations.

The Kyrgyzstan terminals are subordinate to the computer centre in Almaty (Kazakhstan) and those in Tajikistan to the Tashkent centre (Uzbekistan).

The railways are not really interconnected, but they do all belong to the old IT system of the former USSR, the hub of which is in Moscow. The information available locally or via Moscow is adequate for freight management, however the system is more geared towards compensation between the different countries for wagon hire.
An IT management system for international passengers does exist but has not yet been installed in Turkmenistan.
While the system appears to be satisfactory on the whole, the Kyrgyzstan and Tajikistan railways did say they would like their own IT centre so as to tailor the system to their needs.
The biggest fault in the current system is the appalling state of the transmission lines between stations. For more details, refer to the telecommunications section of the report.

There is no electronic exchange of data with administrative bodies, for example customs or police.
There is no electronic exchange of data with customers.
Neither is there any electronic exchange of data with port authorities or shipping companies.

2.3 European Systems Presentation Seminar

The aim of the seminar held in Warsaw from 9 to 13 March 1998 was to provide specialists from the Central Asian and Caucasian railways with the necessary information on modernising telecommunications and IT facilities, interconnection and links to western European systems.

Three main points were covered:

- European telecommunications and IT standards
- railway telecommunications strategy
  with focus on:
    - the needs of railways (traffic safety and control, commercial applications)
    - dedicated networks versus purchase of services from public or private operators
- industrial products for telecommunication networks and systems and software applications for rail
  with focus on:
    - architectures
    - international links

- network supervision
- network redundancy
- network maintenance
- training of operating and maintenance staff
- data transmission

At the end of the seminar, all participants commented that they had received valuable information of a high standard which was needed to modernise their networks.
They proposed setting up a working group which would include representatives from the European Union, the EBRD and UIC and would continue work on modernising the telecommunications and IT networks.

2.4 General Telecommunications Recommendations

Chapter 4 of this report contains preliminary recommendations and basic costs intended for use in drawing up the action and investment plan.

- The project description comprises an outline of the general context and the financial and legal aspects.

- The outline contains a rough investment model and explains that a precise and detailed account of the needs of the railways concerned is not currently available. This will be required in order for projects of an operational nature to be possible.

- This is followed by a detailed list of the services to be provided by the telecommunications networks under the headings Signalling, Railway Operations and Applications.

  Each of the above categories is defined and the telecommunications services required are set out.

- A technical proposal outlines technological developments and the main aspects of network architecture.

  A list of technical specifications is proposed and classified as follows:

  - mandatory,
  - recommendatory,
  - informatory.

  The specifications deal with:

  - telecommunications for signalling and railway operations,
  - transmission cables (type, laying, connection, capacity),
  - the actual telecommunications network (digital transmission equipment, redundancy, management, synchronisation),
  - integration or not of the telecommunications network,
  - energy supply sources.

It is important to note that these technical specifications are generic: they are generally valid but do not govern implementation of specific projects.

This type of specification should be drawn up after a precise and detailed account has been obtained of the needs of the railways concerned.

- The figures for basic costs are approximate. They may be used as a starting point for the future action and investment plan.

  Nonetheless, these figures are average values, affected by a number of variable factors.
  Only the invitation to tender (and ensuing negotiations) will enable definitive prices to be established.

2.5 Caucasus Telecommunications Recommendations

2.5.1 Technical Study

Applying the general guidelines outlined in Chapter 4 to the Caucasian railways produced the following recommendations.

2.5.1.1 Backbone network

A **backbone network proposal** has been drafted for each of the three Caucasian countries, outlining:
- why specific options were taken for a given country,
- general diagram of the backbone network,
- **investment tables** for two network configurations:
  -- without back-up of incoming railway control centre circuits,
  -- with partial back-up of incoming railway control centre circuits.

This data is taken as a basis for the economic study.

The backbone network takes in the following sections:
In Armenia : Ayrum (Georgian border) - Yerevan - Razdan, i.e. 369 km.
In Azerbaïjan : Beyuk-Kasik (Georgian border) - Bakou, i.e. 503 km.
In Georgia : Poti/Batumi - Tbilisi - Sadakhlo (Armenian border)/ Gardabani (Azerbaijani border), i.e. 550 km.

2.5.1.2 Secondary network

A **simplified proposal for secondary railway networks** rounds off the technical study. This is organised along similar lines to the backbone network proposal (justification of options selected, general diagrams, investment tables).

2.5.1.3 Conclusions

The main **conclusions** are as follows:

- It is recommended that a firm decision be made to opt for **optical fibre cables** and **digital transmission** techniques.
Where the backbone telecom network is concerned, it is recommended that use be made of cables with 24 optical fibres, 12 of which would be employed for railway applications and 12 by possible future telecom operators. This cable will be buried to ensure reliability and a long life cycle.

Comparison of laying methods for optical fibre cable :

Method of laying	Aerial		Buried	
	Pro	Con	Pro	Con
Ease of laying	X		X (earth)	X (rocks)
Mechanical protection		X	X	
Sensitivity to wind, trees, snow, etc.		X	X	
Risk of vandalism		X	X	
Effects of catenary poles condition		X	X	
Bullet-proof tests		X	X	
Price of cable		X	X	
Speed of laying	X			X
Laying price	X			X

- It is recommended that the basis of the backbone networks should be SDH technology (synchronous 155 Mbit/s STM1 add/drop multiplexers) supplemented by distribution telecom networks using drop-and-insert PCM (2 Mbit/s add/drop multiplexers with an 8 Mbit/s ADM8 transport medium and 2 Mbit/s add/drop multiplexers with a 2 Mbit/s ADM2 transport medium).

These telecom networks are linear and in this respect they reflect the topology of the railway networks.

- It is recommended that telecom networks be provided at least partially with back-up, without seeking full redundancy for all the various installations, this not being economically justified. The solution whereby incoming control centre circuits are provided with back-up would be preferable but seems unfeasible, given that the public telecom operators do not appear to be able to supply the necessary external cables.

- It would also be advisable to replace the automatic administrative telephone switches with digital equipment.

- The technology to be adopted for the secondary railway telecom networks should consists of a 6-fibre cable and drop-and-insert PCM.

Given the high cost of investment, it is not recommended that secondary networks be systematically equipped but rather that this be done in relation to actual operating needs. However it should be borne in mind that the equipment recovered when replacing the backbone will be available for use in maintaining these secondary lines and this will make it possible to defer investments for them.

2.5.2 Investments

2.5.2.1 Budget for the recommendations

The recommendation that an optical fibre network be installed with SDH and PCM multiplexers, operational telephony and administrative telephone switches would give the following budget:

	EU Investment (MECU)	Railway Investment (MECU)
Total	18.33	2.55

European Union investment covers:

- the cable and its fittings
- supervision of staking out operations and cable laying
- cable connections
- transmission equipment
- PABX
- power supply
- spares
- training

The railways' investment covers:

- staking out
- civil engineering
- cable laying
- rewiring buildings and installing subscriber telephones

The cost calculated is ten times lower than that of similar work in western Europe because of manpower cost differences.

2.5.2.2 Pilot Project

In order to focus on top priority investments that are vital to the railways, and to quickly initiate a preliminary project which would demonstrate the viability of the whole project, a pilot project should be set up.

The pilot project should focus on the main line linking Baku to Poti (through Tbilisi) and to Yerevan, thus entailing the knock-on effects on the backbone proposal :

- Omission of the Samtredia/Batumi section in Georgia
- Omission of the Yerevan/Razdan section in Armenia
- Completion of the whole backbone whilst only installing equipment in 70% of small stations (in relation to the categories in the UIC technical study).
- Inclusion of all PABX but with only 75% of the original capacity

N.B.: not renewing the equipment in 30 to 50% of stations was already a recommendation in the CIE-Consult report on Georgia for the EBRD.

The pilot backbone network takes in the following sections:
In Armenia : Ayrum (Georgian border) - Yerevan, i.e. 309 km.
In Azerbaïjan : Beyuk-Kasik (Georgian border) - Bakou, i.e. 503 km.
In Georgia : Poti - Tbilisi - Sadakhlo (Armenian border)/ Gardabani (Azerbaijani border), i.e. 444 km.

The investment requirement would be as follows:

	EU Investment (MECU)	Railway Investment (MECU)
Total	14.8	2.2

There is quite a substantial degree of uncertainty in the Railway investment figure, as it mainly covers civil engineering which will depend on local costs. And this figure only approximate the work that would be done by the railways themselves. If the civil engineering is undertaken by an external company and paid by the railways, the amount may be much higher.

2.5.3 Economic study

The economic study is composed of a comparison between two scenarios over 20 years.

- Reference scenario, in which the project does not go ahead. The current maintenance budget continues to apply, with an increase of 2% per annum. Locomotives are procured to offset delays caused by telecommunications failures (5 minutes per 6.4 km section per day for all trains in the country concerned).

- Project scenario, in which the investments are made in each of the countries concerned. Operating costs amount to 2% of investment in equipment and maintenance is 1FRF/m of cable laid.
  Cables have a lifespan of 50 years and equipment of 20 years.

  Revenue may be expected from hiring out surplus system capacity to telecom operators. This revenue is taken into account in Armenia from the second year, since the law already allows for this eventuality. In Azerbaijan and in Georgia, the necessary legal framework does not yet exist and as a result revenue is only expected to be earned six years after the start of the project.

The following table shows the corresponding internal rates of return:

	Overall	Armenia	Azerbaijan	Georgia
IRR	21 %	19 %	32 %	16 %

Results will be heavily dependent on revenue earned from leasing excess system capacity. Among the many advantages of this investment, only this revenue has been able to be estimated. But the internal benefits would be sufficient in themselves to justify the project as part of the railway restructuring process.

Despite the rather pessimistic assumptions and a reference situation where the cost of maintenance has probably been underestimated, the internal rates of return of the proposed projects are high (about 20%). They would require changes in the telecommunications legislation in Georgia and Azerbaijan in the next five years.

2.6 Central Asia Telecommunications Recommendations

2.6.1 Technical study

Applying the general guidelines outlined in Chapter 4 to the Central Asian railways produced the following recommendations.

2.6.1.1 Backbone network

A **backbone network proposal** has been drafted for each of the five Central Asian countries, outlining:

- why specific options were taken for a given country,
- general diagram of the backbone network,
- **investment tables** for two network configurations:
  -- without back-up of incoming railway control centre circuits,
  -- with partial back-up of incoming railway control centre circuits.

This data is taken as a basis for the economic study.

The backbone network takes in the following sections:

- In Kazkhstan :
  - Tchengeldy - Almaty - Droujba, i.e. 1808 km.
- In Kyrgyzstan :
  - Lugovaya (Kazakhstan) - Bishkek - Balyktchi, i.e. 327 km.
- In Uzbekistan:
  - Tchengeldi (Kazakhstan) - Tashkent - Bekabad -> Tajikistan
    Talimardjan - > Turkmenistan
    Farab -> Turkmenistan
  - R-161km / Termez / Sariasiya / Amuzang, i.e. a total of 1454 km.
- In Tajikistan:
  - Bekabad (Uzbekistan) - Nay - Kafurov,
  - Saryasia (Uzbekistan) - Pakhtabad - Dushanbe - Yangi-Bazar
  - Amuzan (Uzbekistan) - Ayvadji - Kurgan-Tjube - Kulyab - Yavan, i.e. a total of 509 km.
- In Turkmenistan :
  - Krasnodovsk (near Turkmenbashi - Caspian Sea) - Ashgabad - Farab (border with Uzbekistan)
  - Talimardjan/R-161km, i.e. a total of 1364 km.

2.6.1.2 Secondary network

A **simplified proposal for secondary railway networks** rounds off the technical study. This is organised along similar lines to the backbone network proposal (justification of options selected, general diagrams, investment tables).

2.6.1.3 Conclusions

The main **conclusions** are as follows:

- It is recommended that a firm decision be made to opt for **optical fibre cables** and **digital transmission** techniques.
Where the backbone telecom network is concerned, it is recommended that use be made of cables with 24 optical fibres, 12 of which would be employed for railway applications and 12 by possible future telecom operators. This cable would be buried to ensure reliability and a long life cycle.

- It is recommended that the basis of the backbone telecom networks should be SDH technology (synchronous 155 Mbit/s STM1 add/drop multiplexers) supplemented by distribution telecom networks using drop-and-insert PCM (2 Mbit/s add/drop multiplexers with an 8 Mbit/s ADM8 transport medium and 2 Mbit/s add/drop multiplexers with a 2 Mbit/s ADM2 transport medium).

These telecom networks are linear and in this respect they reflect the topology of the railway networks.

- It is recommended that telecom networks be provided at least partially with back-up, without seeking full redundancy for all the various installations, this not being economically justified. The solution whereby incoming control centre circuits are provided with back-up would be preferable but seems unfeasible, given that the public telecom operators do not appear to be able to supply the necessary external cables.

- It would also be advisable to replace the automatic administrative telephone switches with digital equipment.

- The technology to be adopted for the secondary railway telecom networks should be:
- for railway branch lines: a 6-fibre cable and drop-and-insert PCM
- for other railway lines: same equipment as for the backbone network.

Given the high cost of investment, it is not recommended that secondary networks be systematically equipped but rather that this be done in relation to actual operating needs. However it should be borne in mind that the equipment recovered when replacing the backbone will be available for use in maintaining these secondary lines and this will make it possible to defer investments for them.

2.6.2 Investments

2.6.2.1 Budget for the recommendations

2.6.2.1.1 Transmission network

The recommendation that an optical fibre network be installed with SDH and PCM multiplexers and operational telephony would give the following budget:

	EU Investment (MECU)	Railway Investment (MECU)	Total
Kazakhstan	15.76	2.60	18.36
Kyrgyzstan	3.46	0.47	3.93
Uzbekistan	12.48	2.09	14.57
Tajikistan	3.6	0.73	4.59
Turkmenistan	11.33	1.96	13.29
Total	**46.88**	**7.86**	**54.74**

European Union investment covers:
- the cable and its fittings
- supervision of staking out operations
- cable connections
- transmission equipment
- power supply
- spares
- training

The railways' investment covers:
- staking out
- civil engineering
- cable laying

The cost calculated is ten times lower than that of similar work in western Europe because of manpower cost differences.

2.6.2.1.2 Automatic administrative telephone switches (PABX)

The supplementary option of replacing the automatic administrative telephone switches would require the following budget:

	EU Investment (MECU)	Railway Investment (MECU)	Total
Kazakhstan	0.17	0.02	0.19
Kyrgyzstan	0.00	0.00	0.00
Uzbekistan	0.55	0.05	0.61
Tajikistan	0.00	0.00	0.00
Turkmenistan	0.00	0.00	0.00
Total	**0.72**	**0.08**	**0.80**

The cost of rewiring buildings and installing subscriber telephones would be borne by the railways.

2.6.3 Economic study

The economic study is composed of a comparison between two scenarios over 20 years.

- Reference scenario, in which the project does not go ahead. The current maintenance budget continues to apply, with an increase of 2% per annum. Locomotives are procured to offset delays caused by telecommunications failures

- Project scenario, in which the investments are made in each of the countries concerned within a twelve-month period. Operating costs amount to 2% of investment in equipment and maintenance is 1FRF/m of cable laid.
  Cables have a lifespan of 50 years and equipment of 20 years.

  Revenue may be expected from hiring out surplus system capacity to telecom operators. This revenue is taken into account in Kazakhstan from the second year, since the law already allows for this eventuality. In the other countries, the necessary legal framework does not yet exist and as a result revenue is only expected to be earned six years after the start of the project. Tajikistan has been omitted from the economic study for want of sufficient data.

The following table shows the rates of return calculated:

	Kazakhstan	**Kyrgyzstan**	**Uzbekistan**	**Turkmenistan**
IRR	24%	21%	24%	24%

Results will be heavily dependent on revenue earned from leasing excess system capacity. Among the many advantages of this investment, only leasing revenue has been able to be estimated. But the internal benefits would be sufficient in themselves to justify the project as part of the railway restructuring process.

Despite the rather pessimistic assumptions and a reference situation where the cost of maintenance has probably been underestimated, the internal rates of return of the proposed projects are high (about 20%). They would require changes in national telecommunications legislation over the next five years.

2.7 Electronic data interchange recommendations

Since the railways exchange no electronic data whatsoever with third parties, the first step should be to organise information seminars.

It is advocated that UNCTAD's ACIS RailTracker system be installed in the Caucasus region, where the level of computerisation is low. An added advantage is that this system is compatible with UNCTAD's customs system, Asycuda, which is currently used in Armenia and Georgia.

Executive Summary

The recommendation for Central Asia is to retain the ASU system currently used by the railways and increase its communications interfaces to enable links to customers, customs and shipping companies to be installed.

Appendices

1 List of local operators

Armenia
Armenian Railways (ARM) 50, Tigran Meci st. 375000, Erevan Phone: (3742) 52 04 28 Fax: (3742) 57 36 30 Vladimir V. Asriianc Director General
Azerbaijan
Azerbaijan State Railway (AZ) 230, D. Aliyev str. Baku 370010 Phone: (99412) 98 44 67 Fax: (99412) 98 42 80 Ziya A. Mamedov Director General
Georgia
Georgian Ministry of Transport Railway Department (GR) 12, Kazbegi str. Tibilisi, 380060 Phone: (7-8832) 99 40 12 Fax: (7-8832) 95 36 65 Akakii V. Chkhiadze Director General
Kazakhstan
Republican State Enterprise " Kazakhstan Temir Zholy " (KZH) 127 Furmanov str. Almaty 480091 Republic of Kazakstan Phone (7-3272) 604 100 Fax (7-3272) 503 870 Myrzakhmetov Ablay Director General

Kyrgyzstan
Kyrgyzstan Railways (KRG) 83, Lva Tolstovo st. 720009 Bichkek Phone: (7-3312) 25 30 54 Fax: (7-3312) 24 56 11 Omurkulov Isa Director General
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Chapter 1

Caucasian countries - Inventory

Contents

1. General information on the railway networks

1.1 Armenia

Railway abbreviation	**ARM**			
Total country surface area:				
Population:				
Total line length :	798 km			
Length of lines electrified				
Railway employees :				
Passenger traffic figures:	*1995:*		*1996:*	
- number of passengers:		2,969 $x10^3$		1,859 $x10^3$
- number of passenger/km:	166 $x10^6$		84 $x10^6$	
Freight traffic figures	*1989:*		*1996:*	
- hauled tonnage:	33,900 $x10^3$		1,200 $x10^3$	
- number of tonne/km:		5,121 $x10^6$		351 $x10^6$
Length of Traceca corridor:				
Length of corridor electrified				
Type of electric current	3.3 kV D.C.			
Number of trains per day:	*(capacity)*	35	*(at the present time)*	4
- forecast		12		

1.2 Azerbaijan

Railway abbreviation	**AZ**			
Total country surface area:	86,600 km^2			
Population:	7,500 000			
Total line length :	2,117 km			
Length of lines electrified	1,278 km			
Length of double-track line	791 km			
Length of single-track line	487 km			
Railway employees :	42,800			
Passenger traffic figures:	*1995:*		*1996:*	
- number of passengers:		8,955 x10^3	x10^3	
- number of passenger/km:	791 x10^6		558 x10^6	
Freight traffic figures	*1995:*		*1996:*	
- hauled tonnage:	9,073 x10^3		x10^3	
- number of tonne/km:	2,409 x10^6			2,778 x10^6
Length of Traceca corridor:	503 km			
Length of corridor electrified	503 km			
Type of electric current	3.3 kV D.C.			
Number of stations on corridor	47, *distance :*		mean =12km, max =15km	
Number of trains per day:	*(capacity)*	2x 45	*(at the present time)* 2x 8	
- forecast *(opt., pes.)*	2x 30		2x 15	

1.3 Georgia

Railway abbreviation	**GR**		
Total country surface area:	69,700 km^2		
Population:	5,400 000		
Total line length :	1,575 km		
Railway employees :	10,800		
Passenger traffic figures:	*1995:*		*1996:*
- number of passengers:	3,674 x10^3		x10^3
- number of passenger/km:	371 x10^6		380 x10^6
Freight traffic figures	*1995:*		*1996:*
- hauled tonnage:	4,656 x10^3		x10^3
- number of tonne/km:	1,246 x10^6		1141 x10^6
Length of Traceca corridor:			
Length of corridor electrified			
Type of electric current	3.3 kV D.C.		
Number of trains per day:	*(capacity)*	2x 45	*(at the present time)* 2x 7
- forecast *(opt., pes.)*	2x 25		2x 15

2. Telecommunications

2.1 Inventory

2.1.1 Armenia

2.1.1.1 Introduction

Armenian Railways use analog systems only and are equipped with electromechanical telecom switches. Local calls (between subscribers connected to the same telecom switch) are processed automatically; outside calls (requiring a link between two different telecom switches) go through an operator. The transmission links are HF (frequency modulation) electronic transmission facilities. The media used are copper cables and aerial lines.

Figure 2.1.1.A depicts the Armenian railway network, with the Traceca corridor marked out in bold.

2.1.1.2 General characteristics

The telecommunications installations are standardised (GOST) and comply with OSJD leaflets as regards railway applications. Parts originate from the former Soviet Union or eastern Europe and are no longer in production. Neither are they compatible with today's technology.

Installations are primarily fed from the public grid. A secondary power supply (transformation, rectification, back-up) is provided by the railway. Back-up energy is generated by a battery with an few hours' capacity (depending on the condition of the battery). Major centres have the additional safeguard of diesel generators which are activated, automatically or manually, in the event of a public grid power cut.

2.1.1.3 Switching

Switching nodes are located at the following stations: Yerevan, Masis, Gyurmi, Vanadzor, Sanain and Ayrum. To make a local call, the subscriber dials the desired number and is put through automatically.

To make an outside call, the subscriber must dial the operator and state the name and number of the connection sought. The operator calls back once end-to-end communication has been established (a process which may involve several operators) This manual procedure is limited by the operator's switchboard capacity and the number of transmission channels. The switchboards used are type MPU-80, MPU-20 or MPU-60. Call connection times no longer meet modern-day requirements.

Figure 2.1.1.B shows the location of telecom switches on the railway network. The following table lists the capacity (number of subscribers) per node. Telecom switches are currently saturated.

Location	*Kilometre point*	*Number of subscribers*	Model
Yerevan	2877/0	2000	KR
Masis	2863/598	500	ATS
Gyurmi	2723	2000	ATS
Vanadzor	2654	500	ATS
Sanain	2613	400	ATS
Ayrum	2582	100	ATS

The telecom switches employ either rotary or crossbar technology. The oldest dates from 1949 (Gyurmi) and is still operational. It is powered by a central 48 or 60 V battery.

2.1.1.4 Services

To complement the switched telephone network (cf. § 2.1.1.3), a certain number of voice services are also provided on dedicated lines. These links consist of a primary railway telephone transmitter/receiver and terminal installations (subscribers) linked in parallel on the transmission line. The operator (controller) is in permanent receiver mode. Subscribers are selected manually by pressing a button on the operator's switchboard. The primary transmitter/receiver emits the dial tone frequency, which is received by the subscriber selector (APC-1). These connections date from the 70s-90s. Nothing further has been introduced since then, although some circuits are planned.

The services involved are:

- Traffic control (2 wire link)

The traffic control centre is located in the same building as the railway headquarters (Yerevan). It manages 4 line sections, but a proposed upgrading programme would reduce this number to two, which would mean replacing the telecommunications installations and re-organising the circuits.

- Energy control (2 wire link)

This line runs between the energy control centre and energy controllers in the OHL power supply sub-stations. The energy and traffic control centres are situated side by side and cover identical geographical zones.

- Dedicated station-to-station telephone lines (2 wire link between the manual KPS-2/3 and UKSS-8 telecom switches). Call frequency is 25 or 50 Hz.
- Distribution of reserved tickets.

The ticket reservation/distribution centre is connected to some main-line passenger stations.

- Teleconferencing

A 4-wire link connects a supervisor's installation to those of his/her team.

- Railway police
- Operator management of outside calls to and from line stations connected in parallel to a dedicated circuit.
  (2 wire link).
- Signalling and telecommunications maintenance
- Track maintenance
- Lineside alarm (2 wire link).
- Traffic controller - depot link.
- Traffic controller - passenger train formation yard link.

The local circuits at stations are arranged in the same fashion and energised by local 50 or 80 V batteries.

- Telegraphy

Armenian Railways also has telegraph links: The network dates from the latter half of the 60s, with a few changes in terminal equipment (upgrade in models), and remains in service today. The models currently in use are T-63, STA 67 and F-1100. Several dozen of these terminal installations still function today.

Transmission rates correspond to those achieved by older European systems, i.e. 50 baud (24-channel transmission system), 100 baud (12-channel transmission system) or 200 baud (6-channel transmission system). Connection is automatic and P-327-3 or P-327-12 transmission equipment is used.

The telegraph office is located at the railway undertaking's headquarters. Terminal installations are connected to the switch and can be linked to other installations in the former SZD telegraph network (the central switch of the RZD network is situated in Moscow). Today, the telegraph links are used to send written instructions concerning traffic control and commercial aspects.

2.1.1.5 Transmission media

The transmission media are copper cables and aerial lines. Most of the cables are buried. Transmission links are generally served by HF (frequency modulation) electronic transmission installations, although use is also made of direct audiofrequency transmission over copper cables and aerial lines. Adaptation is carried out by a translator.

The cables are type 7x4x1.2+5x2x0.7+1x0.7 (7 star-shaped quads, 1.2 mm diameter wire; 5 pairs and 1 wire of diameter 0.7 mm) MKPAB (paper insulation, aluminium armouring and PVC outer sheath). The wire pairs also carry signalling information.

The following table indicates the inauguration year and overall transmission quality for the main cable sections.

Section	*Length*	*Year introduced*	*Quality*	
Yerevan - Masis	14.5 km	1966	poor condition, not in use	
Masis - Ararat	39 km	1986	poor condition, not in use	
Ararat - Eraskh	12 km	1986	8 km missing	
Masis - Araks	46 km	1987	in use	
Yerevan - Kanaker	17 km	1975	poor condition	
R-51km - Razdan	36 km	1985	in use	
Razdan - Indjevan	83 km	1985	poor condition; 2.5km missing	
Sevan - Shorja	45 km	1978	poor condition	
Masis - R-51km	51 km	1981	poor condition	
Araks - Gyumri	95 km			
Gyumri - Vanadzor	69 km			
Gyumri - Arevik				
R-51km - Kanaker		1997	adequate; insufficient capacity : 4 quads, 1.2 mm wire diameter	*Note:*

Poor transmission quality is primarily due to cable insulation lying outside the minimum tolerance limits. This is more often than not caused by moisture penetrating through to the cables at the junction boxes. Penetration increases over time in relation to the different materials used for the junction boxes and the cable armouring.

In some cases, it was necessary to replace a faulty junction box with two new boxes linked by a strip of intermediate cable. Such measures trigger signal reflections and interfere with capacitance regulation. This interference is not easily eliminated from cables that have already been laid. All these problems also arise when cable sections are stolen.

The situation is worsened by the poor condition of earthing cable protective material (theft, inadequate maintenance), leading to an increase in stray currents and, hence, greater cable sheath permeability via electrolysis.

Some sections of the aerial line between Vanadzor and Ayrum (72 km) are fitted out with cables :

Location	Length
Vanadzor	570 m
Pambak	28+45 m
Site N°517	920 m
Shagali	30 m
Tumyan	30 m
Kober	60 m
Sanain	2x130 m
km 2609	150 m
Alaberdy	92+52 m
Akhnat	57 m
Akhmala	400 m
km 2589	40 m
Ayrum	54+137+20 m

The cables used are 7x4x1.2 (TZB). The alternation between cables and aerial lines generates signal reflections, thus exacerbating transmission quality. The aerial line wires are made of bronze or steel, with diameters of 4 mm (main line, 6 HF wires) or 5 mm (main line, 10 LF wires).

Figure 2.1.1.C shows the layout of cables and aerial lines.

Most of the transmission installations are HF (frequency modulation), with 3 (frequency range of 4 kHz to 31 kHz) or 12 (frequency range of 36 kHz to 143 kHz) channels.

The frequency influences the cable attenuation coefficient. The following signal attenuation values apply to 1km of cable:
0.41 dB / km for 0.8 kHz,
1.78 dB / km for 110 kHz,
3.04 dB / km for 250 kHz.

The distance between two consecutive amplification points is inversely proportional to the selected frequency range. Along the Vanadzor-Arask line (length 164 km ; district telecommunications headquarters at Gyurmi), amplifiers are positioned at the following stations /KP : Arask / 2818, Karakert / 2803, Aragats / 2786, Anyi/ 2767, Aguin / 2748, Bayandur / 2735, Gyurmi / 2723, Maisyan / 2712, Kaltakhin / 2692, Spitak / 2673, Vanadzor / 2654. Furthermore, signals are amplified at emitting stations and at the channel endpoints listed in the table below. Amplification takes place in telecommunications facilities (as opposed to lineside cabins).

Transmission channel capacity between centres is as follows:

Station	*Station*	*Number of channels*
Yerevan	Gyumri	(2x)24 channels
Gyumri	Vanadzor	24 channels
Vanadzor	Sanain	12 channels
Vanadzor	Sanain	3 channels
Sanain	Ayrum	12 channels
Yerevan via Kanaker	Razdan	12 channels
Yerevan via Egvard	Razdan	12 channels
Yerevan	Abovyan	3 channels
Yerevan	Egvarg	3 channels
Razdan	Sevan	12 channels
Sevan	Shorja	3 channels
Razdan	Dilijan	12 channels
Dilijan	Idjevan	12 channels
Shorja	Zod	

An international 3-channel link between Sanain and Tbilisi (Georgia) is fed by V-3-3 installations.

Figure 2.1.2.D illustrates the railway's transmission capacity.

48 channels are currently required between Yerevan and Gyurmi, however, only 24 are in working order as a result of one transmission installation being dismantled and recycled for spare parts. Transmission between Yerevan and Razdan via Egvard is down due to the critical state of the cable between Masis and the R-51 km split.
Transmission between Razdan and Indjevan via Dilijan is down and no longer operational following a break in the cable (2.5 km) between Dilijan and Kuybyshevo.

2.1.1.6 Radiocommunications

The railway employs radiocommunications for railway operations. In general, all locomotives are fitted with 2Mhz/VHF radio sets, with the exception of shunting and freight locomotives, which have only VHF radio. Rolling stock comprises electric and diesel locomotives. A breakdown of electric locomotives reveals 47 VL-8 series, 44 VL-10 series and 11 EP-2 EMUs (Electric Multiple Units), 4 of which are in active service.

Two radio systems are used conventionally:

- Train radio

The train radio system enables drivers and controllers/stations to communicate. It is similar to the ground-to-train radio system (standardised in UIC Leaflet 751.3) in all but the following points:

The selected frequency is unique (2.130 MHz) and the operating mode is simplex. All transmitters are positioned in stations. Aerials are situated at a distance of 20 to 50 m from the corresponding radio base. Transmission power is 10 W. Radio bases are not synchronised.

As a result, radio coverage does not extend beyond the station itself and the line sections on either side. However, it should be noted that coverage is not continuous (this would require several distinct frequencies).

Furthermore, from a traffic control point of view, a control circuit is divided up into radio blocks, each comprising several stations and therefore several radio transmitters/receivers.

The locomotives are in permanent receiver mode. Communication is limited to one train per radio block, at the instigation of the controller, the station or the locomotive.

Most of the radio equipment used is 15 to 20 years old.

- Shunting radio

This system provides for communication between the head station traffic controller and shunting team members, including the driver of the shunting locomotive. A similar system is used by maintenance teams (intervention in the event of an accident, etc.).

The shunting radio is a stand-alone system mainly covering station or railway location sites. It is based on the use of simplex frequencies in the 150 - 156 MHz VHF range.

The radio system is similar to those still sometimes used in Europe to transmit over distances of several dozen kilometres. This point was not examined any further within the framework of the present project.

- Transcaucasian radio

This radiocommunications system is shared by all Caucasian railways and was donated by the United Nations "World Food Program". It serves mainly to manage empty wagons and trace trains loaded at ports.

Codan 8528 SSB Transceiver radio sets are used. If connected to a Codan 9001 HF Fax & Data Interface, these sets can also transmit and receive data and faxes. At present, voice communication is most prevalent (only a few sets have a 9001 interface).

See Figure 2.1.1.E

The following Armenian stations are connected: Ayrum, Sanain, Vanadzor, Gyumri, Vardenis, Razdan and Yerevan (traffic control). The transmission channels used are type P01 (3695 kHz), P03 (4560kHz), P05 (5845 kHz), P06 (6995 kHz), P09 (7645 kHz) and P10 (7740 kHz).

2.1.2 Azerbaijan

2.1.2.1 Introduction

Azerbaijan Railways use analog systems only and are equipped with electromechanical telecom switches. Local calls (between subscribers connected to the same telecom switch) are processed automatically; outside calls (requiring a link between two different telecom switches) go through an operator. The transmission links are HF (frequency modulation) electronic transmission installations. The physical media used are copper cables and aerial lines.

Figure 2.1.2.A depicts the Azerbaijan railway network, with the Traceca corridor marked in bold. A ferryboat service ensures rail transport between the ports of Bakou and Krasnovodsk (Turkmenbashi). The service to Aktau port (Mangyshlak station) is not yet running.

2.1.2.2 General characteristics

The telecommunications installations are standardised (GOST) and comply with OSJD leaflets as regards railway applications. Parts originate from the former Soviet Union or eastern Europe and are no longer in production. Neither are they compatible with today's technology.

Installations are primarily fed from the public grid. A secondary power supply (transformation, rectification, back-up) is provided by the railway. Back-up energy is generated by a battery with a few hours' capacity (depending on the condition of the battery). Major centres have the additional safeguard of diesel generators which are activated, automatically or manually, in the event of a public grid power cut.

2.1.2.3 Switching

Switching nodes are located at the following stations: Bakou, Alyati, Kazi-Magomed, Gyandja, Akstafa, Beyuk-Kyasik, Evlakh, Udzari, Baladjari, Eybat, Sangatchali, Duvanyiy, Karadag, Kyurdamir, Dolyar. To make a local call, the subscriber dials the desired number and is put through automatically.

To make an outside call, the subscriber must dial the operator and state the name and number of the connection sought. The operator calls back once end-to-end communication has been established (a process which may involve several operators). This manual procedure is limited by the operator's switchboard capacity and the number of transmission channels. The switchboards used are type MPU-80, MPU-20 or MPU-60. Call connection times no longer meet modern-day requirements.

The following table lists the number of subscribers per node. Capacity is currently at saturation point.

Station	*KP*	*Number of subscribers*	*Model*	*Level*
Bakou	2661	3000	ATS-54	LAZ
Baladjari	2648	2100	UATS-49	Trans
Alyati-gl.	461	100	KRJ	Trans
Alyati-pr.	5	100	KRJ	LAZ
Kazi-Magomed	417	300	ATS-49	LAZ
Kyurdamir	342	200	ATSK-50	Trans
Udzari	295	200	UATS-49	Trans
Evlakh	250	200	ATSK-50	Trans
Gyandja	183	2300	ATSK-100	LAZ
Dolyar	149	100	KRJ	Trans
Akstafa	88	400	ATSK	LAZ
Beyuk-Kiasik	45	50	ATSK	LAZ

Telecom switches employ either rotary or crossbar technology. They were put into service in the 80s and remain operational today. They are powered by 48 or 60 V central batteries.

The position of the telecom switches is shown in Figure 2.1.2.B

2.1.2.4 Services

To complement the switched telephone network (cf. Section 2.1.2.3), a certain number of voice services are also provided on dedicated lines. These connections consist of a primary railway telephone transmitter/receiver and terminal installations (subscribers) linked in parallel on the transmission line. The operator (controller) is in permanent receiver mode. Subscribers are selected manually by pressing a button on the operator's switchboard. The primary transmitter/receiver emits the dial tone frequency, which is received by the subscriber selector (APC-1). These connections date from the 70s-90s. Nothing further has been introduced since then, although some circuits are planned. The services involved are:

- Traffic control (2 wire link).

The traffic control centre is housed in the same building as the railway headquarters (Bakou) and manages several line sections totalling 479 km. Rationalisation has triggered an overhaul of traffic regulation, resulting in circuits being reorganised and telecommunications equipment replaced.

- Energy control (2 wire link).

This line runs between the energy control centre and energy controllers in the OHL power supply sub-stations. The energy and traffic control centres are situated side by side and cover identical geographical zones.

- Dedicated station-to-station telephone lines (2 wire link between manual KPS-2/3 and UKSS-8 telecom switches). Call frequency is 25 or 50 Hz.
- Distribution of reserved tickets.

The ticket reservation/distribution centre is connected to some main-line passenger stations.

- Teleconferencing

A 4-wire link connects a supervisor's installation to those of his/her team.

- Railway police

- Operator management of outside calls to and from line stations connected in parallel on a dedicated circuit.
  (2 wire link).
- Signalling and telecommunications maintenance
- Track maintenance
- Lineside alarm (2 wire line).
- Traffic controller - depot link.
- Traffic controller - passenger train formation yard link.

Station circuits are arranged in the same fashion and energised by local 50 or 80 V batteries.

- Telegraphy

Azerbaijan Railways also has telegraphic links. The network dates from the latter half of the 60s, with a few changes in terminal equipment (upgrade in models), and is still in service today. The models currently in use are T-63, STA 67 and F-1100. 155 terminal installations still function today.

Transmission rates correspond to those achieved by older European systems, i.e. 50 baud (24-channel transmission system), 100 baud (12-channel transmission system) or 200 baud (6-channel transmission system). Connection is automatic and P-327-3 or P-327-12 transmission equipment is used.

The telegraph office is located at the railway undertaking's headquarters. Terminal installations are hooked up to the switch and can be connected to other installations in the former SZD telegraph network (the central switch of the RZD network is situated in Moscow). Today, the telegraph links are used to send written instructions concerning traffic control and commercial aspects.

2.1.2.5 Transmission media

The transmission media are copper cables and aerial lines. Most of the cables are buried. Transmission links are generally served by HF (frequency modulation) electronic transmission installations, although use is also made of direct audiofrequency transmission over copper cables and aerial lines. Adaptation is generally carried out by a translator.

The cables are type 7x4x1.2+5x2x0.7+1x0.7 (7 star-shaped quads, 1.2 mm diameter wire; 5 pairs and 1 wire of diameter 0.7 mm) MKPAB (paper insulation, aluminium armouring and PVC outer sheath). The wire pairs also carry signalling information.

The following tables indicates the inauguration year and overall transmission quality for the main cable sections.

Section	*Length*	*Number*	*Year introduced*	*Quality*
Bakou - Alyati	89 km	2 cables	1980	7 quads; 4 meet standards
Baladjari - Shirvan	40 km	1 cable		
Divetchi - Yalama	65 km	1 cable		

On the whole, maintenance has ensured relatively adequate transmission quality. Deterioration is primarily due to cable insulation lying outside the minimum tolerance limits, more often than not as a result of moisture penetrating through to the cables at the junction boxes. Penetration increases over time depending on the different materials used for the junction boxes and the cable armouring.

In some cases, it was necessary to replace a faulty junction box with new boxes linked by a strip of the intermediate cable. Such measures trigger signal reflections and interfere with capacitance regulation. This interference is not easily eliminated from laid cables. All these problems also apply when cables sections are stolen.

The situation is worsened by the poor condition of earthing cable protective material (theft, inadequate maintenance), leading to an increase in stray currents and, hence, greater cable sheath permeability by electrolysis.

Aerial lines total 414 km. The Alyati/Beyuk-Kyasik line section is fitted with 32 bronze (4 mm diameter) and steel (5 mm diameter) wires. This aerial line is sited along the 3.3 kV DC electric railway line, and the operation of electric locomotive engines produces electromagnetic disturbances which undermine transmission quality.

Some sections of the aerial line are fitted with TZB or TEB 7x4x1.2 cables. Alternation between the cables and aerial lines generates signal reflections which exacerbate transmission quality.

The cables and aerial lines are mapped out in Figure 2.1.2.C

Transmission installations are generally HF (frequency modulation) models. 60-channel equipment is type
K-60 (frequency range 12-252 kHz) and 12-channel installations (frequency range 36-143 kHz) are V-12-3, PV-12-3 and P-305 series.

The frequency influences the cable attenuation coefficient. The following signal attenuation values apply to 1km of cable:
0.41 dB / km for 0.8 kHz,
1.78 dB / km for 110 kHz,
3.04 dB / km for 250 kHz.

The distance between two consecutive amplification points is inversely proportional to the selected frequency range. Amplifiers are positioned at the following stations : Dolyar, Evlakh, Udziari, Kyurdamir, Alyati, Dubanyi, Sangatchali, Karadag, Eubat et Baladjari. Furthermore, channels are amplified at emitting stations and at the endpoints listed in the table below. Amplification takes place in telecommunications facilities (as opposed to lineside cabins).

Transmission channel capacity between centres is as follows:

Station	*Station*	*Number of channels*
Bakou	Kazi-Magomed	12 channels
Kazi-Magomed	Gyandja	12 channels
Akstafa	Beyuk-Kyasik	12 channels
Bakou	Alyati	2x60 channels
Alyati	Beyuk-Kyasik	12 channels
Shirvan	Devitchi	12 channels

An international transmission line (1 channel) links Bakou and Tbilisi (Georgia).
The section between Alyati and Beyuk-Kyasik was built in 1943.

Figure 2.1.2.D: Diagram of Azerbaijan Railway's transmission capacity.

Transmission quality corresponds to that obtained from analog systems with proper maintenance but a lack of spare parts. This level of quality no longer meets modern-day requirements.

2.1.2.6 Radiocommunications

The railway employs radiocommunications for railway operations. In general, all locomotives are fitted with 2Mhz/VHF radio sets, with the exception of shunting and freight train locomotives, which have only VHF radio. Rolling stock comprises electric and diesel locomotives. The breakdown of electric motive power units is: 252 VL-8 and V-11 series and 76 EP-2 EMUs (Electric Multiple Units). Diesel engines total 280 with 4 models : TEM-2, TE-3, 2-TE10M, 2M62 and 4ME3.

Two radio systems are used conventionally:

- Train radio

The train radio system enables drivers and controllers/stations to communicate. It is similar to the ground-to-train radio system (standardised in UIC Leaflet 751.3) in all but the following points:

The selected frequency is unique (2.130 MHz) and the operating mode is simplex. All transmitters are positioned in stations. Aerials are situated at a distance of 20 to 50 m from the corresponding radio base. Transmission power is 10 W. Radio bases are not synchronised.

As a result, radio coverage does not extend beyond the station itself and the line sections on either side. However, it should be noted that coverage is not continuous (this would require several distinct frequencies).

Further, from a traffic control point of view, a control circuit is divided up into radio blocks, each comprising several stations and therefore several radio transmitters/receivers.

The locomotives are in permanent receiver mode. Communication is limited to one train per radio block, at the instigation of the controller, the station or the locomotive.

Most of the radio equipment used in 15 to 20 years old.

- Shunting radio

This system provides for communication between the head station traffic controller and the shunting team members, including the driver of the shunting locomotive. A similar system is used by maintenance teams (intervention in the event of an accident, etc.).

The shunting radio is a stand-alone system mainly covering the station or railway sites. It uses simplex frequencies in the 150 - 156 MHz VHF range.

The radio system is similar to those still sometimes used in Europe to transmit over distances of several dozen kilometres. This point was not examined any further within the framework of the present project.

- Transcaucasian radio

This radiocommunications system is shared by all Caucasian railways and was donated by the United Nations "World Food Program". It serves primarily to manage empty wagons and trace trains loaded at ports.

Codan 8528 SSB Transceiver radio sets are used . If connected to a Codan 9001 HF Fax & Data Interface, these sets can also transmit and receive data and faxes. At present, voice communication is most prevalent (only a few sets have the 9001 interface).

See Figure 2.1.2.E

The following Azerbaijani stations (including the traffic control centre) are connected: Bakou, Beyuk-Kyasik, Astara, Mindjevan, Nakhichevan, Yalama, Gyandja, Evlakh, Salyani, Imishli, Kazi-Magomed, Ali-Bayramli, Udzari, Divetchi. The selected transmission channels are P02 (4020 kHz), P04 (5810 kHz), P07 (7095 kHz) and P08 (7605 kHz).

2.1.3 Georgia

2.1.3.1 Introduction

Georgian Railways use both analog and digital systems with electromechanical telecom switches. Local calls (between subscribers connected to the same telecom switch) are processed automatically. Outside calls (requiring a link between two different telecom switches) generally go through an operator, although connection between some telecom switches is obtained automatically (by dialling an area code). The transmission links are HF (frequency modulation) electronic transmission facilities and digital equipment for part of the network. The physical media used are copper cables, aerial links and optical fibre cables.

Figure 2.1.3.A describes the Georgian railway network, with the Traceca corridor marked in bold. At the ports of Poti and Batumi, freight is transferred to boats. There are plans for a ferry to transport broad-gauge wagons to Odessa.

2.1.3.2 General characteristics

The telecommunications installations are standardised (GOST) and comply with OSJD leaflets as regards railway applications. Parts originate from the former Soviet Union or eastern Europe and are no longer in production. Neither are they compatible with today's technology. The digital equipment used for optical fibre transmission was specially commissioned from the technical university at Tbilisi.

The primary power supply for installations is from the public grid. A secondary power supply (transformation, rectification, back-up) is provided by the railway. Back-up energy is generated by a battery with a few hours' capacity (depending on the condition of the battery). Major centres have the additional safeguard of diesel generators which are activated, automatically or manually, in the event of a public power cut. These diesel generators are located at Tbilisi, Khashuri, Samtredia and Supsa.

2.1.3.3 Switching

Switching nodes are located at the following stations: Gardabani, Rustavi-Gruzovaya, Tbilisi-Uzlovaya, Tbilisi-Passagirskaya, Tbilisi- Elektricheskoe depo, Mskheta, Gori, Khashuri, Zestafoni, Samtredia, Supsa, Batumi, Senaki and Poti. To make a local call, the subscriber dials the desired number and is put through automatically.

To make an outside call, the subscriber must dial the operator and state the name and number of the connection sought. The operator calls back once end-to-end communication has been established (a process which may involve several operators). This manual procedure is limited by the operator's switchboard capacity and the number of transmission channels. The switchboards used are type MPU-80, MPU-20 or MPU-60. Call connection times no longer meet modern-day requirements.

Calls are put through automatically between the telecom switch at Tbilisi - Passagirskaya and those positioned at the following stations: Tbilisi - Elektricheskoe depo, Tbilisi - Uzlovaya, Zestafoni, Samtredia, Khashuri, Batumi and Sukhumi. The line to Moscow could be obtained automatically (using the dialling code 6), but is not currently operational. Diagram 2.1.3.B illustrates the dialling code scheme.

The following table lists capacity (number of subscribers) per node. The telecom switches are currently at saturation point.

Station	*KP*	*No. of subscribers*	*Model*	*Note*
Gardabani	33			
Rustavi (Gruz.)	25	50	ATS	
Tbilisi (Uzlov.)	0/2510	600	ATS	
Tbilisi (Pass.)	2503/2304	4500+300	Kor+ATS	1990
Tbilisi (El.depo)		900	ATS	
Mskheta	2482			
Gori	2428	100	ATS	
Khashuri	2384	1000	Kor	1980
Zestafoni	2321	200	ATS	
Samtredia	2260/106	1300	ATS	
Batumi	0	500	ATS	
Poti	41	200	ATS	

The telecom switches use rotary or crossbar technology. They were installed between 1947 and 1956 and are still in working order. The inauguration years for the telecom switches at Tbilisi - Passagirskaya and Khashuri are given in the column headed "Note". Power is supplied by 48 or 60 V central batteries.

The position of the telecom switches is shown in Figure 2.1.3.C.

2.1.3.4 Services

To complement the switched telephone network (cf. Section 2.1.1.3), a certain number of voice services are also provided on dedicated links. These links consist of a primary railway telephone transmitter/receiver and terminal installations (subscribers) linked in parallel on the transmission line. The operator (controller) is in permanent receiver mode. Subscribers are selected manually by pressing a button on the operator's switchboard. The transmmitter/receiver emits the dial tone frequency, which is picked up by the subscriber selector (APC-1). These connections date from the 70s-90s. Nothing further has been introduced since then, although some circuits are in the pipeline.

The services involved are:

- Traffic control (2 wire link)

Traffic control centres are located at the railway headquarters in Tbilisi and in the Samtredia region. Together they manage 7 line sections. The following table lists the sections managed and corresponding lengths. A proposed upgrading programme would see all control sets transferred to Tbilisi and the number of line sections cut. This, in turn, would involve replacing telecommunications equipment and rearranging existing circuits

Control centre	*Line section*	*Length*
Samtredia	Batumi - Samtredia	106 km
Samtredia	Poti - Samtredia	70 km
Samtredia	Samtredia - Zestafoni	61 km
Tbilisi	Zestafoni - Khashuri	63 km
Tbilisi	Khashuri - Tbilisi	120 km
Tbilisi	Tbilisi - Beyuk-Kyasik	45 km (Gardabani) + 12 = 67 km
Tbilisi	Tbilisi - Ayrum	70 km (Sadakhlo) + 13 = 83 km

- Energy control (2 wire link)

This line runs between the energy control centre and regulation points in the OHL power supply sub-stations. The energy and traffic control centres are situated side by side and generally cover identical geographical zones.

- Dedicated station-to-station telephone lines (2 wire link between the manual KPS-2/3 and UKSS-8 telecom switches). Call frequency is 25 or 50 Hz.
- Distribution of reserved tickets.

The ticket reservation/distribution centre is connected to some main-line passenger stations.

- Teleconferencing

A 4-wire link connects a supervisor's installation to those of his/her team.

- Railway police
- Operator management of outside calls to and from line stations connected in parallel on a dedicated circuit.
  (2 wire link).
- Signalling and telecommunications maintenance
- Track maintenance
- Lineside alarm (2 wire line).
- Traffic controller - depot link.
- Traffic controller - passenger train formation site link.

The local circuits at stations are arranged in the same fashion and energised by local 50 or 80 V batteries.

- Telegraphy

Georgian Railways also has a telegraph network. It dates from the latter half of the 60s, with a few changes in terminal equipment (upgrade in models), and is still in service today. The model currently used is the G-2000 model (for communication in the Russian or Georgian language) Over a hundred terminal installations still function today.

Transmission rates correspond to those achieved by older European systems, i.e. 50 baud (24-channel transmission system), 100 baud (12-channel transmission system) or 200 baud (6-channel transmission system). Connection is automatic and P-327-3 or P-327-12 transmission equipment is used.

The telegraph office is located at the railway undertaking's headquarters. AT-PS-PD equipment is used. Terminal installations are connected to the switch and can be connected to other installations in the former SZD telegraph network (the central switch of the RZD network is located in Moscow). The following stations are linked to the central office: Batumi, Poti, Samtredia, Zestafoni, Khashuri, Gori, Tbilisi-Pass and Tbilisi-Uzi. Today, the telegraph network is used to send written instructions concerning traffic control and commercial aspects.

2.1.3.5 Transmission media

The transmission media used are copper cables, aerial lines and optical fibre cables. Most of the cables are buried. Transmission lines are generally served by HF (frequency modulation) electronic transmission installations. Part of the network is served by IKM (8-channel input/output unit) and IKM-30 (30-channel input/output unit) digital equipment constructed locally at Tbilisi Technical University. Use is also made of direct audiofrequency transmission over copper cables and aerial lines. Adaptation is generally carried out by a translator.

Cables are type 14 or 7x4x1.05+5x2x0.7+1x0.7 (14 or 7 star-shaped quads, 1.05 mm diameter wire; 5 pairs and 1 wire of diameter 0.7 mm) MKPAB (paper insulation, aluminium armouring and PVC outer sheath), MKBAB, MKPAP, MKPAP and MKVM-K replaced by 4-fibre OKP-10-01-04-4 single-mode VOK (optical fibre cables). The copper wire has an electrical resistance to direct current of 55Ω/km for a diameter of 0.7 mm, and 21.2Ω/km for a diameter of 1.05 mm.

The following table gives the section lengths and the number and type of cables for the major cables sections. The Khashuri - Zestafoni section was inaugurated in 1979 with the Samtrediya extension following a year later. The Khashuri - Tbilisi cable began transmission in 1982 and the Gardabani extension (Azerbaijani border) was added two years later. The optical fibre cables were launched in 1995.

Station / KP	*Station / KP*	*Length*	*Number of cables*	*Type*
Rustavi / 25	Tbilisi / 2510	25,5 km	2	MKPAP 7x4+5x2
Sadakhlo / 2563	Tbilisi / 2510	53 km	2	MKBAB 7x4+5x2
Tbilisi / 2510	Garajani / 116	116 km	1	MKBAB 7x4+5x2
Tbilisi / 2510	Khashuri / 2384	126 km	2	MKPAB 7x4+5x2
Khashuri / 2384	Zestafoni / 2321	63 km	2	MKBAB 7x4+5x2
Zestafoni / 2321	Senaki / 2232	89 km	1	MKBAB 7x4+5x2
Zestafoni / 2321	Senaki / 2232	89 km	1	MKBAB 14x4+5x2
Batumi / 0	Samtrediya / 2260	106 km	1	VOK (4 wire)
Samtrediya /2260	Poti / 39	67 km	1	VOK (4 wire)

The low transmission quality is primarily due to cable insulation lying outside the minimum tolerance limits. This is more often than not caused by moisture penetrating through to the cables at the junction boxes. Penetration increases over time in relation to the different materials used for the junction boxes and the cable armouring.

In some cases, it was necessary to replace a faulty junction box with two new boxes linked by a strip of the intermediate cable. Such measures trigger signal reflections and interfere with capacitance regulation. This interference is not easily eliminated from cables that have already been laid. All these problems also apply when cables sections are stolen.

The situation is worsened by the poor condition of earthing cable protective material (theft, inadequate maintenance), leading to an increase in stray currents and, hence, greater cable sheath permeability by electrolysis.

The aerial lines have a diameter of 4 mm (main line, 6 HF wires) or 5 mm (main line; 10 LF wires). Some sections of the aerial lines are fitted with cables, generally type TEB or TZB 7x4x1.2. Alternation between cables and aerial lines generates signal reflections which exacerbate transmission quality.

The cables, aerial lines and optical fibre cables are mapped out in Figure 2.1.3.D

HF (frequency modulation) transmission equipment is used for the copper cables and aerial lines:

OV-3-3 (3 channels) 4-31 kHz frequency range,
OV-12-3 (12 channels) 36-143 kHz frequency range,
P-305 (12 channels) 36-143 kHz frequency range,
K-12+12 (24 channels) 8-150 kHz frequency range,
K-60-P (60 channels) 1-252 kHz frequency range, i.e.:
- group I (12 channels) 208-252 kHz frequency range,
- group II (12 channels) 160-204 kHz frequency range,
- group III (12 channels) 112-156 kHz frequency range,
- group IV (12 channels) 64-108 kHz frequency range,
- group V (12 channels) 12-57 kHz frequency range.

These installations are fed 24 V direct current taken from the 220 V alternating current public grid.

The frequency affects the cables attenuation coefficient. The following values are for signal attenuation over 1km of cable :
0.41 dB / km for 0.8 kHz,
1.78 dB / km for 110 kHz,
3.04 dB / km for 250 kHz.

The distance between two consecutive amplification points is inversely proportional to the selected frequency bandwidth. Amplifiers are positioned at the following stations: Sadakhlo, Marnauli, Rustavi, Tbilisi-Uzlovaya, Sagaredjo, Katchreti, Mskheta, Gori, Khashuri, Zestafona and Rioni. In addition, channels are amplified at the emitting station and the endpoints indicated in Diagram 2.1.3.E. Amplification takes place in telecommunications facilities (as opposed to lineside cabins).

Transmission channel capacity between centres and the types of installation used are listed below:

Station	*Station*	*Number of channels*	*Type of installation*
Tbilisi	Khashuri	60 channels	K-60-P
Tbilisi	Samtrediya	120 channels	2 x K-60-P
Tbilisi	Garajani	24 channels	K-12+12
Tbilisi	Rustavi	12 channels	V-12-3
Tbilisi	Gardabani	12 channels	P-305
Tbilisi	Marnauli	12 channels	P-305
Tbilisi	Sadkhlo	3 channels	V-3-3
Khashuri	Gory	12 channels	P-305
Khashuri	Borjomi	12 channels	P-305
Khashuri	Vale	3 channels	V-3-3
Khashuri	Zestafoni	3 channels	V-3-3
Zestafoni	Tchyatura	(12+3) channels	P-305 + V-3-3
Zestafoni	Kutaisi	3 channels	V-3-3
Kutaisi	Samtrediya	3 channels	V-3-3
Samtrediya	Poti	30 channels	IKM-30
Samtrediya	Batumi	30 channels	IKM-30
Samtrediya	Kolobani	8 channels	IKM
Samtrediya	Sadjavakho	8 channels	IKM

An international 3-channel line serviced by V-3-3 equipment links Tbilisi and Sanain (Armenia).

Figure 2.1.3.D below illustrates the railway's transmission capacity.

Transmission is down between Zestafoni and Tchyatura due to missing cable in the line section. Installations are operational thanks to recycling of other transmission facilities to obtain spare parts. Transmission quality is often poor as a result of the inferior cable technology.

2.1.3.6 Radiocommunications

The railway employs radiocommunications for railway operations. In general, all locomotives are fitted with 2Mhz/VHF radio sets, with the exception of shunting and freight train locomotives, which have only VHF radio. Rolling stock comprises electric and diesel locomotives and electric multiple units (EMU). A further breakdown reveals 235 VL-8, VL-10 and VL-11 series electric locomotive, 92 EP-2 EMUs and 185 TE and M series diesel locomotives (range of models).

Two radio systems are used conventionally:

- Train radio

The train radio system enables drivers and controllers/stations to communicate. It is similar to the ground-to-train radio system (standardised in UIC Leaflet 751.3) in all but the following points:

The selected frequency is unique (2.130 MHz) and the operating mode is simplex. All transmitters are positioned in stations. Aerials are situated at a distance of 20 to 50 m from the corresponding radio base. Transmission power is 10 W. Radio bases are not synchronised.

As a result, radio coverage does not extend beyond the station itself and the line sections on either side. However, it should be noted that coverage is not continuous (this would require several distinct frequencies).

Furthermore, from a traffic control point of view, a control circuit is divided up into radio blocks, each comprising several stations and therefore several radio transmitters/receivers.

The locomotives are in permanent receiver mode. Communication is limited to one train per radio block, at the instigation of the controller, the station or the locomotive.

Most of the radio equipment used in 15 to 20 years old.

- Shunting radio

This system provides for communication between the head station traffic controller and the shunting team members, including the driver of the shunting locomotive. A similar system is used by maintenance teams (intervention in the event of an accident, etc.).

The shunting radio is an stand-alone system mainly covering the station or railway sites. It uses simplex frequencies in the 150 - 156 MHz VHF range.

The radio system is similar to those still sometimes used in Europe to transmit over distances of several dozen kilometres. This point was not examined any further within the framework of the present project.

- Transcaucasian radio

This radiocommunications system is shared by all Caucasian railways and was donated by the United Nations "World Food Program". It serves mainly to manage empty wagons and trace trains loaded at ports.

Codan 8528 SSB Transceiver radio sets are used . If connected to a Codan 9001 HF Fax & Data Interface, these sets can also transmit and receive data and faxes. At present, voice communication is most prevalent (only a few sets have the 9001 interface).

See Figure 2.1.3.F

The following Georgian stations and control centres are hooked up: Batumi (station + port), Poti (station + port), Gardabani, Sadakhlo, Tbilisi, Samtredia, Zestafoni, Gory, Rioni, Telavi, Gurjaani, Tsalka, Kazreti and Dedoplitskaro.

2.2 Survey of existing studies

2.2.1 Infrastructure Maintenance 1 - Railways pre-investment study and Baku - Tbilisi - Batumi/Poti pilot train - Module A - Draft Final Report - May 1997. (Tewet / DE-Consult)

2.2.1.1 Azerbaijan

2.2.1.1.1 Summary

Although it is old, the signalling system is in satisfactory condition. Nonetheless the technology is old and the condition of the system is deteriorating. Renovation is advocated in the short and medium term. The requisite budget is estimated at US$ 138.6 million. Priority investment over the first four years will be US$ 16.5 million.

The telecommunications system cannot ensure reliable communications. The insulating outer sheath dates back to 1983 and has become porous. The poor quality of transmission has a direct impact on rail traffic.
Renovation in the short term is necessary. The budget is US$ 43.1 million, 13.2 of which would go on priority investment.

The current condition of both signalling and telecommunications makes it impossible to manage more traffic.

2.2.1.1.2 Technical solutions
The signalling system can largely be maintained. It is proposed above all to replace faulty components. It is proposed that the replacement parts be Russian and of the same type. The equipment in question is robust and the staff familiar with it can install it with ease.

It is advocated that the equipment in the following stations be completely replaced over the next 5-10 years :

Kasi-Magomed
Mugan
Gadshievo
Kyrdamir
Yevlakh
Geran
Kyurok-Tshai
Beyuk-Kyassik

Owing to the increase in traffic on the Baku to Beyuk-Kyassik line, it is advocated that the following manual signal boxes be replaced :

Kyrdamir
Alabashli
Shamkir
Dallyar
Dsegam
Kovlyar

The telecommunications system needs to be totally replaced. A system of optical fibres is recommended for the Baku - Beyuk-Kyassik line.

An architecture based on two 147-fibre (!) cables, using SDH/STM-1 technologies is recommended. A 155Mbits/s STM-1 can carry 1920 channels per optical fibre. By installing a second cable, a ring is created and thus a very high rate of system availability achieved.

The following stations are to be equipped :

Beyuk-kyassik
Akstafa
Alabashli
Gyandsha
Yevlakh
Padar
Kasi-Magomed
Alyat
Baku
Baladshary

Baku will have a CCM (cross connect multiplexer) to allow connection with other telecommunications networks and other stations will be equipped with ADM (add/drop multiplexer).
This capacity will be sufficient to meet both railway and non-railway needs.
By installing spare capacity, system saturation and subsequent works can be avoided.

Switching equipment should gradually be replaced with digital equivalents.

It is advocated that a ground-to-train radio system be installed : "train radio 2002", which complies with current European standards.

2.2.1.2 Georgia

2.2.1.2.1 Summary

The signalling system as a whole is in satisfactory condition. However, the Samtredia - Poti and Samtredia - Batumi sections are down. The main problem seems to be electricity supply to these installations.
The budget for signalling renewal and maintenance for the next ten years is estimated at US$ 124 million, 12.65 of which for priority work to be carried out by 2000.

The telecommunications system is in critical condition. Renewal of the system is a top priority. The impact of the current situation on train running is substantial.
The budget for signalling renewal and maintenance for the next ten years is estimated at US$ 34.4 million, 5.3 of which to be invested before 2000.

2.2.1.2.2 Technical solutions

Basically the signalling system can be retained. Equipment is to be replaced by Russian components of the same type. The Russian equipment is robust and easy for the staff to install, as they are already familiar with it. Some of the equipment will be manufactured locally. Re-establishment of the automatic block system is necessary to increase rail traffic.
The Samtredia - Poti and Samtredia - Batumi sections will be re-equipped with semi-automatic blocks. Transmission of information from these two sections will be via the optical fibre already fitted on the above-mentioned sections.

The telecommunications system is to be totally changed. An optical fibre system is recommended.
An architecture based on two 147-fibre (!) cables, using SDH/STM-1 technologies is advocated. The 155Mbits/s STM-1 can carry 1920 channels per optical fibre. By installing a second cable, a ring is created and thus a very high rate of system availability achieved.

The following stations are to be equipped :

Gardabani	
Tbilisi	
Gori	
Khashuri	
Rioni	
Samtredia	
Senaki	Natanebi
Poti	Batumi

Tbilisi and Samtredia will have a CCM (cross connect multiplexer) to allow connection with other telecommunications networks and other stations will be equipped with an ADM (add/drop multiplexer).

NB : there is already a cable between Samtredia and Poti, Samtredia - Batumi.

This capacity would meet both railway and non-railway needs.
By installing spare capacity, system saturation and subsequent works can be avoided.

Switching equipment should be gradually replaced with its digital equivalent.

It is advocated that a ground-train radio system be installed : "train radio 2002", which complies with current European standards.

UIC comments :
- It is unrealistic to recommend that the signalling system be repaired to Soviet-era standards, both in light of current and expected traffic and of available budgets.
- Regarding telecommunications, 147 fibres seems excessive, perhaps there has been a typing error and in fact only 14 fibres are proposed.

2.2.2 Project Identification Report for Georgian Railways - EBRD (CIE Consult)

2.2.2.1 Context

This report was commissioned by the EBRD in order to define the priority investments for Georgian railways within a maximum budget of USD 30 million.

Apart from the Tbilisi/Kaspi section where the automatic block has been restored, signalling installations have been almost totally destroyed in the western region.
The sections around Samtredia have a centralised traffic control system which is fairly sophisticated.

During the civil war, buried cables were dug up for their copper, as were track circuits for their metal components. Signalling equipment lights and lenses, points motors (...) were stolen.

Thanks to the optical fibre cable supplied by the European Union for the Samtredia/Batumi & Poti section, the telephone system is back in operation allowing minimum "telephone block" traffic management.

2.2.2.2 Technical proposal

2.2.2.2.1 Signalling

By contrast to the Tewet reports, only emergency measures are recommended owing to the low levels of finance available.

Between Tbilisi and Senaki, the average block length is 6.4km which is a lot less than necessary.
The proposal is to close at least 50% of stations in order to double or triple of the size of the sections.
The resulting network should be reconstructed with a reduced automatic block only.

Freight operations are to be concentrated in the main stations.

The equipment recommended is the type used in existing installations, i.e. Soviet.

The investment is estimated at USD 6.5 million.

2.2.2.2.2 Telecommunications

The current system based on a 4-optical fibre cable between Poti, Batumi and Samtredia is unsatisfactory in that it is regularly damaged owing to a lack of armouring.
It is proposed to replace the system and to install a general SDH system based on optical fibres. It will first be used in STM-1 with 155Mbits/s, i.e. 1890 audio channels. Throughputs could be improved in the future.

The system should form a ring with two 12-fibre cables. The ring ensures redundancy should one of the cables be damaged.
This system offers sufficient capacity for current and future railway needs. Furthermore, it supplies excess capacity which could be marketed.

The two cables should be armoured, not made of metal and strung between the catenary masts on each side of the track. An additional mast will have to be erected on the other side of the track on single track sections.

To maintain the benefits of the ring configuration, it is proposed to extend it with a micro-wave link between Poti and Batumi (additional investment : USD 0.5 million).

The investment would consist of the following :
- 2x500km of 12-fibre cable @ USD 3,500/km, i.e. USD 3.5 million.
- 35 sets of station installations @ USD 50,000 each, i.e. USD 1.75 million.
- 2 supervision centres, i.e. USD 0.40 million
- USD 1 million for installation
- USD 0.35 million for training and spare parts.

Thus a total of USD 7 million.

UIC comments :
- Station installations : the section concerned includes 55 stations, thus only 2/3 of the stations will be equipped.
- Installation : USD 7,000/km is more in line with the European prices. The enormous difference in salaries between Europe and Georgia can go some way towards explaining such a differential. The cost of erecting additional masts on the single-track sections and on certain curves (the pitch between catenary masts is substantially greater than the usual in Europe) does not seem to have been calculated.

2.2.2.3 Financing and calls for tender

2.2.2.3.1 Signalling

The bulk of the USD 6.5 million budget is earmarked for Soviet spare parts.

A call for tender (ICB - International Competitive Bidding) in line with EBRD rules (EBRD will provide the finance) is recommended.

The railways' signalling and telecommunications departments will carry out installation work.

Date of call for tender : 09/98
Date contract is awarded : 02/99
Date contract expires : 12/99

2.2.2.3.2 Telecommunications

The budget will be provided by the European Union. The calls for tender will thus be open in accordance with European Union rules.

The cable will be installed by the railways' signalling and telecommunications department.
Note from UIC : the total budget is USD 7 million. Only USD 6 million will be provided by the European Union. The railways will provide USD 1 million, which is equivalent to the budget set aside for installation.

The first call for tender is for the optical fibre cable, the second for the supervision system and station installations. Installation and training will be carried out by the contract holder.

Detailed technical specifications will be part of the technical assistance for the call for tender and for installation.

Cable :
Date of call for tender : 09/98
Date contract is awarded : 12/98
Date contract expires : 12/99

Station installations and supervision :
Date of call for tender : 01/99
Date contract is awarded : 07/99
Date contract expires : 05/00

1.3.2.4 Commercial openings

Cursory consideration is given to the commercial potential of the optical fibre system in an appendix to this document.
The conclusions drawn are that the main potential markets are for communications between Europe and Asia. Installation of an optical fibre system is thus highly recommended for the railways of Central Asia. However, connections across the Black Sea and the Caspian Sea are not considered.

A study proposal on the matter is requested. It should include :
- An analysis of potential telecom traffic on an optical fibre running through Traceca as a whole.
- Financial analysis of the sales potential offered by a higher-capacity cable.
- Technical restrictions
- Institutional aspects and intentions in the various countries
- An action and investment plan

2.2.3 Joint venture(s) for the Caucasian railways - Draft Final Report - October 1997. (Tewet / DE-Consult / Gtz)

2.2.3.1 Summary

This project follows on from "Infrastructure Maintenance 1"(cf 2.2.1). Armenia has been added to the project.

The technical condition and interoperability of the equipment no longer ensures safe train running. Train running relies heavily on radio and operational procedures.
Signalling equipment has not been replaced as it should have been in recent years.

The disastrous state of the railway telecommunications system has become a priority.
A common telecommunication system via which information can be exchanged between railways is imperative.

It is proposed to install a system of optical fibres along the tracks. In the first instance the following sections would be fitted out :

Baku - Tbilisi - Poti
Tbilisi - Gyumri - Yerevan

Total investment breaks down as follows :

Description	Cost of investment in millions of USD			
	ARM	AGZD	GRZD	total
Signalling	42.5	148.0	135.0	325.5
Telecom	25.0	38.5	31.4	94.9
Total	67.5	186.5	166.4	420.4

2.2.3.2 Technical proposal

Three-phase implementation is proposed.

1st phase :
Installation of an optical fibre system, based on a 12-fibre cable strung between the catenary masts, and PCM equipment (32 digital channels) on main lines, and fitting out all stations :
- Yerevan - Ayrum
- Baku - Beyuk-Kyassik
- Gardabani - Tbilisi - Samtredia - Poti & Batumi.

(24 fibres between Baku and Baladshary).

2nd phase :
Installation of an optical fibre system, based on a 12-fibre cable strung between catenary masts, and PCM equipment (32 digital channels) on other lines, and fitting out all stations.

3rd phase :
Installation on all lines of a second six-fibre cable, connected with interchange stations and installation of higher-capacity equipment of the SDH/STM-1 type (1920 digital channels). A ring is thus formed.
This cable will be strung between catenary masts on double-track sections, and buried on other sections.

2.2.3.3 Financing

It is proposed that the railways set up a joint venture for the telecommunications part of phases 1 and 2. A foreign partner could be involved in the third phase.

Phase 1 is covered by a European Union grant for USD 15 million.

The expected revenue from selling the excess capacity created during the 3rd phase (for example to the national telecom operator) will not cover all the other investments immediately. A sum of USD 13.7 million is needed to cover the period before the cash flow becomes positive in 2002. This sum should come from either the foreign partner, the European Union, or the EBRD.

It should be noted that the legal situation regarding telecommunications in these countries does not yet allow for this type of joint venture.

2.2.4 Summary of the TRACECA report - Communication Network for the Caucasian Railway Feasibility Study 1/10/1997 (F.W.Krämer 19/10/1997)

1. Any new investment in railway telecommunications must be in line with the EV-TACIS/TRACECA/EBRD recommendations and the EBRD's financing prospects.

2. The contribution of telecom investments to improving railway system operation.

3. Inventory of telecom installations.
- mostly analog, old, with limited functionality, low level of automation, limited performance.

Inventory of IT equipment.
- old, a proportion of applications centralised in Moscow and Rostov.

4. Difficulties in identifying railway telecom requirements (in particular requirements for typical activities such as management, operations and administration).

5. TEWET study proposal (pilot project) consists of the following items:
- Installation of an overhead 12-optical fibre cable along the Bakou-Tbilisi-Poti and Tbilisi-Yerevan lines (i.e. 1225 km):
  - with capacity for 30 telephone channels (PCM type, 2 Mbit/s),
  - 70 % of which would be used by the railways.
- Connection of all stations.
- It is supposed that the signalling and communications equipment and the computers are used without additional technical equipment.
- Network supervision centre in Tbilisi.

6. In addition to the pilot project, TEWET proposes 2 additional phases:
- Second, parallel, optical fibre cable, separate from the first, allowing safety to be ensured by means of a ring. Introduction of the SDH.
- Rehabilitation of the switches in all stations.

7. Opinion and proposal of the expert:
- There is no need for a second cable parallel to the first. Complete redundancy and an SDH ring structure are not justifiable in economic terms.
- The cables must be buried.
- The SDH (155 Mbit/s) and 120-channel telephone capacity, in 6 main stations (Bakou, Tbilisi, Poti, Yerevan and 2 border stations) is needed at once. Connection of all stations is recognised as difficult.
- The various analog switching systems must be replaced by a single standard digital system.
- The main railway stations must be connected with digital equipment replacing analog equipment (depending on available funds or at a later stage).
- Installation of a single supervision system in each country.

8. Problems regarding implementation
- Use a "turnkey" project structure
- The "turnkey" contractor must guarantee all the performance levels and functionalities for the whole project during at least one year.
- An experienced consultant, for instance, should be entrusted with supervising the "turnkey" contractor.
- The "turnkey" contractor must be selected following a call for tenders.

9. Project budget (in Ecus):

9.1
- Module A (Georgia) 4.45 Mecu
- Module B (Azerbaijan) 5.125 Mecu

- Module C (Armenia) 3.42 MEcu Total: 15.01 Mecu
- Supervision of "turnkey" contractor 1.3 Mecu
- Contingency fund 0.715 MEcu

9.2 A firm commitment from the 3 countries concerned is essential.

10. Project feasibility

- The 3 governments concerned must guarantee joint funding of the cost of installing the optical fibre network locally, including for transmission equipment.
- Furthermore, the railways must release staff to supervise installation.
- It will be difficult for the project to survive without substantial subsidies if telecom service suppliers cannot be attracted.
- The project cannot be expected to be viable, given the current insufficient level of rail traffic.
- Thus the project cannot attract private or commercial funding. The European Union is planning to provide a grant. The EBRD will consider the latter as a complement to the loans which it is planned to grant to the Georgian and Azeri railways.
- If the economy, and thus the railways, enjoy a revival, the second phase of the project will be necessary and all the stations will have to be connected to the network.

11. The project will not be complete until competition is allowed by law and new services can be offered by privatised telecom companies.

12. In short, the project is worth pursuing.
The European Union grant will serve as a catalyst to the project.
The impact may run to complete de-regulation of the railway and telecom sectors.

2.2.5 The equipment and cables used in the Optical Fibre Network at Banverket, Sweden (Ericsson)

Topic: Analysis of the document.
"The equipment and cables used in the Optical Fibre Network at Banverket, Sweden"
(K.N. Skalman, E. Siönäs, S. Edman and G. Danielsson) (1991).

The article describes the installation of a 2500 km optical fibre network by Banverket at the beginning of the 90s.

It provides detailed information on the techniques used to lay the optical cable and quantified indications of the level of performance obtained.

The following key pieces of information may be retained:

- Banverket has set an availability objective of almost 100 %, with less than three hours downtime over a 3 year period. To this end, the network redundancy is ensured by means of a ring structure.
- The article includes a description (fig. 2) of a 40-60 km repeater section with a pair of dedicated signalling fibres branching off every 2.5-4.5 km.
- Cable-laying procedures are described in detail:
    - civil engineering resources: plough, mini-excavator, tractor on the track able to clear the track rapidly (the main objective being not to interrupt traffic),
    - detailed planning of cable-laying work - to contain downtime losses at less than 1%, instead of 7% for fixed-length cable sections,
    - splices at about every 3 km,
    - cable buried 0.65 m below surface and at least 0.3 m from existing cables,
    - 3-5 m of reserve cable at special points: bridges, maintenance sites, etc.
    - loss of less than 0.1 dB at points where welded splices are made.
- The cable contains 24 optical fibres (monomodal) ?. Transmission is in the ranges 1285-1330 nm and 1530-1570 nm. The cable has the following principle features:
    - ability to bear high crushing loads (>6000 N),
    - operating temperature range of -30 to +70°C (storage -40 to +70°C, installation between -10 and +50°C),
    - sufficient rigidity for laying in an environment as awkward as an embankment,
    - sufficiently resistant to vibrations,
    - can be ploughed into the ground,
    - to carry external markings to identify and distinguish it from other cables,
    - be completely dielectric,
    - block water longitudinally.

The following results were obtained:
- Laying the 2770 km cable took 17 months,
- The rate was 1.5 km/day/12-man team with tractor on track,
- 1220 cable splices, at a rate of 4 splices/week/team,
- 48 sets of 565 Mbit/s equipment and 175 sets of 34 Mbit/s equipment were installed.

The article gives the cost of various types of laying (on the catenary mast side, on the side opposite the catenary mast, outside the catenary masts, in a duct) (figure 15).

3. Electronic data interchange

The aim of the information technology part of this project is to improve the exchange of electronic data between railways and their partners.

To this end, the current situation was first surveyed during on-site visits. The survey was followed up with examination of other studies, past and present.

An action and investment plan will follow. It will also contain a proposal for interconnection with Europe.

There is no intention whatsoever to examine issues regarding in-house information technology on the railways. Other Traceca projects have already done so or are doing so in the Caucasus region (e.g. : Joint Venture for the Caucasian Railways / Tewet). Needless to say, the recommendations of this study will take as much account as possible of studies focusing more closely on " in-house railway IT".

3.1 Inventory

Information technology on the railways of the Caucasus region (Armenia, Azerbaijan and Georgia) is generally quite limited.

They do not have mainframes, thus the IT resources are limited to PC and terminals, which are confined to the head offices and border points.

The railways are not interconnected, but all three are linked, each via a single terminal, to the railway computer centre in Moscow. The Moscow centre is the ex-USSR's railway information technology centre. The Central Asian Traceca countries are part of this system.
The information available via Moscow is substantial enough to manage freight traffic but the system is essentially used for organising wagon hire charge clearing transactions between the various countries.
No IT system for managing international passenger traffic has been installed in these countries. In general the system is deemed satisfactory, however the railways have expressed the desire to have a system which links them more directly, and which is more in line with their needs.
Transmission links between stations, the condition of which is appalling, seems to be the biggest shortcoming of the existing system. For further information, please consult the telecommunications part of this report.

Data is not exchanged electronically with the administrative bodies, in particular the customs services and police.

Data is not exchanged electronically with customers.

Nor is data exchanged electronically with port authorities or shipping companies.

The railways have indicated that they wish to improve such contacts, in order to be more competitive vis-à-vis the road mode.

Hereafter, the term "information technology system" refers to all IT resources, "information technology centre" refers to all IT resources housed in a single building and "computer centre" to an IT centre with a mainframe.

3.1.1 Armenia.

3.1.1.1 Introduction

The IT system of Armenian Railways (ARM) is very limited.
There is a small IT centre at the head office in Erevan.
This centre is linked to Ayrum, the border point with Georgia, and to Moscow.
The system is above all used to register wagons and containers, amongst other reasons to facilitate payment of their owners.

3.1.1.2 Overview of the IT system

The Erewan IT centre has about 10 PC (PC-type computers) on a Ethernet 10Base-2 network.
It has neither a small nor a large system.
Four of the computers are 486, the others are 286. They are all of Soviet manufacture.

One of the PCs is linked with the Georgian border station PC via a US Robotics Sportster 14400 modem (complying as closely as possible to Standard V32bis with 14400 bauds). The link is only operated at 1200 bauds.
The daily transfer of information from the border point takes 10 to 60 minutes although the volume of data to be transferred is in fact extremely low : there are only about ten trains per day and there is about 1 kbyte of information to be transmitted per train, i.e. approximately 10 kbytes per day.
At times, data transmission is impossible several days in a row.
The quality of transmission thus seems deplorable.

The border point with Turkey at Akhuriyan is currently closed.
The border points with Azerbaijan are also closed.
The railway route to Iran is via Nakhitchevan which is in Azerbaijan. It is thus closed at the moment, whereas the road route does not pass via Nakhitchevan.

Another of these PC is linked to the Moscow IT system, also by a 1200 baud link.

For more information, please refer to the project reports

- Infrastructure Maintenance 1 / Tewet
- Joint Venture for the Caucasian Railways / Tewet
- Study on the Communication Network for the Caucasian Railways / Tractebel.

3.1.1.3 IT system diagram

(Diagram 3.1.1.3)

3.1.1.4 Electronic data interchange with the administrative bodies (customs, police, etc.)

3.1.1.4.1 Status quo

Data is not exchanged electronically with other countries.
A pre-printed form (train log) is filled in and handed over at the border. The log is the only paper exchanged between the parties concerned.

3.1.1.4.2 Projects

The railways want to carry out customs formalities electronically, yet there are no real projects as of yet.

3.1.1.5 Electronic data interchange with customers

3.1.1.5.1 Status quo

Transactions are only by paper and by telephone.
Enquiries are made by telephone.

3.1.1.5.2 Projects

The railways want to carry out customs formalities electronically, nonetheless there are no firm projects to date.
An objective in the shorter term is to have a system for locating freight on a daily basis, so that customers can be informed accordingly. This service would be invoiced.

3.1.1.6 Electronic data interchange with port authorities and shipping companies

3.1.1.6.1 Status quo

Armenia has no access to the sea.
Armenian railways do not exchange electronic data with the port authorities of neighbouring countries.

3.1.1.6.2 Projects

Armenia has no access to the sea.

3.1.1.7 Electronic data interchange with other railway companies

3.1.1.7.1 Outline of the systems

The Erewan IT centre has a terminal enabling connection to the ASSOUP freight management system in the Moscow Computer Centre (MCC).
This system serves above all to manage wagons : accounting, identification of their owner, financial compensation, border crossing.
The following information can be accessed via the system:

- Train numbers
- Train loads
- Goods carried
- Consignee
- Originating station
- Receiving station
- Train consist
- Train planning
- Demurrage charges

Wagons not belonging to the ARM must be returned as rapidly as possible to their owner or pay a penalty. They are often returned empty.

At present, electronic information is not exchanged with Georgian railways.
What is worse, train and wagon information entered in Georgia, in general at the Sadakhlo border station (Georgia), is gathered afresh a few kilometres down the line, in Ayrum (Armenia).
As a result border crossing times are considerably lengthened.
Regarding this state of affairs, the railways refer to their legal obligations, for example in the event of a vehicle being damaged or goods stolen.

They seem to be able to access a certain amount of information on traffic in other countries via the Moscow IT system.
The IT link with Moscow is only available one hour a day.

3.1.1.7.2 Message format

These messages are apparently in line with OSJD rules.
The consultants have been unable to obtain more information on this point.

3.1.1.7.3 Projects

The consultants have observed a desire to set up one or more mini-systems, in collaboration with Georgia.
The aim is to no longer be dependent on centralised electronic data processing in Moscow and the related exchange of information regarding freight traffic in the Caucasian area.

3.1.2 Azerbaijan.

3.1.2.1 Introduction

The IT system on Azerbaijan railways (AGZD) is very limited.
There is a small IT centre in Baku, not located at head office.
This centre is linked to the border points and to Moscow.
The system is above all used to register wagons and containers, for various reasons including facilitating compensation vis-à-vis their owner.

3.1.2.2 Overview of the IT system

The Baku computer centre had a Soviet-designed mini-computer, but it is down. It has some thirty PCs.

Each border point has two or three PCs.

The computer centre is linked by telegraph to :
Beyuk-Kassik border station (with Georgia)
Yalama border station (with Russia)
Astara border station (with Iran)
Gandja station

Border points with Armenia are closed owing to the conflict in Upper Karabagh.

The computer centre is also linked to the Moscow IT system as well as that of Rostov.

For more information, please consult the project reports
- Infrastructure Maintenance 1 / Tewet
- Joint Venture for the Caucasian Railways / Tewet
- Study on a Communication Network for the Caucasian Railways / Tractebel.

3.1.2.3 IT system diagram

(Diagram 3.1.2.3)

3.1.2.4 Electronic data interchange with administrative bodies (customs, police, etc.)

3.1.2.4.1 Status quo

Electronic data is not exchanged with the other countries.
A pre-printed form (train log) is filled in and handed over at the border. This log is the only document exchanged between the parties concerned.

3.1.2.4.2 Projects

During an interview, Mr PANAHOV, Deputy Managing Director of the railway, confirmed his determination to speed up freight traffic on the TRACECA corridor, to sharpen the competitive edge vis-à-vis the road mode, by simplifying customs formalities for example.
He is looking to this study for proposals to that end.

3.1.2.5 Electronic data interchange with customers

3.1.2.5.1 Status quo

Transactions are carried out by paper and telephone only.
Enquiries are dealt with by telephone.

3.1.2.5.2 Projects

The railways intend to carry out formalities electronically, nonetheless there are no firm projects as of yet.
An objective in the shorter term is to have a system for locating freight on a daily basis, so that customers can be informed accordingly. This service would be invoiced.

3.1.2.6 Electronic data interchange with port authorities and shipping companies

3.1.2.6.1 Status quo

There appears to be a telegraphic link with the station at Baku port.

3.1.2.6.2 Projects

The consultants received no information on this point.

3.1.2.7 Electronic data interchange with other railway companies

3.1.2.7.1 Outline of the systems

The Baku computer centre has a terminal enabling connection to the ASSOUP freight management system in the Moscow Computer Centre.
This system serves above all to manage wagons : accounting, identification of their owner, financial clearance, border crossing.
The following information can be accessed via the system:

- Train numbers
- Train loads
- Goods carried
- Consignee
- Originating station
- Receiving station
- Train consist
- Train planning
- Demurrage charges

Wagons not belonging to the AGZD must be returned as rapidly as possible to their owner or pay a penalty. They are often returned empty.

At present, electronic information is not exchanged with Georgian railways.
What is worse, train and wagon information entered in Georgia, in general at the Gardabani station (Georgia), is gathered afresh a few kilometres down the line in Beyuk-Kassik (Azerbaijan).
As a result, border crossing times are considerably lengthened.
Regarding this state of affairs, the railways refer to their legal obligations, for example in the event of a vehicle damaged or goods stolen.

They seem to be able to access a certain amount of information on traffic in other countries via the Moscow IT system.

3.1.2.7.2 Message format

These messages are apparently in line with OSJD rules.
The consultants have been unable to obtain more information on this topic.

3.1.2.7.3 Projects

The consultants have observed a desire to set up one or more mini-systems, in collaboration with Georgia.
The aim is to no longer be dependent on centralised electronic processing in Moscow and the related exchange of information regarding freight traffic in the Caucasian area.

3.1.3 Georgia

3.1.3.1 Introduction

Georgian railways' (GRZD) IT system is very limited.
There is a small IT centre at the head office in Tbilisi.
The centre is liked to the Sadarkhlo border point with Armenia, the Gardabani border point with Azerbaijan and to Moscow.
The system is used above all to register wagons and containers, for various reasons including to facilitate compensation vis-à-vis their owner.

3.1.3.2 Overview of the IT system

The Tbilisi IT centre has ten or so PCs in an Ethernet network, including several Pentiums, with Windows 95. The server is a Pentium with Windows NT.
It has no mini/large system.

A PC-type communications server is connected to the two border stations and to Moscow.

The link with the border stations Sadarkhlo (with Armenia) and Gardabani (with Azerbaijan) is via two old Russian-designed modems (TAM-1200) V22 at 1200 bauds.
If there are problems with the link, the border station gives the guard a disk to be delivered to Tbilisi.
The railways are currently carrying out trials with radio equipment donated by the United Nation's World Food Programme to replace the unreliable railway transmission system.
The equipment viewed on site consisted of :
Codan 8528 SSB Transceiver
Codan 9001 HF Fax & Data Interface
According to the manufacturer's technical specifications, this equipment accommodates Hertzian transmission of compacted data at 6000 bits/s and non-compacted data at 1475 bits/s and faxes.
The other railways of the Caucasian countries also seem to be equipped.
At the moment these radios are predominantly used in voice mode, and in particular for communication with the ports with a view to organising trains.

The link to the IT system in Moscow is by means of a recent Russian-design modem (TAINET-T288C) : it seems to comply with the V34 at 28800 bauds standard. It is only used in V22 at 1200 bauds.

The TCP/IP protocol is used on the local network.
The modem links use the BSC-1 and AP-70 protocols.

The Poti and Batumi port stations have computers but no modem. Thus information to be entered is dictated over the telephone.

For more information, please consult the project report
- Infrastructure Maintenance 1 / Tewet
- Joint Venture for the Caucasian Railways / Tewet
- Study on a Communication Network for the Caucasian Railways / Tractebel.

3.1.3.3 IT system diagram

(Diagram 3.1.3.3)

3.1.3.4 Electronic data interchange with the administrative bodies (customs, police, etc.)

3.1.3.4.1 Status quo

Data is not exchanged electronically with the other countries.
A pre-printed form (train log) is filled in and handed over at the border. This train log is the only paper exchanged between the parties concerned.

3.1.3.4.2 Projects

The railways want to carry out customs formalities electronically, nonetheless there are no firm projects to date.

3.1.3.5 Electronic data interchange with customers

3.1.3.5.1 Status quo

Transactions are only by paper and by telephone.
Enquiries are dealt with by telephone.

3.1.3.5.2 Projects

The railways want to offer the following services to their customers via EDI:
- Reference timetables
- Transport schedule
- Freight tracking
- Information on freight arrivals
- Consignment note processing
- Statistical data

3.1.3.6 Electronic data interchange with port authorities and shipping companies

3.1.3.6.1 Status quo

Formalities with the ports of Poti and Batumi are dealt with on paper and by telephone.
The port stations in Poti and Batumi are equipped with computers, but do not have modems and thus cannot communicate with the Tbilisi IT centre.

3.1.3.6.2 Projects

The railways would like to process formalities electronically, however there are no firm projects as yet.

3.1.3.7 Electronic data interchange with other railway companies

3.1.3.7.1 Outline of the systems

The Tbilisi IT centre has a terminal enabling connection to the ASSOUP freight management system in the Moscow Computer Centre.
This system serves above all to manage wagons : accounting, identification of their owner, financial clearance, border crossing.
The following information can be accessed via the system:

- Train numbers
- Train loads
- Goods carried
- Consignee
- Originating station
- Receiving station
- Train consist
- Train planning
- Demurrage charges

Wagons not belonging to the GRZD must be returned as rapidly as possible to their owner or pay a penalty. They are often returned empty.

At present, there is no electronic exchange of information with Armenian and Azerbaijani railways. See 2.1.1.7.1 and 2.1.2.7.1.
Incoming wagons are given a technical inspection that lasts approximately one hour at the border station, which lengthens the journey time by as much.

They seem to be able to access a certain amount of information on traffic in other countries via the Moscow IT system.

3.1.3.7.2 Message format

These messages are apparently in line with OSJD rules.
The consultants have been unable to obtain more information on this topic.

3.1.3.7.3 Projects

The consultants have observed a desire to set up one or more mini-systems, in collaboration with the two other Caucasian countries.
The aim is to no longer be dependent on centralised electronic processing in Moscow and the related exchange of information regarding freight traffic in the Caucasian area.

There are plans to extend the IT centre's local network rapidly with 5/6 additional terminals at head office. The aim is to link the tariff, statistics, and transport departments.
Extension of the network to sites in other towns (e.g. locomotive & wagon depot, regional railway offices, the ports of Poti & Batumi, shipping and insurance companies) is planned in the longer term.
As regards the railways alone, about fifteen stations, depots and regional offices are deemed priority sites network connections.

3.2 Survey of existing studies

3.2.1 Infrastructure Maintenance 1 - Railways pre-investment study and pilot train Baku - Tbilisi - Batumi/Poti - Module B - Draft Final Report - May 1997. (Tewet / DE-Consult)

It is recommended that a modest IT system be set up to market and sell the Trans-Caucasian Logistic Express service.

The system would consist of PC-type computers, not constituting an LAN, but linked by modem via the railway telephone network.

The places to be equipped in the first phase are :

Poti station
Tbilisi station
Gardabani border station
Beyuk-Kyassik border station
Kishli (Baku) station
Azerbaijani railways head office
Georgian railways head office

The places to be equipped in the second phase are :

Samtredia station
Gyandsha station

The information messages on consignments are

Status Information
Departure Information
Arrival Information
Exception Information

The message formats to be used would appear to be custom made.

The application will be based on Microsoft Access.

3.2.2 Joint Venture(s) for the Caucasian Railways - Draft Final Report - October 1997. (Tewet / DE-Consult / Gtz)

The railways of the Caucasus region have relatively few computer facilities.

The aim is to give freight customers more satisfaction.

Three systems are described :
- Freight transport operation system
- Processing and freight cost calculation system
- Decision support system

In addition, the technical proposal briefly outlines:
- Train management and marshalling yard management system
- Invoicing and statistics system
- Marketing
- Computer terminal system
- Operating company IS

The isolated computers or LANs to be installed in stations will be connected via an X25 optical fibre network to the central systems.
Workstations will be equipped with Microsoft Windows.

As regards the passenger sector, IT facilities are only recommended for international traffic and should be hooked up to the Russian Express system.

The study contains neither an action plan nor a budget estimate.

3.2.3 Trade Facilitation, Customs Procedures & Freight Forwarding Project - Completion Report - March 1997. (Scott Wilson Kirkpatrick)

3.2.3.1 Objectives

- To enhance operational efficiency by drafting customs and trade documentation in compliance with the United Nations and international standards.
- To put forward the prerequisites for modern information processing systems and upgrading customs facilities.
- To examine the institutional aspects with a view to setting up transport and trade associations and promoting cooperation between customs authorities, freight forwarders and carriers.

3.2.3.2 General information

The inventory and recommendation reports are well put together.
They have been approved by recipients.

Freight forwarding associations are being set up in Azerbaijan, Georgia and Kazakhstan. Uzbekistan already has such an association, which is a FIATA member.

Customs advisory committees were proposed but the idea was never followed through. The committees would comprise freight forwarders, traders and customs officials.

The "Uzbekistan Cotton Project" has been launched to demonstrate the corridor's key role.

3.2.3.3 Computer systems

This area appears to be covered by a fairly comprehensive report, albeit without a funding request proposal due to failure to reach consensus on a common system. However, the report does put forward quite precise recommendations and outlines the main features which the system as a whole should incorporate.
It has been accepted that an IT system is required to enhance the customs system.
The cost is estimated to be US$ 8/10 million per country.

Armenia already has an ASYCUDA system and Georgia is being assessed.

3.2.4 Trade Facilitation, Customs Procedures & Freight Forwarding Project - Computer Systems Report - March 1997. (Scott Wilson Kirkpatrick)

The report is part of the customs and trade system study referred to in 3.2.3 above (summary of final report).

In general, it should be noted that customs authorities have few IT facilities and use tends to be limited to statistics matters.
Freight forwarders equipped with computers generally employ them for data input without subsequent electronic transmission.

The overall recommendation is to install UNCTAD's Asycuda system (National Data Trade System) in each country, as has already been done in 70 other states. These national systems would be interconnected at a later stage.

3.2.4.1 Armenia

3.2.4.1.1 Customs

UNCTAD's ASYCUDA system is being installed.
The pilot phase has been completed with 12 months to go until launch.

Fitting "Direct Trader Input" (DTI) is envisaged in the long term only owing to poor telecommunications quality.

US$ 1.5 million will be required to install ASYCUDA, not including the pilot phase and implementation teams, which are being funded by UNCTAD and the World Bank.
The pilot phase has been completed, with 12 months to go until launch.

3.2.4.1.2 Other parties

Information technology does not appear to be used, although that could change in the light of the new customs IT system.

3.2.4.2 Azerbaijan

3.2.4.2.1 Customs

There are a few dozen PCs spread out amongst the headquarters, regional head offices and border stations. Communications is sometimes on-line (modem), but mainly via disk.

An draft expansion and upgrade programme has been put forward totalling US $12.5 million. No final decision has been reached on the system to be used.

The budget requirement for launching ASYCUDA is estimated to be US $ 7.5 million, and work is scheduled to take 42 months.

3.2.4.2.2 Other parties

Information technology seems to be quite widely used by parties with whom the customs authorities have dealings. A good case in point is the Caspian Shipping Company, which is equipped with an IBM 4381 mini-system.

3.2.4.3 Georgia

3.2.4.3.1 Customs

The system currently used was developed by the customs authorities.

There are a few dozen PCs spread out amongst headquarters, regional head offices and border stations. Information is exchanged via disk.

The UNCTAD ASYCUDA system is in its pilot phase, but is being rivalled by an in-house project to upgrade the current system.

The ASYCUDA pilot phase budget requirement is US $ 1.5 million. Across-the-board installation will cost a further US $5 million and take 48 months.

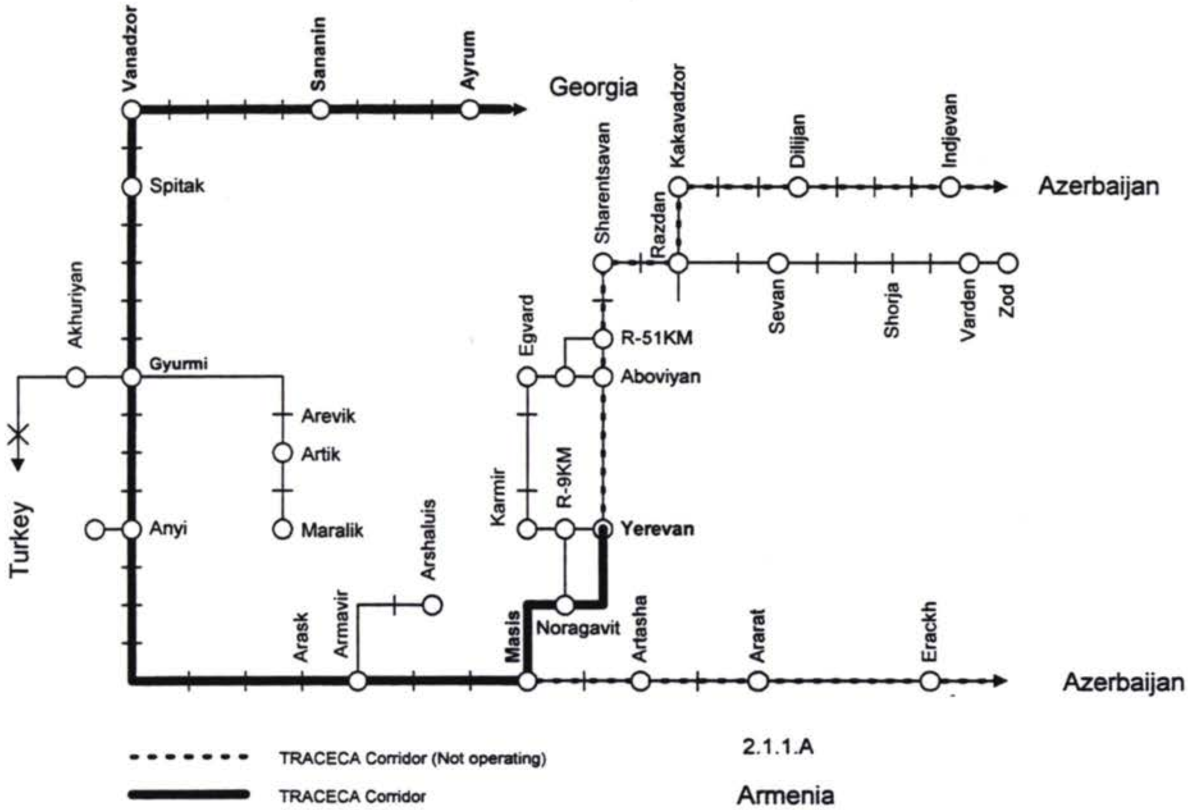
3.2.4.3.2 Other parties

Poti port has no IT facilities whatsoever. However freight forwarders and transport companies seem to be equipped with PCs and are willing to engage in DTI.

Chapter 1

Caucasian countries - Inventory
Appendix 1 - Telecommunications

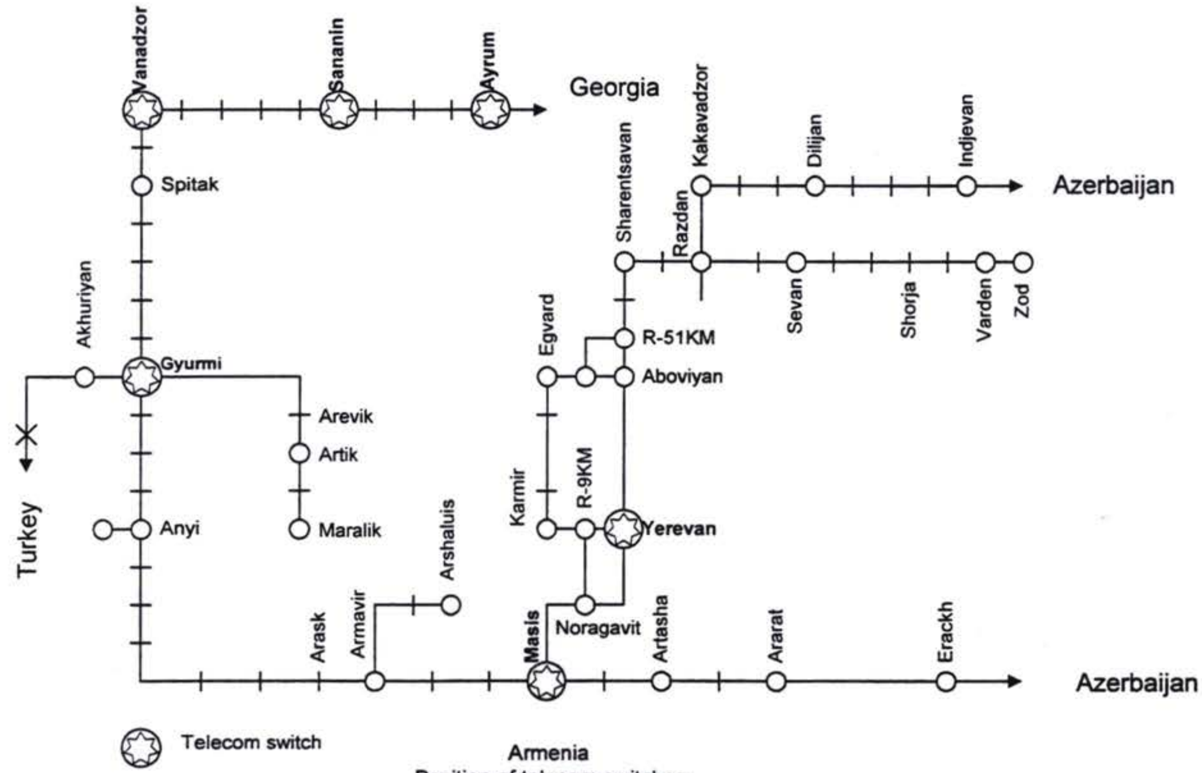
Appendix 1 - Telecommunications



2.1.1.A

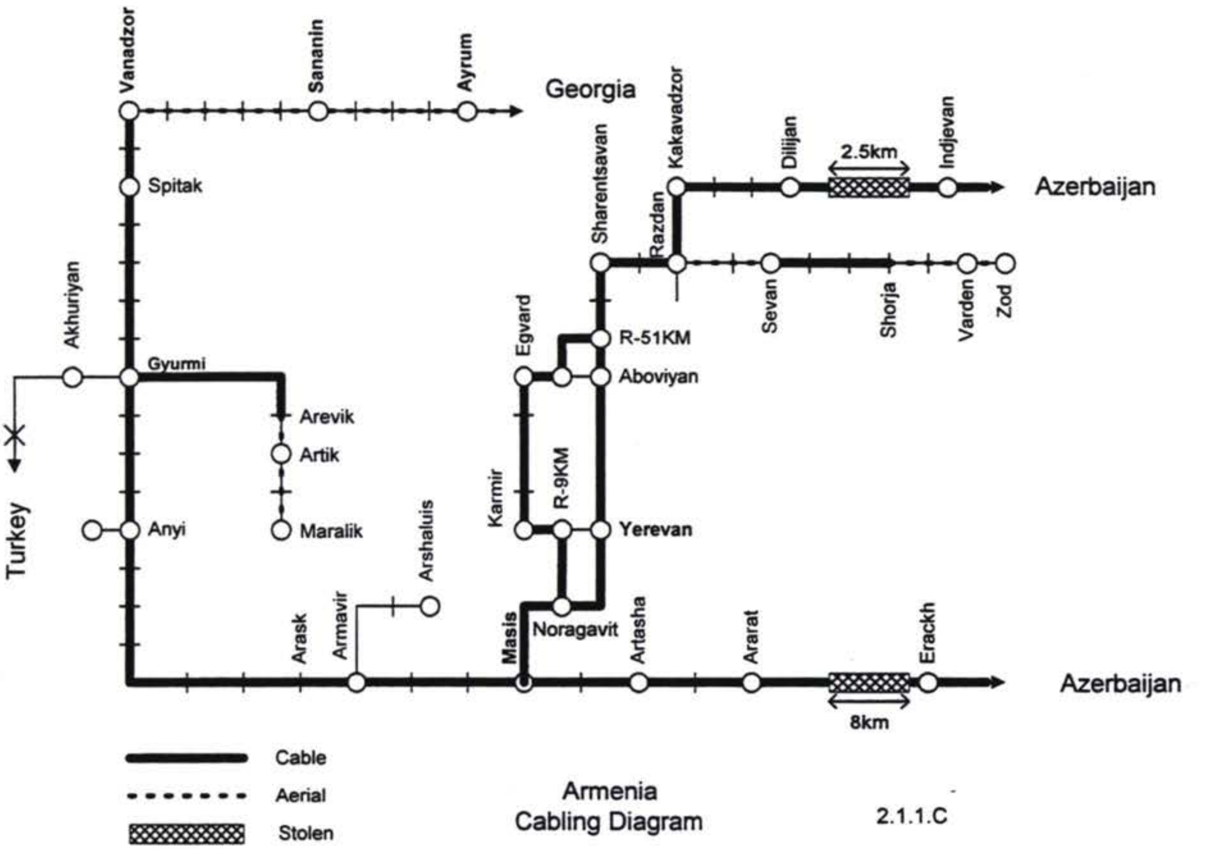
Armenia
Railways Diagram

Appendix 1 - Telecommunications



Armenia
Position of telecom switches
2.1.1.B

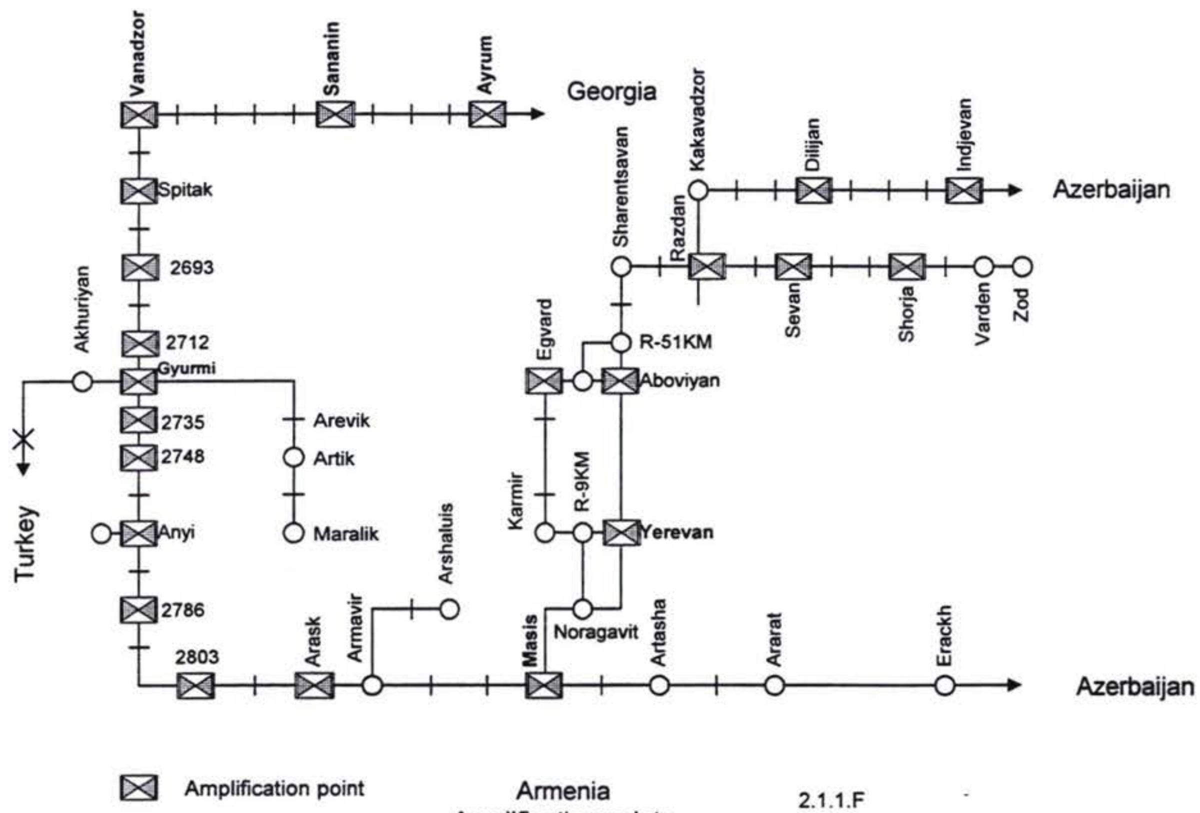
Appendix 1 - Telecommunications



Armenia
Cabling Diagram

2.1.1.C

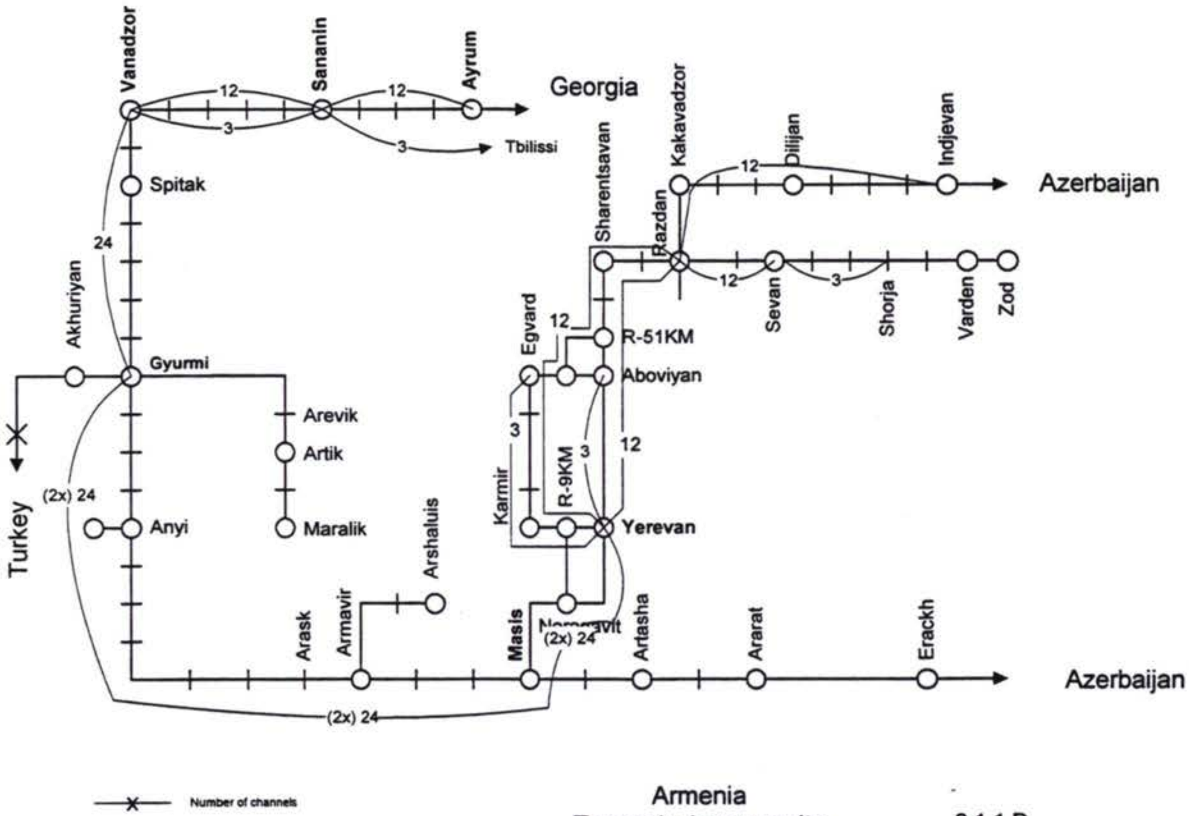
Appendix 1 - Telecommunications



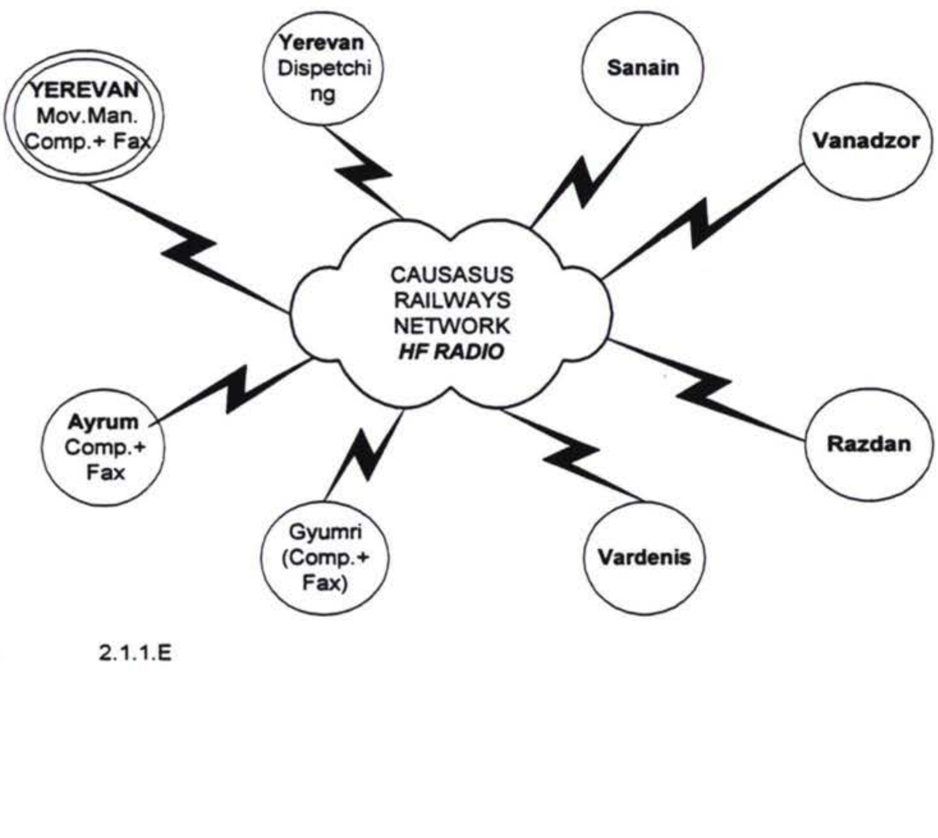
Armenia
Amplification points

2.1.1.F

Appendix 1 - Telecommunications



Armenia
Transmission capacity 2.1.1.D



Armenie 2.1.1.E

Appendix 1 - Telecommunications

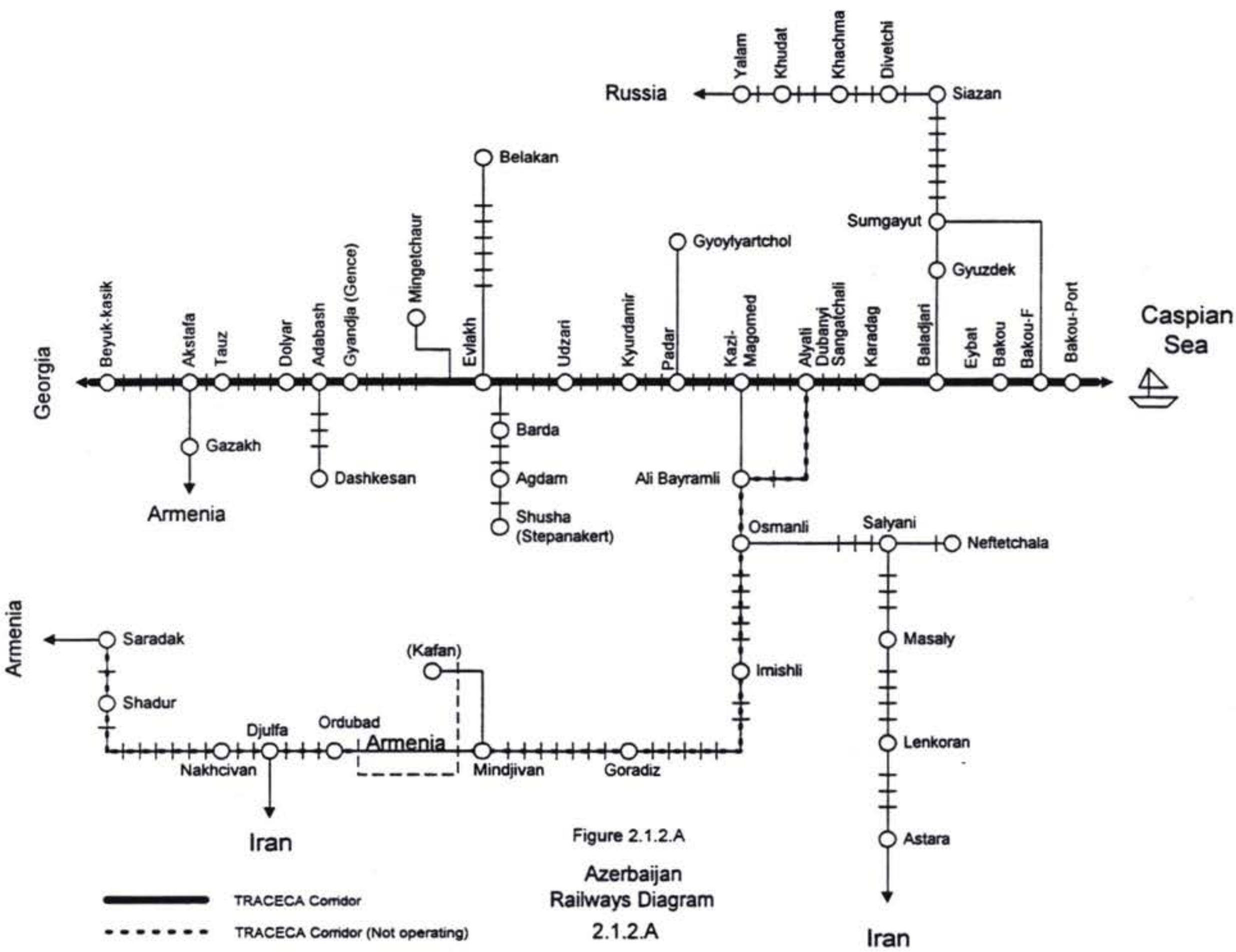
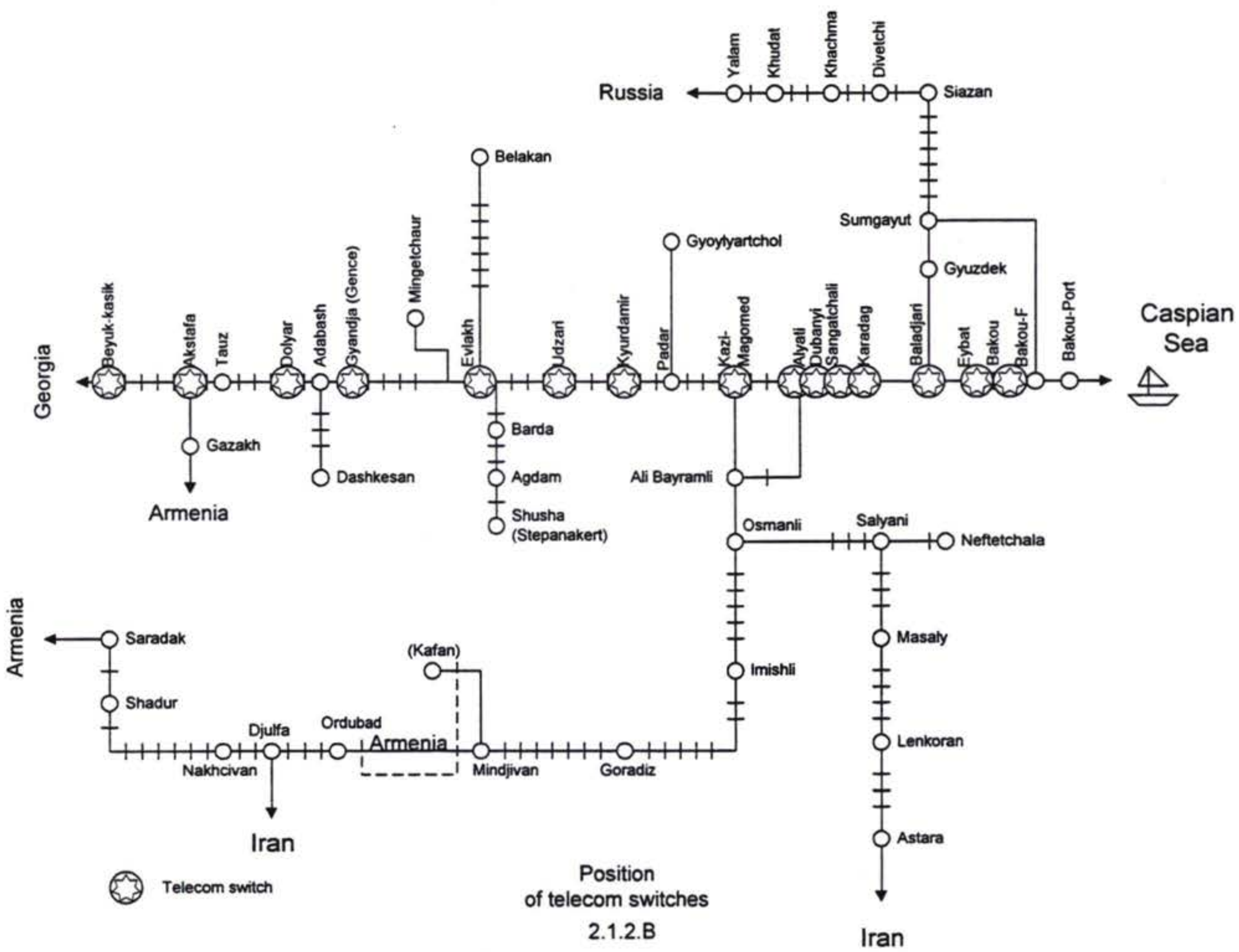


Figure 2.1.2.A

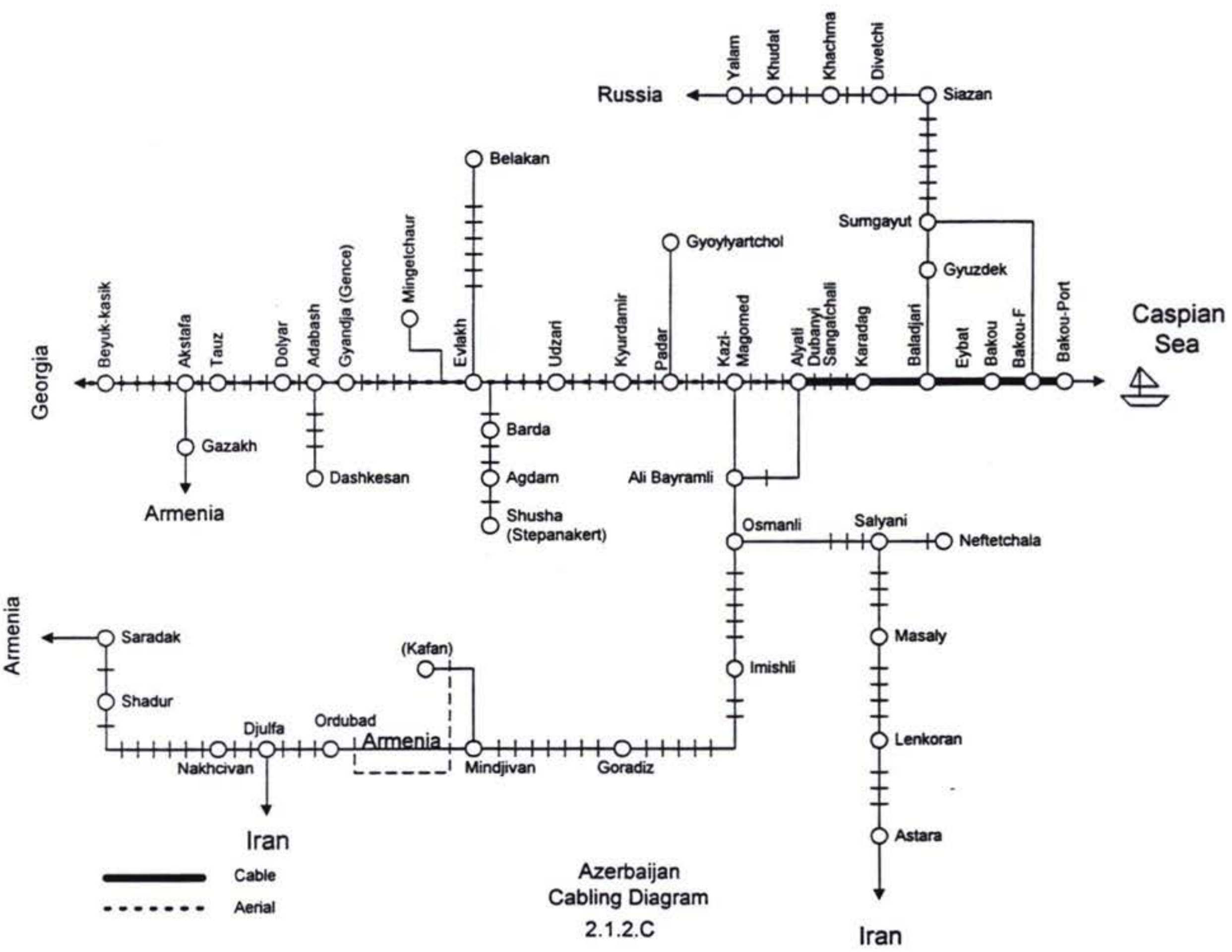
Azerbaijan
Railways Diagram
2.1.2.A

Appendix 1 - Telecommunications



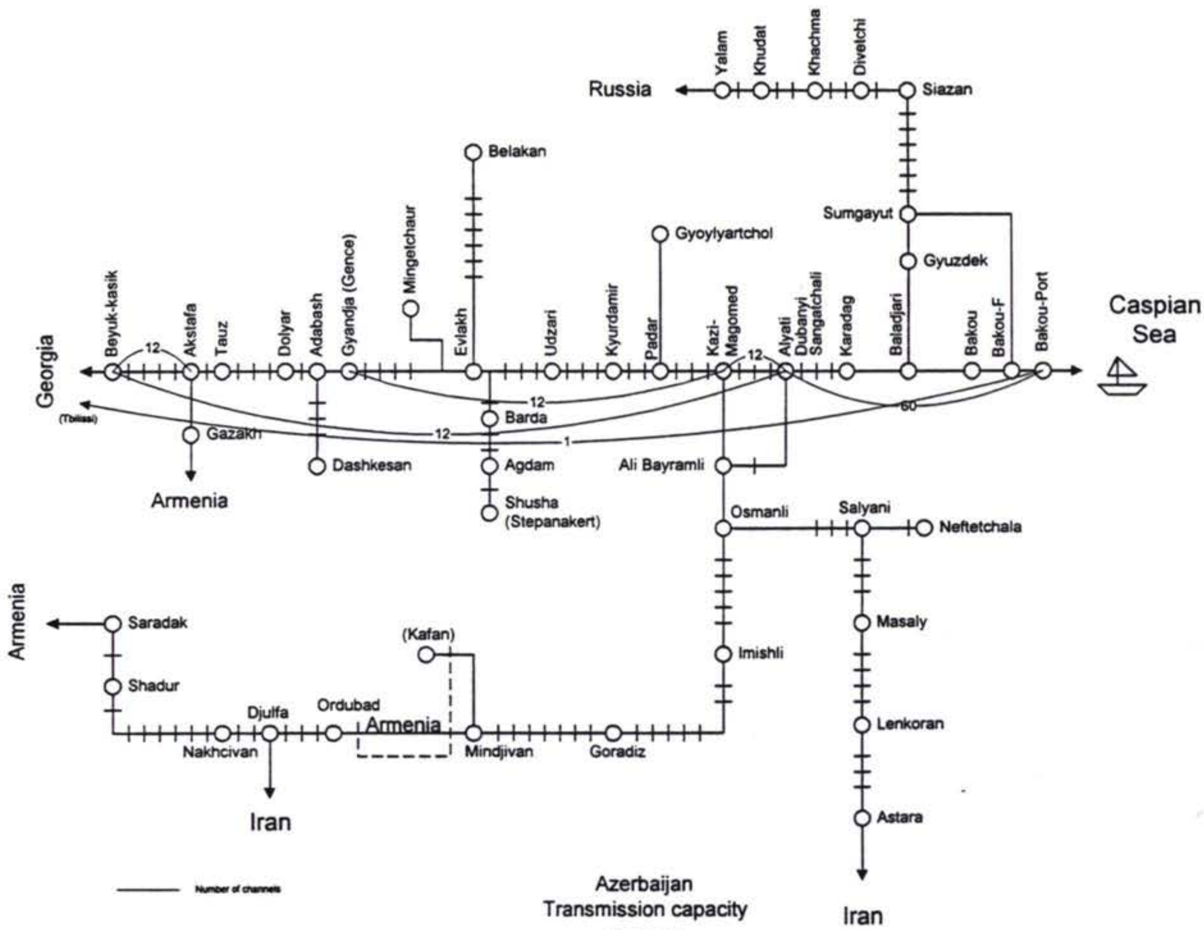
Position
of telecom switches
2.1.2.B

Appendix 1 - Telecommunications



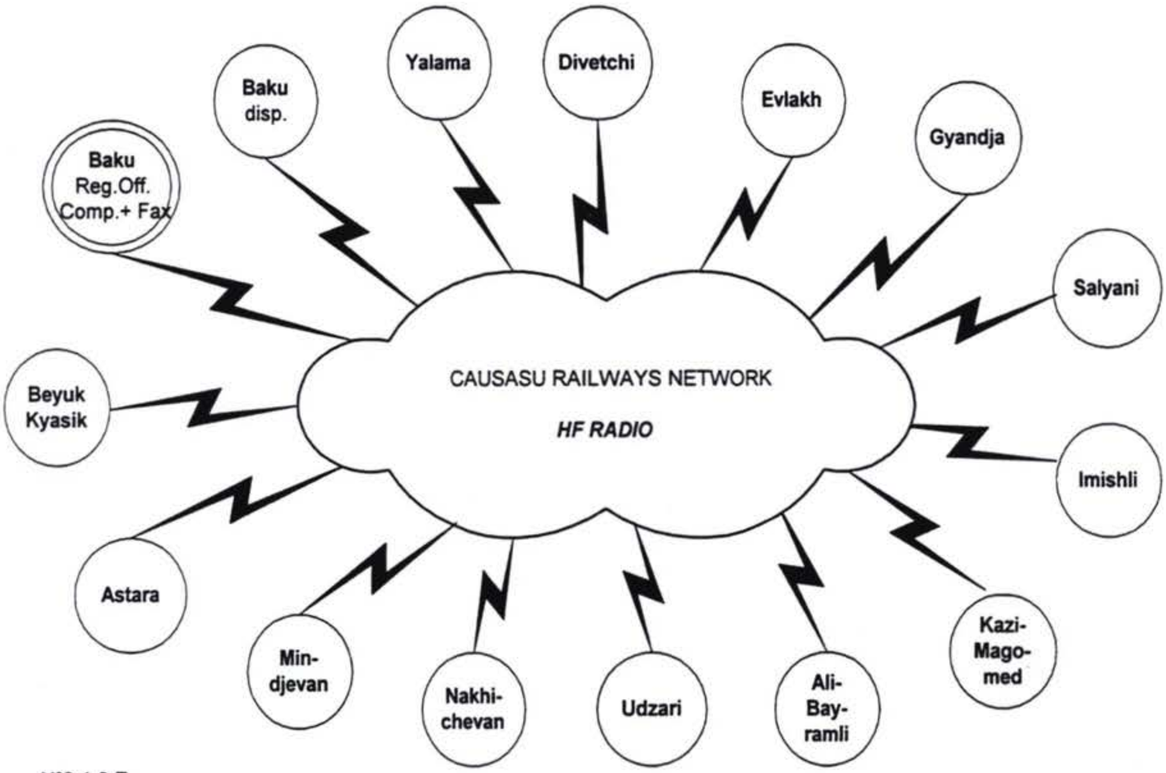
Azerbaijan
Cabling Diagram
2.1.2.C

Appendix 1 - Telecommunications



Azerbaijan
Transmission capacity
2.1.2.D

Appendix 1 - Telecommunications



N°2.1.2.E

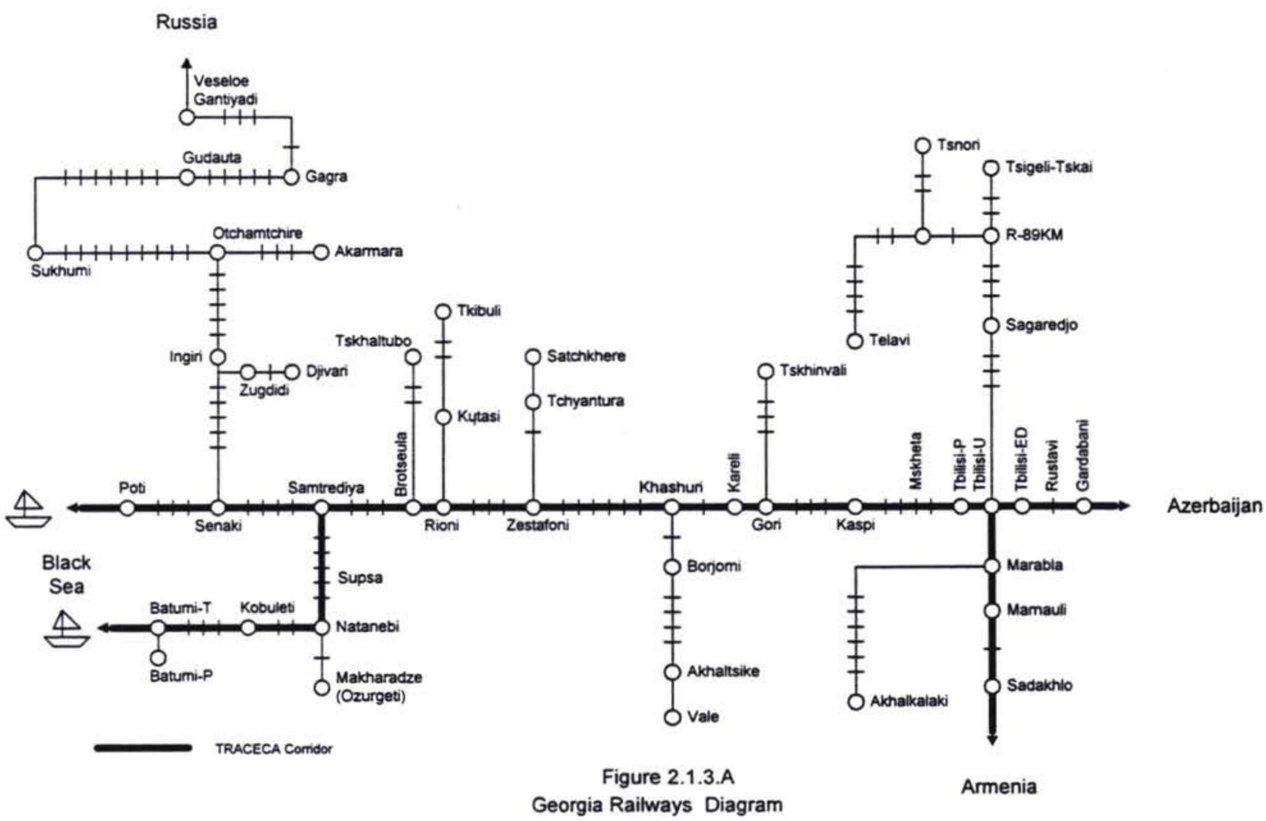
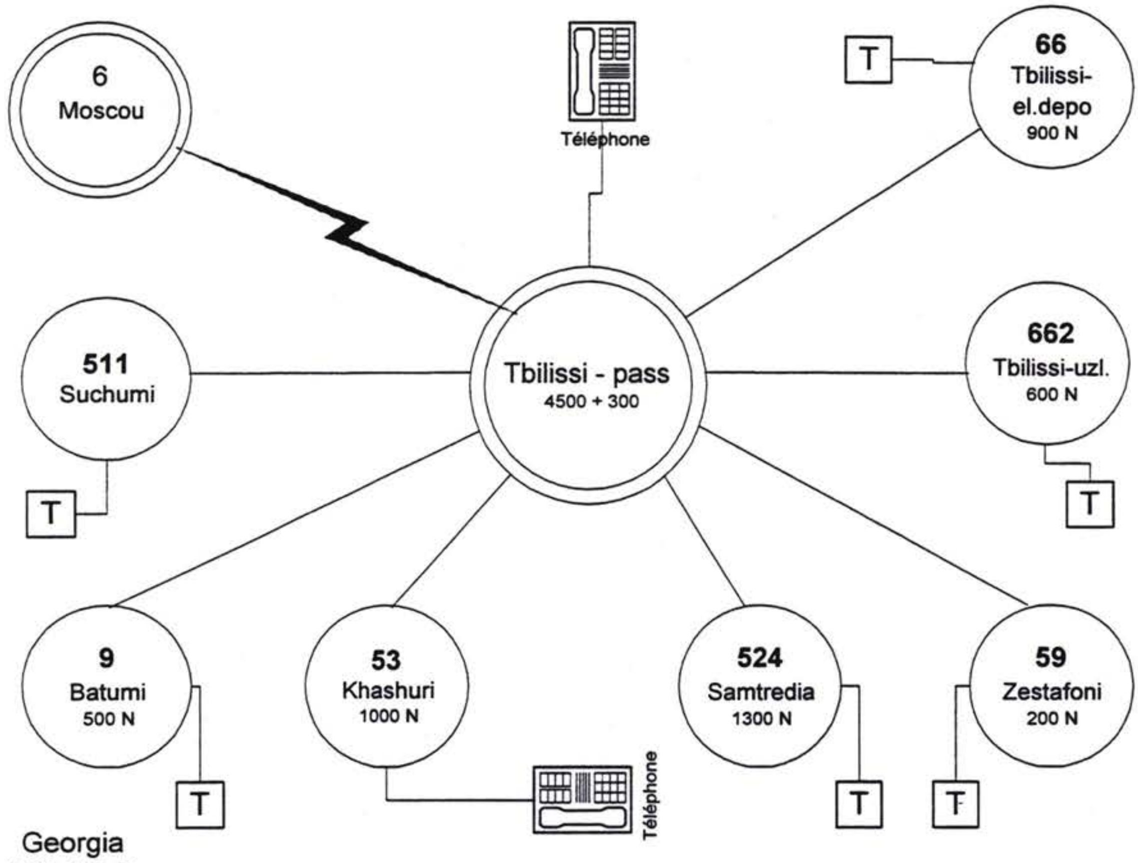


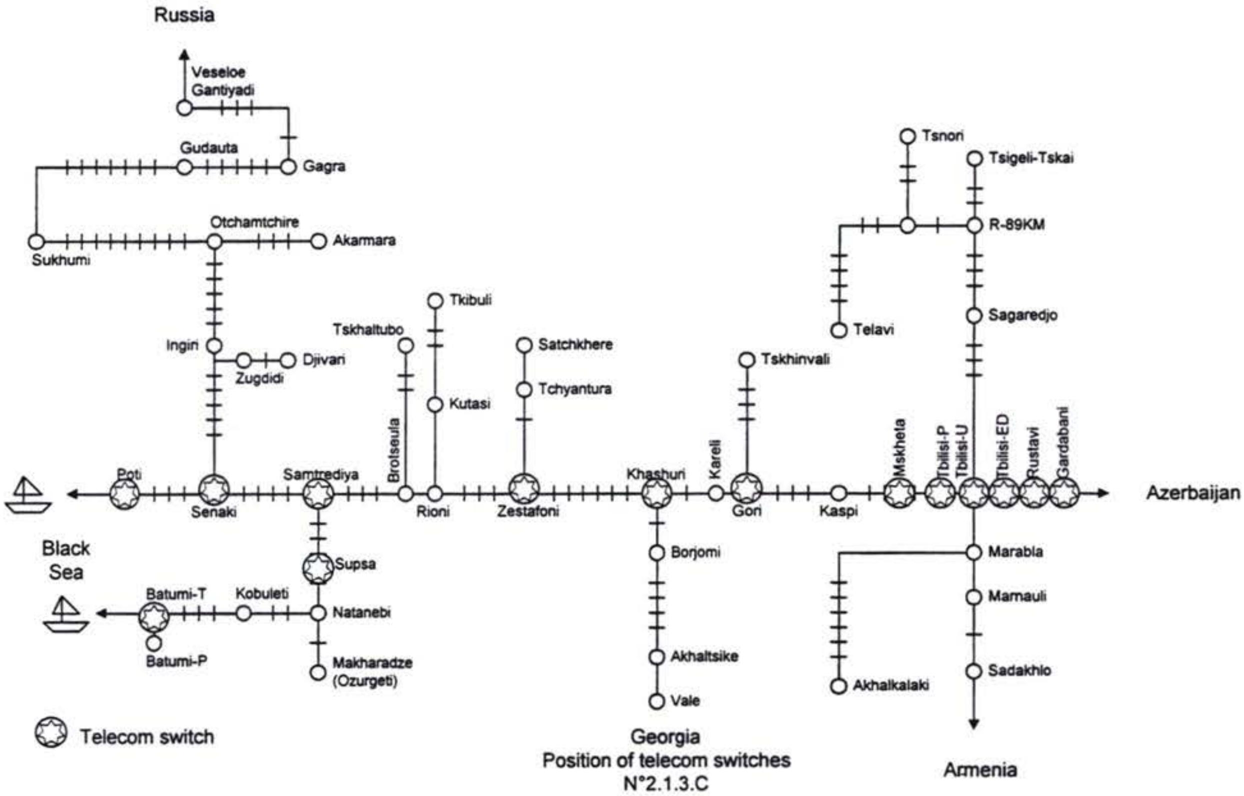
Figure 2.1.3.A
Georgia Railways Diagram

Appendix 1 - Telecommunications



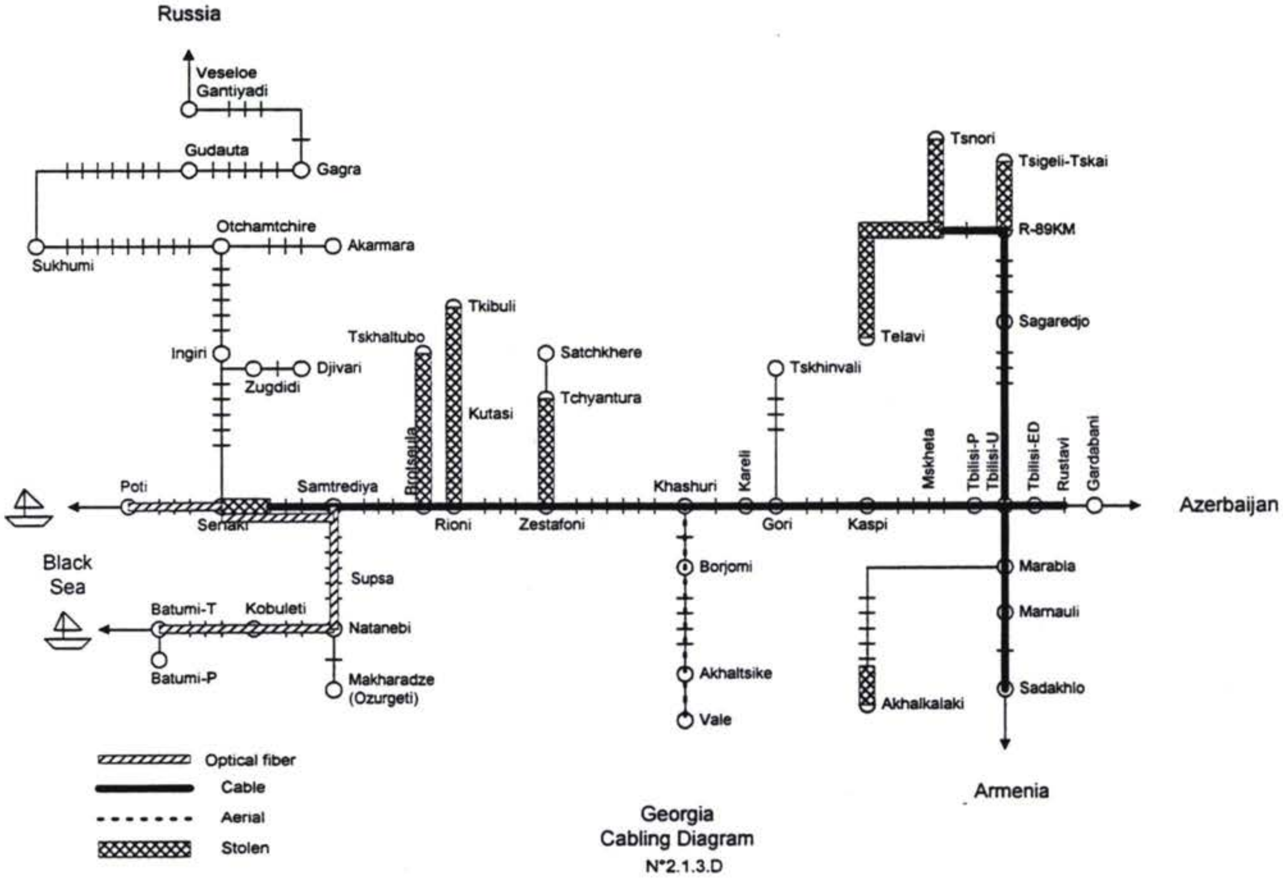
Georgia
N°2.1.3.B

Appendix 1 - Telecommunications



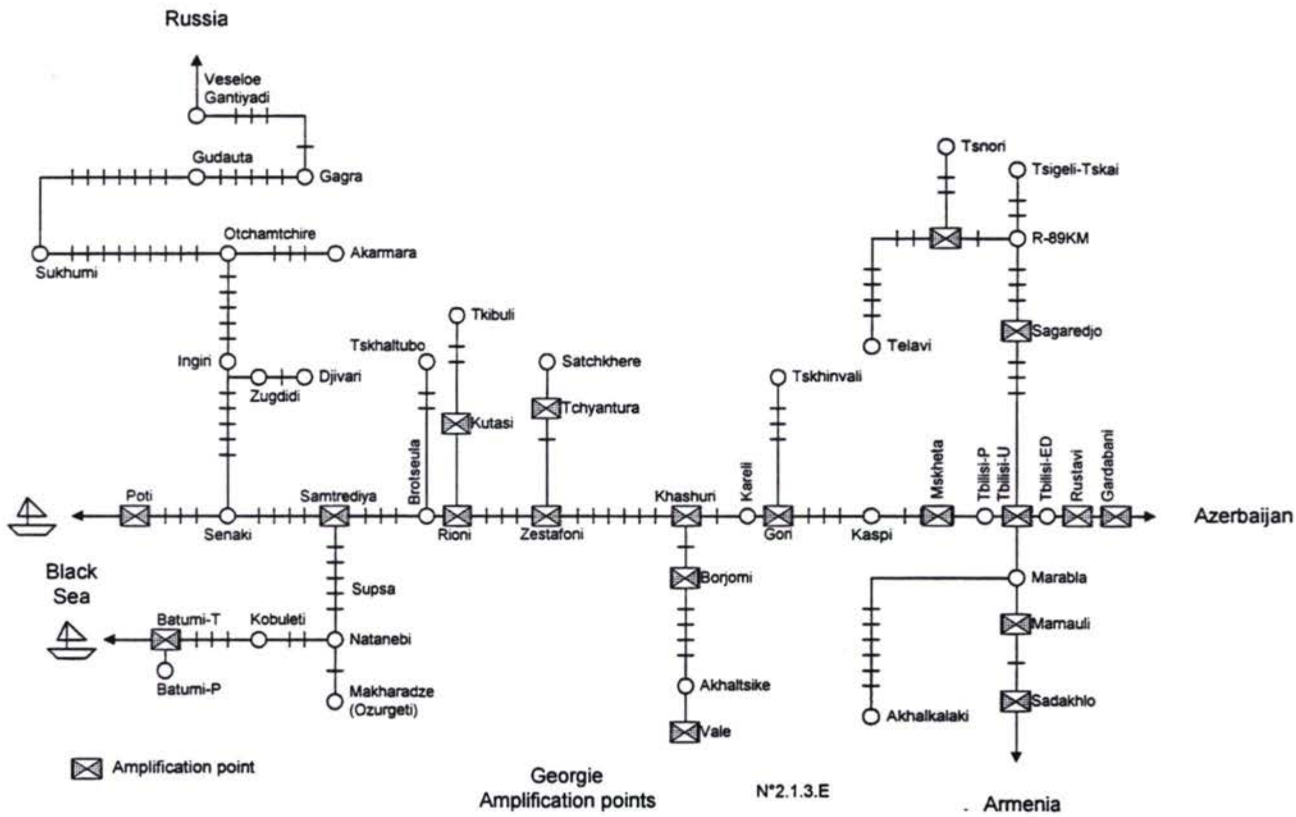
Georgia
Position of telecom switches
N°2.1.3.C

Appendix 1 - Telecommunications

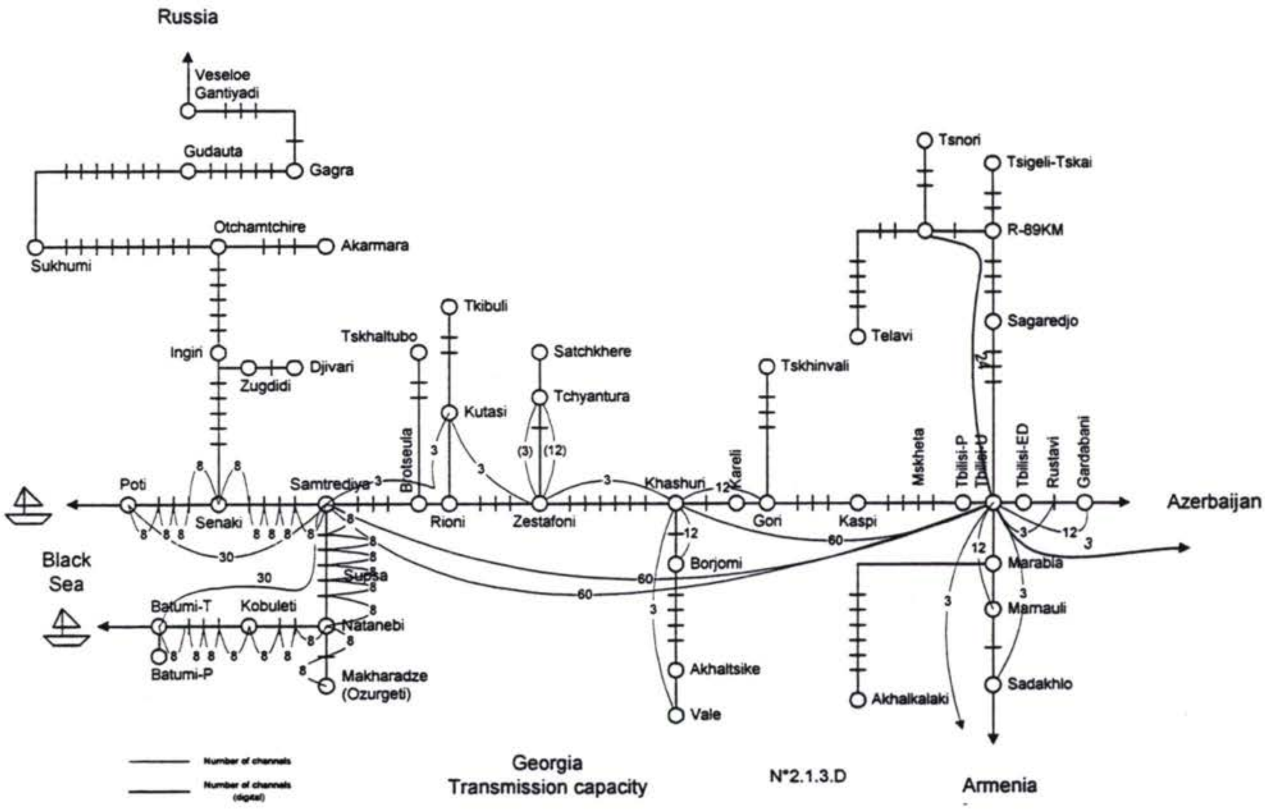


Georgia
Cabling Diagram
N°2.1.3.D

Appendix 1 - Telecommunications

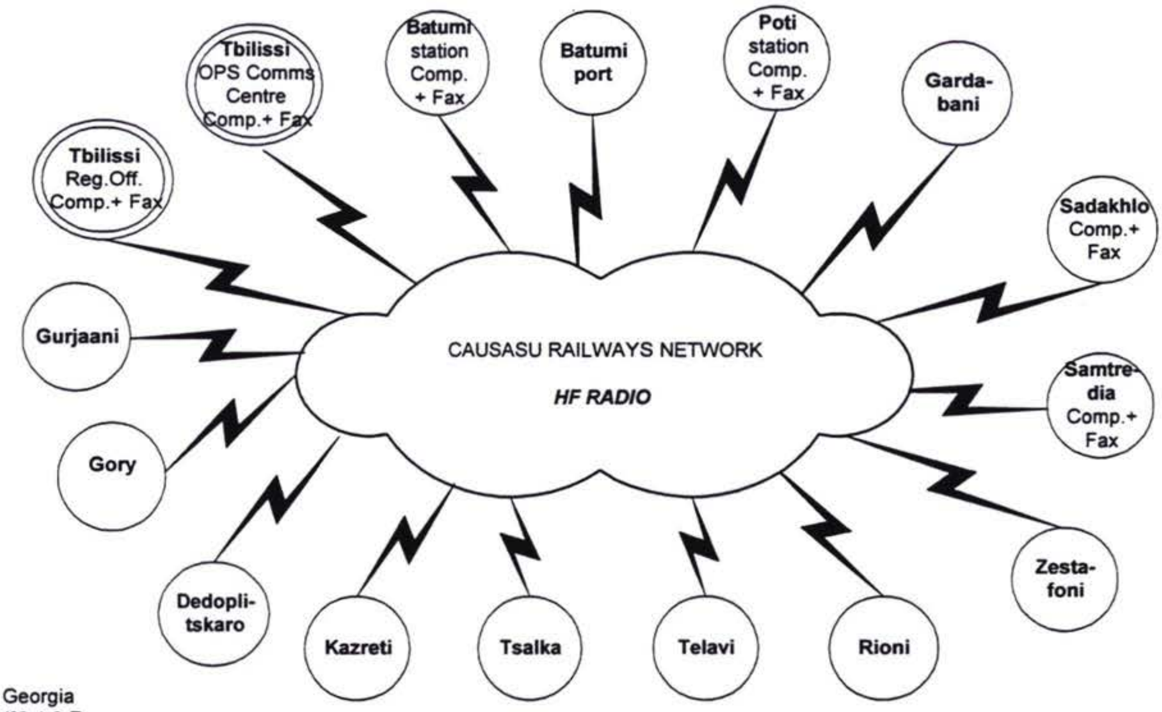


Appendix 1 - Telecommunications



Georgia
Transmission capacity

Appendix 1 - Telecommunications



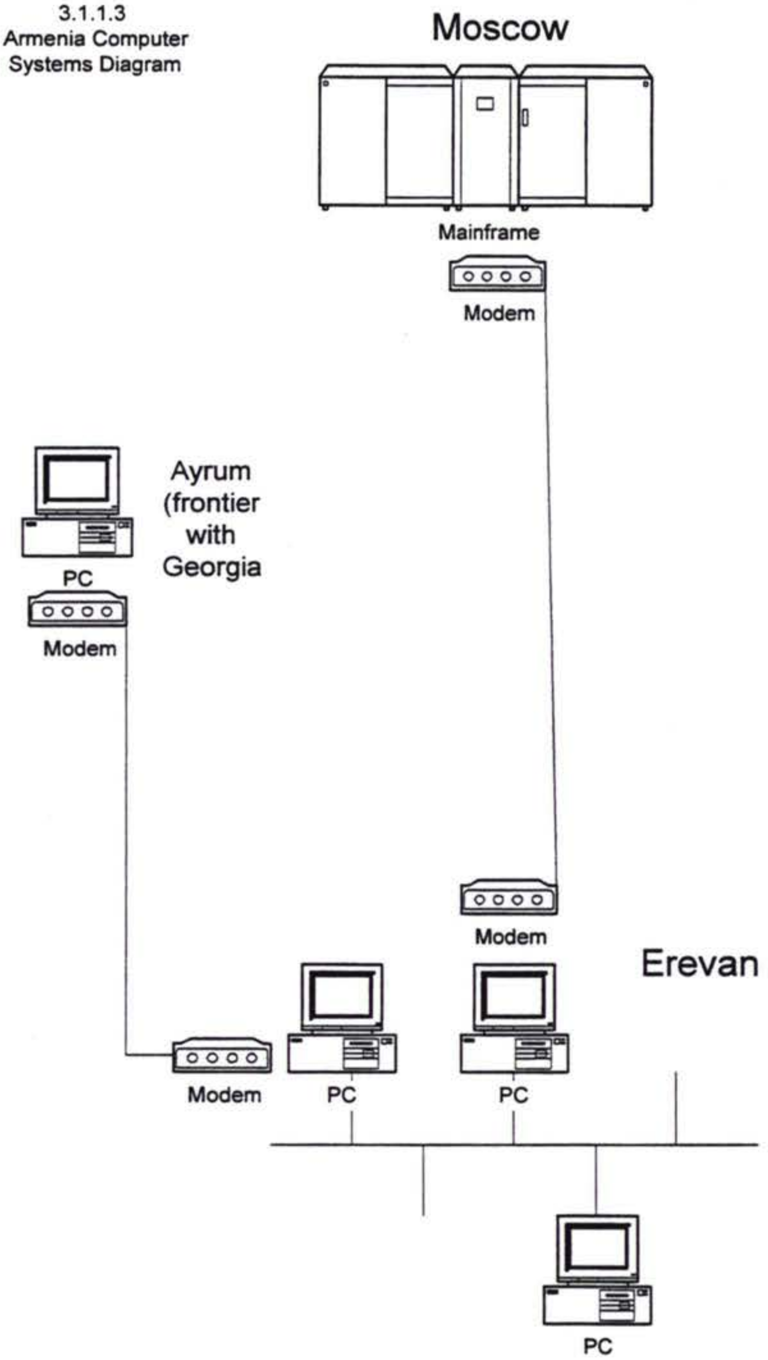
Georgia
N°2.1.3.F

Chapter 1

Caucasian countries - Inventory
Appendix 2 - Electronic data interchange

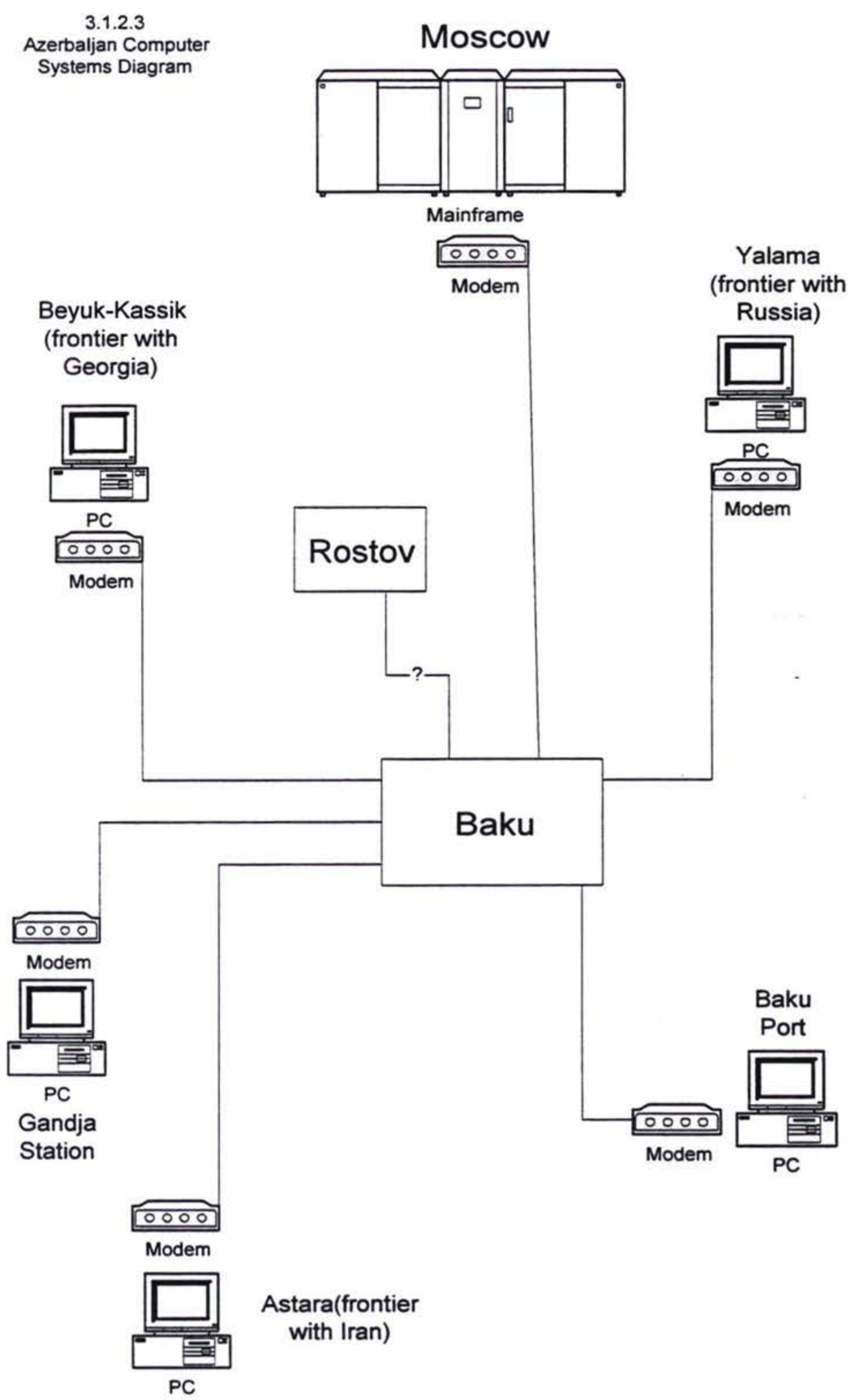
Appendix 2 - Electronic data interchange

3.1.1.3
Armenia Computer
Systems Diagram



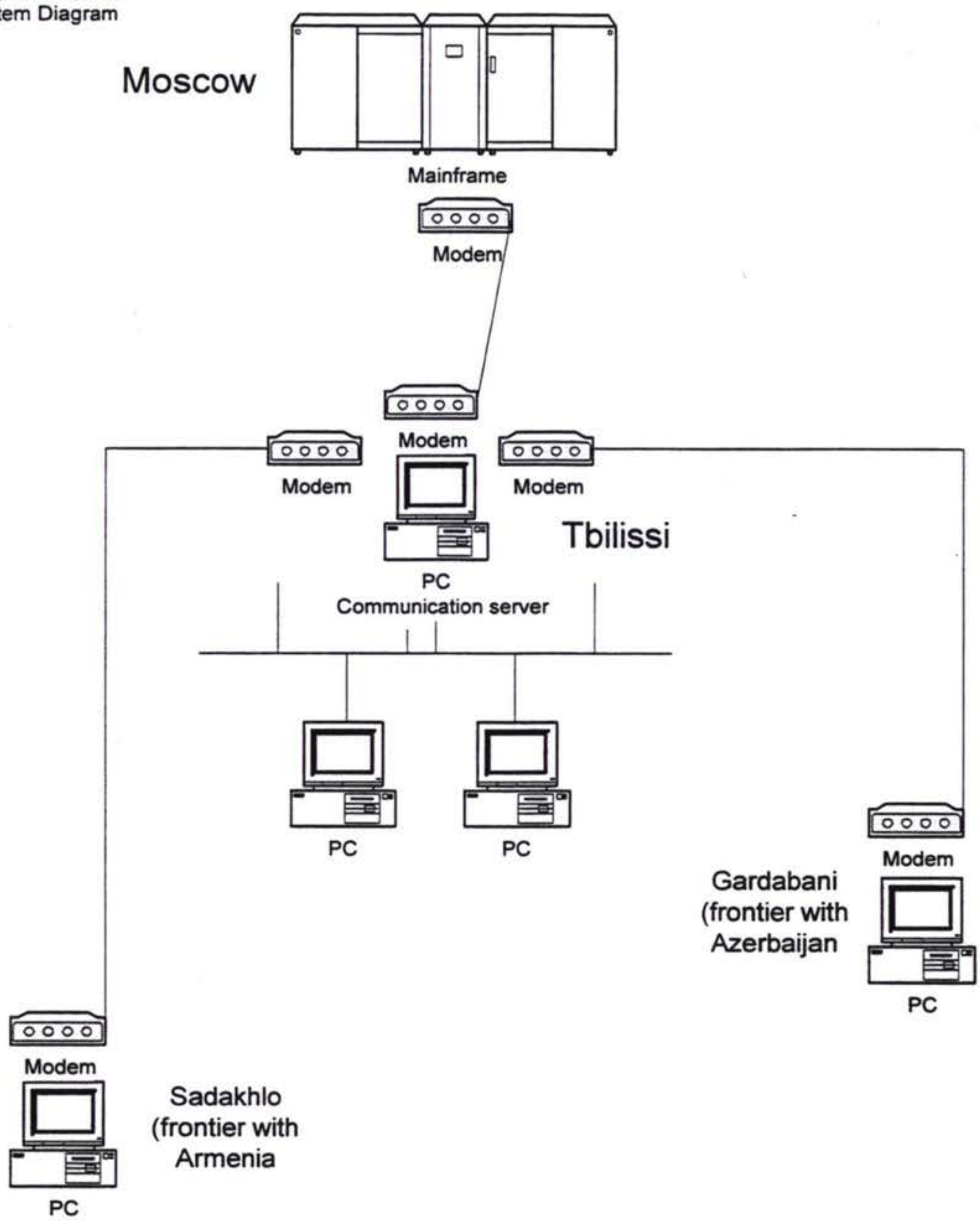
Appendix 2 - Electronic data interchange

3.1.2.3
Azerbaijan Computer
Systems Diagram



Appendix 2 - Electronic data interchange

3.1.3.3
Gorgia Computer
System Diagram



Chapter 2

Central Asia - Inventory

CONTENTS

Central Asia - Inventory

1. General information on the railway networks

1.1 Kazakhstan

Railway abbreviation:	**KSH**	
Total country surface area:	2,717,000 km^2	
Population:	16,700,000	
Total line length:	13,917 km	
Length of lines electrified	3,611 km	
Railway employees:	161 000	
Passenger traffic figures:	*1995:*	*1996:*
- number of passengers:	41,331 $x10^3$	$x10^3$
- number of passenger/km:	13,159 $x10^6$	14,188 $x10^6$
Freight traffic figures	*1995:*	*1996:*
- hauled tonnage:	207,320 $x10^3$	$x10^3$
- number of tonne/km:	167,507 $x10^6$	108,596 $x10^6$
Length of Traceca corridor:		
Length of corridor electrified		
Type of electric current		
Number of trains per day:		
- forecast		

1.2 Kyrgyzstan

Railway abbreviation:	**KRG**	
Total country surface area:	198,500 km^2	
Population:	4,500,000	
Total line length:	417 km	
Length of lines electrified	0 km	
Railway employees:	5,200	
Passenger traffic figures:	*1995:*	*1996:*
- number of passengers:	899 $x10^3$	$x10^3$
- number of passenger/km:	87 $x10^6$	92 $x10^6$
Freight traffic figures	*1995:*	*1996:*
- hauled tonnage:	3,171 $x10^3$	$x10^3$
- number of tonne/km:	408 $x10^6$	473 $x10^6$
Length of Traceca corridor:		
Length of corridor electrified		
Type of electric current	*(diesel only)*	
Number of trains per day:		
- forecast		

1.3 Uzbekistan

Railway abbreviation:	**UTI**	
Total country surface area:	447,200 km²	
Population:	22,900,000	
Total line length:	3,655 km	
Length of lines electrified	489 km	
Railway employees:	78,000	
Passenger traffic figures:	*1995:*	*1996:*
- number of passengers:	16,500 $x10^3$	$x10^3$
- number of passenger/km:	2,498 $x10^6$	2,026 $x10^6$
Freight traffic figures	*1995:*	*1996:*
- hauled tonnage:	66,599 $x10^3$	$x10^3$
- number of tonne/km:	16,831 $x10^6$	19,653 $x10^6$
Length of Traceca corridor:		
Length of corridor electrified		
Type of electric current	3.3 kV D.C.	
Number of trains per day:		
- forecast		

1.4 Tajikistan

Railway abbreviation:	**TZD**	
Total country surface area:	143,100 km²	
Population:	5,700,000	
Total line length:	483 km	
Length of lines electrified	0 km	
Railway employees:	2,800	
Passenger traffic figures:	*1995:*	*1996:*
- number of passengers:	976 $x10^3$	$x10^3$
- number of passenger/km:	124 $x10^6$	85 $x10^6$
Freight traffic figures	*1995:*	*1996:*
- hauled tonnage:	3,199 $x10^3$	$x10^3$
- number of tonne/km:	2,115 $x10^6$	1,719 $x10^6$
Length of Traceca corridor:		
Length of corridor electrified		
Type of electric current	3.3 kV D.C.	
Number of trains per day:		
- forecast		

1.5 Turkmenistan

Railway abbreviation:	**TRK**	
Total country surface area:	488,100 km^2	
Population:	4,600,000	
Total line length:	2,153 km	
Length of lines electrified	0 km	
Railway employees:	19,600	
Passenger traffic figures:	*1995:*	*1996:*
- number of passengers:	5,496 $x10^3$	$x10^3$
- number of passenger/km:	1,876 $x10^6$	2,104 $x10^6$
Freight traffic figures	*1995:*	*1996:*
- hauled tonnage:	22,164 $x10^3$	$x10^3$
- number of tonne/km:	8,568 $x10^6$	6,779 $x10^6$
Length of Traceca corridor:		
Length of corridor electrified		
Type of electric current	*(diesel only)*	
Number of trains per day:		
- forecast		

2. Telecommunications

2.1 Inventory

2.1.1 Kazakhstan

During their trip UIC's specialists were unable to obtain details on the current state of the network or development perspectives. Consequently, this sub-section has been drafted on the basis of the brief written report supplied by the railway and the specialist's own experience.

Account has only been taken of that part of the rail network included in the Traceca corridor.

This problem has been highlighted on several occasions.

2.1.1.1 Introduction

Kazakhstan Railways use analog systems only and are equipped with electromechanical and electronic telecom switches. Local calls (between subscribers connected to the same telecom switch) are processed automatically; outside calls (requiring a link between two different telecom switches) go through an operator or are processed automatically. The transmission links are HF (frequency modulation) electronic transmission facilities. The media used are copper cables and aerial lines.

Figure 2.1.1.A depicts the part of the Kazakhstan railway network included in the Traceca corridor.

2.1.1.2 General Characteristics

The telecommunications installations are standardised (GOST) and comply with OSJD leaflets as regards railway applications. Parts originate from the former Soviet Union or eastern Europe and are no longer in production. Neither are they compatible with today's technology.

Installations are primarily fed from the public grid. A secondary power supply (transformation, rectification, back-up) is provided by the railway. Back-up energy is generated by a battery with a few hours' capacity (depending on the condition of the battery). Major centres have the additional safeguard of diesel generators which are activated, automatically or manually, in the event of a public grid power cut.

2.1.1.3 Switching

Switching nodes are located in the following stations: Arys, Tchimkent, Djambul, Tchou, Almaty-1, Sary-Ozek, Utch-tiube, Matay, Aktogay, Beskoli, Droujba. To make a local call, the subscriber dials the desired number and is put through automatically.

Figure N 2.1.1.B plots the positions of the telecom switches.

Some telecom switches can be connected automatically (for most outside calls). The installations used are marked DATS and KTN.

International connections are made automatically (using dialling codes) or manually by an operator. They run from Tchengueldy to Uzbekistan Railways, Lougovaya to Kyrygzstan Railways and Droujba to Chinese Railways. Calls are carried over direct (trunk) lines operated by "Kazakhstan Temir Joly" RGP(Kazakhstan Railway's telecom division). These same telecommunications links provide a transit service for the Tashkent-Arys-Aktiubinsk-Moscow, Ashkhabat-Arys-Aktiubinsk-Moscow and Bishkek-Lougovaya-Tchimkent-Tashkent lines.

An outside call (between telecom switches) is also connected manually, i.e. the subscriber must dial the operator and give the name and number of the connection sought. The operator calls the subscriber back once end-to-end communication has been established (a process which may involve several operators). This manual procedure is restricted by the operator's switchboard capacity and the number of transmission channels. Call connection times for this type of operation no longer meet modern-day requirements.

There are some automatic links on the public telecommunications network (STOP-OAO), which is operated by "Kazaktelekom" using its nodes (GTC). The most important of these links are between switching nodes encompassing a large number of subscribers: Arys, Tchimkent, Djambul, Lougovaya, Tchou, Almaty-I, Kaptchangay, Tsary-Ozek, Utch-tiube and Aktogay. Little information is available on the dialling scheme (using dialling codes), but the dialling system itself is open.

The table below lists the number of subscribers per switching node. Capacity is currently at saturation point, particularly for the oldest installations.

Station name	*Number of subscribers*	*Model*	*Year introduced*
Arys - I	2000	G-ATS 54-A	1987
Tchimkent	3000	G-ATS KU 100/2000	1994
Tiulkubas	400	ECK-400-E	1990
Djambul	2000	G-ATS KU 100/2000	1987
Lougovaya	800	ECK-400-E	1988
Tchou	2000	G-ATS 54-A	1991
Otar	400	ECK-400-E	1982
Almaty-I	2000	ATS-K 100/2000	1990
Tsary-Ozek	700	ATS 54	1971
Utch-tiube	800	ECK-400-E	1981
Matay	1000	ATS 54-A	1993
Aktogay	800	ECK-400-E	1982
Beskoli	200	U-ATS 49	1959
Droujba.	1000	ATS-K 2000	1994

Switching installations are rotary (ATS) or electronic (ECK). The oldest installations date back to 1959 (Beskoli) and 1971 (Tsary-Ozek) and are still operational. The years the other telecom switches were introduced are indicated in the last column. Most of them function and have not yet exceeded the planned lifespan.

The systems used are based exclusively on analog technology. The signalling system between telecom switches is type E&M. Power is supplied by a 48 or 60 V d.c. central battery.

2.1.1.4 Services

To complement the switched telephone network (cf. § 2.1.1.3), a certain number of voice services are also provided on dedicated lines.

These links consist of a primary railway telephone transmitter/receiver and terminal installations (subscribers) linked in parallel on the transmission line. The operator (controller) is in permanent receiver mode. Subscribers are selected manually by pressing a button on the operator's switchboard. The primary transmitter/receiver emits the dial tone frequency, which is received by the subscriber selection device (APC-1).

These connections date from the 70s-90s. Nothing further has been introduced since then (some circuits are still at the planning stage).

The services involved are the following:

- traffic control (2 wire link).

The railway traffic control centres are located at the regional head offices run by "Kazakhstan Temir Joly's" transport divisions at Tchimkent, Djambul and Almaty-1. Each centre manages the line sections in its control area, with no option to transfer responsibility to another centre.

- Energy control (2 wire link).

This link is between the energy control centre and the power-supply sub-stations. The geographical areas covering energy and traffic control are identical as a matter of course.

- Dedicated station-to-station telephone line (2 wire link between the manual telephone switches).

The call frequency is 25 or 50 Hz.

- Distribution of reserved tickets.

This link runs between the ticket reservation/distribution centre and some main-line passenger stations.

- Teleconferencing.

A 4 wire link enables teleconferences to be organised by connecting the conference supervisor to his team.

- Railway police.

The security centre is linked to station patrol teams;

- Operator management of outside calls to and from station lines connected in parallel on a dedicated circuit (2 wire link).
- Lineside alarm (2 wire link).
- Signalling and telecommunications maintenance.
- Track maintenance.
- Controller - depot link.
- Controller - passenger train formation yard link.

The local circuits in stations are arranged in a similar fashion with power supplied by local 50 V or 80 V d.c. batteries.

- Telegraphy

The railways also operate telegraph links. The telegraph network dates back to the latter half of the 1960s with a few changes to the terminal equipment (upgraded models). Most of the terminals currently in use are AT-PC-PD models.

The transmission speed is 50 Bd (using the 24 channel transmission system), 100 Bd (using the 12 channel transmission system) or 200 Bd (using the 6 channel transmission system) over a telephone line. Connections are established automatically.

The central telegraph office is located at railway headquarters (scheduled for relocation to another town). The other offices are housed in the regional transport centres (Tchimkent, Djambul and Almaty-1 stations). Station terminals are connected to switches and can be connected to equipment in the former telegraph network of the ex-SZD (the central switch is in Moscow). Telegraphs are used nowadays to send written instructions on railway traffic control and commercial aspects.

2.1.1.5 Transmission media

Transmission media consist of copper cables and aerial lines. Most of the cables are buried. Transmission lines are usually served by HF (frequency modulation) electronic transmission equipment. Adaptation is generally carried out by a translator.

Cables are symmetric with copper wires of 1.2 mm diameter (paper insulation, aluminium armouring and PVC outer sheath). A section measures 870 m in length and d.c. electrical resistance is less than 12 Ω/km. The cables used are not coil-loaded. The wire pairs also serve to transmit signalling data.

We were unable to obtain information regarding the inauguration year and cable length and quality per line section.

It is difficult to evaluate the overall transmission quality given that it was impossible to collate information in Kazakhstan itself, particularly in relation to the inauguration year and maintenance quality. Extrapolating from similar examples in the region, it may be assumed that the deterioration in transmission quality is mainly due to the cable lying outside the tolerance limits, more often than not as a result of moisture penetrating through to the cables at the junction boxes. Penetration increases over time depending on the different materials used for the junction boxes and the cable armouring.

In some cases, it was necessary to replace a faulty junction box with two other boxes linked by a strip of the intermediate cable. Such measures trigger signal reflections and interfere with capacitance regulation. This interference is not easily eliminated from laid cables.

The situation is worsened by the poor condition of earthing cable protective material on electrified lines, leading to an increase in stray currents and, hence, greater cable sheath permeability by electrolysis.

Sometimes, the aerial lines are interspersed with short cable sections. This alternation between cables and aerial lines generates signal reflections, hence aggravating transmission quality.

Aerial line wires are copper, bronze or steel. The diameters used are 4 mm (on the main line, 6 wires for HF) or 5 mm (on the main line, 10 wires for LF), with an overall total of 16 wires.

We were unable to secure details of the cable and aerial line layout and therefore cannot depict them in a diagrammatic overview.

Transmission installations are usually HF (frequency modulation), comprising 12 Z-12 channels (36 - 143 kHz range) and 60 V-60 channels (12 to 252 kHz range).

The cable attenuation coefficient is influenced by the frequency. The following signal attenuation values apply to 1 km of cable:

- 0.41 dB / km for 0.8 kHz,
- 1.78 dB / km for 110 kHz,
- 3.04 dB / km for 250 kHz.

The higher the frequency range used, the shorter the distance between two consecutive amplification points. Amplification takes place in telecommunications facilities (as opposed to lineside cabins). Amplification points are located at stations (average spacing of 35 km). Signals are also amplified in the emitting stations and at telephone and telegraph switches.

No information is available on amplification points, inter-station transmission channel capacity, equipment models, the inauguration year and transmission quality.
Consequently, we are unable to provide a summary table or diagram.

It is safe to assume that a greater number of transmission channels are required today. Hence, the railway should either lease some channels from the public telecommunications network (Kazaktelekom) or undertake work to extend the existing capacity.

Transmission channels provide international links between Tchengueldy and Uzbekistan, Lougovaya and Kyrygzstan and Droujba and China and are borne on direct (trunk) lines operated by "Kazakhstan Temir Joly" RGP. These same telecommunications links provide a transit service for the Tashkent-Arys-Aktiubinsk-Moscow, Ashkhabat-Arys-Aktiubinsk-Moscow and Bishkek-Lougovaya-Tchimkent-Tashkent lines.

A back-up circuit could be installed on the Tchengueldy - Arys - Kyzylorda - Kandagatch - Makat - Beyneu - Kungrad - Tchardjoy lines (transmission sections managed by Kazakhstan Railway's telecom division, RGP). A 24 wire aerial line stretches 250 km between Arys and Tchiyli stations. A 1152.1 km cable (symmetric, V-60 transmission equipment) runs between Tchiyli, Kyzylorda, Kandagatch and Shubar-Kuduk, at which point a 16 wire, 812 km aerial line takes over linking Shubar-Kuduk, Makat, Beyneu and Kungrad (Uzbekistan).

Transmission installations are supplied 24 V d.c. from the 220 V a.c. public grid.

There is a lack of spare parts for these installations as they are no longer manufactured.

2.1.1.6 Radiocommunications

The railway uses radiocommunications for railway operations. On the whole all locomotives are equipped with two radio sets (at 2Mhz and VHF), except for shunting and freight train locomotives, which are equipped solely with VHF radio. Rolling stock comprises mainly diesel-powered locomotives, with electric locos worked on part of the corridor. The ratio of diesel to electric locomotives is 3:1 (the railway owns an aggregate of 2,489). It is difficult to ascertain the exact number of locos operated on the corridor alone.

It is hard to gauge overall radio transmission quality along the corridor as we were unable to conduct on-site measurements.

Two radio systems are commonly used:

- Train radio

This system enables train drivers and the traffic controller or station to communicate. The system is similar to the ground-to-train radio system, laid down in UIC Leaflet 751-3, with however, the following differences:

  - The selected frequency is unique operating at 2.130 MHz. The operating mode is simplex. The transmitters are located in stations only. The aerials are 20 to 50 m away from their radio base. Transmission power is 10 W. The radio bases are not synchronised.
  - Thus, radio coverage does not extend beyond the station itself nor line sections either side of the station. However, it should be noted that coverage is not continuous (which would require several separate frequencies).
  - Moreover, from a traffic control point of view, a control circuit is divided into radio blocks, which each comprise several stations (and therefore several radio transmitters/receivers).
  - Locomotives are permanently connected in receiver mode. Only one communication can take place within a given radio block, at the instigation of the traffic controller, the station or the driver.

On the whole, the radio equipment used is 15 - 20 years old.

- Shunting radio

This system allows the head station traffic controller to communicate with the shunting team members, including the driver of the shunting locomotive. The same type of system is used to equip maintenance teams (intervention in the event of an accident, etc.).

Shunting radio is a stand-alone system which mainly covers station or railway location areas. It uses simplex frequencies operating on the VHF 150 - 156 Mhz band.

This radio is similar to that still sometimes used in Europe to transmit over distances of several dozen kilometres. This point was not examined any further in the framework of this project.

2.1.2 Kyrgyzstan

2.1.2.1 Introduction

Kyrgyzstan railways use both analog and digital systems with electromechanical telecom switches. Local calls (between subscribers connected to the same telecom switch) are processed automatically. Outside calls (involving a link between telecom switches) go through an operator or are made automatically. Transmission lines consist of HF (frequency modulation) electronic transmission equipment. Physical media consist of copper cables, aerial lines and Hertzian links.

Figure 2.1.2.A is a diagram of the Kyrgyzstan rail network. The corridor is highlighted in bold. The stations of Tchaldovar, Merke, Munjke, R-3639 up to Lugovaya are under the responsibility of the railway operating on the territory of Kazakhstan. The stations of Khanabad and Sultanabad, located in Uzbekistan are also served.

2.1.2.2 General characteristics

Telecommunications installations are standardised (GOST) and comply with OSJD leaflets for railway applications. The parts originate from the former Soviet Union with some from Eastern Europe and are no longer in production. Neither are they compatible with current technology.

The primary power supply for the different facilities is the public electricity supply network. The secondary power supply (transformation, rectification, back-up) is provided by the railway. The emergency power supply is provided by a battery with a few hours' capacity (depending on the state of the battery). The main centres also have emergency diesel generators which are activated automatically or manually in the event of a power cut in the public supply network.

2.1.2.3 Switching

Switching nodes are located in the following stations: Bishkek-I, Bishkek-II, Lugovaya, Balyktchi, Bystrovka, Tokmak, Alamedin, Sokuluk, Shopokovo, Belovodskaya, Karabalta, Kaindy, Merke, IVC (IT centre), Vagonnoe depo (wagon depot), Lokomotivnoe depo (locomotive depot), Djalal-Abad, Karasu, Osh. To make a local call, the subscriber dials the number he is calling and is automatically put through.

Figure 2.1.2.B plots the positions of the telecom switches.

Some telecom switches can already be automatically connected (mainly for outside calls).

There is also an automatic international connection between Bishkek and Almaty (using the dialling codes 007⇔04). Connections to Moscow or abroad are mainly provided as described below, through an operator.

To make an outside call from Djalal-Abad, Karasu, Osh to the other telecom switches, the subscriber must dial the operator and give the destination and phone number he is calling. The subscriber is then called back by the operator once end-to-end communication has been established (which may involve several operators). This manual procedure is restricted by the operator's switchboard capacity and the number of transmission channels. The switchboards used by the operators are MPU-80, MPU-20 or MPU-60 type. Call connection times no longer meet present day standards.

An automatic link has already been set up with the telecommunications network (using the dialling codes 28⇔8). The dialling scheme is set out in Figure 2.1.2.C.

The table overleaf indicates the number of subscribers for each switching node. Capacity has reached saturation point.

Station name	*Number of subscribers*	*Model*	*Year introduced*
Bishkek I	1,200	ATS - Uzl.	1971
Bishkek II	100	KoR	1973
Lugovaya	400	KoR	1982-85
Balyktchi	100	KoR	1982-85
Bystrovka	50	KoR	1982-85
Tokmak	50	KoR	1982-85
Alamedin	100	KoR	1982-85
Sokuluk	100	KoR	1982-85
Shopokovo	50	KoR	1982-85
Belovodskaya	50	KoR	1982-85
Karabalta	100	KoR	1982-85
Kaindy	50	KoR	1982-85
Merke	50	KoR	1982-85
IVC (IT centre)	100	ATS - Uzl.	1982-85
Vagonnoe depo	50	KoR	1982-85
Lokomotivnoe depo	50	KoR	1982-85
Djalal-Abad	100	KoR - Uzl.	1982-85
Karasu	50	KoR	1982-85
Osh	50	KoR	1982-85

Switching installations are rotary (ATS) and crossbar (crossbar connection system: Kor) of the 104 or 204 series. The oldest installations date back to 1971 and 1973 (at Bishkek) and are still operational. The years the other telecom switches were introduced are indicated in the last column. Power is supplied by a 48 or 60 V central battery.

2.1.2.4 Services

To complement the phone service provided through the switched telephone network (cf Ch. 2.1.2.3) a number of voice services are provided through dedicated lines. These dedicated lines consist of a primary railway telephony transmitter/receiver and terminal installations (subscribers) connected in parallel to the transmission line. The operator (controller) is permanently connected. Subscribers are manually selected by pressing a switch on the operator's switchboard. The primary equipment sends a dial tone frequency which is picked up by the subscriber selection device (APC-1). These various links date from the 70s to the 90s. Nothing further has been introduced since then (some circuits are planned).

The services involved are the following:

- Traffic control (2 wire link).

The traffic control centre is located at railway headquarters (Bishkek). The centre is responsible for the line sections; the total length of lines managed is 156 km. When it comes to controlling movements of trains in operation, the traffic controller uses „Neva", a device which pinpoints the location of the train (on a line block section or in a station) and indicates the colour of the key signals. This information is then transmitted to the traffic control centre through telecommunications channels. From a technological point of view, the system is a little outdated but is fairly efficient in terms of meeting current needs. The equipment was manufactured in Russia.

- Energy control (2 wire link).

This link is between the energy control centre and energy controllers in power supply sub-stations. The geographical areas covering energy and traffic control are identical as a matter of course.

- Dedicated station-to-station telephone line (2 wire link between the manual KPS-2/3 and UKSS-8 telephone switches).

The call frequency is 25 or 50 Hz.

- Distribution of reserved tickets.

This link runs between the ticket reservation/distribution centre and some main-line passenger stations.

- Teleconferencing.

The conference supervisor is connected to his team over a 4 wire link.

- Railway police.

A security centre is linked to station patrol teams;

- Operator management of outside calls to and from station lines connected in parallel on a dedicated circuit (2 wire link).
- Lineside alarm (2 wire link).
- Signalling and telecommunications maintenance.
- Track maintenance.
- Controller - depot link.
- Controller - passenger train formation yard link.

The local circuits in stations are arranged in a similar fashion with power supplied by local 50V or 80V batteries.

- Telegraphy

The railways also operate telegraph links. The telegraph network dates back to the latter half of the 1960s with a few changes to the terminal equipment (upgraded models) and is still used today. Currently models T-63, STA 67 and F-1100 are used. A few dozen of these ATA PC-PD terminals are still in use today.

The transmission speed is that of telephone links of systems built some time ago in Europe, namely 50 Bd (using the 24 channel transmission system), 100 Bd (using the 12 channel transmission system) or 200 Bd (using the 6 channel transmission system). Connections are established automatically. The transmission equipment consists of types P-327-3 or P-327-12.

The telegraph office is located at railway headquarters. The terminals are connected to the switch and can be connected to other equipment in the former telegraph network of the ex-SZD (the central switch is in Moscow). Telegraphs are used nowadays to send written instructions on railway traffic control and commercial aspects.

2.1.2.5 Transmission media

Transmission media consist of copper cables, aerial lines and Hertzian links. Most of the cables are buried. Transmission lines are usually served by HF (frequency modulation) electronic transmission equipment and partly through digital transmission equipment. Use is also made of direct audiofrequency transmission over copper cables and aerial lines. Adaptation is generally carried out by a translator.

The cables used are 7x4x1.2+5x2x0.9+1x0.9 (7 star-shaped quads, wire diameter 1.2 mm, 5 pairs and 1 wire of 0.9 mm in diameter) MKBASh (paper insulation, aluminium armouring and PVC outer sheath) and TZB. The pairs of wires also carry signalling information.

The table below indicates the year of introduction and the overall transmission quality for the main sections of cables laid.

Station name	*Station name*	*length*	*Cable type*	*quality of link*
Lugovaya	Bishkek-I	151.5 km	MKBASh	satisfactory
Bishkek-I	Bishkek-II	4.5 km	TZAVB	permissible
Bishkek-II	Alamedin	3.5 km	TZBL	good
Bishkek-I/II	Bishkek City Centre	2.5 km		very good

The cable between Lugovaya and Bishkek was laid in 1983 and 1984. The overall cable transmission quality is reasonably good.
The cable for the Bishkek-I/II / Bishkek-City Centre link was introduced in 1998 between the railway telecom switch and the public telecommunications network switch.

The installations must withstand extreme temperature variations (continental climate). Transmission quality deteriorates mainly when cable insulation lies outside the tolerance limits. This stems most frequently from moisture penetrating through the cable at junction box level. Penetration increases over time in view of the different materials used for the junction boxes and the cable armouring.

In some cases, it has proved necessary to replace a faulty junction box with two additional junction boxes and a strip of intermediate cable. This triggers signal reflections and interferes with the capacitance setting. This interference is very difficult to remove from cables which have been already laid. All these problems apply also for sections of stolen cables.

The situation is worsened by the poor condition of earthing cable protective material (theft, inadequate maintenance), leading to an increase in stray currents and, hence, greater cable sheath permeability via electrolysis.

In addition to the cable described below, the other sections of the network are equipped with aerial lines. On the aerial line covering the Bishkek to Balyktchi line (174 km), some sections are equipped with cables, namely:

Station name	*Station name*	*Length*	*Cable type*	*Year introduced*
Bishkek	Alamedin	4.5 km	T3AVB 7x4x1.2	1967
		+3.5 km	+TZBL 14x4x1.2	1993
Km 3897	R - 148	7 km	TZB 7x4x1.2	1968
R - 148	Km 3913	13 km	TZB 7x4x1.2	1973

As well as the lengths indicated in the previous tables, several sections of a few dozen metres are equipped with cables on the aerial lines too. Signal reflections are generated by the alternation between cables and aerial lines. This is one factor which exacerbates transmission quality.
Aerial line wires are bronze or steel. The diameters used are 4 mm (on the main line, 6 wires for HF) or 5 mm (on the main line, 10 wires for LF).

The layout of cables and aerial lines is depicted in Figure 2.1.2.C.

Transmission equipment is usually HF (frequency modulation). It consists of 3 channels (frequency range of 4 to 31 kHz), or 12 channels (range from 36 to 143 kHz). A line of 5.6 km in length has the benefit of modern equipment (IKM-15 input/output unit), which consists of 15 channels between Bishkek I and II. It was introduced in 1997. An extension running to Bishkek-City Centre (public telecommunications network) was introduced in 1998. The IKM-15 equipment is digital.

The cable attenuation coefficient is influenced by the frequency. The following signal attenuation values apply to 1 km of cable:
| 0.41 dB / km for 0.8 kHz,
| 1.78 dB / km pour 110 kHz.

The higher the frequency range used, the shorter the distance between two consecutive amplification points. The amplification points are located in the following stations: Munjke, Tchaldovar, Kaindy, Belovodskaya and Shonokovo. Furthermore, channels are amplified in the emitting and end stations indicated in Diagram 2.1.2D. Amplification takes place in telecommunications facilities (as opposed to lineside cabins).

The following table gives transmission channel capacities between the stations and details of the type of equipment used.

Station name	*Station name*	*Number of channels*	*Type of equipment*
Bishkek I	Lugovaya	2x 12 channels	OK-12
Merke	Karabalta	12 channels	OK-12
Karabalta	Bishkek I	2x 12 channels	OK-12
Bishkek i	Bishkek II	15 channels	IKM-15
Bishkek I	Alamedin	12 channels	P-305
Bishkek I	Kant	3 channels	V-3-3
Bishkek I	Tokmak	12 channels	PV-12-3
Tokmak	R - 148	12 channels	PV-12-3
R -148	Balyktchi	12 channels	P-305
Balyktchi	Bishkek I	12 channels	P-305
Osh	Karasu	3 channels	V-3-3
Karasu	Djalal-Abad	12 channels	TK-12
Djalal-Abad	Khanabad	12 channels	V-12-3
Andijan	Karasu	12 channels	V-12-3
Merke	Lugovaya	(12 channels)	OK-12
Lugovaya	Karabalta	(12 channels)	MP-12-2

Transmission from the station of Lugovaya is provided by the Kazakhstan network.
Two 12 channel installations between Lugovaya, Merke et Karabalta, are currently out of order due to lack of spare parts.
The transmission installations are powered at 24 V dc, generated by the 220 V ac public network.

Figure 2.1.2.E charts the network transmission capacities.

Hertzian links have had to be built due to the deterioration in transmission quality caused by poor cable insulation and saturation of the existing transmission channels. The system used covers a frequency range of 140 to 161.5 MHz (UKV band). The aerials used are directional aerials and located in columns 30 metres high. According to manufacturers' specifications, this equipment allows transmissions to be made up to a distance of 60 km. This installation allows the railway the possibility to broadcast 4 telephone channels between equipped stations.

Station name	*Station name*	*Number of channels*	*Length*
Bishkek I	Shopokovo	4 channels	21 km
Shopokovo	Karabalta	4 channels	38 km
Karabalta	Merke	4 channels	54 km

The southern sections of the country's network have no rail connection with the line to the north of the country. Moreover, they concern relatively short sections of line which cross the Uzbekistan territory (see network map). A few telecommunications links are provided by ITU network equipment. However, Kyrgyzstan railways are forced to lease a certain amount of transmission capacity from the public telecommunciations network, as indicated in the table below.

Station name	*Station name*	*Number of channels*
Bishkek I	Djalal-Abad	2 channels
Djalal-Abad	Tashkumir	1 channel
Karasu	Kyzilkiya	1 channels

These channels are leased at a rate approved by the Telecommunications Ministry. Thanks to the link opened in 1998 (described above), the connection with Djalal-Abad, Almaty, Tashkent, Moscow, Yekaterinburg and Sverdlovsk is better.

2.1.2.6 Radiocommunications

The railway uses radiocommunications for railway operations. (The fixed point radio transmission link is described in Chapter 4.1.2.5). On the whole all locomotives are equipped with a radio set (at 2Mhz and VHF), except for shunting and freight train locomotives, which are equipped solely with VHF radio.

Rolling stock comprises diesel-powered locomotives only. There are 55 diesel locomotives of the TE and M series.

Two radio systems are used conventionally:

- Train radio

This system enables train drivers and the traffic controller or station to communicate. The system is similar to the ground-to-train radio system, laid down in UIC Leaflet 751-3, with however, the following differences:

The selected frequency is unique operating at 2.130 MHz. The operating mode is simplex. The transmitters are located in stations only. The aerials are 20 to 50 m away from their radio base. Transmission power is 10 W. The radio bases are not synchronised.

Thus, radio coverage does not extend beyond the station itself nor line sections either side of the station. However, it should be noted that coverage is not continuous (which would require several separate frequencies).

Moreover, from a traffic control point of view, a control circuit is divided into radio blocks, which each comprise several stations (and therefore several radio transmitters/receivers).

Locomotives are permanently connected in receiver mode. Only one communication can take place within a given radio block, at the instigation of the traffic controller, the station or the locomotive.

On the whole, the radio equipment used is 15 - 20 years old.

- Shunting radio

This system allows the head station traffic controller to communicate with the shunting team members as well as the driver of the shunting locomotive. The same type of system is used to equip maintenance teams (intervention in the event of an accident, etc.).

Shunting radio is a stand-alone system which mainly covers station or railway establishment areas. It uses simplex frequencies operating on the VHF 150 - 156 Mhz band.

This radio is similar to that still sometimes used in Europe to transmit over distances of several dozen kilometres. This point was not examined any further in the framework of this project.

2.1.3 Uzbekistan

2.1.3.1 Introduction

Uzbekistan railways use analog and digital systems with electromechanical and digital telecom switches. Local calls (between subscribers on the same telecom switch) are processed automatically. Outside calls (which involve links between telecom switches) go through an operator. Transmission lines consist of HF (frequency modulation) electronic transmission equipment. Physical media consist of copper cables and aerial lines.

Figure 2.1.3.A is a diagram of the Uzbekistan rail network. The corridor is highlighted in bold. After the creation of „Uzbekistan Temir Yullari" on 7 November 1994 (restructured into a fully-state owned public company), and in the light of the revised territorial boundaries, the railway is split into 7 sections (all in Uzbekistan) but inter-connected through neighbouring networks (Turkmenistan, Tajikistan, Kyrgyzstan and Kazakhstan). The stations of Sary-Agatch, Darbaza, Djilga up to Tchengeldi and R-201, Djetisay up to Tchardara are served by the same network located in Kazakhstan.

2.1.3.2 General characteristics

Telecommunications installations are standardised (GOST) and comply with OSJD leaflets for railway applications. The parts originate from the former Soviet Union with some from Eastern Europe and are no longer in production. Neither are they compatible with current technology. A telecom switch in Termez complies with the technical conditions laid down in UIC Leaflet 753-2 and in general with the CCITT conditions, albeit with a few simplifications allowed to private networks.

The primary power supply for the different facilities is the public electricity supply network. The secondary power supply (transformation, rectification, back-up) is provided by the railway. The emergency power supply is provided by a battery with a few hours' capacity (depending on the state of the battery). The main centres also have emergency diesel generators which are activated automatically or manually in the event of a power cut in the public supply network.

2.1.3.3 Switching

Switching nodes are located in the following stations: Tashkent, Karshi, Khavast, Djizak, Samarkand, Bukhara, Bekabad, Kokand, Andijan, Urgentch, Khodjeili, Kungrad and Termez. To make a local call, the subscriber dials the number he is calling and is automatically put through.

Figure 2.1.3.B plots the positions of the telecom switches.

Outside calls can be made automatically between telecom switches with equipment allowing automatic outside connections (DATS-60, operating on a call frequency of 2100 Hz).

To make an outside call between the other telecom switches, the subscriber must dial the operator and give the destination and phone number he is calling. The subscriber is then called back by the operator once end-to-end communication has been established (which may involve several operators). This manual procedure is restricted by the operator's switchboard capacity and the number of transmission channels. The switchboards used by the operators are MPU-80, MPU-20 or MPU-60 type. Call connection times no longer meet present day standards.

A few international connections can be made through the operator in a similar fashion. The table below indicates these connections as well as the channel capacities.

Emitting switches	*End switches*	*Number of channels*
Tashkent	Moscow	2
Tashkent	Aktyubinsk	2
Tashkent	Almaty	2
Tashkent	Bishkek	1
Tashkent	Ashkhabad	2
Tashkent	Dushanbe	2

Railway telecom switch subscribers can in principle be connected automatically to subscribers on the local telecom switch in the public telephone network. Connection with the other telecom switches in the public national and also international network is prohibited.

The following table indicates the location of the telecom switches, their capacity in terms of subscriber numbers, the model and the year introduced.

Station name	*Number of subscribers*		*Type*	*Year introduced*
Tashkent	3,000		ATS	1985
Djizak	400		ESK	1980
Samarkand	1,000		ATS	1965
Bukhara	3,000		ESK	1985
Karshi	1,300		ATS-54	1975
Khavast	1,400	400	ESK	1985
				1992
Bekabad	100		ATK-50/200	1992
Andijan	1,600		ESK	1992
Kokand	3000		ATS-E	1995
Urgentch	400	400	ESK	1985
				1986
Khodjeili	400		ATS-100	1977
Kungrad	400	300	ESK	1981
				1982

The telecom switches are rotary or crossbar (ESK). The oldest installation dates back to 1965 (in Samarkand) and is still operational. The capacity of the telecom switches built over the last decade meets current requirements although the other telecom switches have already reached saturatation point. Power is supplied by a 48 or 60 V central battery.

The Termez telecom switch is digital. This telecom switch fulfils in particular, with a few simplifications, the technical conditions laid down in UIC Leaflet 753-2 and on the whole, CCITT conditions. It is supplied by Tesla Zagreb (Croatia) and licensed by Ericsson type MD-110.

2.1.3.4 Services

To complement the phone service provided through the switched telephone network (cf Ch. 2.1.3.3) a number of voice services are provided through dedicated lines. These dedicated lines consist of a primary railway telephony transmitter/receiver and terminal installations (subscribers) connected in parallel to the transmission line. The operator (controller) is permanently connected. Subscribers are manually selected by pressing a switch on the operator's switchboard. The primary equipment sends a dial tone frequency which is picked up by the subscriber selection device (APC-1). These various links date from the 70s through to 90s. Nothing further has been introduced since then (some circuits are planned).

The services involved are the following:

- Traffic control (2 wire link).

The traffic control centre is located in the railway main headquarters and regional headquarters building. The centres are responsible for running several line sections. In a bid to rationalise traffic control operations, telecommunications equipment is being replaced and circuits reorganised.

- Energy control (2 wire link).

This link is between the energy control centre and energy controllers at OHL power supply sub-stations. The energy control centre is situated right beside the traffic control centre. The geographical areas covering energy and traffic control are identical as a matter of course.

- Dedicated station-to-station telephone line (2 wire link between KPS-2/3 and UKSS-8 manual telephone switches). The call is made on a frequency of 25 or 50 Hz.
- Distribution of reserved tickets.

This link connects the ticket reservation/distribution centre with some main-line passenger stations.

- Teleconferencing.

The supervisor is connected to his team over a 4 wire link.

- Railway police.

A security centre is linked to station patrol teams.

- Operator management of outside calls to and from station lines connected in parallel on a dedicated circuit (2 wire link).
- Signalling and telecommunications maintenance.

- Track maintenance.
- Lineside alarm (2 wire link).
- Controller - depot link.
- Controller - passenger train formation yard link.

The local circuits in stations are arranged in a similar fashion. Power is supplied by local 50V or 80V batteries.

- Telegraphy

The railways also operate telegraph links. The telegraph network dates back to the latter half of the 1960s with some changes in the terminal equipment (upgraded models) and is still used today. Currently models T-63, STA 67 and F-1100 are used. A few hundred of these terminals (ATA PC-PD) are still operated today.

The transmission speed is that of telephone links of systems built some time ago in Europe, namely 50 Bd (using the 24 channel transmission system), 100 Bd (using the 12 channel transmission system) or 200 Bd (using the 6 channel transmission system). Connections are established automatically. The transmission equipment consists of types P-327-3 or P-327-12.

The telegraph office is located at railway Headquarters. The terminals are connected to the switch and can be connected to other equipment in the former telegraph network of the ex-SZD (the central switch is in Moscow). Telegraphs are used nowadays to send written instructions on railway traffic control and commercial aspects.

2.1.3.5 Transmission media

Transmission media consist of copper cables and aerial lines. Most of the cables are buried. Transmission lines are usually served by HF (frequency modulation) electronic transmission equipment, although use is also made of direct audiofrequency transmission over copper cables and aerial lines. Adaptation is generally carried out by a translator.

Cables are 7x4x1.2+5x2x0.9+1x0.9 (7 star-shaped quads, wire diameter 1.05 mm, 5 pairs and 1 wire of 0.7 mm in diameter) MKUMK (hanging) or MKPAB (paper insulation, aluminium armouring and PVC outer sheath). The electrical resistance of the copper wire 0.7 mm in diameter is 55Ω / km, and for a diameter of 1.05 mm, 21,2Ω / km for direct current. The pairs of wires also carry signalling information.

The table overleaf indicates the year of introduction and the overall transmission quality for the main sections of cables laid.

Station name	*Station name*	*Length*	*Year introduced*
Tchengeldy	Tashkent	79,700 km	1986
Tashkent	Mekhmat	80,200 km	1986
Mekhmat	Khavast	78,400 km	1987
Khavast	Djizak	201,340 km	1993
Djizak	Samarkand	126,120 km	1996
Samarkand	Karshi	168,450 km	1985
Karshi	Bukhara	157,100 km	1987
Bukhara	Khodjablet	91,730 km	1990

The overall transmission quality is reasonably good due to the cabling practices of the last fifteen years. Transmission quality deteriorates mainly when the insulation of the cable lies outside the tolerance limits. This stems most frequently from moisture penetrating the cable at junction box level. Penetration increases over time, in view of the different materials used for the junction boxes and the cable armouring.

In some cases, it has proved necessary to replace a faulty junction box with two additional junction boxes and a strip of intermediate cable. This triggers signal reflections and interferes with the capacitance setting. This interference is very difficult to remove from cables which have been already laid. All these problems apply also for sections of stolen cables.

The situation is worsened by the poor condition of earthing cable protective material (theft, inadequate maintenance), leading to an increase in stray currents and, hence, greater cable sheath permeability by electrolysis.

A certain number of sections are cable-equipped on the aerial line between the Mekhmat (Noviy Tchinaz) and Djizak (via Djetisai) section (120 km in length), and the Samarkand and Bukhara (via Navoi) section (247 km in length). The cables used are 7x4x1.2 (TZB). Signal reflections are generated by the alternation between cables and aerial lines. This is one factor which exacerbates transmission quality.
Aerial line wires are bronze or steel. The diameters used are 4 mm (on the main line, 6 wires for HF) or 5 mm (on the main line, 10 wires for LF).

The layout of cables and aerial lines is depicted in Figure 2.1.3.C.

Transmission equipment is usually HF (frequency modulation). It consists of 12 channels (frequency range from 36 to 143 kHz) and 60 channels (range of 12 to 252 kHz).

The cable attenutation coefficient is influenced by the frequency. The following signal attenuation values apply to 1 km of cable:
0.41 dB / km for 0.8 kHz,
1.78 dB / km for 110 kHz.
3.04 dB / km for 250 kHz.

The higher the frequency range used, the shorter the distance between two consecutive amplification points. Amplification is carried out in telecommunications facilities (as opposed to lineside cabins) and amplification points are located in stations with an average distance of 35 km apart. Furthermore, channels are amplified in the emitting and end stations indicated in the table below which gives details of the transmission channel capacities between the stations and type of equipment used:

Station name	*Station name*	*Number of channels*	*Type of equipment*
Tchengeldi	Tashkent	60 channels	K-60P
Tashkent	Mekhnat	60 channels	K-60P
Mekhnat	Khavast	60 channels	K-60P
Mekhnat	Djizak	12 channels	V-12-3
Djizak	Samarkand	60 channels	K-60P
Samarkand	Karshi	60 channels	K-60P
Samarkand	Bukhara	12 channels	V-12-2
Karshi	Bukhara	60 channels	K-60P
Bukhara	Khodjadablet	60 channels	K-60P

Current requirements exceed the number of channels on offer. A few transmission links are provided by the neighbouring networks. Because the network has been divided into 7 sections which are not interconnected on the Uzbekistan territory (see network map), some channels have to be leased from the public telecommunications network. The channels are leased at a rate approved by the Ministry of Telecommunications.

Figure 2.1.2.D plots the network transmission capacities.

The transmission installations are powered at 24 V dc, generated by the 220 V ac public network. Nevertheless, spare parts for transmission equipment are no longer available as production has been halted.

2.1.3.6 Radiocommunications

The railway uses radiocommunications for railway operations. On the whole all locomotives are equipped with a radio set (at 2Mhz and VHF), except for shunting and freight train locomotives, which are equipped solely with VHF radio. Rolling stock comprises electric, diesel and EMU's (Electric Multiple Units). There are 80 VL electric locomotives. There are 820 diesel locomotives of the TE and M series.

Two radio systems are used conventionally:

- Train radio

This system enables train drivers and the traffic controller or station to communicate. The system is similar to the ground-to-train radio system, laid down in UIC Leaflet 751-3, with however, the following differences:

The selected frequency is unique operating at 2.130 MHz. The operating mode is simplex. The transmitters are located in stations only. The aerials are 20 to 50 m away from their radio base. Transmission power is 10 W. The radio bases are not synchronised.

Thus, radio coverage does not extend beyond the station itself and line sections either side of the station. However, it should be noted that coverage is not continuous (which would require several separate frequencies).

Moreover, from a traffic control point of view, a control circuit is divided into radio blocks, which each comprise several stations (and therefore several radio transmitters/receivers).

Locomotives are permanently connected in receiver mode. Only one communication can take place within a given radio block, at the instigation of the traffic controller, the station or the motive power unit.

On the whole, the radio equipment used is 15 - 20 years old.

- Shunting radio

This system allows the head station traffic controller to communicate with the shunting team members as well as the driver of the shunting locomotive. The same type of system is used to equip maintenance teams (intervention in the event of an accident, etc.).

Shunting radio is a stand-alone system which mainly covers station or railway establishment areas. It uses simplex frequencies operating on the VHF 150 - 156 Mhz band.

This radio is similar to that still sometimes used in Europe to transmit over distances of several dozen kilometres. This point was not examined any further in the framework of this project.

2.1.4 Tajikistan

2.1.4.1 Introduction

Tajikistan railways use analog systems only, electromechanical telecom switches. Local calls (between subscribers on the same telecom switch) are processed automatically. Outside calls (which involve links between telecom switches) go through an operator or are made automatically. Transmission lines consist of HF (frequency modulation) electronic transmission equipment. Physical media consist of copper cables, aerial lines and Hertzian links.

Figure 2.1.4.A is a diagram of the Tajikistan rail network. The corridor is highlighted in bold.

2.1.4.2 General characteristics

Telecommunications installations are standardised (GOST) and comply with OSJD leaflets for railway applications. The parts originate from the former Soviet Union with some from Eastern Europe and are no longer in production. Neither are they compatible with current technology.

The primary power supply for the different facilities is the public electricity supply network. The secondary power supply (transformation, rectification, back-up) is provided by the railway. The emergency power supply is provided by a battery with a few hours' capacity (depending on the state of the battery). The main centres also have emergency diesel generators which are activated automatically or manually in the event of a power cut in the public supply network.

2.1.4.3 Switching

Switching nodes are located in the following stations: Dushanbe-1, Dushanbe-2 , Leninabad, Kurgan-Tyube. To make a local call, the subscriber dials the number he is calling and is automatically connected.

To make an outside call, the subscriber must dial the operator and give the destination and phone number he is calling. The subscriber is then called back by the operator once the end-to-end communication has been established (which may involve several operators). This manual procedure is restricted by the capacity of the operator's switchboard and the number of transmission channels. The switchboards used by the operators are MPU-80, MPU-20 or MPU-60. Call connection times no longer meet present day standards.

An automatic link has already been set up with the public telecommunications network (using the dialling codes 20⇔79). The dialling scheme is set out in Figure 2.1.2.B.

The table below indicates the number of subscribers for each switching node. Capacity has reached saturation point. Figure 2.1.4.C gives the position of the telecom switches.

Station name	*Number of subscribers*	*Switch type*	*Year introduced*
Dushanbe-1	1200	ATSK-54	1979
Dushanbe-2	50	ESK-400	1986
Leninabad	180	KRZ-200	1994
Kurgan-Tyube	80	ESK-400	1980

Switching installations are rotary or crossbar. The oldest installation dates back to 1979 (in Dushanbe) and is still operational. Power is supplied by a central 48 or 60 V battery.

2.1.4.4 Services

To complement the phone service provided through the switched telephone network (cf Ch. 2.1.4.3) a number of voice services are provided through dedicated lines. These dedicated lines consist of a primary railway telephony transmitter/receiver and terminal installations (subscribers) connected in parallel to the transmission line. The operator (controller) is permanently connected. Subscribers are manually selected by pressing a switch on the operator's switchboard. The primary equipment sends a dial tone frequency which is received by the subscriber selection device (APC-1). These various links date from the 70s to the 90s. Nothing further has been introduced since then (some circuits are planned).

The services involved are the following:

- Traffic control (2 wire link).

The traffic control centre is located at the railway headquarters. The centre is responsible for running several line sections. In a bid to rationalise traffic control operations, telecommunications equipment is being replaced and circuits reorganised.

- Energy control (2 wire link).

This link is between the energy control centre and the energy controllers at OHL power supply sub-stations. It will be set up once the lines in Tajikistan have been electrified.
Dedicated station to station telephone line (2 wire link between KPS-2/3 and UKSS-8 manual telephone switches). The call is made on a frequency of 25 or 50 Hz.

- Distribution of reserved tickets.

This link runs between the ticket reservation/distribution centre and some main-line passenger stations.

- Teleconferencing.

The supervisor is connected to his team over a 4 wire link.

- Railway police.

A security centre is linked to station patrol teams;

- Operator management of outside calls to and from station lines connected in parallel on a dedicated circuit (2 wire link).
- Signalling and telecommunications maintenance.
- Track maintenance.
- Lineside alarm
- Controller - depot link.
- Controller - passenger train formation area link.

The local circuits in stations are arranged in a similar fashion. Power is supplied by local 50V or 80V batteries.

- Telegraphy

The railways also operate telegraph links. The telegraph network dates back to the latter half of the 1960s with some changes in terminal equipment (upgraded models) and is still used today. Currently types T-63, STA 67 and F-1100 are used. A few dozen terminals (ATA PC-PD) are still operated today.

The transmission speed is that of telephone links of systems built some time ago in Europe, namely 50 Bd (using the 24 channel transmission system), 100 Bd (using the 12 channel transmission system) or 200 Bd (using the 6 channel transmission system). Connections are established automatically. The transmission equipment consists of types P-327-3 or P-327-12.

The telegraph office is located at railway Headquarters. The terminals are connected to the switch and can be connected to other equipment in the former telegraph network of the ex-SZD (the central switch is in Moscow). Telegraphs are used nowadays to send written instructions on railway traffic control and commercial aspects.

2.1.4.5 Transmission media

Transmission media consist of copper cables, aerial lines and Hertzian links. Most of the cables are buried. Transmission lines are usually served by HF (frequency modulation) electronic transmission equipment, although use is also made of direct audiofrequency transmission over copper cables and aerial lines. Adaptation is generally carried out by a translator.

Cables are 7x4x1.2+5x2x0.7+1x0.7 (7 star-shaped quads, wire diameter 1.2 mm, 5 pairs and 1 wire of 0.7 mm in diameter) MKPAB (paper insulation, aluminium armouring and PVC outer sheath), MKSSTShP and 4x4x1.2+pairs MKSAShP. The pairs of wires also carry signalling information.

The table overleaf indicates the year of introduction and the type of cables laid.

Station name	*Station name*	*Length*	*Year introduced*	*Cable type*
Bekabad (UTI)	Kayrakum	46 km	1990	2x MKPAB
Termez (UTI)	Pakhtabad	162 km	1991	MKSAShP
Regar	Dushanbe-1	53 km		MKSSTShP
R-217	Kulyab	140 km	under construction	

On the Termez /UTI line up to Yangi-Bazar (245 km), the cable section from Termez to Saryasiya (border station) is located in Uzbekistan (155 km). The remainder up to Pakhtabad is located in

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Tajikistan. Cabling between Pakhtabad and Regar has been halted. There is an aerial line running from Dushanbe-1 to the line terminus (23 km) which was built in the 1930's.

Transmission quality deteriorates mainly when cable insulation lies outside the tolerance limits. This stems most frequently from moisture penetrating the cable at junction box level. Penetration increases over time in view of the different materials used for the junction boxes and the cable sheathing.

In some cases, it has proved necessary to replace a faulty junction box with two additional junction boxes and a strip of intermediate cable. This triggers signal reflections and interferes with the capacitance setting. This interference is very difficult to remove from cables which have been already laid. All these problems apply also for sections of stolen cables.

The situation is worsened by the poor condition of earthing cable protective material (theft, inadequate maintenance), leading to an increase in stray currents and greater cable sheath permeability by electrolysis.

A certain number of sections on the Termez / UTI - Amuzang (border station, MP 42,100) - Yavan (270 km) line are cable-equipped as opposed to fitted with aerial lines, namely the longest part:

Place	*Place*	*Length*	*Year introduced*
MP 137 (R-Kabadian)	MP 176 (Kolkhozabad)	40 km	1969

The cable used is 7x4x1.2 (TZB). Signal reflections are generated by the alternation between cables and aerial lines. This is one factor which exacerbates transmission quality.
Aerial line wires are bronze or steel. The diameters used are 4 mm (on the main line, 6 wires for HF) or 5 mm (on the main line, 10 wires for LF).

The layout of cables and aerial lines is depicted in Figure 2.1.4.D.

Transmission equipment is usually HF (frequency modulation). There are three types used: three channels (frequency range of 4 to 31 kHz), 24 channels (frequency range from 8 to 150 kHz) and 60 channels (range of 12 to 252 kHz).
The transmission installations are powered at 24 V dc, generated by the 220 V ac public network.

The cable attenutation coefficient is influenced by the frequency. The following signal attenuation values apply to 1 km of cable:
0.41 dB / km for 0.8 kHz,
1.78 dB / km for 110 kHz.
3.04 dB / km for 250 kHz.

The higher the frequency range used, the shorter the distance between two consecutive amplification points. Amplifications takes place in telecommunications facilities (as opposed to lineside cabins) and the amplification points are located in stations with an average distance of 35 km apart. Furthermore, channels are amplified in the emitting and end stations indicated in the table below which gives details of the transmission channel capacities between the stations and type of equipment used:

Station name	*Station name*	*Number of channels*	*Type of equipment*
Bekabad (UTI)	Kayrakum	60 channels	K-60P
Kayrakum	Kanibadam	24 channels	V-12+12
Termez (UTI)	Dushanbe-1	24 channels	V-12+12
Termez (UTI)	Yavan	3 channels	V-3-3

A one channel link crossing the Uzbekistan (Bekabad - Talimardjan), Turkmenistan (R-155 - Kelif) et Uzbekistan (R-161 - Saryasiya) networks provides transmission between the northern section of the railway and headquarters. There is no rail connection between this section in the north and the lines in the south located in Tajikistan. Tajikistan railways are therefore forced to lease some transmission capacity from the public telecommunications network. Details of the capacity leased are contained in the following table.

Station name	*Station name*	*Number of channels*
Kayrakum	Dushanbe	4 channels
Kurgan-Tyube	Dushanbe	3 channels

These channels are leased at a rate approved by the Ministry of Telecommunications.

Figure 2.1.4.E shows the network transmission capacities.

With transmission quality deteriorating due to the state of cable insulation, transmission channels having reached saturation point and the costs of leasing capacity, it has become necessary to construct Hertzian links. The system used operates on the frequency band of 150 to 160 MHz (in UKV wave). The aerials used are directional aerials. The transmitter/receiver is located on a hill not far from Dushanbe. There is therefore a relay point in Kyrgyzstan connecting up with the Bekabad - Kanibadam line, which allows the traffic controller in Dushanbe to send messages to locomotives which are then converted in stations to the 2 132 kHz frequency (ground-to-train radio).This installation dates back to 1996.

2.1.4.6 Radiocommunications

The railway uses radiocommunications for railway operations. (The fixed point radio transmission link is described in Chapter 4.1.4.5). On the whole all locomotives are equipped with a radio set (operating at 2Mhz and VHF), except for shunting and freight train locomotives, which are equipped solely with VHF radio. Rolling stock comprises diesel-powered locomotives. There are 39 2TE10 (2 sections) series trainsets. There are 29 TE and ChME diesel locomotives used for shunting purposes.

Two radio systems are used conventionally:

- Train radio

This system enables train drivers and the traffic controller or station to communicate. The system is similar to the ground-to-train radio system, laid down in UIC Leaflet 751-3, with however, the following differences:

The selected frequency is unique, operating at 2.130 MHz. The operating mode is simplex. The transmitters are located in stations only. The aerials are 20 to 50 m away from their radio base. Transmission power is 10 W. The radio bases are not synchronised.

Thus, radio coverage does not extend beyond the station itself nor line sections either side of the station. However, it should be noted that coverage is not continuous (which would require several separate frequencies).

Moreover, from a traffic control point of view, a control circuit is divided into radio blocks, which each comprise several stations (and therefore several radio transmitters/receivers).

Locomotives are permanently connected in receiver mode. Only one communication can take place within a given radio block, at the instigation of the traffic controller, the station or the motive power unit.

On the whole, the radio equipment used is 15 - 20 years old.

- Shunting radio

This system allows the head station traffic controller to communicate with the shunting team members as well as the driver of the shunting locomotive. The same type of system is used to equip maintenance teams (intervention in the event of an accident, etc.).

Shunting radio is a stand-alone system which mainly covers station or railway establishment areas. It uses simplex frequencies operating on the VHF 150 - 156 Mhz band.

This radio is similar to that still sometimes used in Europe to transmit over distances of several dozen kilometres. This point was not examined any further in the framework of this project.

2.1.5 Turkmenistan

2.1.5.1 Introduction

Turkmenistan Railways employ only analog systems. All telecom switches bar one (electronic) are electromechanical. Local calls (between subscribers connected to the same telecom switch) are processed automatically; outside calls (requiring a link between two different telecom switches) go through an operator. The transmission links are fed by HF (frequency modulation) electronic transmission installations. The tangible media used are copper cables and aerial lines.

Figure 2.1.5.A: Diagram of the Turkmenistan railway network, with the Traceca corridor marked in bold.

There are plans to electrify the railway lines, which would entail replacing installations incompatible with an electric traction system. Such a move would primarily affect transmission media.

2.1.5.2 General characteristics

The telecommunications installations are standardised (GOST) and comply with OSJD leaflets as regards railway applications. Parts originate from the former Soviet Union or eastern Europe and are no longer in production. Neither are they compatible with today's technology.

The primary power supply for installations is from the public grid. A secondary power supply (transformation, rectification, back-up) is provided by the railway. Back-up energy is generated by a battery with a few hours' capacity. (depending on the state of the battery). Major centres have the additional safeguard of diesel generators which are activated, automatically or manually, in the event of a public power cut.

2.1.5.3 Switching

Switching nodes are located at the following stations: Kelif, Amudera, Ashkhabad, Dushak, Kara, Annay, Kulieva, Buzmenij, Bakharden, Kizil-Arbat, Bami, Kazandjik, Turkmenbashi (Krasnovodsk-I), Turkmenbashi-Port, Turkmenbashi (Krasnovodsk-II), Neftebaza, Poselok, Mary, Tedjen, Gushgy, Karabata, Bayram-Ali, Utch-Adji, Dashkhovuz, Tchardoy, Tchardoy-2, Tchardoy-Lok. Depo, Zerger, Seidi, Dargan-Ata and Farab. To make a local call, the subscriber dials the desired number and is connected automatically.

The position of the telecom switches is plotted out in Figure 2.1.2.B

To make an outside call, the subscriber must dial the operator and state the name and number of the connection sought. The operator calls back once end-to-end communication has been established (a process which may involve several operators) This manual procedure is limited by the operator's switchboard capacity and the number of transmission channels.
Operator switchboards are situated at the following stations: Kelif, Amudera, Dushak, Ashkhabad, Kizil-Arbat, Krasnovodsk-I, Krasnovodsk-II, Kazandjik, Gushgy, Tedjen, Mary, Utch-Adji, Dashkhovuz, Dargan-Ata and Tchardoy. The models used are MPU-80, MPU-20 or MPU-60. Call connection times no longer meet modern-day requirements.

An outside call may be put through automatically between certain telecom switches fitted with the necessary technology (DATS-60, call frequency of 2100 Hz). Automatic outside calls are possible between telecom switches located at the following stations: Ashkhabat and Mary, Dushak, Kara, Annay, Kulieva, Buzmenij, Kizil-Arbat and Bati; between Turkmenbashi (Krasnovodsk-I) and Turkmenbashi-Port, Turkmenbashi (Krasnovodsk-II), Neftebaza, Poselok and Kazandjik; between Mary and Ashkhabat, Tedjen, Gushgy, Karabata, Bayram-Ali and Utch-Adji; between Tchardoy-1 and Zerger, Tchardoy-2, Seidi, Tchardoy-Lok. Depo, Farab and Dargan-Ata. In addition, international calls between Tchardoy, Tashkent and Bukhara are placed automatically.

The table overleaf lists the number of subscribers per exchange. At present, capacity is saturated. The location of the telecom switches is indicated in Figure 2.1.5.D.

Station	*Number of subscribers*	*Model*	*Year introduced*
Kelif	100	ATSK-100	1980-90
Amudarya	50	ESK-400	1980-90
Ashkhabad	2000	ATSK-100/2000	1970
Dushak	100	KRZ-104/204	1980-90
Kara	50	KRZ-104/204	1980-90
Annay	50	KRZ-104/204	1980-90
Kulieva	100	UATS-49	1980-90
Bakharden	50	KRZ-104/204	1980-90
Buzmenij	100	KRZ-104/204	1980-90
Kizil-Arbat	100	KRZ-104/204	1980-90
Bami	50	KRZ-104/204	1980-90
Kazandjik	200	ESK-400^E	1980-90
Krasnovodsk-I	800	ATS-54A	1980-90
Turkmenbashi-Port	500	UATS-49	1980-90
Krasnovodsk-II	300	ESK-400	1980-90
Neftebaza		UATS-49	1980-90
Poselok	50	KRZ-104/204	1980-90
Mary	1000	UATS-54A	1980-90
Tedjen	50	ATSK-50/100	1980-90
Gushgy	200	ATSK-50/200	1980-90
Karabata	200	UATS-100/400	1980-90
Bayram-Ali	100	KRZ-104/204	1980-90
Utch-Adji	100	KRZ-104/204	1980-90
Dashkhovouz		ESK-400	1980-90
Tchardoy-1	2000	ESK-3000E	1992
Tchardoy-2	100	KRZ-104/204	1980-90
Tchardoy-Lok.depo	50	KRZ-104/204	1980-90
Zerger	50	KRZ-104/204	1980-90
Seidi	100	ATSK-100/200	1980-90
Dargan-Ata	400	ATSK-100/200	1980-90
Farab	100	KRZ-104/204	1980-90

The telecom switches are rotary or crossbar technology. The oldest dates from 1970 (Ashkhabad) and still functions today. Power is supplied by 48 or 60 V central batteries.

Automatic links already exist between the public telecommunications network and a few telecom switches (using a dialling code), as can be seen in the following table.

Railway telecom switch	*Dialling code*	*Public telecom switch*	*Number of subscribers*	*Model*
Tchardoy	18 / 18	Tchardoy-Ville	7500	ATS-57
Mary	30 / 30	Mary-Ville		Gor. ATS
Krasnovodsk-I	22 / 22	Turkmenbashi-V.	5000	GATS-54
Ashkhabad	36 / 35	Ashkhabad-Ville		GATS
Kazandjik	/	Kazandjik-Ville	2000	ATSK-160/2000

2.1.5.4 Services

To complement the switched telephone network (cf. Section 2.1.5.3), a certain number of voice services are also provided by dedicated connections. These connections consist of a primary railway telephony transmitter/receiver and terminal installations (subscribers) linked in parallel on the transmission line. The operator (controller) is in permanent receiver mode. Subscribers are selected manually by pressing a button on the operator's switchboard. The transmitter/receiver emits the dialling frequency, which is received by the subscriber selection device (APC-1). These connections date from the 70s-90s. Nothing further has been introduced since then, although some circuits are in the pipeline.

The following services are involved:

- Traffic control (2 wire link)

The traffic control centre is housed in the railway headquarters and is responsible for managing the line sections. Rationalisation of traffic control would entail replacing telecommunications equipment and reorganising the circuits.

- Energy control (2 wire link)

This line will run from the energy control centre to regulators at the OHL power supply sub-stations following electrification of Turkmenistan railway lines.

- Dedicated station-to-station telephone lines (2 wire link between the manual KPS-2/3 and UKSS-8 telecom switches). Call frequency is 25 or 50 Hz.
- Distribution of reserved tickets.

The ticket reservation/distribution centre is connected to some main-line passenger stations.

- Teleconferencing

A 4-wire link connects a supervisor's installation to those of his/her team.

- Railway police

The security office is linked to station patrol teams.

- Operator management of outside calls to and from line stations connected in parallel on a dedicated circuit. (2 wire link).
- Signalling and telecommunications maintenance
- Track maintenance
- Lineside alarm (2 wire line).
- Traffic controller - depot link.
- Traffic controller - passenger train formation site link.

Local circuits at the stations are arranged in the same fashion and energised by local 50 or 80 V batteries.

- Telegraphy

Turkmenistan Railways also has a telegraph network. It dates from the latter half of the 60s, with a few changes in terminal equipment (upgrade in models), and is still in service today. The models currently in use are T-63, STA 67 and F-1100 series. Several hundred of these terminal installations (ATA PC-PD) still function today.

Transmission rates correspond to those achieved by older European systems, i.e. 50 baud (24-channel transmission system), 100 baud (12-channel transmission system) or 200 baud (6-channel transmission system). Connection is automatic and P-327-3 or P-327-12 transmission equipment is used.

The telegraph office is located at the railway undertaking's headquarters. Terminal installations are connected to the switch and can be connected to other installations in the former SZD telegraph network (the central switch of the RZD network is located in Moscow). Today, the telegraph links are used to send written instructions concerning traffic control and commercial aspects.

2.1.5.5 Transmission media

The transmission media are copper cables and aerial lines. Most of the cables are buried. Transmission links are generally fed by HF (frequency modulation) electronic transmission installations, although use is also made of direct audiofrequency transmission over copper cables and aerial lines. Adaptation is generally carried out by translators.

The cables are type 7x4x1.2+5x2x0.7+1x0.7 (7 star-shaped quads, 1.2 mm diameter wire; 5 pairs and 1 wire of diameter 0.7 mm) MKPAB (paper insulation, aluminium armouring and PVC outer sheath). The wire pairs also carry signalling information.

The following table indicates the length, introduction year and type of cable laid.

Station	*Station*	*Length*	Year introduced
Krasnovodsk	Nebit-Dag	153 km	< (1980)
Dushak	Mary	172 km	< (1980)
Ashkhabad	Dushak	161 km	< (1980)
Talimardjan	Kelif	178 km	1984
Turkmenbashi-S	Sarakhc	132 km	1996
Farab	Dostlyk	215 km	under construction

Transmission quality is satisfactory for the cables laid over the past 15 years. Poor transmission quality is primarily due to cable insulation lying outside the minimum tolerance limits, which is more often than not caused by moisture penetrating through to the cables at the junction boxes. Penetration increases over time in relation to the different materials used in the junction boxes and the cable armouring.

In some cases, it was necessary to replace a faulty junction box with two new boxes and a strip of intermediate cable. Such measures trigger signal reflections and interfere with capacitance regulation. This interference is not easily eliminated from cables that have already been laid. All these problems apply when cables sections are stolen.

The situation is worsened by the poor condition of earthing cable protective material (theft, inadequate maintenance), leading to an increase in stray currents and greater cable sheath permeability by electrolysis.

Aerial lines account for 60% of all tangible links. Some of the sections are fitted with cables, generally type 7x4x1.2 (TZB). The alternation between cables and aerial lines generates signal reflections which exacerbate transmission quality.
The aerial wires are made of bronze or steel with a diameter of 4 mm (main line, 6 HF wires) or 5 mm (main line, 10 LF wires).

Figure 2.1.5.D maps out the cables and aerial lines.

Most of the transmission installations are HF (frequency modulation) models, with 3 (frequency range of
4 kHz-31 kHz), 12 (frequency range of 36 kHz-143 kHz) or 60 (frequency range of 12-252 kHz) channels. The power supply is 24 V direct current, obtained from the public grid (220 V alternating current).

The frequency influences the cable attenuation coefficient. The following signal attenuation values apply to 1km of cable:
0.41 dB / km for 0.8 kHz,
1.78 dB / km for 110 kHz,
3.04 dB / km for 250 kHz.

The distance between two consecutive amplification points is inversely proportional to the selected frequency range. Amplification takes place in telecommunications facilities (as opposed to lineside cabins). Station amplifiers are positioned at intervals of approximately 35 mm (for aerial lines, this distance is doubled). Furthermore, channels are amplified at the emitting and end stations listed in the following table, which also indicates transmission channel capacity between stations and the installation model used:

Station	Station	Number of channels	Model
Kelif	Amudera	1 channel	V-3-3
Amudera	Ashkhabad	12+60 channel	V-12-3, K-60P
Ashkhabad	Krasnovodsk	12+3 channel	V-12-3, V-3-3
Ashkhabad	Kazandjik	12+3 channel	V-12-3, V-3-3
Ashkhabad	Mary	12+3 channel	V-12-3, V-3-3
Ashkhabad	Tchardoy	12+3 channel	V-12-3, V-3-3
Dushak	Ashkhabad	4x12 channel	K-60P
Talimardjan	Kelif	60 channel	K-60P

In general, 60-channel transmission installations are used for copper cables and 3 or 12 channel equipment for aerial lines. All installations, apart from those feeding the cables, were purchased over 15 years ago. There is a critical lack of spare parts, which are no longer being produced.

Figure 2.1.5.E illustrates the railway's transmission capacity.

Current transmission requirements exceed the capacities indicated in the above table, forcing the railway undertaking to lease capacity from the public telecommunications network, as can be seen in the table below

Station	Station
Mary	Sarakhc
Ashkhabad	Tchardoy
Tchardoy	Amurdera
Ashkhabad	Dashkovuz

The leasing rate has been approved by the Ministry of Telecommunications.

2.1.5.6 Radiocommunications

The railway employs radiocommunications for railway operations. In general, all locomotives are fitted with 2Mhz/VHF radio sets, with the exception of shunting and freight train locomotives, which have only a VHF radio. Rolling stock consists solely of diesel motors. Train and shunting locomotives together total 331 and are all various models of the TE and M series.

Two radio systems are used conventionally :

- Train radio

The train radio system enables drivers and controllers/stations to communicate. It is similar to the ground-to-train radio system (standardised in UIC Leaflet 751-3) in all but the following points:

The selected frequency is unique (2.130 MHz) and the operating mode is simplex. All transmitters are positioned in stations. Aerials are situated at a distance of 20 to 50 m from the corresponding radio base. Transmission power is 10 W. Radio bases are not synchronised.

As a result, radio coverage does not extend beyond the station itself and the line sections on either side. However, it should be noted that coverage is not continuous (this would require several distinct frequencies).

Further, from a traffic control point of view, a control circuit is divided up into radio blocks, each comprising several stations and therefore several radio transmitters/receivers.

The locomotives are in permanent receiver mode. Communication is limited to one train per radio block, at the instigation of the controller, the station or the locomotive.

Most of the radio equipment used in 15 to 20 years old.

- Shunting radio

This system provides for communication between the head station traffic controller and shunting team members, including the driver of the shunting locomotive. A similar system is used by maintenance teams (intervention in the event of an accident, etc.).

The shunting radio is an stand-alone system mainly covering the station or railway sites. It uses simplex frequencies in the 150 - 156 MHz VHF range.

The radio system is similar to those still sometimes used in Europe to transmit over distances of several dozen kilometres. This point was not examined any further within the framework of the present project.

2.2 Overview of existing studies

2.2.1 Rail Maintenance Central Asia - Infrastructure Maintenance 2 - Module B - Proposals and training to improve Freight and Passenger traffic on the TRACECA route - Draft Final Report - July 1997. (DE-Consult/ARE/Systra).

2.2.1.1 General points and status quo

The study took in Kazakhstan, Tajikistan, Turkmenistan and Uzbekistan.

2.2.1.1.1 Signalling

The condition of most installations is adequate and should allow them to be used for a further 15 years. Indeed, they could even cope with significantly higher traffic levels.
The only deficit worth noting is the lack of maintenance facilities and, in particular, of spare parts and tools.
Nonetheless, Kyrgysztan aside, 20-40% of installations are over 30 years old, nearing the end of their lifespan and, most importantly, impossible to maintain.

It should be borne in mind that some spare parts (for very old equipment) may soon cease to be available.
The only solution for the oldest equipment (e.g. NEVA and MINSK CTC systems) is to dismantle and recycle existing installations.

The network comprises colour-light signals, blocks, track circuits and automatic switch gear and tends to be remote controlled by CTC systems. These systems also cover all stations, except the larger ones, where traffic control is local.

The CTC systems used are:

- NEVA, very old, relay/electronic technology
- MINSK, quite old, electronic
- LUTCH, more recent, electronic model
- Dialogue, via computer

2.2.1.1.2 Telecommunications

Networks are composed of buried copper cables and aerial lines, all served by analog transmission equipment (with a few rare exceptions).
Aerial lines are completely outdated. Transmission quality is poor, the number of available channels are inadequate and data transmission throughput is mediocre.

PABXs are mainly rotary or crossbar, although some electronic and/or digital switches are also used.
Most links between PABXs go through an operator.

On the whole, network transmission capacity is saturated and it is no longer possible to obtain spare or add-on parts.
The only solution for the oldest models (e.g. rotary PABXs) is to dismantle and recycle existing installations.

2.2.1.2 Projects

2.2.1.2.1 Kyrgyzstan

2.2.1.2.1.1 Telecommunications

Siemens has put forward a proposal to upgrade transmission facilities along the main corridor, including installation of a 6 optical fibre cable and SDH/STM-1 equipment for the sum of US $ 2.9 million.

2.2.1.2.2 Kazakhstan

2.2.1.2.2.1 Telecommunications

A microwave transmission project (130 km) is being implemented in conjunction with Siemens, linking Aktyubinsk and Uralsk (Russian border) and costing a total of US $ 5 million. This sum seems to be somewhat high.

Another (Japanese-funded) project to install two copper cables between Druzhba and Aktogay (320 km) will cost a total of US $ 5 million, including multiplexers and stations. It is surprising that optical fibres are not used for the second cable as the cost is roughly the same.

2.2.1.2.3 Tajikistan

2.2.1.2.4 Turkmenistan

2.2.1.2.4.1 Signalling

In 1996, Alcatel Germany put in a bid to install a new computerised CTC system in Ashgabad, Krasnovodks and Chardjew. The proposal, costing US $ 21 million, was turned down.

2.2.1.2.4.2 Telecommunications

The railway wishes to hand over PABXs to telephone companies, which would entail the administrative telephone network falling into non-railway hands.

2.2.1.2.5 Uzbekistan

2.2.1.2.5.1 Telecommunications

In 1996, a project to install an optical-fibre cable between Tashkent and Samarkand as well as 34Mbits/s digital transmission equipment was not implemented owing to a shortage of funds (US $ 5.3 million).
Another project to replace the Tashkent PABX (US $ 1.5 million) ran aground over the same period for the same reason.

2.2.1.3 Recommendations

2.2.1.3.1 General points

2.2.1.3.1.1 Signalling

The bulk of equipment is over 30 years old and should be replaced by equivalent models.

Maintenance facilities urgently need to be renewed.

2.2.1.3.1.2 Telecommunications

It is advocated that a completely new communications network be installed along the corridor, based on a ten optical fibre cable. A second, copper, cable (ten pairs) is also recommended for signalling purposes. Both cables would be aerial, slung across any existing masts (catenary, signalling power supply).

Fibres would be used as follows:
- 2 pairs for SDH redundancy,
- 2 pairs for the railway network,
- 2 pairs for leasing.

Transmission equipment should be type 155Mbits/s SDH/STM-1.

Maintenance facilities urgently need to be renewed.

2.2.1.3.2 Kyrgyzstan

2.2.1.3.2.1 Signalling

An investment of US$ 500,000 is recommended for maintenance.

2.2.1.3.2.2 Telecommunications

Recommended investment:

	US$ million
Install 322 km of optical fibre cabling (including transmission and power supply equipment) and 172 km of copper cabling (eastern section) along the corridor	4.6
Replace operational telephones (dispatchers)	0.3
Renew radio equipment	0.5
Upgrade the Bishkek PABX	0.36
Total	5.76

Furthermore, it is advocated that US$ 250,000 be urgently released to renew the facilities used by maintenance teams in their daily work.

2.2.1.3.3 Kazakhstan

2.2.1.3.3.1 Signalling

An investment of US$ 1 million is urgently required for maintenance (spare parts, tools and instruments)

Other recommended investments:

Western corridor:
Aktyubinsk/Ozinki (682 km), US$ 18.5 millions
- New station equipment
- New automatic block
- CTC

Northern Traceca corridor:
Druzhba/Aktogay (310 km), US$ 3.4 million)
- New station equipment

Aktogay/Tobe (240 km), US$7.5 millions
- New station equipment
- New automatic block
- CTC

Ush-Tobe/ Almaty (220 km), US$ 0.6 million
- CTC

Trans-Asian corridor:
Sajak/Mointy (350 km); US$ 8 million
- New station equipment
- New automatic block
- CTC

Total: US$ 38 million.

2.2.1.3.3.2 Telecommunications

An investment of US$ 750,000 is urgently required for maintenance (spare parts, tools and instruments).

Other recommended investments:

	US$ million
Replace the aerial lines with a 10 fibre optical fibre cable (with multiplexers and power supply equipment) and a copper cable	
Aktyubinsk/Uralsk (550 km)	9.2
Kzyl-Orda/Arys (393 km)	6.6
Mointy/Sajaks (336 km)	5.8 km
Upgrade some copper cables (100 km)	1
Replace operational telephones (dispatchers)	0.98
Renew radio equipment	0.9
Replace 25 PABXs	10.8

Total investment requirement is US$ 36 million.

2.2.1.3.4 Tajikistan

2.2.1.3.4.1 Signalling

An investment of US$ 0.25 million is urgently required for maintenance (spare parts, tools and instruments)

Other recommended investments:
Sections of the northern corridor (65 km), US$ 2.2 million
- New station equipment
- New automatic block

2.2.1.3.4.2 Telecommunications

An investment of US$ 0.1 million is urgently required for maintenance (spare parts, tools and instruments)

Other recommended investments:

	millions of US$
Replace the aerial lines along the northern corridor (171 km with a 10 fibre optical fibre cable (with multiplexers and power supply equipment) and a copper cable	3

2.2.1.3.5 Turkmenistan

2.2.1.3.5.1 Signalling

An investment of US$ 0.75 million is urgently required for maintenance (spare parts, tools and instruments).

Other recommended investments:
Dushak/Ashgabad (169 km) and Barmi/Krasnovodsk (391 km), US$ 18 million

- New station equipment
- New automatic block
- CTC

2.2.1.3.5.2 Telecommunications

An investment of US$ 0.5 million is urgently required for maintenance (spare parts, tools and instruments).

Other recommended investments:

	US$ million
Replace the aerial lines with a 10 fibre optical fibre cable (with multiplexers and power supply equipment) (840 km) and a copper cable (450 km) along the corridor	14.5
Ashgabad/ Nebit-Dag (400 km)	
Dushak / Farap (440 km)	
Renew radio equipment	0.52
Total	15

2.2.1.3.6 Uzbekistan

2.2.1.3.6.1 Signalling

On main lines:

	US$ million
Station equipment (31)	
Hot box detectors (7)	
Renewing automatic block (340 km)	
CTC covering 340 km	
Total	**11.4**

It is equally important to invest US$ 2 million in maintenance (spare parts, vehicles, tools and instruments).

2.2.1.3.6.2 Telecommunications

An investment of US$ 0.5 million is urgently required for maintenance (spare parts, tools and instruments).

Other recommended investments:

	US$ million
Install a 10 fibre optical fibre cable (with multiplexers and power supply equipment) (732 km) and a copper cable (450 km) along the corridor	10.4
Replace operational telephones (dispatchers)	0.45
Renew radio equipment	0.76
Upgrade 6 PABXs	2.7

Total investment requirement is US$ 14.4 million.

2.2.2 Central Asian railways restructuring - Module A - Kazakhstan - Draft Final Report - December 97

The telecommunications and signalling department employs 13,000 people.

2.2.2.1 Telecommunications

Telecommunications infrastructure comprise the following:

- Central dispatcher to local operator (dispatching)
- Station operators along the line with each other (dispatching)
- Central dispatcher to locomotive driver (radio communication with trains)
- Station inspectors to locomotive drivers (radio communication with trains)
- Locomotive drivers to each other (radio communications with trains)
- Shunting personnel to locomotive drivers and station operator (station radio)
- Party lines for permanent way maintenance staff
- Party lines for telecommunication and signalling maintenance staff
- Communication for remote control
- Local lines between two railway stations ; these include the telephones at the signals and turnouts at the entry and exit area
- Administrative and managing communications for all the staff (private switching telephone networks PSTN)
- Teleprinter links with other networks
- Data transmission links with the main railway stations and other railway networks
- Public address system at larger stations
- Loudspeaker announcement system at marshalling yards

It is roughly equivalent to the rail infrastructure found in other CIS countries.

The main lines (Almaty - Akmola, Almaty - Aktogay) and lines running east and north of Akmola are fitted with buried cables, whereas the other lines are served by aerial lines.

The Bank of Japan is funding the installation of two copper cables between Aktogay and the Chinese border (320km) plus the attendant telephone equipment costing US$ 5 million in all.

The telecommunications network operates satisfactorily, although breakdowns are increasing. A US$ 0.75 million investment is imperative to renew maintenance facilities.

Main line equipment is more than 30 years old and should be replaced over the coming years.

The chapter on MIS stresses the need to renew the telecommunications network and refers readers to the report on "Infrastructure Maintenance 2".

2.2.2.2 Signalling

Roughly 80% of the network is fitted with colour-light signals, automatic or semi-automatic block, track circuits and electrical switch gear.

Two-thirds of the line is controlled centrally (CTC), broken down into 14 control areas. The control centres are located at Almaty, Akmola, Shimkent, Aktubinsk, Karaganda and Semipalatinsk.

There are three types of CTC :
PCH : oldest model, relay technology.
Niva : relay and electronic technology.
Minsk : fitted with integrated circuits and digital-keyboard control panels.
All three models have a function for setting train paths automatically.

Block length does not exceed 2.5 km. There are no intermediary signals to deal with crossing traffic on dual-track lines. Automatic block track is equipped with 50 Hz track circuits.

On main lines, the automatic traffic control system forwards information to the cabin and can halt the train if it runs through a "stop" sign.

This type of equipment is actually suited to larger traffic flows than those recorded since the 1991 drop. Substantial savings could be made in maintenance costs alone by simplifying the signalling system.

21% of the CTC break-downs are related to signalling and telecommunications.

30% of station equipment was installed before 1978.
70% of equipment is in good condition but a US$ 1 million investment is required to renew maintenance facilities.

Other equipment will be due for renewal in a few years' time.

2.2.3 Central Asian railways restructuring - Module B - Uzbekistan - Draft Final Report - February 98

2.2.3.1 Organisation

The Signalling and Telecommunications Department has a workforce of 3,290.
Maintenance is divided up into ten sectors, each with its own workshop and emergency team.
The sectors are:

Tashkent junction
Tashkent permanent way
Khavask
Koland
Samarkand
Boukhara
Karchi
Termez
Ourgentch
Koungrad

The Department's annual budget stands at CYM 473,000,000, i.e. US$ 7,800,000 broken down as follows:

Salaries	35%
Charges	14%
Material purchase	5%
Factory repairs	8%
Energy expenses	21%
Structure & others	14%

2,158 incidents were registered in 1996, resulting in average delays of 3 hours, primarily due to equipment age and inadequate maintenance caused by a lack of resources.

The investment requirement for maintenance is US$ 1 000 000.

2.2.3.2 Telecommunications

Aerial lines account for 80% and buried cables for 20%.

Priority investment required over the next five years is estimated to be US$ 20 000 000.

This sum does not include Module E investments.

In the MIS chapter:
An in-depth study was carried out in 1995 to renew the entire telecommunications network with a total budget of US$ 55,000,000 until 2010. A shortage of funds has resulted in only the Termez PABX (2,000 subscribers) being installed (by Ericsson).

Readers are referred to the "Infrastructure maintenance 2" study.

2.2.3.3 Signalling

The railway network is fitted with colour-light signals, track circuits and electrical switch gear. Lines and stations are equipped with a centralised control system (CTC) located in Tashkent.
The network is divided up into 13 areas supervised by 9 dispatchers.
Major stations also have their own signal box.

There are three kinds of CTC:

NEVA (5ex, 1975), relay
LUCH (7 ex, 1985), relay and electronic model
DIALOGUE (1ex) computerised

40% of automatic blocks and station equipment is over 30 years old and maintenance is extremely difficult. Furthermore, there is a shortage of spare parts.

Priority investment requirements for the next five years are estimated to be US$ 53,756,000.

2.2.4 Central Asian railways restructuring - Module C - Turkmenistan - Draft Final Report - January 98

2.2.4.1 Organisation

The Signalling and Telecommunications Department has a workforce of 1,790.
The Department is divided up into five regional sectors:

- Kizyl-Arvat - Douchak, employing roughly 400
- Talimardjan - Gare-16, employing roughly 200
- Takhiatach, Farap, Outch-Adjii, employing circa 200
- Outch-Adji, Kouchka, Serakhs, Douchkak, employing around 440
- Turkmenbashy, Kizil-Arvat, employing approx. 200

The annual budget for 1996 was 14 million manat, i.e. almost US$ 2.7 million.

Salaries	33%
Costs & taxes	26%
Equipment and spare parts	11%
Energy	20%
Structure & other	17%

Approximately 2,000 incidents were registered in 1996, leading to delays of roughly 6,000 hours. It is estimated that the proposed investment would cut these delays to 1,800 hours per annum.

The most pressing problem is the lack of spare parts, tools and maintenance equipment.

It is proposed that US$ 500,000 be invested in maintenance.

2.2.4.2 Telecommunications

Buried cables account for 40% of the network, with the remainder consisting of aerial cables.
In response to a shortage of available channels in the existing system, additional channels are leased from the Ministry for Telecommunications on certain routes.

A list of items for renewal, including station equipment and optical fibres, is proposed at a cost of US$ 71,320,000.

It is judged imperative to replace some radio equipment and upgrade the stations at Bami, Duskak and Mary, requiring an investment of US$ 2.5 million.
For all remaining points, readers are referred to Module E.

2.2.4.3 Signalling

1,275 of the 2,313 km of track are set up as automatic block, while the remainder is semi-automatic. Control for almost the entire network is centralised, except for at Krasnovodsk-1, Kala-i-mor and Razezd-199.

The centralised traffic control equipment used is:
NEVA relay technology dating from 1970 and no longer in production. Dismantling and recycling installations is the only maintenance option available. In five years' time no servicing whatsoever will be possible.
LUCH, electronic and relay technology; spare parts can still be purchased.

It is advocated that the signal boxes, track equipment, automatic and semi-automatic blocks and control centres at some stations and on some line sections be replaced.

Central Asia - Inventory

The aggregate investment requirement is estimated to be US$ 32,664,000, broken down into US$ 10,800,000 for urgent work and US$ 2,500,000 recommended for maintenance facilities and upgrading equipment at the station at Turkmenbashi port.

2.2.5 Central Asian railways restructuring - Module D - Part 1 - Kyrgyzstan - Draft Final Report - June 98

2.2.5.1 Telecommunications

Cf. Module E.

2.2.5.2 Signalling

The Lugovaya - Bishkek line is fitted with a NEVA automatic signalling system centralised at Bishkek.

The other lines are controlled by telephone.

Traffic volumes do not warrant upgrading the signalling system.

3. Electronic data interchange

The IT section of this project aims to improve the electronic exchange of data between railways and their partners.

The first step was to gain an overview of existing facilities through on-site visits. This was followed by an analysis of other past and ongoing studies.

An action and investment plan will be prepared and will also contain a proposal for links with Europe.

A detailed examination of IT facilities for in-house use within the railways is not planned. Other Traceca projects have already dealt with or are dealing with this point for the Central Asian area (e.g.: Central Asian Railways Restructuring / CIE-Consult & Systra). Naturally the recommendations made in this report will, insofar as is possible, take account of those studies with a more in-house slant.

3.1 Inventory

On the whole, IT facilities are quite well developed at the railways of Central Asia - Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

These facilities rely on three computer centres equipped with mainframes and located in Kazakhstan, Turkmenistan and Uzbekistan.
In addition, the railways have PCs and terminals, a large number of which are connected to the mainframes.
Most of the facilities are located at headquarters and border stations.

The Kyrgyzstan terminals depend on the computer centre in Almaty (Kazakhstan) and those in Tajikistan on the Tashkent centre (Uzbekistan).

The railways are not really interconnected, but they are all part of the old IT system of the former USSR, the hub of which is in Moscow. The information available locally or via Moscow is adequate for freight management, however the system is more geared towards compensation between the different countries for lease of wagons.
An IT management system for international passengers does exist but has not yet been installed in Turkmenistan.
While the system appears to be satisfactory on the whole, the railways in Kyrgyzstan and Tajikistan did say they would like their own computer centre so as to tailor the system to their needs.
The biggest fault in the current system is the appalling state of the transmission links between stations. For more details refer to the telecommunications section of this report.

There is no electronic exchange of data with administrative bodies, for example customs or police.

There is no electronic exchange of data with customers.

Neither is there any electronic exchange of data with port authorities or shipping companies.

For the purpose of this report an "IT system" refers to IT facilities as a whole, an "IT centre" to all IT facilities in a given building and an "computer centre" to an IT centre equipped with a mainframe.

3.1.1 Kazakhstan.

The consultants have received no information whatsoever on Kazakhstan railways.

3.1.1.1 Introduction

3.1.1.2 Overview of the IT system

For more details, refer to the project report on "Central Asian Railways Restructuring, Module A - Kazakhstan".

3.1.1.3 IT system diagram

3.1.1.4 Electronic data interchange with administrative bodies (customs, police, etc.)

3.1.1.4.1 Status quo

3.1.1.4.2 Projects

3.1.1.5 Electronic data interchange with customers

3.1.1.5.1 Status quo

3.1.1.5.2 Projects

3.1.1.6 Electronic data interchange with port authorities and shipping companies

3.1.1.6.1 Status quo

3.1.1.6.2 Projects

3.1.1.7 Electronic data interchange with other railway companies

3.1.1.7.1 Outline of the systems

3.1.1.7.2 Message format

3.1.1.7.3 Projects

3.1.2 Kyrgyzstan

3.1.2.1 Introduction

The IT system at Kyrgyzstan railways is fairly basic, as is the rail network itself.

There is a small IT centre at the headquarters in Bishkek.
This centre is connected to the border stations, all stations in Kyrgyzstan and to Almaty (Kazakhstan). The system is mainly used to record wagons and containers, among other things, for payments to their owners. It is also able to issue international train tickets.

3.1.2.2 Overview of the IT system

The railway has an IT centre in Bishkek which has a LAN but no computer system as such, small or large.
The Bishkek IT centre has a relay to Almaty in Kasakhstan, via which station terminals linked to the capital can access the mainframe in Almaty.
The consultants could not find out the specifications of this relay.

Local specialists reported several monthly break-downs in the Almaty link.

Each border station is equipped with a PC which is hooked up to the capital via a 1200 baud modem.

These border stations are:

With Kazakhstan :	Lougavaya,
With Uzbekistan :	Karasu, Kizil-Kygard, Tashkumyr Khanabad (Uzbek territory)

The other on-line stations, which also use 1200 baud modems, are:

- Merke
- Kaindy
- Karabalta
- Belovodskaya
- Shokovo
- Alamedin
- Kant
- Ivanovka
- Tokmak
- Bystrovka
- Balyktchi
- Djalal-Abad
- Osh

The railway has a total of approximately 120 PCs in all.

Local applications, most of which were developed using FoxPro, are mainly geared towards management and accounting. In particular, they are used to check wagon count figures received from Almaty or Moscow.

For more information refer to the project report on "Central Asian Railways Restructuring, module D - Kyrgyzstan/Tajikistan / CIE-Consult & Systra".

3.1.2.3 IT system diagrams

3.1.2.3.1 Diagram of the main computer sites

(Diagram 3.1.2.3.1)

3.1.2.3.2 Detailed diagram of computer sites

(Diagram 3.1.2.3.2)

3.1.2.4 Electronic data interchange with administrative bodies (customs, police, etc.)

3.1.2.4.1 Status quo

A pre-printed form (train log) is filled in and sent to border offices. This log is the only document to change hands between the parties concerned.
Both countries use the same station to settle all formalities, including those required by the railways.

3.1.2.4.2 Projects

UIC's specialists could not obtain any information on projects.

3.1.2.5 Electronic data interchange with customers

3.1.2.5.1 Status quo

There are no IT links with customers.

3.1.2.5.2 Projects

UIC's specialists could not obtain any information on projects.

3.1.2.6 Electronic data interchange with port authorities and shipping companies

3.1.2.6.1 Status quo

Kyrgyzstan does not have access to the sea.
The Kyrgyzstan railway has no IT interchange with the port authorities in neighbouring countries.

3.1.2.6.2 Projects

Kyrgyzstan does not have access to the sea.

3.1.2.7 Electronic data interchange with other railway companies

3.1.2.7.1 Outline of the systems

Terminals at all interconnected stations can access:

- the ASSOUP FREIGHT management system
- the EXPRESS-2 management system for international passenger traffic (since June 97)

Processing is carried out at the computer centre in Tashkent (Uzbekistan) which is in turn hooked up, via Kazakhstan, to the MCC in Moscow.

The system is used predominantly for wagon management: accounting, owner identification, financial settlements and border crossings.
The system supplies the following information:

- Train numbers
- Train loads

- Goods transported
- Consignee
- Originating station
- Receiving station
- Train consist
- Train planning
- Demurrage charges

A rather limited wagon search function is also available.

Wagons which do not belong to a particular railway must be returned to their real owner as quickly as possible to avoid penalties. These wagons are often returned empty.

Terminals in the capital can also issue train tickets to passengers via the EXPRESS-2 system. Other stations can make reservations but can only issue a hand-written ticket.

There is no real electronic link between these neighbouring railways, however they do use the same ASSOUP system, which is centralised in Moscow and thus have access to information on trains circulating in their region.
The system appears to function satisfactorily.

Border stations are common to the two neighbouring countries, which facilitates border formalities, all the more so because the use of information technology means that data is generally available in advance and directly in electronic form.

3.1.2.7.2 Message format

Messages apparently conform to OSJD standards.
The consultants could not obtain further details on this point.

3.1.2.7.3 Projects

The consultants noted the desire to have a mainframe system to avoid dependency on Kazakhstan railways, since some irregularities had been discovered in the calculation of settlement balances for wagon traffic.

3.1.3 Uzbekistan

3.1.3.1 Introduction

Uzbek railways have one of the largest railway IT systems in the region. In USSR times, it was home to what was the computer centre for the entire region.

This centre is connected to the border stations, some marshalling yards and to Kazakhstan and Turkmenistan. Moreover, it is the host for all terminals in Tajikistan.
The system is mainly used to record wagons and containers among other things, for payments to the owners. It may also print international train tickets.

3.1.3.2 Overview of the IT system

The computer centre in Tashkent is equipped with IBM mainframes.

- Two Hitashi LX-60 (IBM S/370)
- Two IBM 4381

They appear to have been purchased second-hand.

The border stations and certain other stations (in general the marshalling yards) are fitted with PCs which are linked to the control centre via a 1200 baud modem.

The Tashkent mainframes are connected to those in Kazakhstan and Turkmenistan via a 2400 baud modem and using the BSC protocol.

The border stations are:
With Turkmenistan: Farab (on Turkmen territory)
With Kazakhstan: Tchengeldi (on Kazakhstan territory)
With Tajikistan: Bekabad, Saryasia, Amuzan
Kanibadam (on Tajik territory)
With Kyrgyzstan: Karasu, Kizil-Kygard, Tashkumyr (on Kyrgyzstan territory)
Khanabad

The other stations connected are:

- Khodjadable
- Navoi
- Buchara
- Marakand
- Djizak
- Karshi
- Talimarjan
- Termez
- Sariasiya
- Khavast
- Gulistan
- Yangier
- Tchinaz
- Bekaban
- Angren
- Uzbekistau
- Yangiyut
- Bozsy
- Kizil
- Sergeli
- Utchkurgan
- Namangan
- Kokand 1 & 2
- Altyarik
- Margelan

For more detail, refer to the project report on "Central Asian Railways Restructuring, module B - Uzbekistan/ CIE-Consult & Systra".

3.1.3.3 IT system diagrams

3.1.3.3.1 Diagram of the main computer sites.

(Diagram 3.1.3.3.1)

3.1.3.3.2 Detailed diagram of computer sites

(Diagram 3.1.3.3.2)

3.1.3.4 Electronic data interchange with administrative bodies (customs, police, etc.)

3.1.3.4.1 Status quo

A pre-printed form (train log) is filled in and sent to border offices. This log is the only document to change hands between the parties concerned.
Both countries use the same station to settle all formalities, including those required by the railways.

3.1.3.4.2 Projects

UIC's specialists could not obtain any information on projects.

3.1.3.5 Electronic data interchange with customers

3.1.3.5.1 Status quo

At present, there are no IT links with customers.

3.1.3.5.2 Projects

UIC's specialists could not obtain any information on projects.

3.1.3.6 Electronic data interchange with port authorities and shipping companies

3.1.3.6.1 Status quo

Uzbekistan does not have access to the sea.
The Uzbek railway has no IT links with port authorities in neighbouring countries.

3.1.3.6.2 Projects

Uzbekistan does not have access to the sea.

3.1.3.7 Electronic data interchange with other railway companies

3.1.3.7.1 Outline of the systems

Terminals at all interconnected stations can access:

- the ASSOUP FREIGHT management system
- the EXPRESS-2 management system for international passenger traffic

Processing is carried out at the computer centre in Tashkent which is in turn hooked up, via Kazakhstan, to the rest of the CIS system.

The system is used predominantly for wagon management: accounting, owner identification, financial settlements and border crossings.
The system supplies the following information:

- Train numbers
- Train loads
- Goods transported
- Consignee
- Originating station
- Receiving station
- Train consist
- Train planning
- Demurrage charges

A rather limited wagon search function is also available.
The Moscow centre keeps a record of which country the wagon is in and the nearest computer centre gives a more exact location if it can.

Wagons which do not belong to a particular railway must be returned to their owner as quickly as possible to avoid penalties. These wagons are often returned empty.

There is no real electronic link between these neighbouring railways, however they do use the same ASSOUP system, which is centralised in Moscow and thus have access to information on trains circulating in their region.

The system appears to function satisfactorily.

Border stations are common to the two neighbouring countries, which facilitates border formalities, all the more so because the use of information technology means that data is generally available in advance and directly in electronic form.

3.1.3.7.2 Message format

Apparently messages are in conformity with OSJD standards.
The consultants could not obtain further details on this point.

3.1.3.7.3 Projects

The railway would like all stations to be equipped with computer facilities and hooked up to Tashkent.

UIC' s specialists saw the disk demo of a software program which would optimise wagon management. The program, which runs under Windows, extracts data from ASSOUP and enters it in a database. It then offers a large number of search options which are not available in ASSOUP and which optimise the management of rail vehicles.
The aim is not to replace ASSOUP, but merely to install a more-user friendly interface.
The project is being directed by Mrs. Babajnova.

3.1.4 Tajikistan

3.1.4.1 Introduction

The IT manager at Tajikistan railways (TAD) was not available. The information contained in this report was supplied by the telecommunications manager.

The IT system at Tajikistan railways is fairly basic.
There is a small IT centre in Dushanbe.
This centre is linked to the border stations and to Taschkent (Uzbekistan).
The system is mainly used to record wagons and containers, among other things, for payment of their owners. It is also able to issue international train tickets.

3.1.4.2 Overview of the IT system

The railway has an IT centre in Duchambe, which has a LAN but no computer system as such, large or small.
This IT centre is linked by relay to Tashkent in Uzbekistan, which enables terminals at stations connected with the capital to access the mainframe at Tashkent.
The consultants could not find out the specifications of this relay.

Each border station is equipped with a PC which is hooked up to the capital via a 1200 baud modem.

The border stations with Uzbekistan are:
Kanibadam
Bekabad (Uzbek territory)
Saryasia (Uzbek territory)
Amuzan (Uzbek territory)

The railway has approximately 50 Pentium 486 PCs in total.

For more information, refer to the project report on "Central Asian Railways Restructuring, module D - Kyrgyzstan/Tajikistan/ CIE-Consult & Systra".

3.1.4.3 IT system diagram

(Diagram 3.1.4.3)

3.1.4.4 Electronic data interchange with administrative bodies (customs, police, etc.)

3.1.4.4.1 Status quo

A pre-printed form (log) is filled in and sent to border offices. This log is the only document to change hands between the parties concerned.
Both countries use the same station to settle all formalities, including those required by the railways.

3.1.4.4.2 Projects

UIC's specialists could not obtain any information on projects.

3.1.4.5 Electronic data interchange with customers

3.1.4.5.1 Status quo

All transactions use paper and/or telephone.
Requests for information are made by telephone.

3.1.4.5.2 Projects

UIC's specialists could not obtain any information on projects.

3.1.4.6 Electronic data interchange with port authorities and shipping companies

3.1.4.6.1 Status quo

Tajikistan does not have access to the sea.
Tajik railways have no IT links with port authorities in neighbouring countries.

3.1.4.6.2 Projects

Tajikistan does not have access to the sea.

3.1.4.7 Electronic data interchange with other railway companies

3.1.4.7.1 Outline of the systems

Terminals at all interconnected stations can access:

- the ASSOUP FREIGHT management system
- the EXPRESS-2 management system for international passenger traffic

Processing is carried out at the computer centre in Tashkent which is in turn hooked up, via Kazakhstan, to the MCC in Moscow.

The system is used predominantly for wagon management: accounting, owner identification, financial settlements and border crossings.
The system supplies the following information:

- Train numbers
- Train loads
- Goods transported
- Consignee
- Originating station
- Receiving station
- Train consist
- Train planning
- Demurrage charges

A rather limited wagon search function is also available.

The Moscow centre keeps a record of which country the wagon is in and the nearest computer centre gives a more exact location if it can.

Wagons which do not belong to a particular railway must be returned to their owner as quickly as possible to avoid penalties. These wagons are often returned empty.

There is no real IT link between these neighbouring railways, however they do use the same ASSOUP system, the centre of which is in Moscow and thus all have access to information on trains circulating in their region.
The system appears to function satisfactorily.

Border stations are common to the two neighbouring countries, which facilitates border formalities, all the more so because the use of information technology means that data is generally available in advance and directly in electronic form.

3.1.4.7.2 Message format

Apparently messages are in conformity with OSJD standards.
The consultants could not obtain further details on this point.

3.1.4.7.3 Projects

There appears to be a desire to hook all stations up to the IT centre in the capital.
Moreover, the consultants noted the wish to install a mainframe to avoid dependency on Uzbek railways, since some irregularities had been discovered in the calculation of settlement balances for wagon traffic.

3.1.5 Turkmenistan

3.1.5.1 Introduction

Major developments are taking place in the IT system of Turkmen railways. The computer centre used to be located in Chardzhev, near the Uzbek border. However at the time of writing this report, a new centre was due to be put into operation at headquarters. The Chardzhev facility is to be retained as a regional centre in order to ease the load at the main centre in Ashgabad.

The railway has a fairly well-equipped IT system : it has a mainframe and can thus carry out some of the processing locally.
Some of the stations are connected to this mainframe, and the main impediment to linking up all stations appears to be the lack of communication channels.

3.1.5.2 Overview of the IT system

The Chardzhev centre has an IBM 4831 mainframe.
The new centre at Ashgabad will be equipped with an IBM 9000 mainframe.

When the Ashgabad centre is in operation, the northern stations will continue to be serviced from Chardzhev and the rest will be hooked up to Ashgabad.

The border stations and certain other stations have PCs which are hooked up to the computer centre via a 1200 baud modem.

These border stations are:
With Iran: Seraks (a link is planned).
With Uzbekistan: Farap
Furthermore, there is a line in the the north of the country which is shared with Uzbekistan and comprises a number of border stations because the line crosses between the two countries at several points. These stations are perhaps computer-linked.

The other on-line stations are:
- Krasnovodsk
- Nebit-Dag
- Tazandjik
- Buzmenij
- Annay
- Dushak
- Turkmenbashi / Tedjen
- Mary
- Utchadji
- Zertcher
- Amyrdere
- Talimardjan
- Kelif
- Darganata
- Gazatchak
- Dashkhavuz
- Takhiatash

For more details, refer to the project report on "Central Asian Railways Restructuring, module C - Turkmenistan / CIE-Consult & Systra".

3.1.5.3 IT systems diagrams

3.1.5.3.1 Diagram of the main computer sites

(Diagram 3.1.5.3.1)

3.1.5.3.2 Detailed diagram of computer sites

(Diagram 3.1.5.3.2)

3.1.5.4 Electronic data interchange with administrative bodies (customs, police, etc.)

3.1.5.4.1 Status quo

A pre-printed form (log) is filled in and sent to border offices. This log is the only document to change hands between the parties concerned.
Both countries use the same station to settle all formalities, including those required by the railways.

3.1.5.4.2 Projects

UIC's experts could not obtain any information on projects.

3.1.5.5 Electronic data interchange with customers

3.1.5.5.1 Status quo

At present, there are no IT links with customers.

3.1.5.5.2 Projects

The consultants could not find any information on projects.

3.1.5.6 Electronic data interchange with port authorities and shipping companies

3.1.5.6.1 Status quo

Turkmenbashi port is connected via the neighbouring station at Katrasnovodsk.
There is no IT link with the railway.

3.1.5.6.2 Projects

The consultants could not obtain any information on projects.

3.1.5.7 Electronic data interchange with other railway companies

3.1.5.7.1 Outline of the systems

Terminals at all interconnected stations can access:

- the ASSOUP FREIGHT management system

Processing is carried out in the Chardzhev centre which is in turn linked, via Tashkent, to the rest of the CIS system.

The system is used predominantly for wagon management: accounting, owner identification, financial settlements and border crossings.
The system supplies the following information:

- Train numbers
- Train loads
- Goods carried
- Consignee
- Originating station
- Receiving station
- Train consist
- Train planning
- Demurrage charges

A rather limited wagon search function is also available.
Locating a wagon in Kazakhstan takes about half an hour.
The Moscow centre keeps a record of which country the wagon is in and the nearest computer centre gives a more exact location if it can.

Wagons which do not belong to a particular railway must be returned to their owner as quickly as possible to avoid penalties. These wagons are often returned empty.

There is no real electronic link between these neighbouring railways, however they do use the same ASSOUP system, which is centralised in Moscow and thus all have access to information on trains circulating in their region.
The system appears to function satisfactorily.

Border stations are common to the two neighbouring countries, which facilitates border formalities, all the more so because the use of information technology means that data is generally available in advance and directly in electronic form.

3.1.5.7.2 Message format

Apparently messages are in conformity with OSJD standards.
The consultants could not obtain further details on this point.

3.1.5.7.3 Projects

UIC' s specialists were informed of plans to increase the number of stations linked to the computer centres.
Further, the centres are dissatisfied with the architecture in the region and intend to set up a direct link with Moscow rather than via Uzbekistan and Kazakhstan.
There are also plans to install the Express-2 system for international passenger traffic.

3.2 Survey of existing studies

3.2.1 Central Asian railways restructuring - Module A - Kazakhstan - Draft Final Report - December 97

Kazakhstan Railways (KTZ) is equipped with an IT system dating from the 1970s, installed in accordance with former USSR specifications.

There are two major applications :
- Assoup, for freight
- Express 2 for passengers

Both applications have been developed and are managed by the Moscow-based MPS (main railways computer centre).

The mainframes are :
- IBM 4381
- Hitachi 33

with approximately 4,500 terminals connected.
There are roughly 500 PCs, 80% of which are on-line and hooked up to the mainframes.

The mainframes are connected to those in Moscow.

Quite an ambitious project to install the financial management software SAP R3 has been under way since April 1997, with completion scheduled for the end of 1999, by which time 1,500 computers will be connected. Indications are that the project is being funded internally by KTZ.

The recommendations set out in the report are as follows:
Top priority:
- Install R3

2nd priority:
- Maintenance management application (Infrastructure & rolling stock)
- Marketing management application
- Train circulation

3rd priority: (not included in the investment plan)
- Freight information system (replacing Assoup)
- Passenger information system (replacing Express-2), perhaps Express-3.

The budget estimate is US$ 15 million, excluding SAP R3 requirements which are already being met by KTZ.

It is not planned to replace Assoup or Express-2 for at least five years, by which time the equipment on which both applications run will be out of service.

3.2.2 Central Asian railways restructuring - Module B - Uzbekistan - Draft Final Report - February 98

Uzbekistan Railways (UTY) is equipped with an IT system dating from the 1970s, installed in accordance with former USSR specifications.

The Tashkent computer centre was Central Asia's main control centre in the days of the USSR.

There are two major applications :
- Assoup, for freight
- Express 2 for passengers

Both applications have been developed and are managed by the Moscow-based MPS.

The mainframes are :
- IBM 4381
- Hitachi LX-50

Some 100 terminals have access to the passenger application.

The mainframes are connected to those in Moscow.

The report makes the following recommendations:
Urgent priority:
- Finance and accounting management system
- Personnel management system

2nd priority (quite urgent):
- Maintenance management application (Infrastructure & rolling stock)
- Marketing management application
- Train circulation

3ème priority : (not included in the investment plan)
- Freight information system (replacing Assoup)
- Passenger information system (replacing Express-2), perhaps Express-3.

The budget requirement is estimated to be US$ 16 million.

It is not planned to replace Assoup or Express-2 for at least five years, by which time the equipment on which both applications run will be out of service.

3.2.3 Central Asian railways restructuring - Module C - Turkmenistan - Draft Final Report - January 98

Turkmenistan Railways (TDY) is equipped with an IT system dating from the 1970s, installed in accordance with former USSR specifications.

The computer centre is located in Chardjew but is due to be transferred to the capital, Ashgabad.

There are two major applications :

- Assoup, for freight trains
- Diskor for freight wagons

Assoup has been developed and is managed by the Moscow-based MPS.

The mainframe situated at Chardjew is an IBM 4381, which is hooked up to Tashkent, in Uzbekistan.

There are also some PCs.

The report places great emphasis on the new computer centre in Ashgabad and advocates installing a financial management application.

The existing freight applications should be retained. It would seem that there are plans afoot to install Express-2, the passenger traffic management application already in use in other Traceca countries.

The budget requirement is estimated to be US$ 9.7 million.

3.2.4 Central Asian railways restructuring - Module D - Part 1 - Kyrgyzstan - Draft Final Report - June 98

Kyrgyzstan Railways (KZD) is equipped with an IT system dating from the 1970s, installed in accordance with former USSR specifications. It has since been developed independently.

There are two major applications :
- Assoup, for freight
- Express 2 for passengers

Both applications have been developed and are managed by the Moscow-based MPS.

During the Soviet era, the KZD IT terminals were hooked up to the Almaty-based RCC (Regional Computer Centre) mainframe belonging to Kazakhstan Railways (KTZ). This has remained the status quo since independence.

In order to achieve independence from KTZ, a plan to kit out the railway with on-line PCs (currently about 140) has been implemented (present status: 60%). Ancillary aims include supplementing the ASSOUP system and replacing Express-2 with the national system LUCH. Unfortunately, LUCH has not been approved to interface with Express-2 and is thus limited to nationwide use. Express-2 is not available at Bishkek-1 station.

An old IBM mainframe (circa twenty years) is still in use, albeit for calculating the payroll only.

KZD plans to continue putting their PCs on line and also intends to buy an IBM 9300 mainframe, thereby acquiring RCC status and use of ASSOUP and Express-2 functions.
This type of computer is thought to cost US$ 600K to US$ 700K second-hand.

The report recommends:
- creating an IT steering committee
- installing accounting software
- installing human resources software
- training
- extending IT networks to all stations
- setting up a telecommunications network (➔ Module E)

The budget requirement is estimated to be US$ 200K.

3.2.5 Trade Facilitation, Customs Procedures & Freight Forwarding Project - Completion Report - March 1997. (Scott Wilson Kirkpatrick)

See Chapter 1

3.2.6 Trade Facilitation, Customs Procedures & Freight Forwarding Project - Computer Systems Report - November 1996. (Scott Wilson Kirkpatrick)

This report is part of the customs and trade system study referred to in § 3.2.3 (summary of final report).

On the whole, IT applications are rarely employed by customs authorities and use tends to be limited to statistics purposes.
Freight forwarders equipped with computers generally use them for input, although data is not subsequently transmitted electronically.

The main recommendation is to install the UNCTAD Asycuda system (National Data Trade System), already used in over 70 countries. These national systems would be interconnected at a later stage.

The report's references to the Caucasian countries are summarised in Chapter 1.

3.2.6.1 Kazakhstan

3.2.6.1.1 Customs

The existing system was supplied by Russia and is based on Clipper.
The railway owns 170 PCs in all, distributed amongst the head offices and border stations. Communication is via disk.

A rather ambitious upgrading project has been put forward in-house, covering installation of communications links between the head offices and border stations. The project will be implemented in liaison with Russia and the budget requirement is estimated to be US$ 16 million.

Indications are that US$ 10.5 million will be needed to set up Asycuda over a 54-month period.

3.2.6.1.2 Other parties

IT coverage is relatively good, with one company (Business Inform) even specialised in direct data input of goods declarations at customs.

3.2.6.2 Kyrgyzstan

3.2.6.2.1 Customs

The existing software was developed by an independent company (Mitra) and is based on Clipper.
It is installed on a few PCs which exchange disks with the statistics centre at headquarters.

This system should be upgraded by Mitra to make it real-time, by adding on radio modems to some computers.

A project to install the French customs system SOFIX has been prepared but is awaiting funding.

The cost of installing Asycuda is estimated to be US$ 8.5 million, with a 42-month timeframe for set-up.

3.2.6.2.2 Other parties

Little use is made of IT technology, although there is a demand for "Direct Trader Input" (DTI) if it becomes available via Sofix.

3.2.6.3 Tajikistan

3.2.6.3.1 Customs

The current system was developed by the railway itself on the basis of FexPro.
The customs authorities are equipped with circa 20 computers.
Communication is via disk, modem and, most commonly, radio-modem.

It is estimated that US$ 4 million will be required to install Asycuda over a 30-month period.

3.2.6.3.2 Other parties

Little use is made of IT technology, even though these parties are computerised to a certain extent.

3.2.6.4 Turkmenistan

3.2.6.4.1 Customs

The existing system was developed by the customs authorities on the basis of Clipper and FoxPro.
The PC count is roughly 70, only half of which are used.
Communication is via modem or disk.

A project to install SOFIX has not been completed owing to a lack of funding.
Another upgrading project, implemented locally, has also been abandoned for the same reason.

The budget requirement for installing Asycuda is estimated to be US$ 5 million, with set-up likely to take 36 months.

3.2.6.4.2 Other parties

Little use is made of IT technology and, in particular, carriage documents drawn up by the Turkmen Shipping Company are hand-written.

3.2.6.5 Uzbekistan

3.2.6.5.1 Customs

The system was developed in-house on the basis of Clipper.
All 14 regional sections are computerised and connected to the railway headquarters via a modem. Some customs computers are also hooked up.

A number of projects have been put forward:

- Installion of an X25 network to interconnect the regional head offices and headquarters (US$ 7 million).
- Switch from DOS/Clipper tors Unix/Oracle
- Control and tracking of goods on board.

The cost of installing Asycuda is estimated to be US$ 9 million, with an estimated 42-month timeframe for set-up.

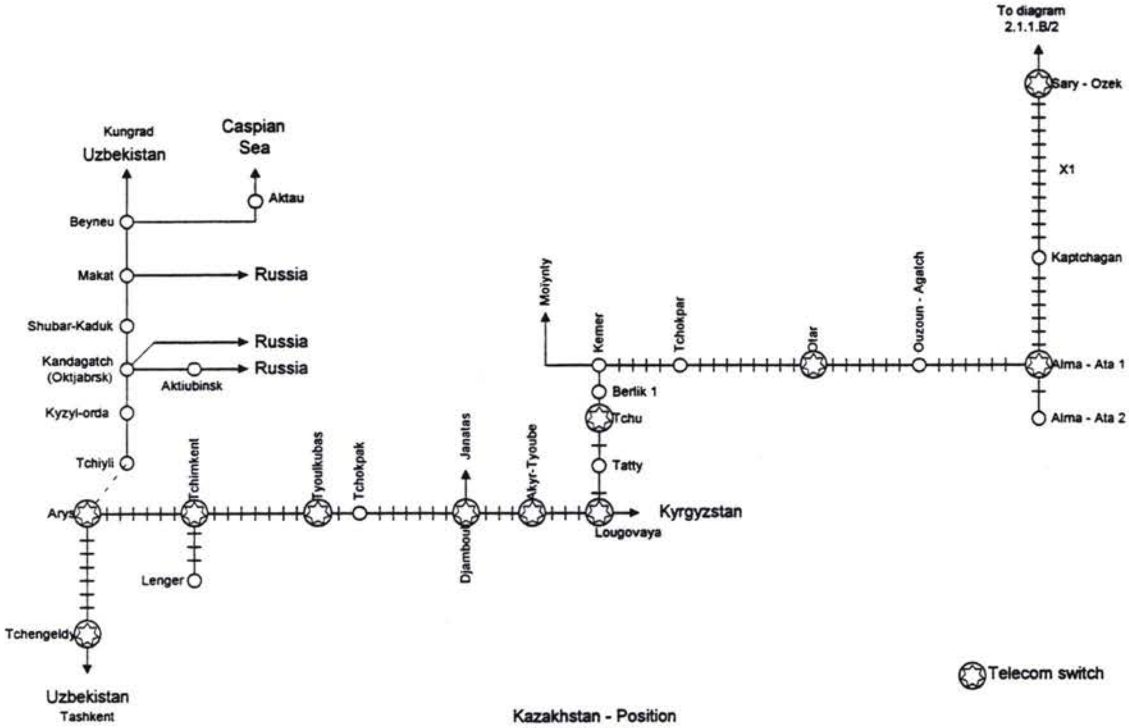
3.2.6.5.2 Other parties

Computerisation seems to be rare.

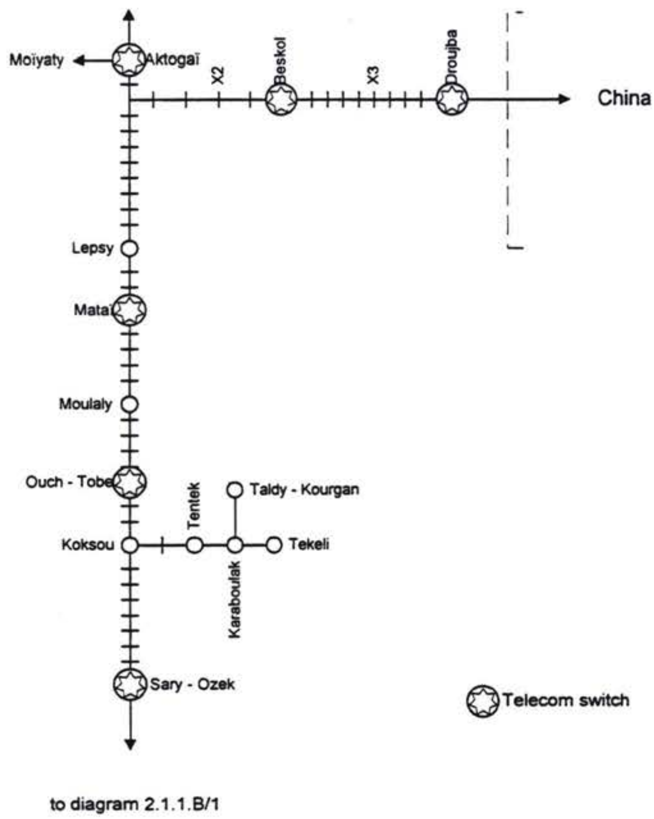
Chapter 2

Central Asia - Inventory
Appendix 1 - Telecommunications

Appendix 1 - Telecommunications

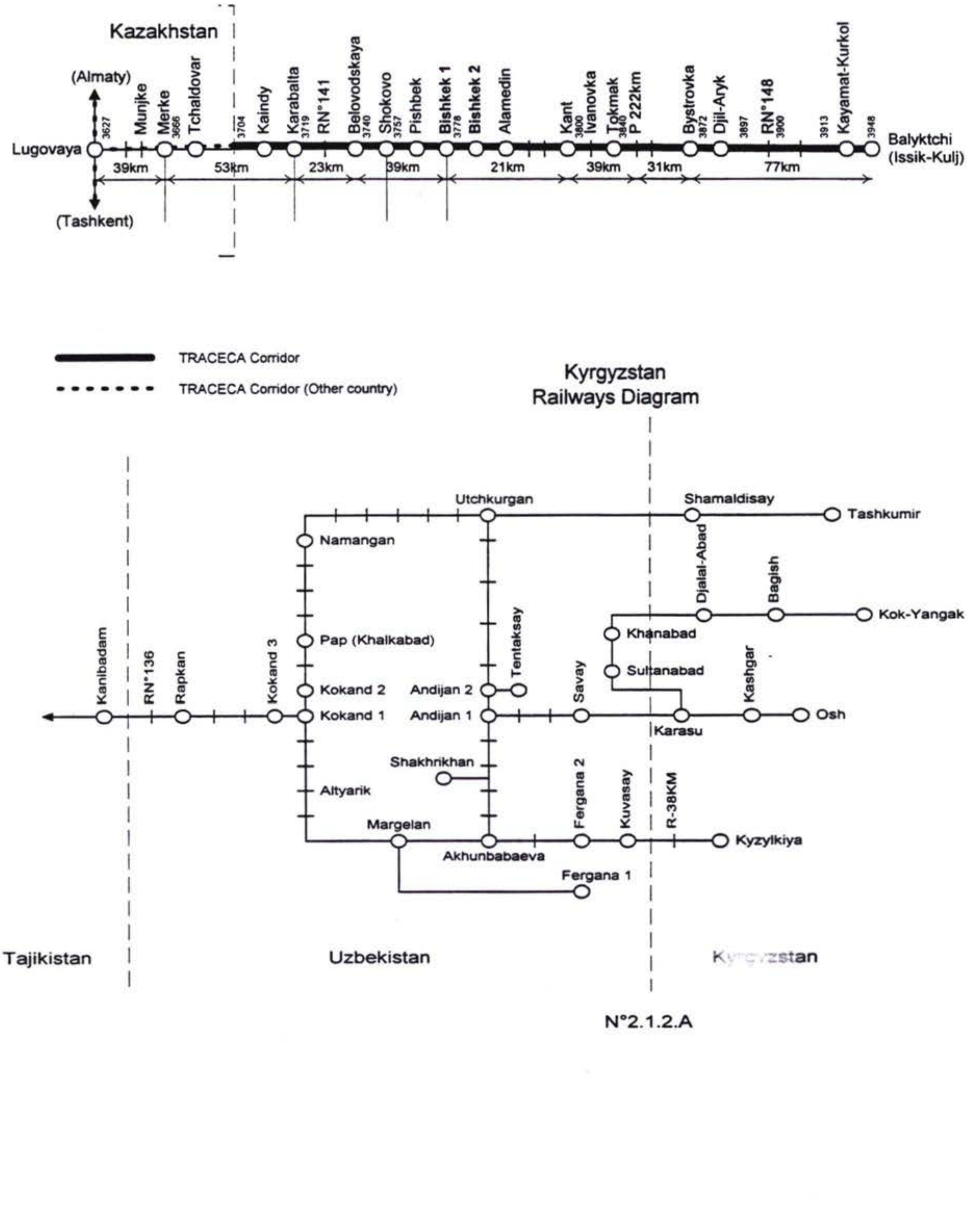


Kazakhstan - Position of telecom switches
2.1.1.B/1



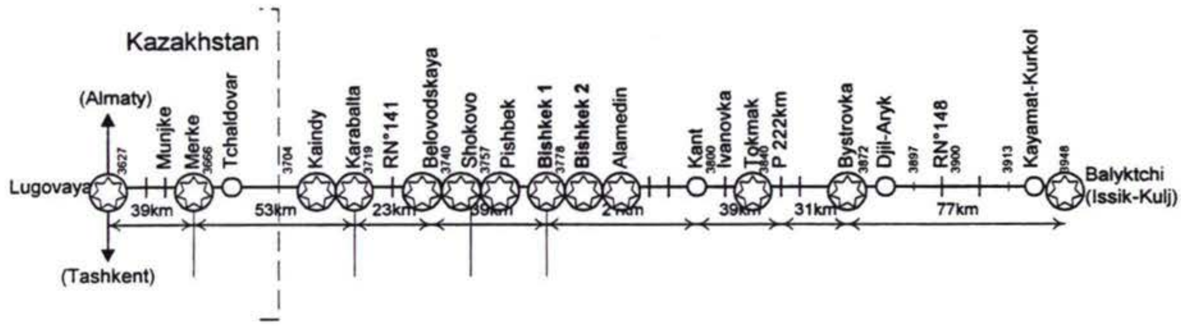
Kazakhstan - Position of telecom switches
2.1.1.B/2

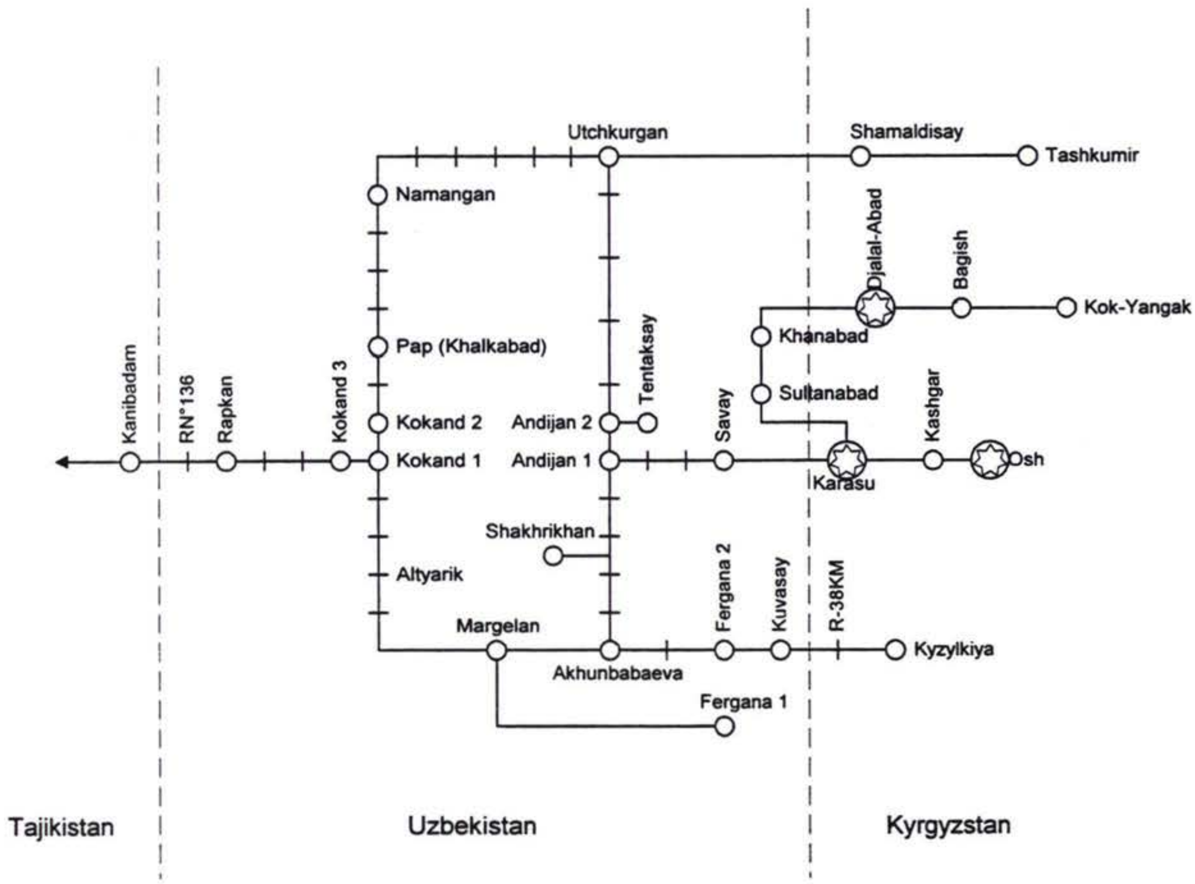
Appendix 1 - Telecommunications



N°2.1.2.A

Appendix 1 - Telecommunications

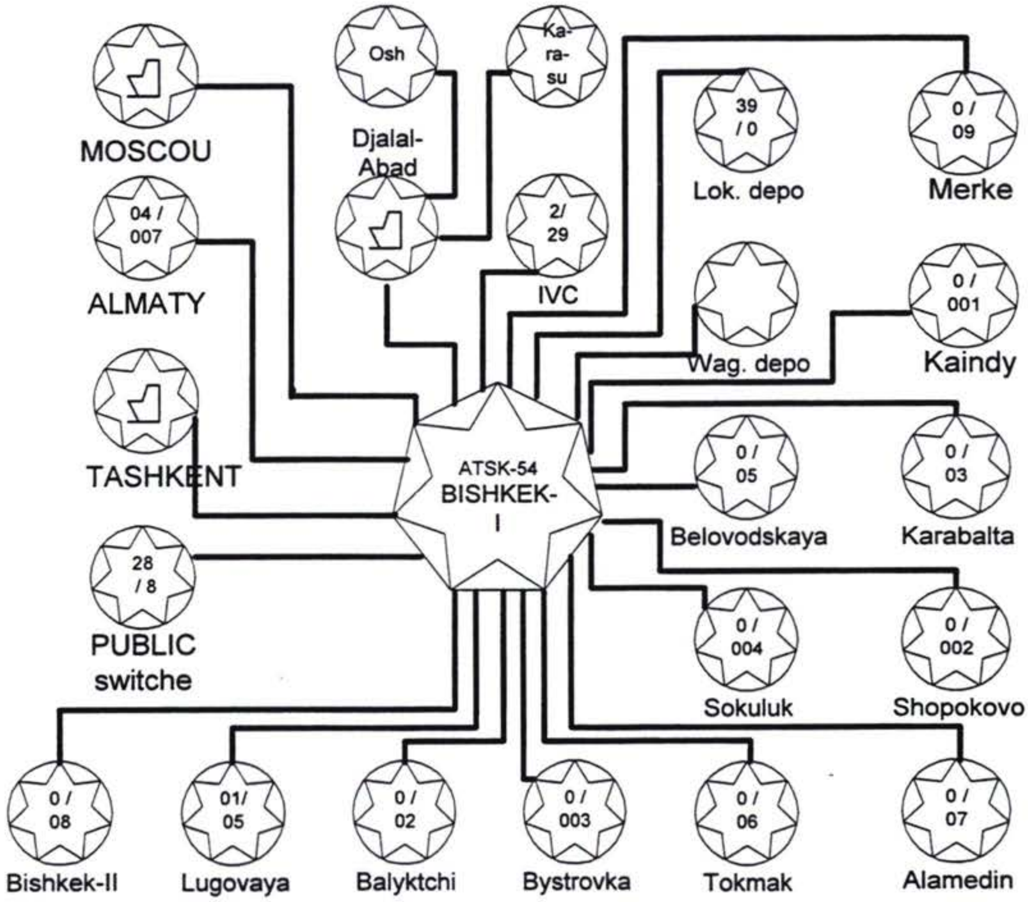




Telecom switch

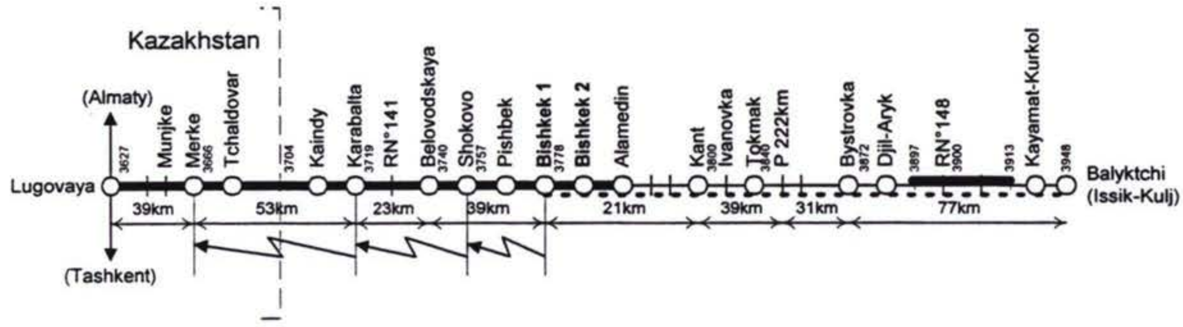
Kyrgyzstan
Position of telecom switches
N°2.1.2.B

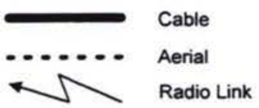
Appendix 1 - Telecommunications



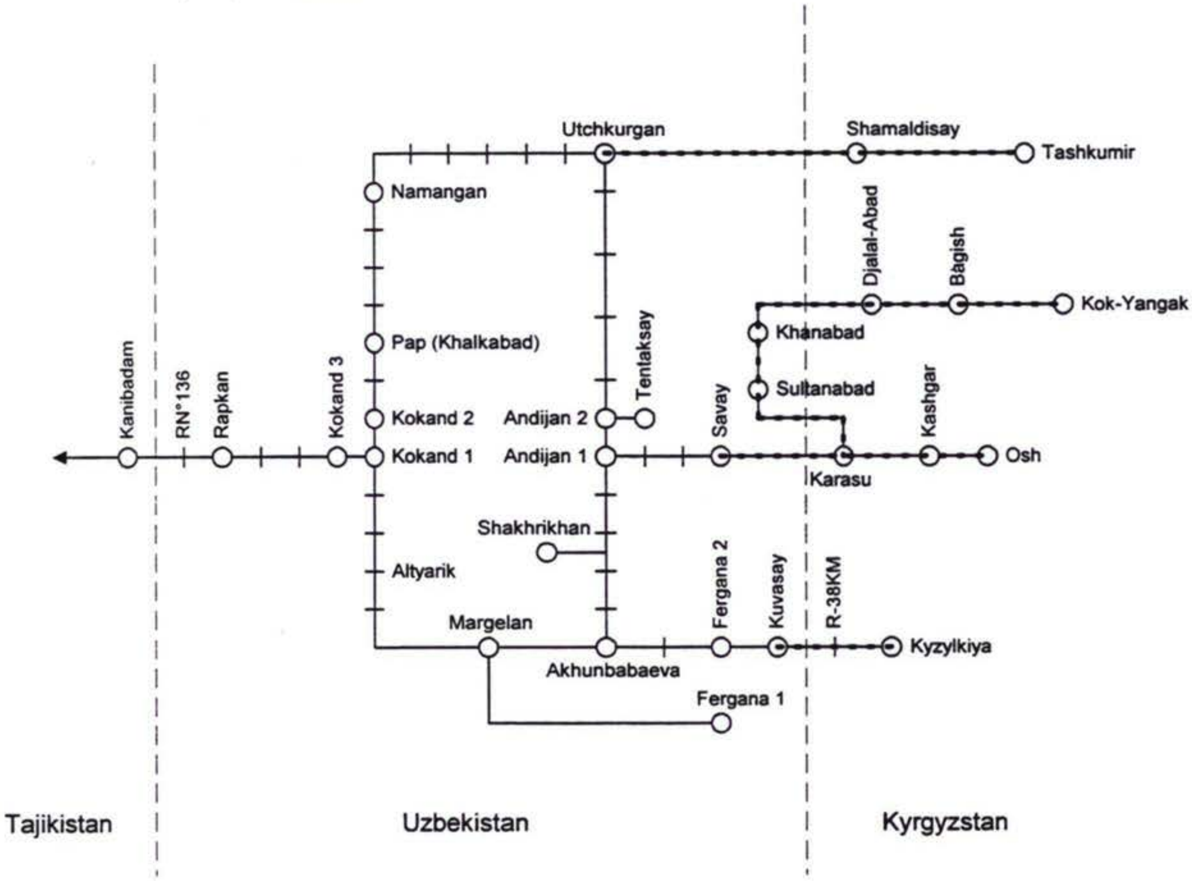
Kyrgyzstan
N°2.1.2.C

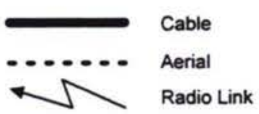
Appendix 1 - Telecommunications





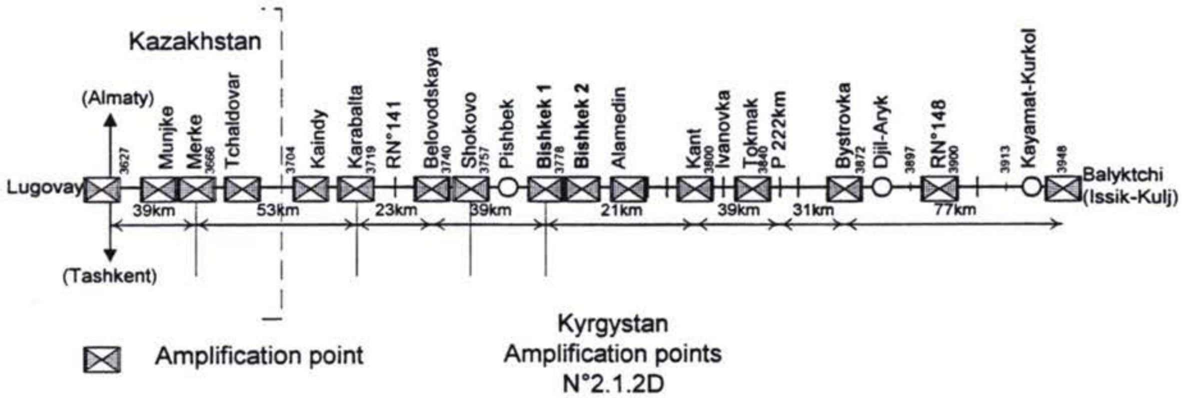
Kyrgyzstan
Cabling Diagram

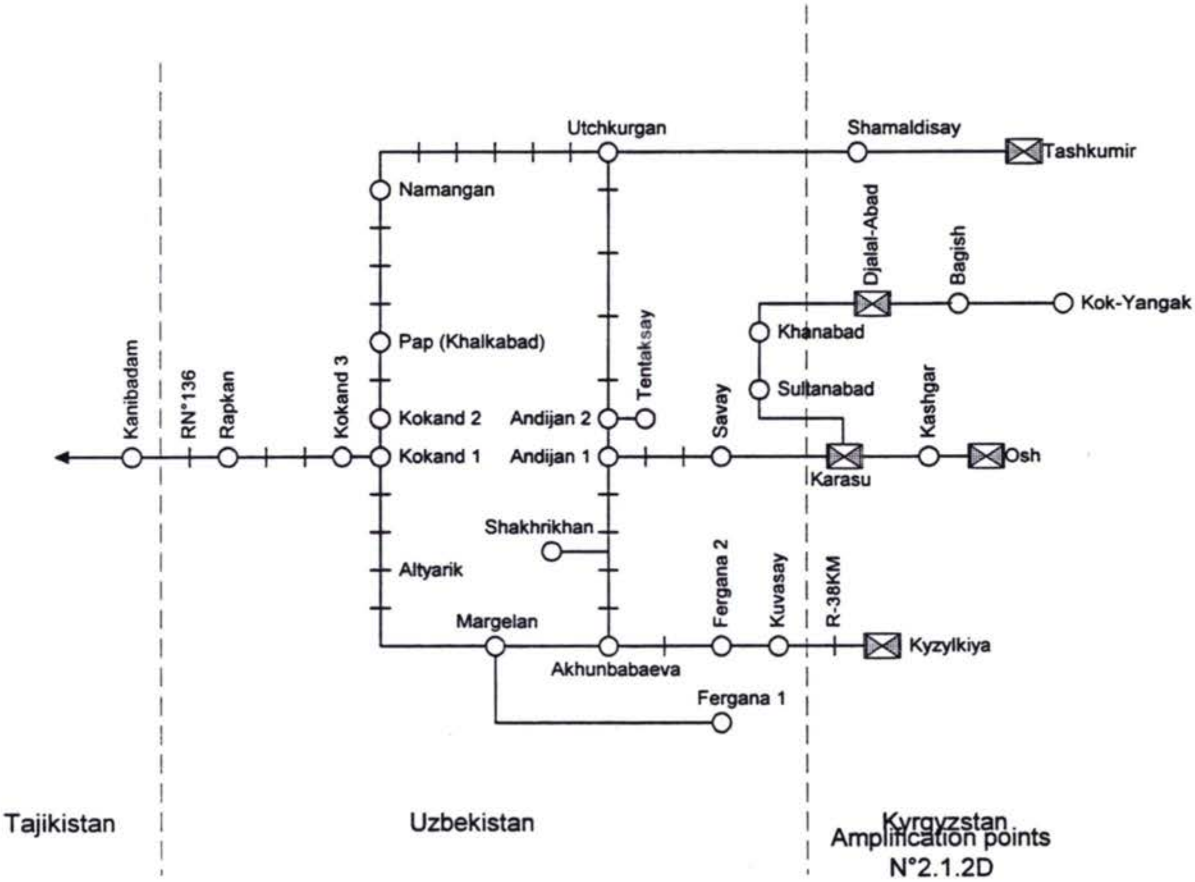




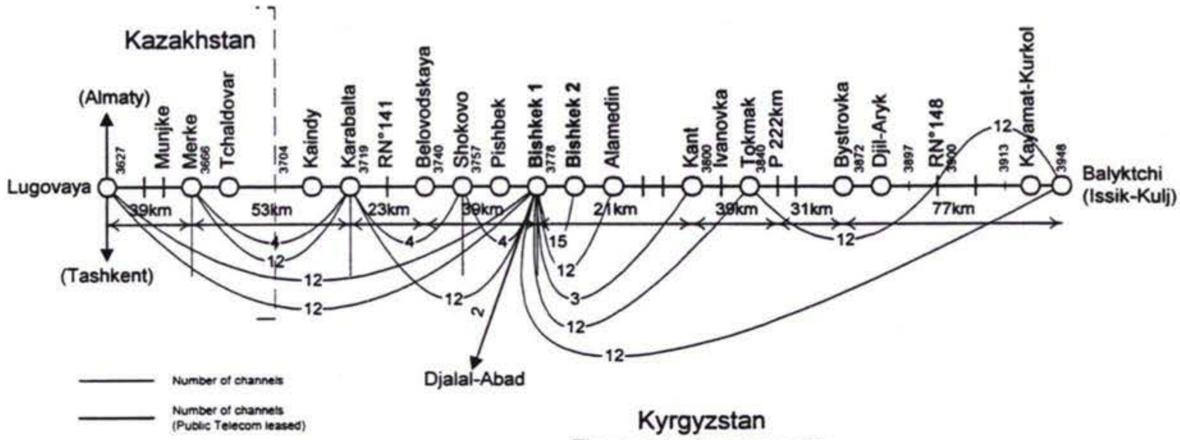
Kyrgyzstan
Cabling Diagram
N°2.1.2.C

Appendix 1 - Telecommunications

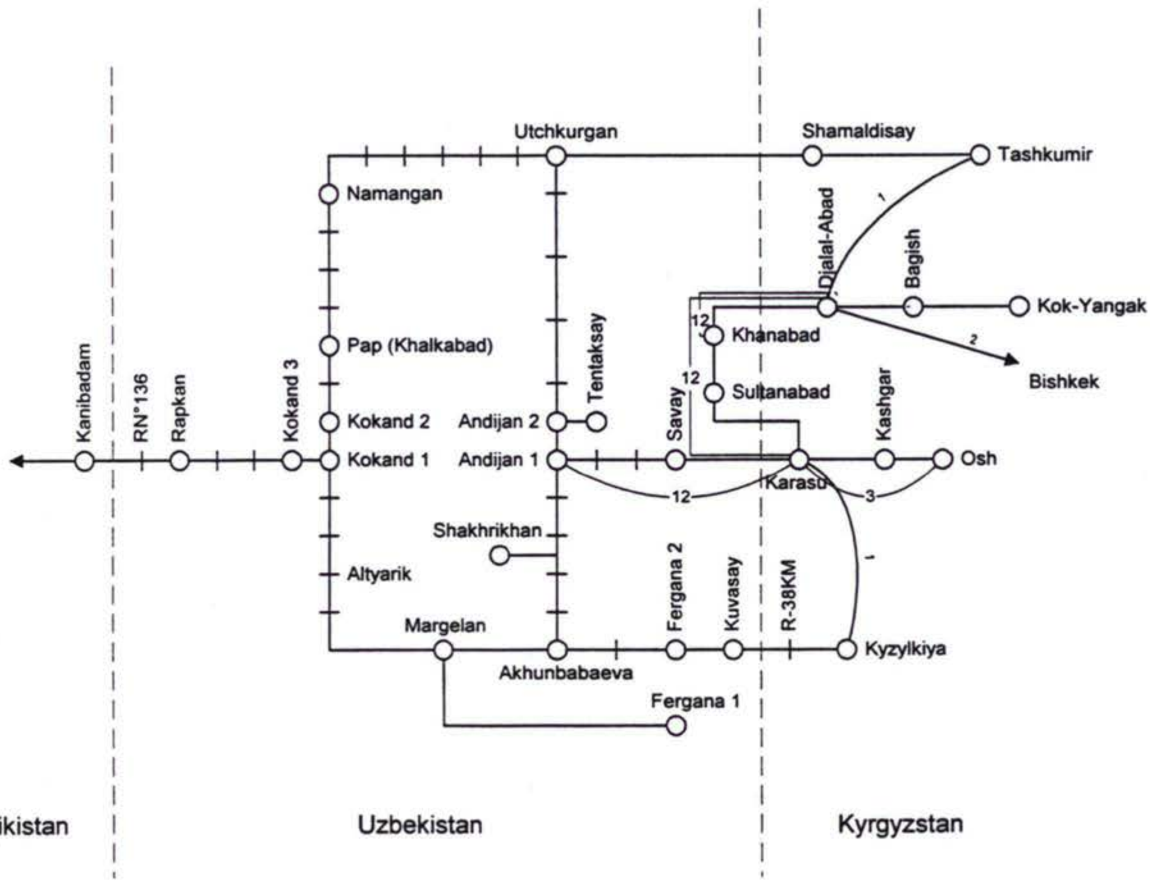




Appendix 1 - Telecommunications



Kyrgyzstan
Transmission capacity

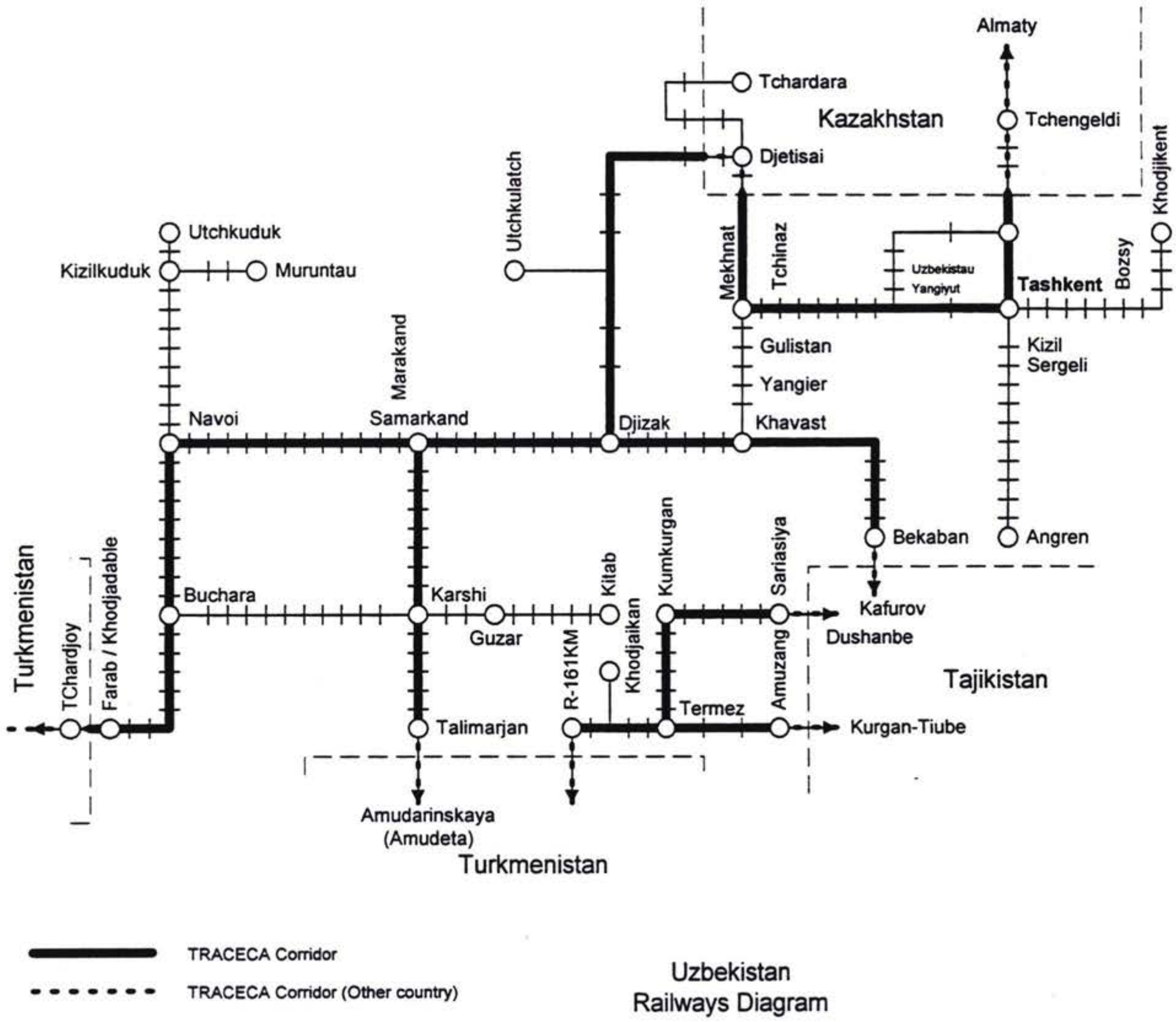


Number of channels

Number of channels (Public Telecom leased)

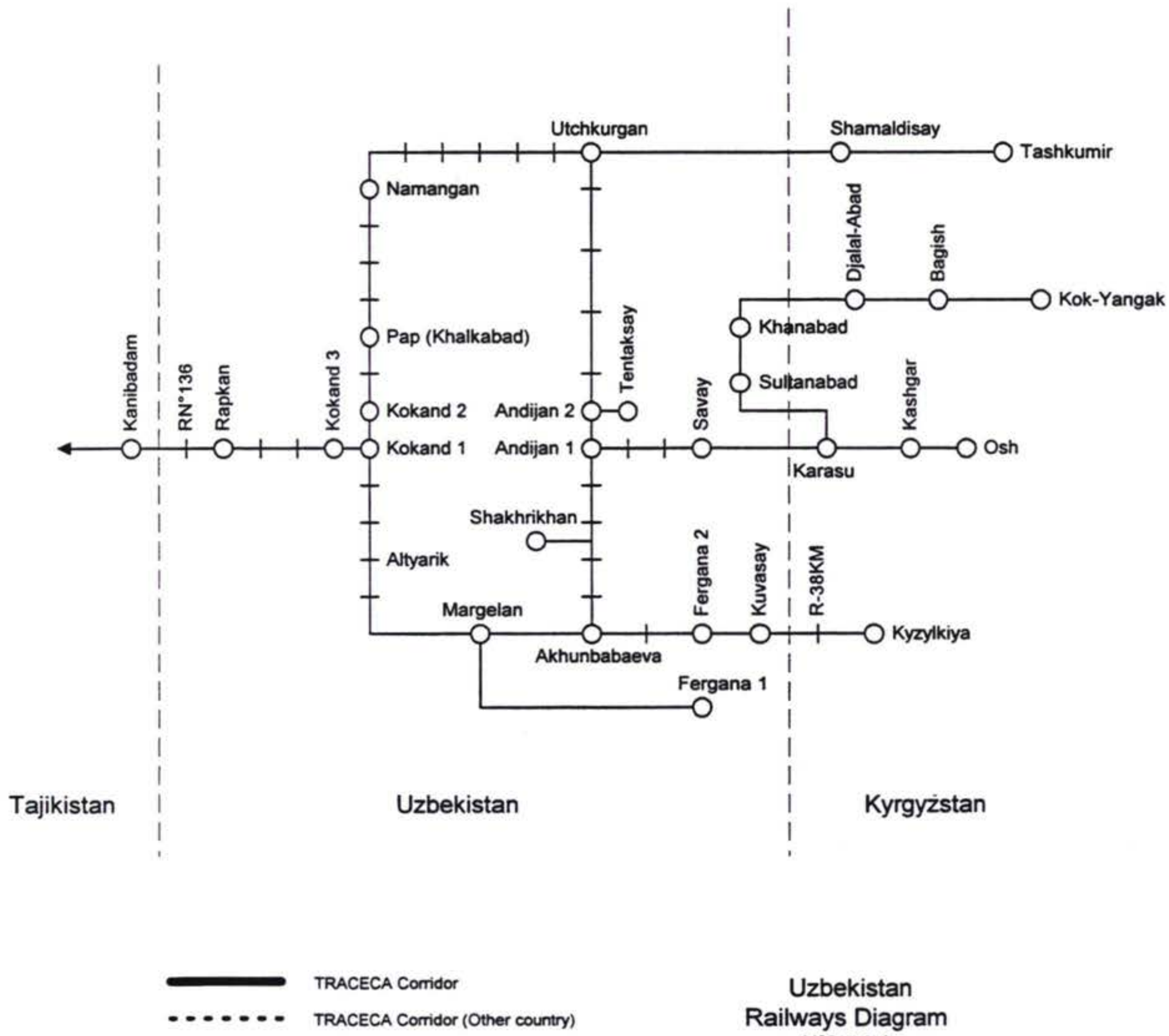
Kyrgyzstan
Transmission capacity
N°2.1.2.E

Appendix 1 - Telecommunications



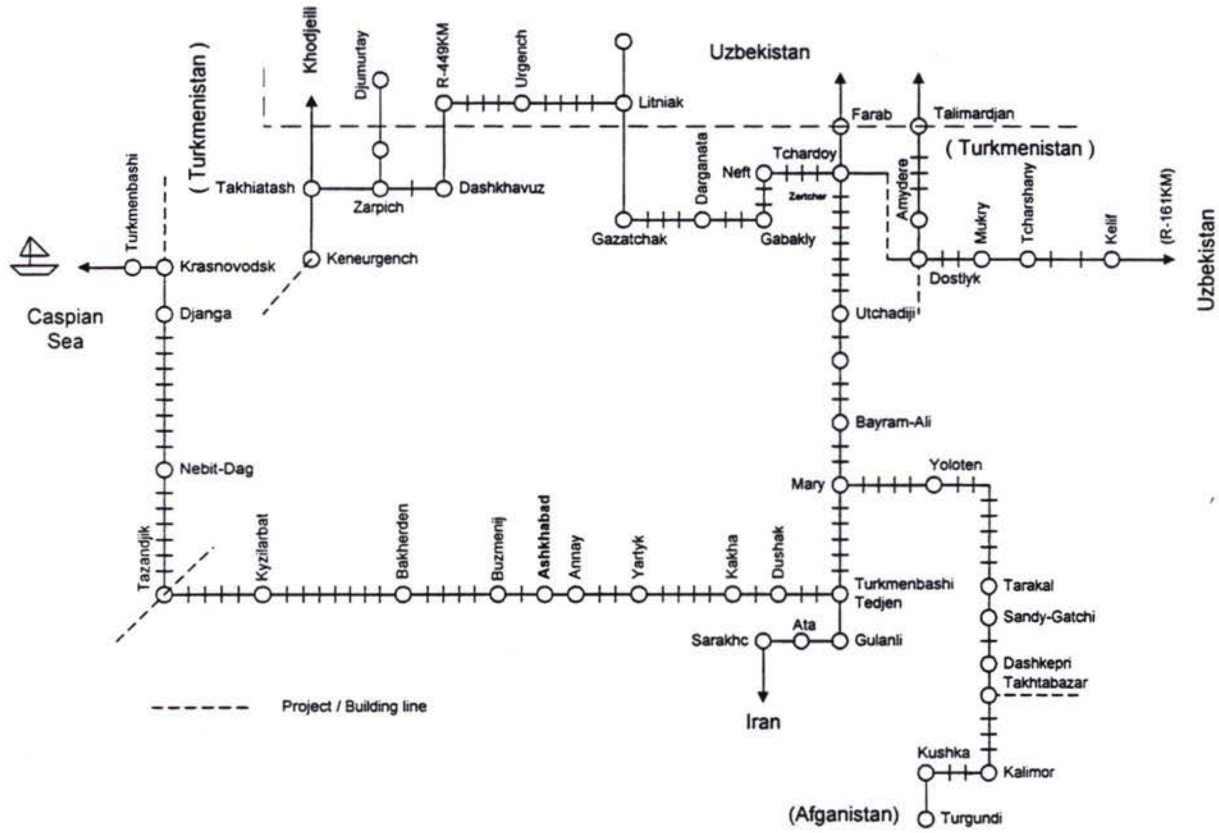
Uzbekistan
Railways Diagram

Appendix 1 - Telecommunications

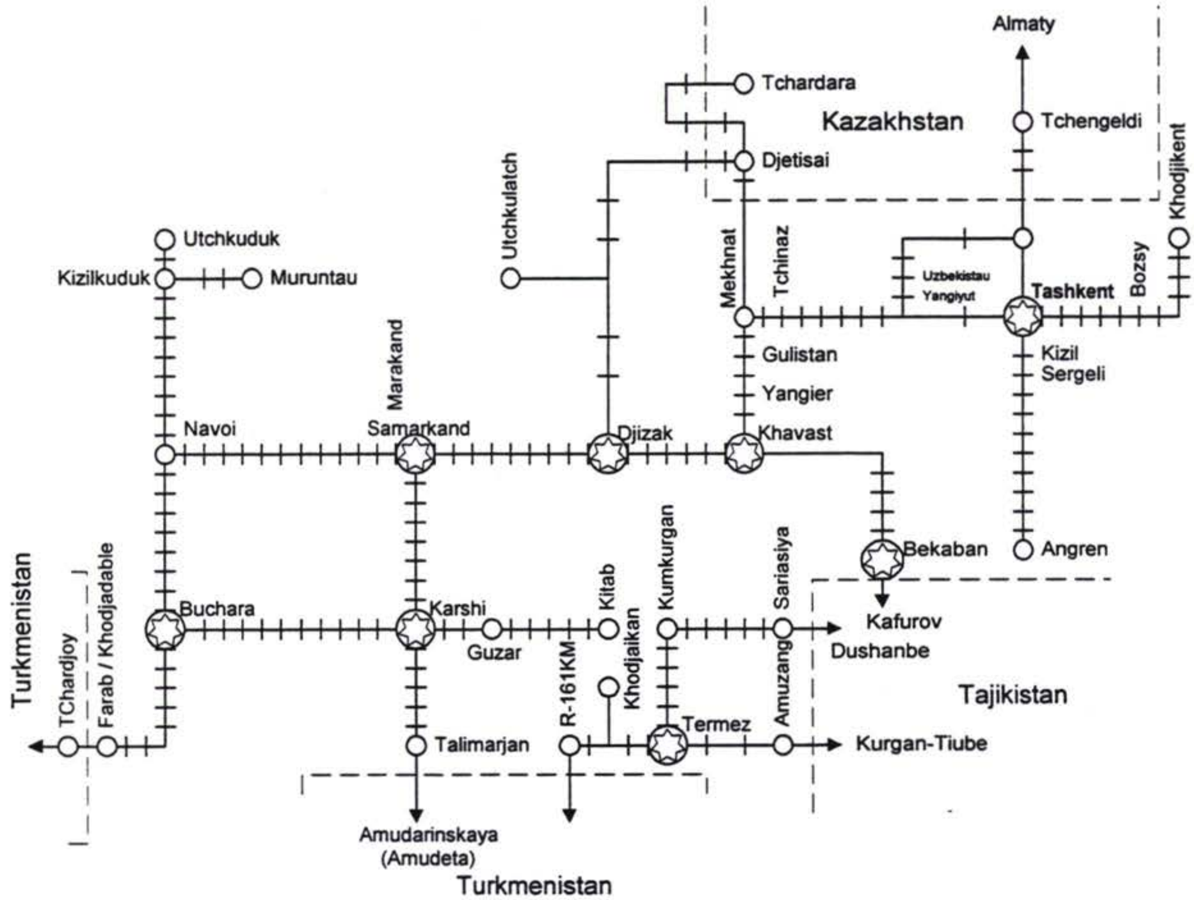


Uzbekistan
Railways Diagram
N°2.1.3.A

Appendix 1 - Telecommunications



Appendix 1 - Telecommunications



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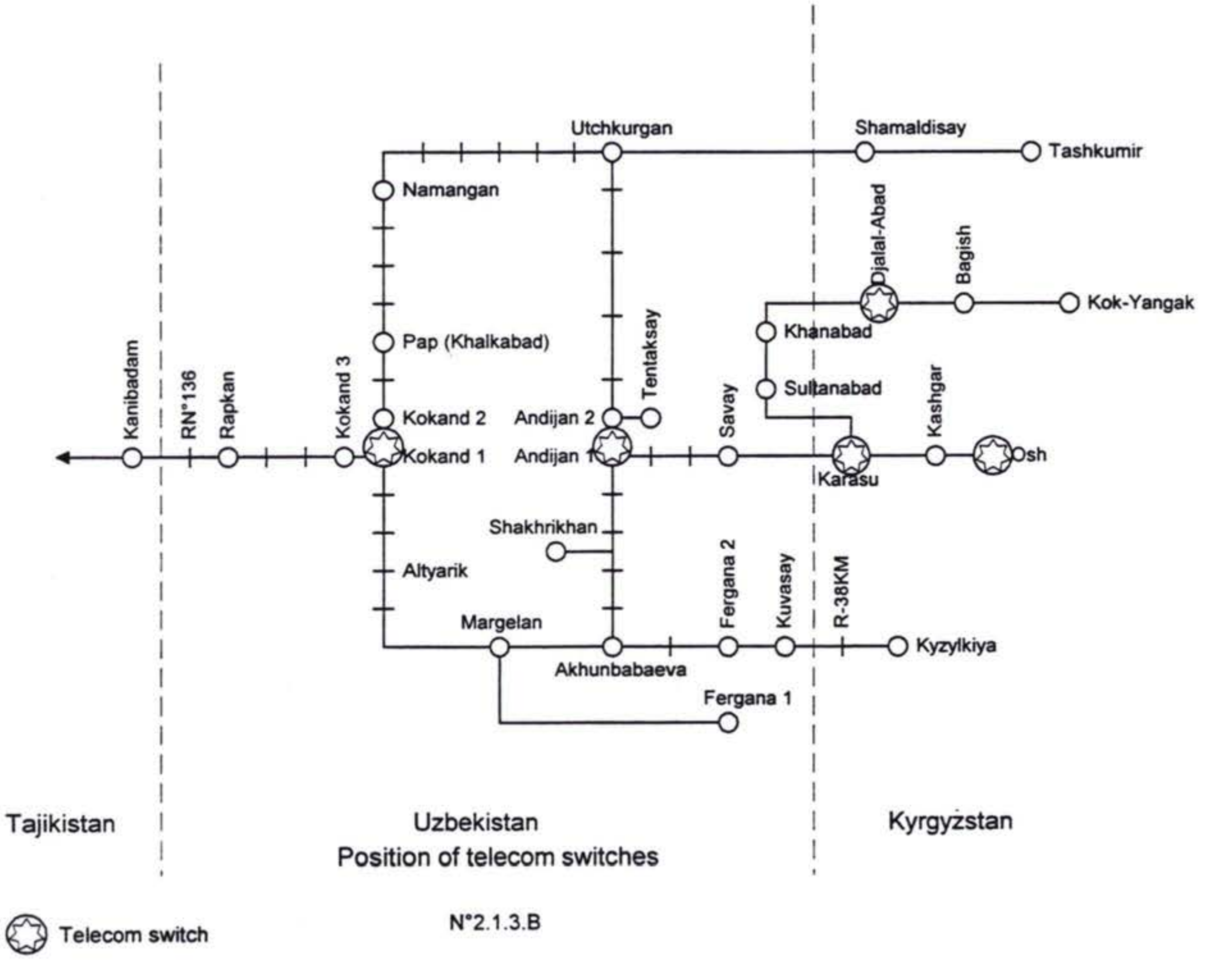
Appendix 1 - Telecommunications

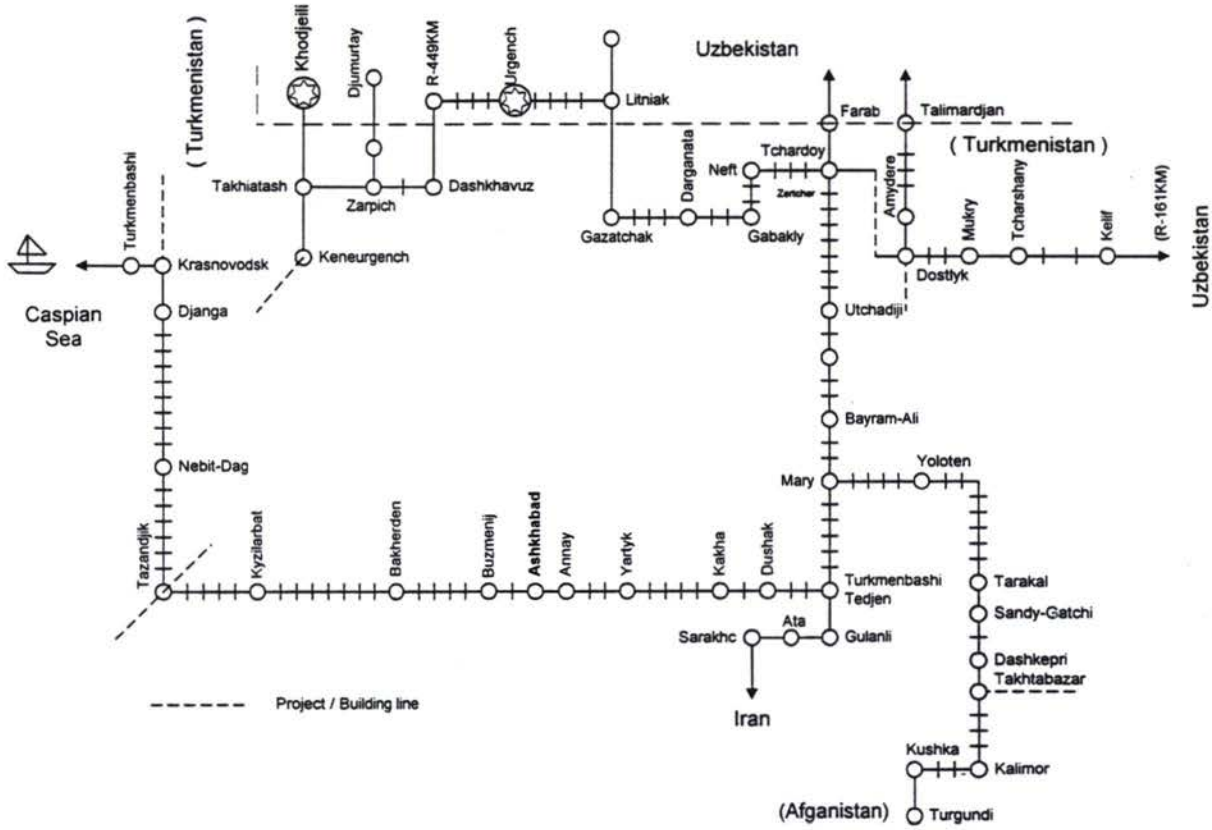


Position of telecom switches

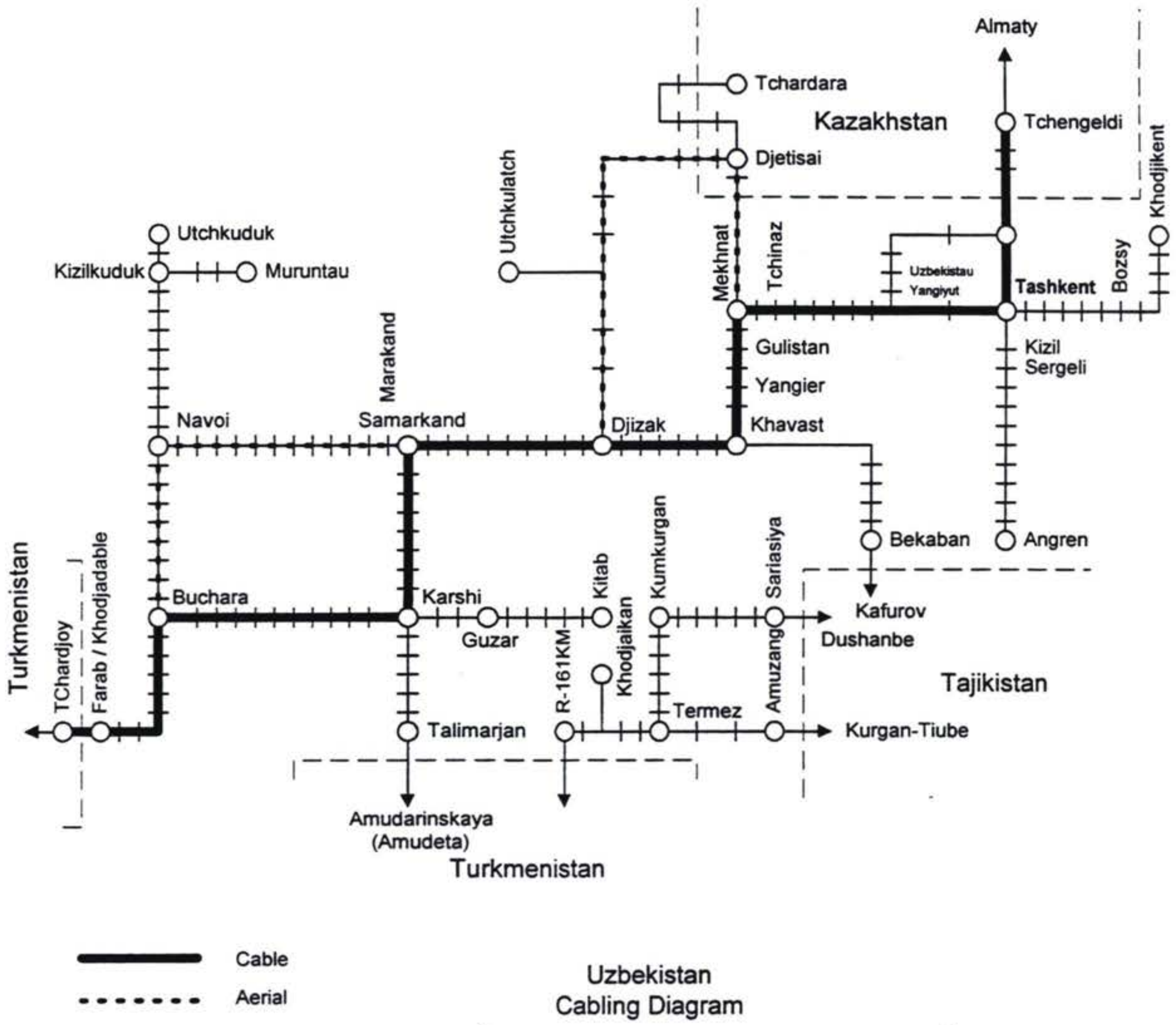
N°2.1.3.B

↕ ↕ ↕

Appendix 1 - Telecommunications

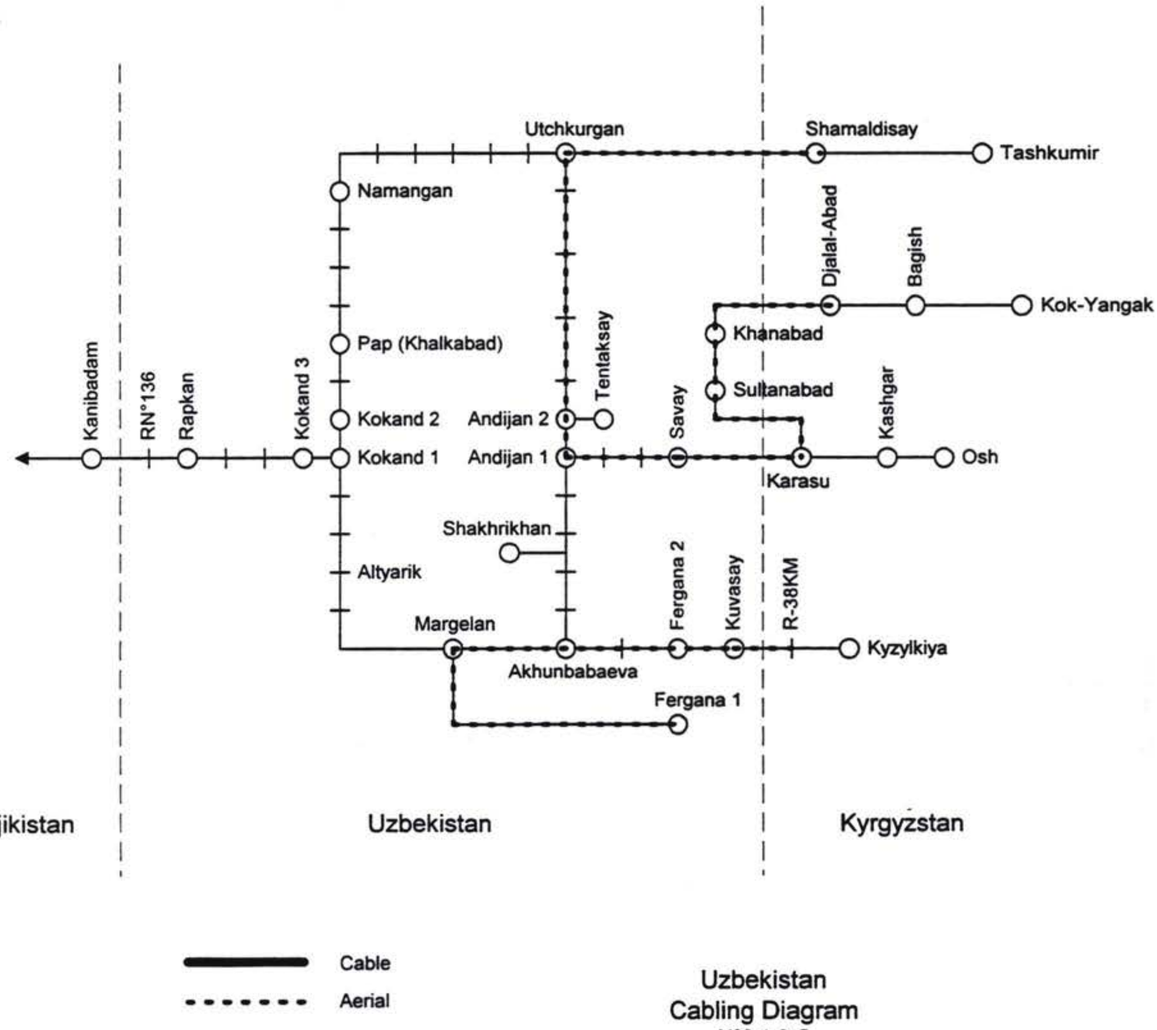


Appendix 1 - Telecommunications



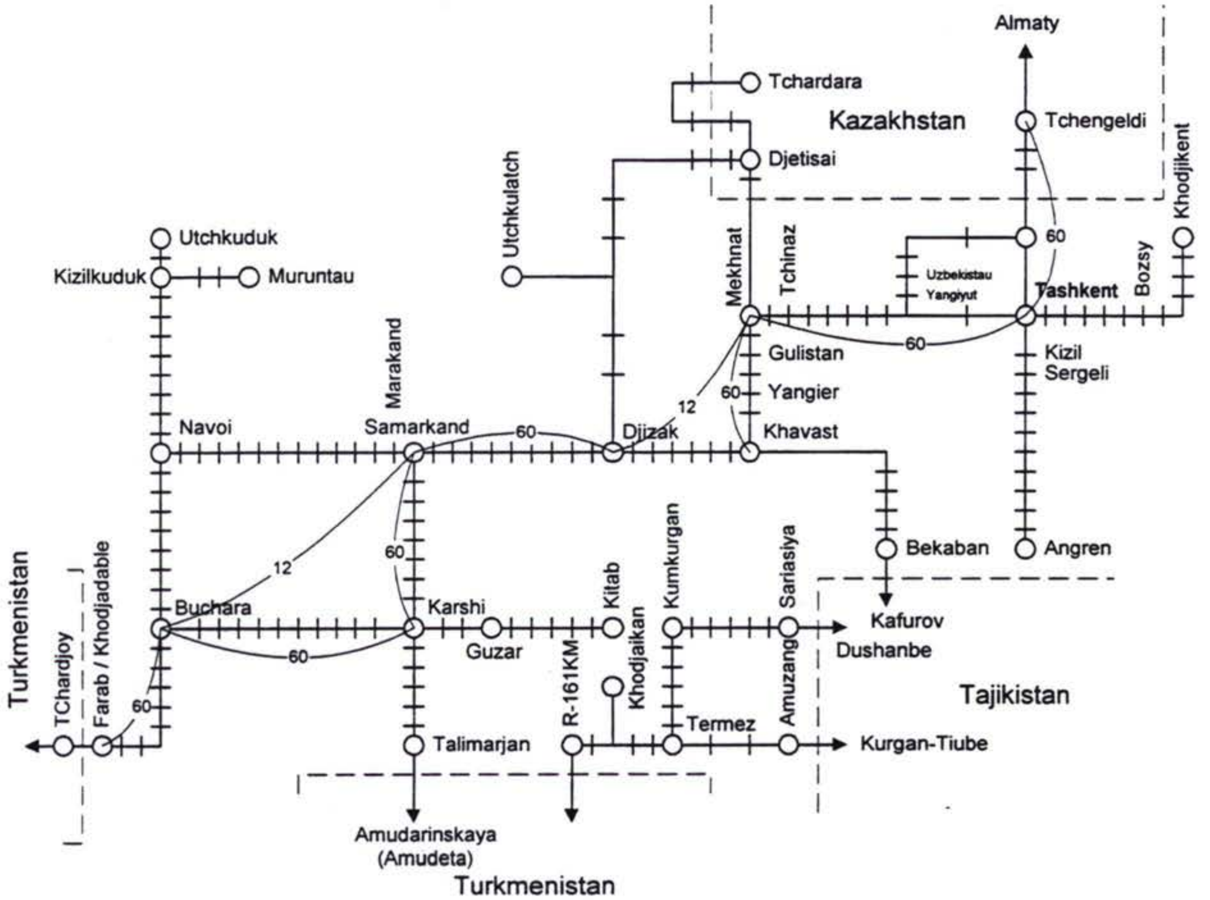
Uzbekistan
Cabling Diagram

Appendix 1 - Telecommunications



Uzbekistan
Cabling Diagram
N°2.1.3.C

Appendix 1 - Telecommunications

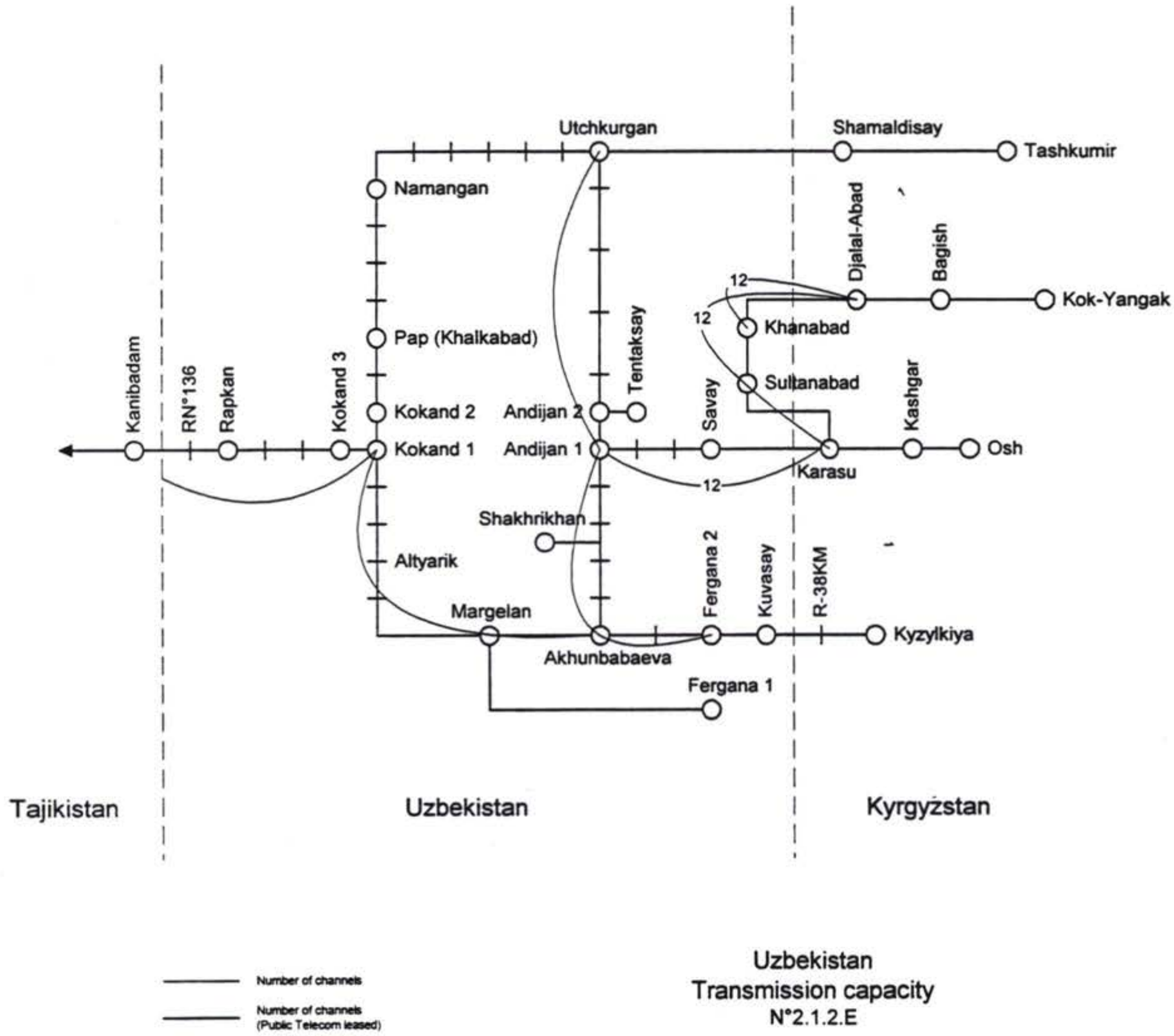


Number of channels

Number of channels (Public Telecom leased)

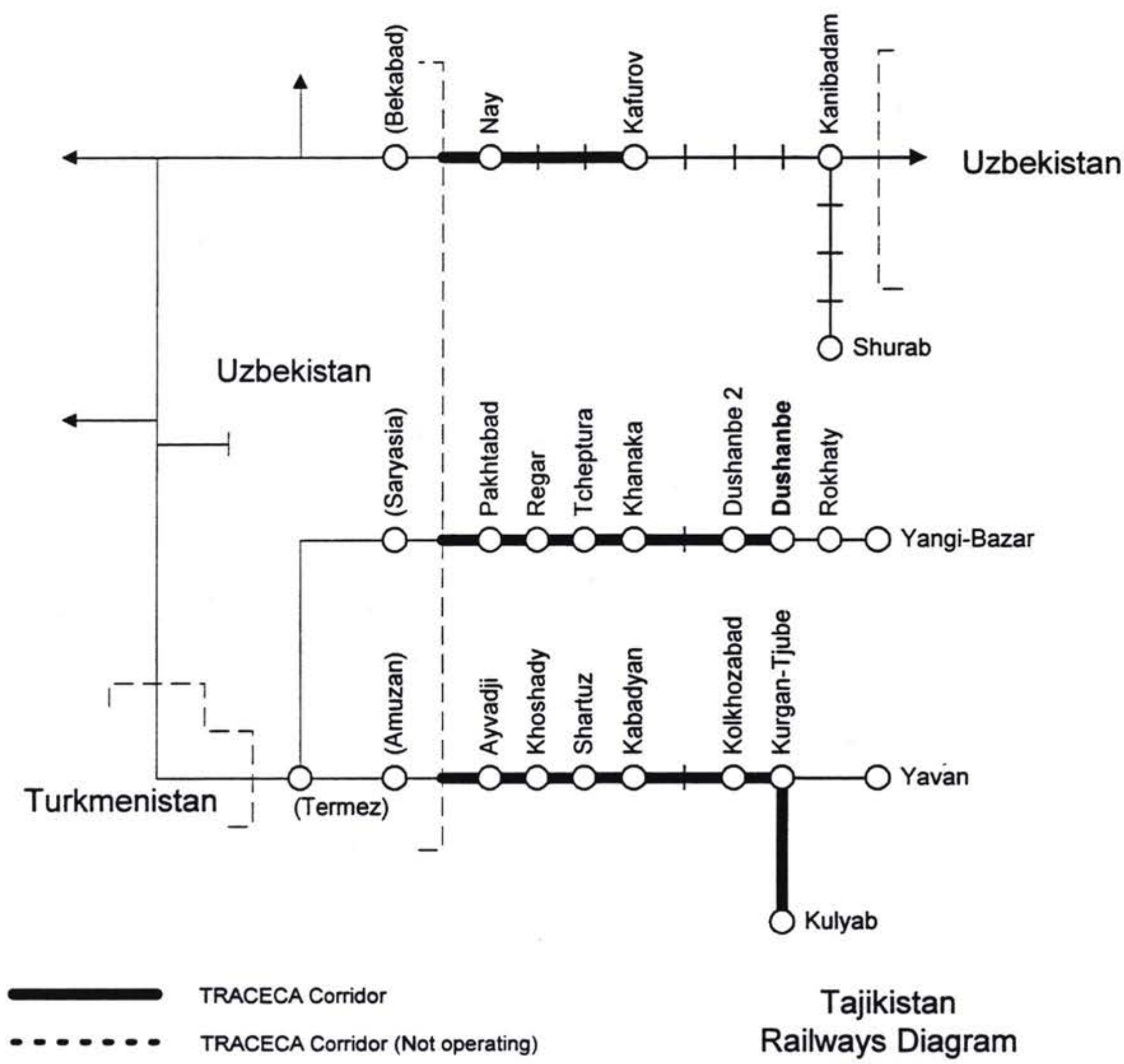
Uzbekistan
Transmission capacity

Appendix 1 - Telecommunications



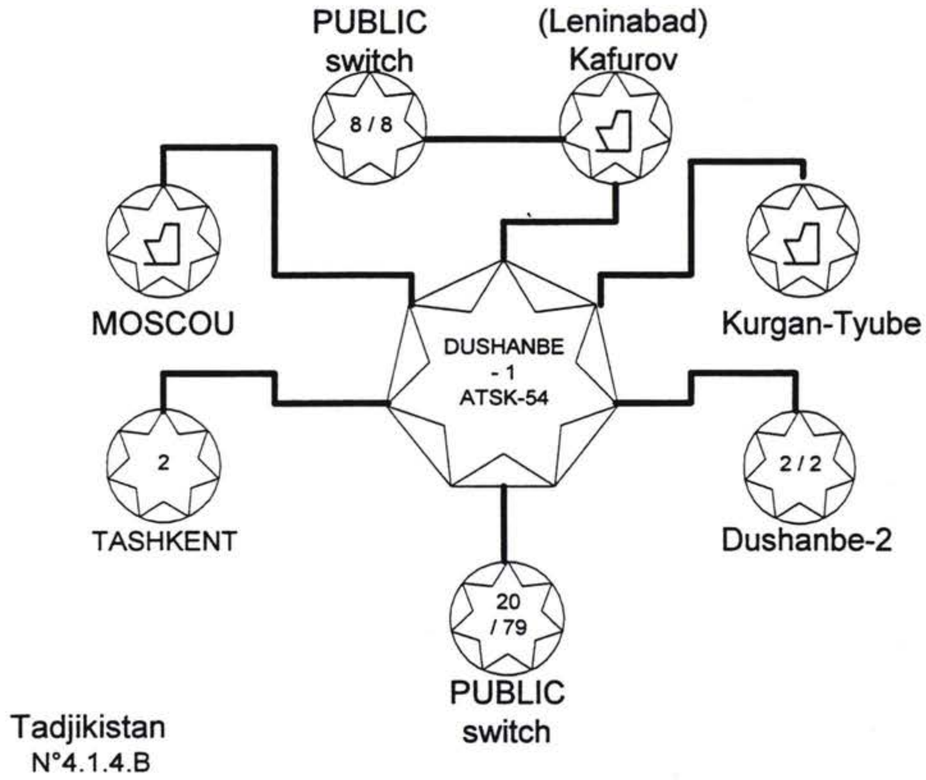
Uzbekistan
Transmission capacity
N°2.1.2.E

Appendix 1 - Telecommunications



Tajikistan
Railways Diagram
N°2.1.4.A

Appendix 1 - Telecommunications



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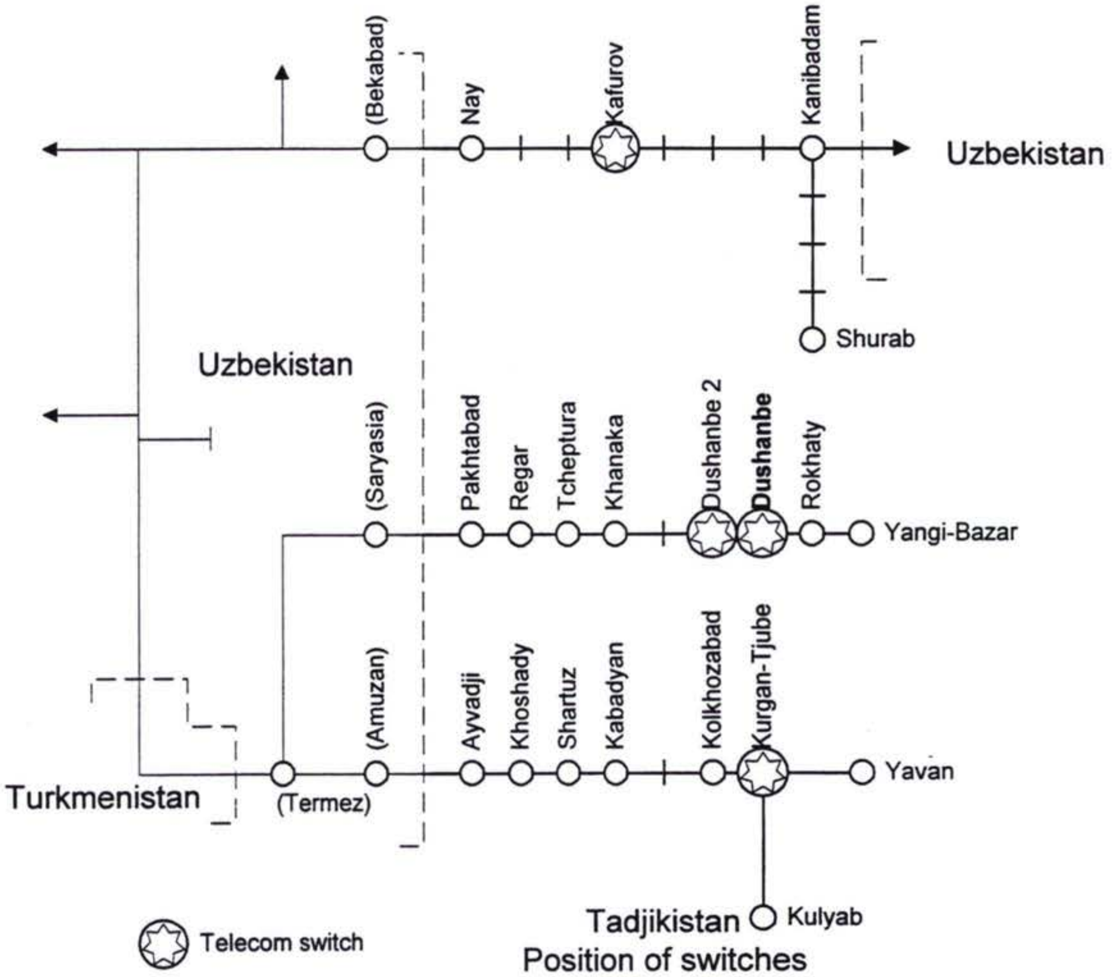
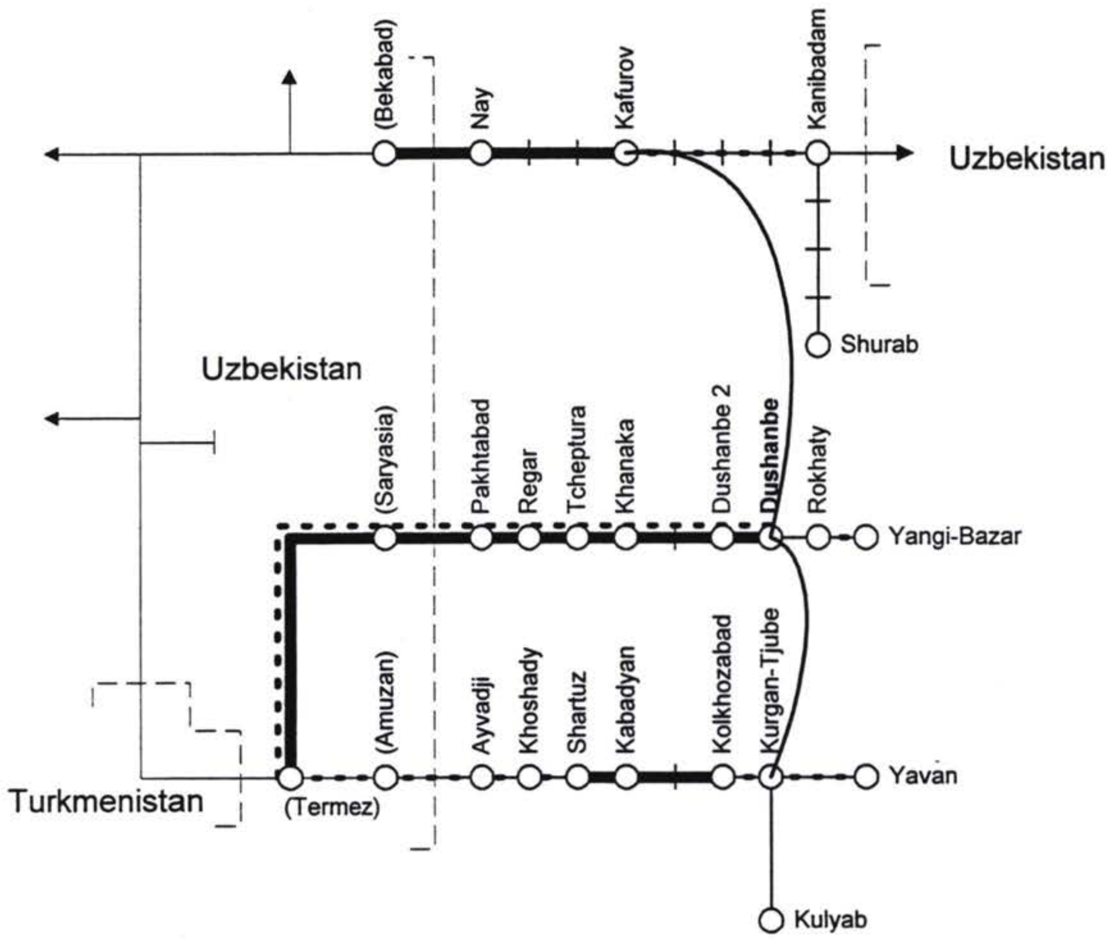
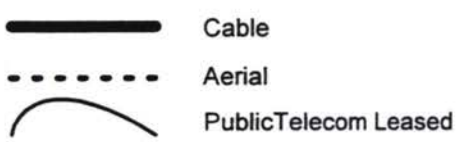


Position of switches
N°2.1.4.C

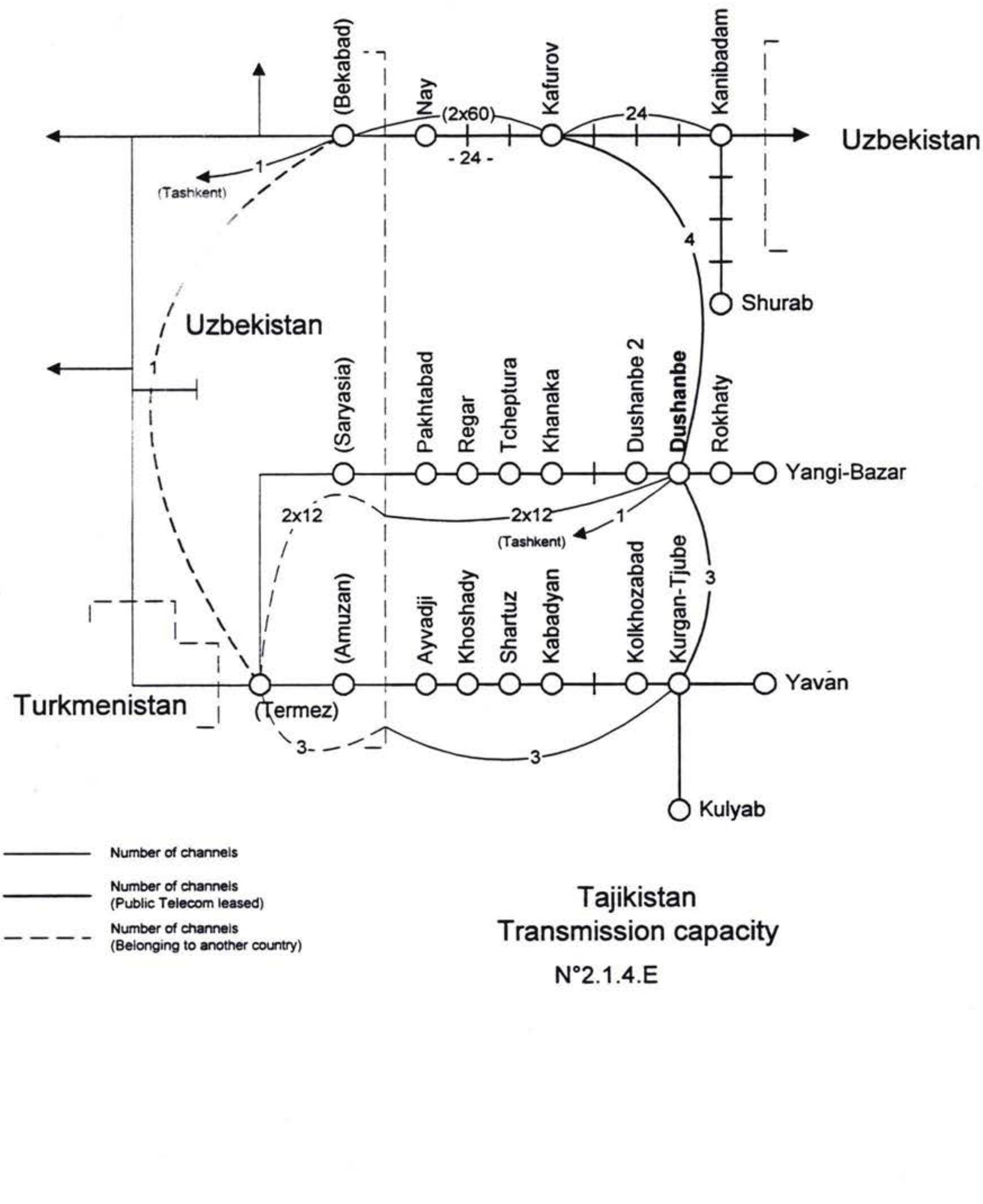
Appendix 1 - Telecommunications





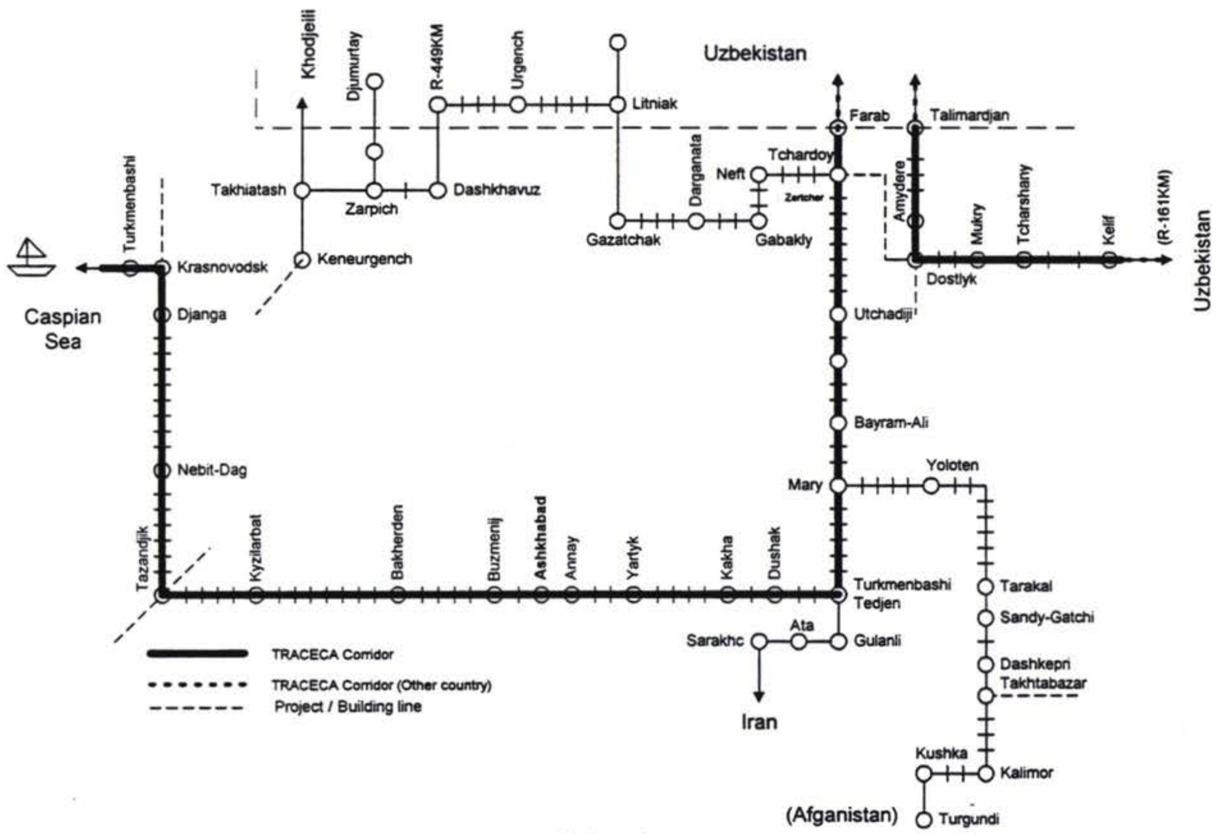
Tajikistan
Cabling Diagram
N°2.1.4.D

Appendix 1 - Telecommunications



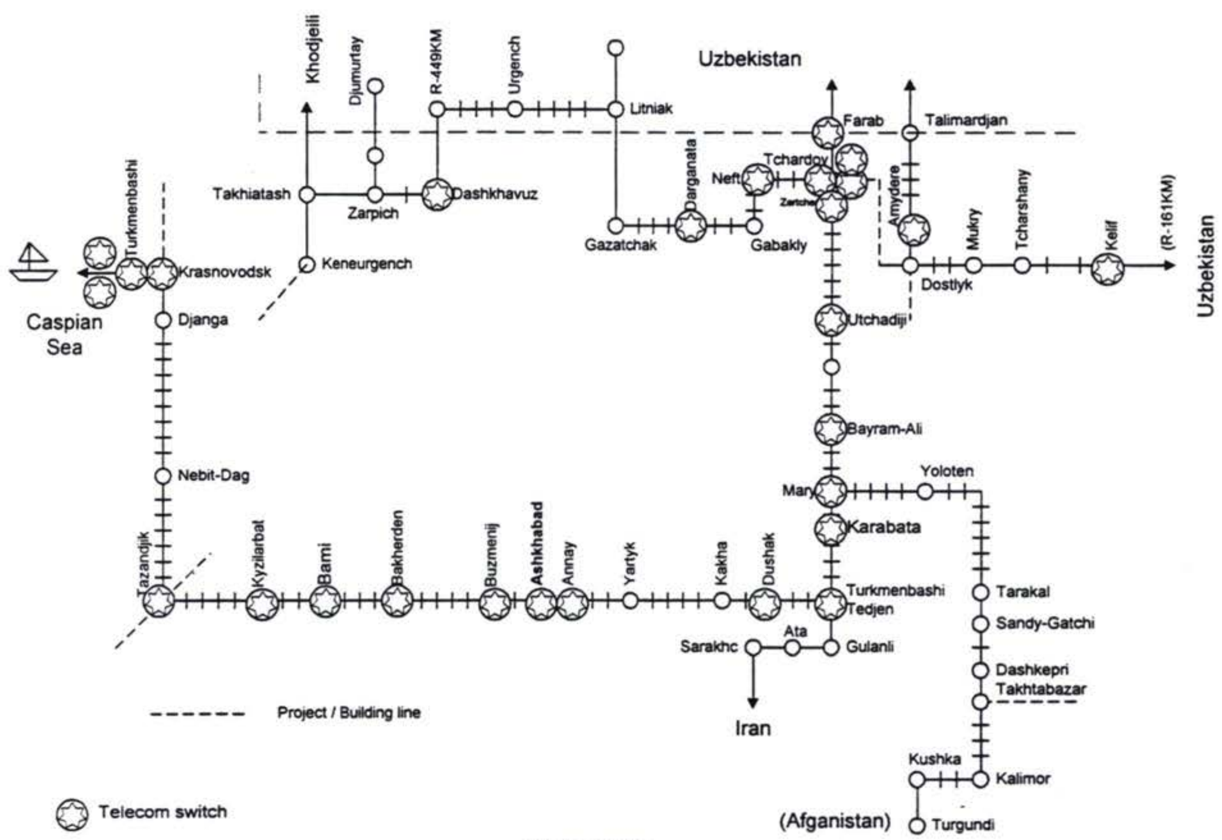
Tajikistan
Transmission capacity
N°2.1.4.E

Appendix 1 - Telecommunications



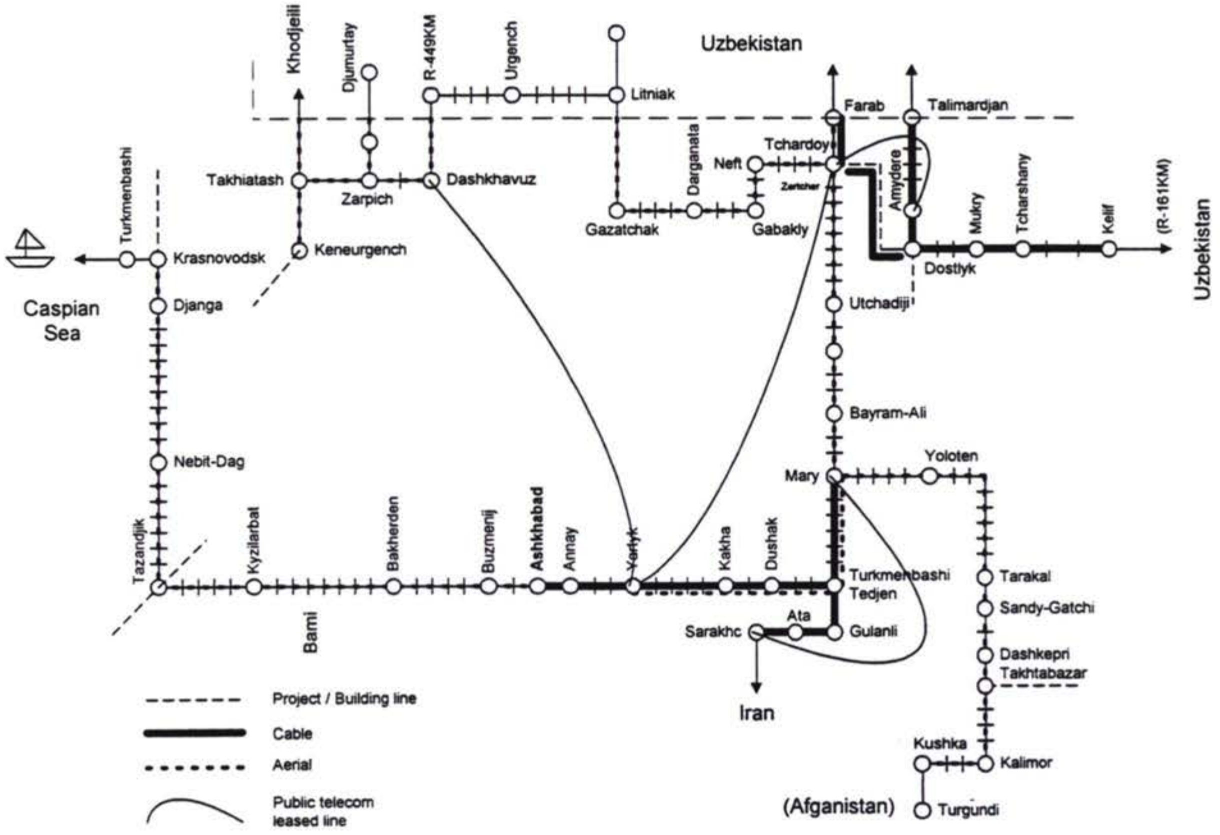
Turkmenistan
Railways diagram
N°2.1.5.A

Appendix 1 - Telecommunications



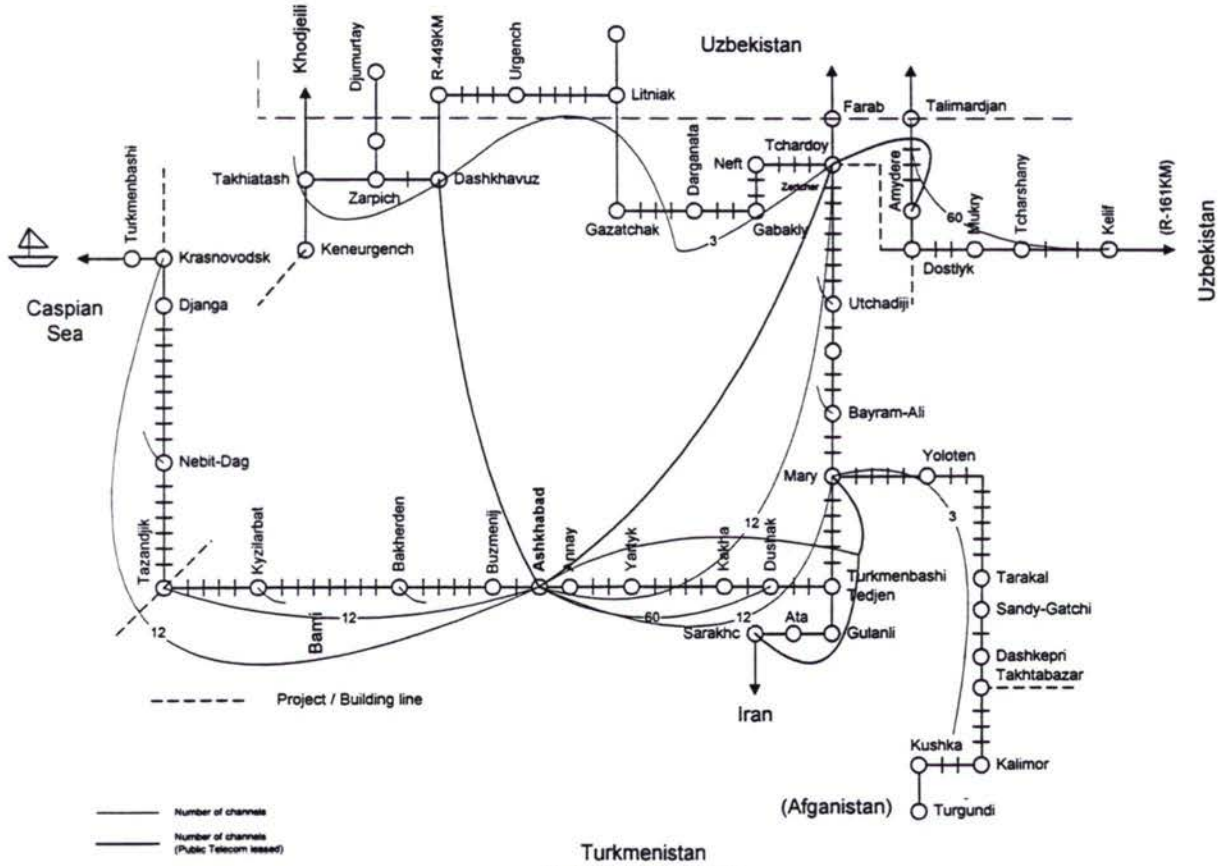
Turkmenistan
Position of telecom switches
N°2.1.5.B

Appendix 1 - Telecommunications



Turkmenistan
Cabling diagram
N°2.1.5.D

Appendix 1 - Telecommunications

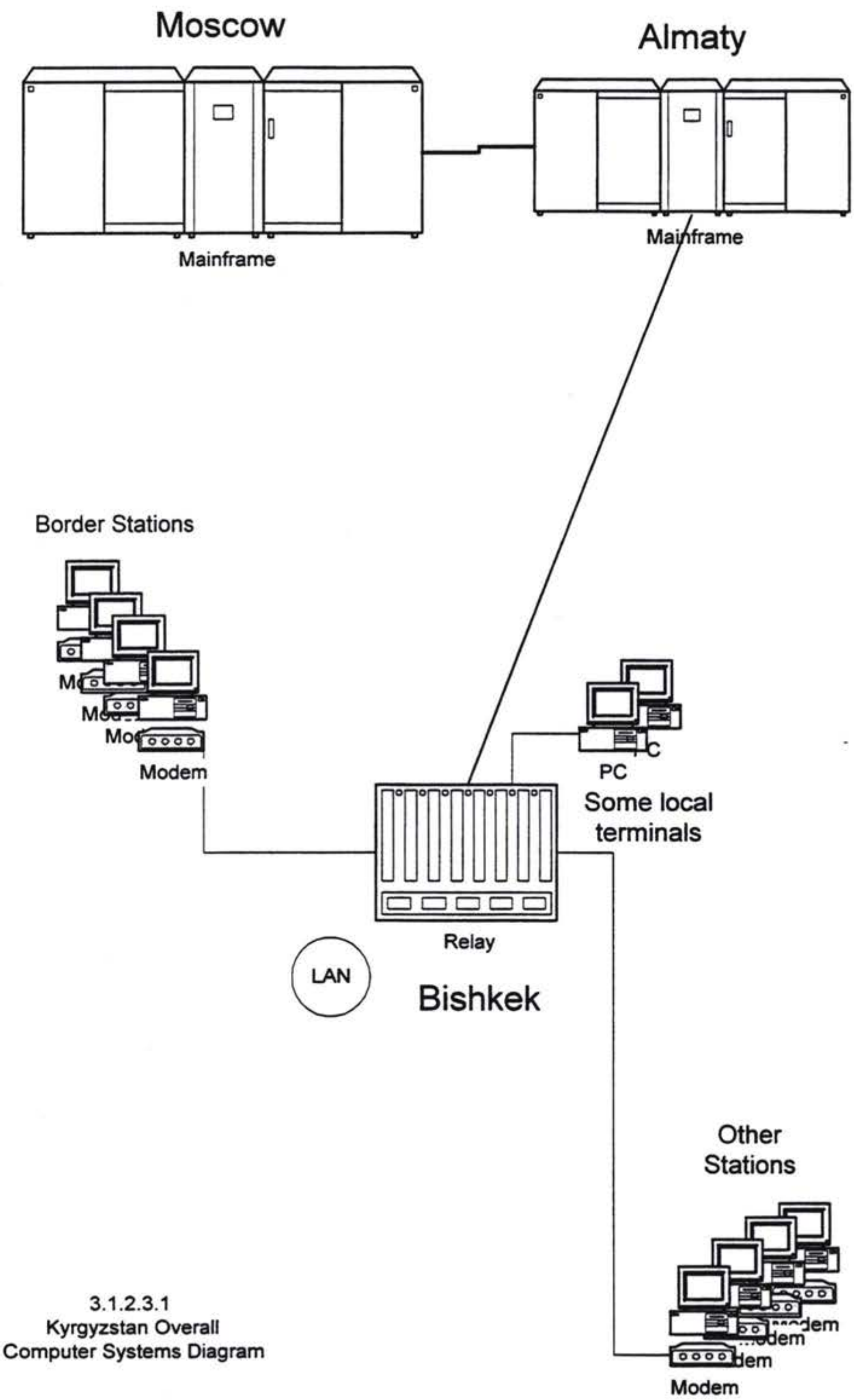


Turkmenistan
Transmission capacity
N°2.1.5..E

Chapter 2

Central Asia - Inventory
Appendix 2 - Electronic Data Interchange

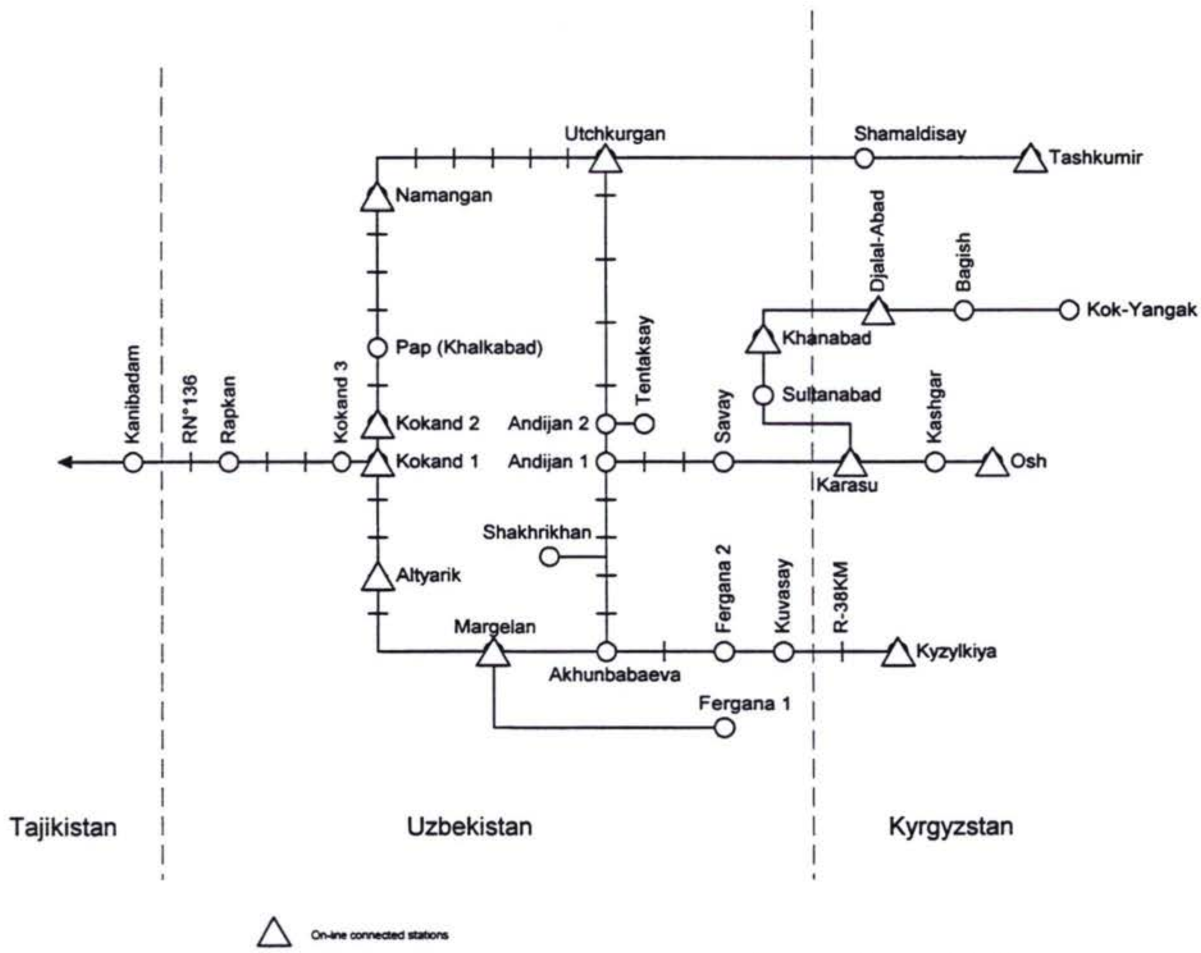
Appendix 2 - Electronic Data Interchange



3.1.2.3.1
Kyrgyzstan Overall
Computer Systems Diagram

Appendix 2 - Electronic Data Interchange

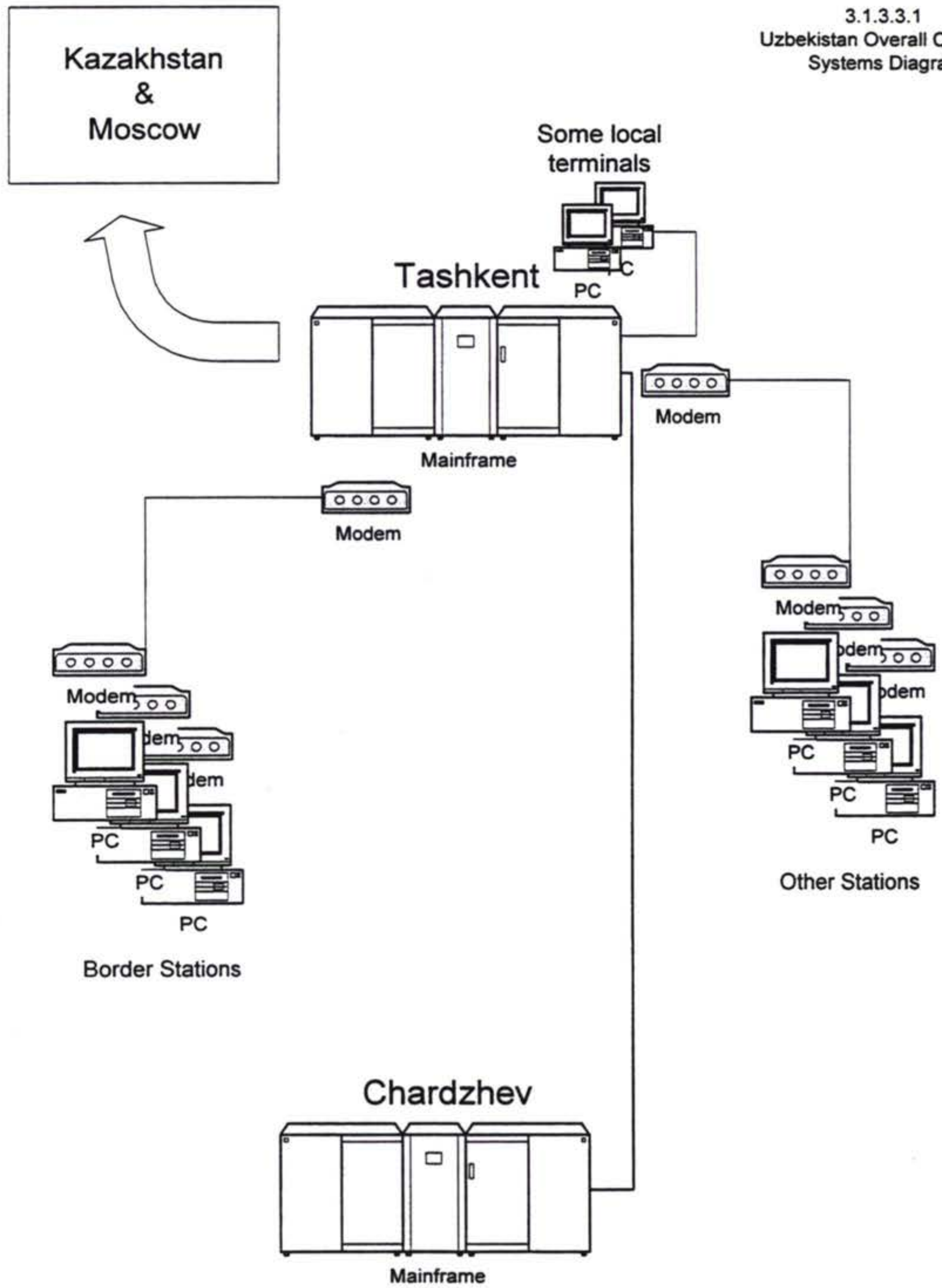
3.1.2.3.2 Kyrgyzstan
Computer system
Diagram



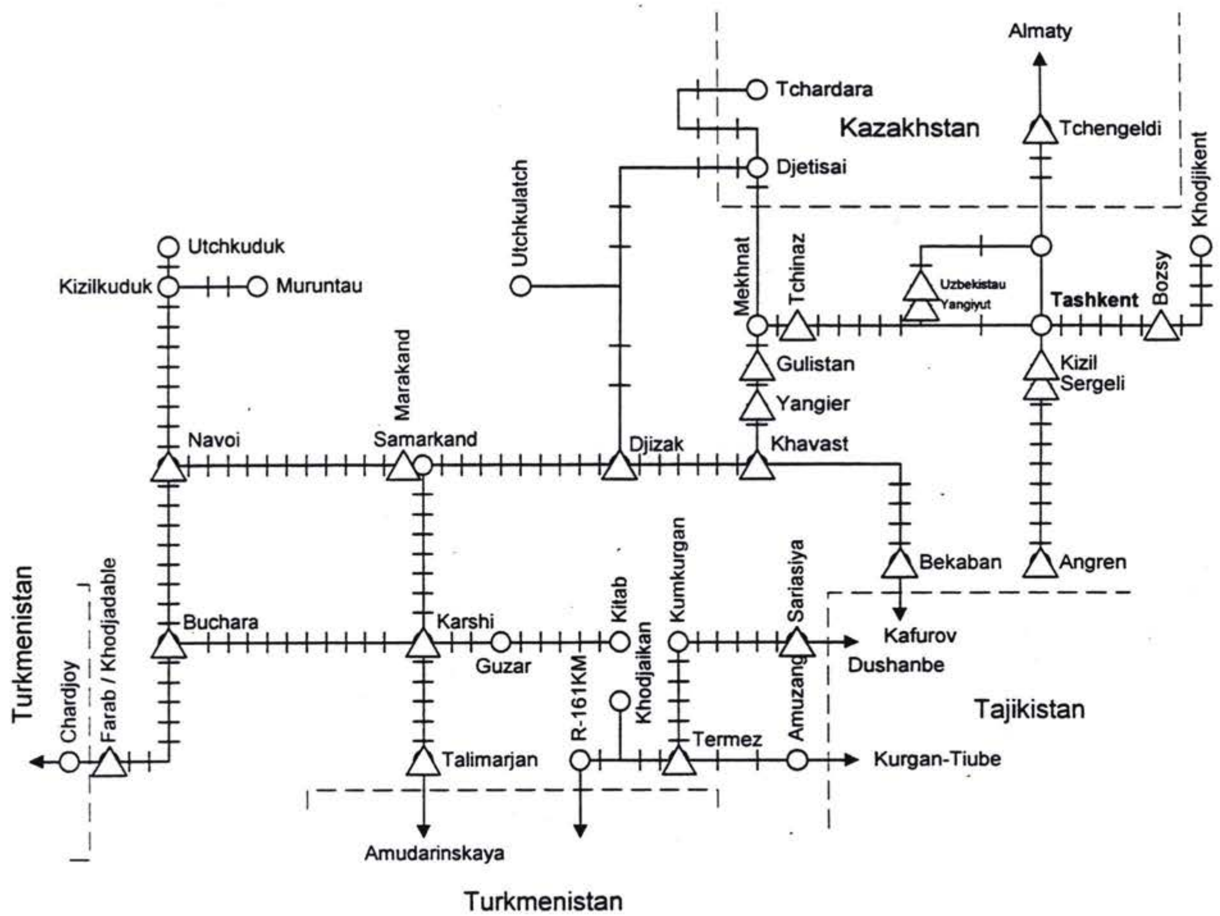
3.1.2.3.2 Kyrgyzstan & Uzbekistan
Computer system
Diagram

Appendix 2 - Electronic Data Interchange

3.1.3.3.1
Uzbekistan Overall Computer
Systems Diagram



Appendix 2 - Electronic Data Interchange

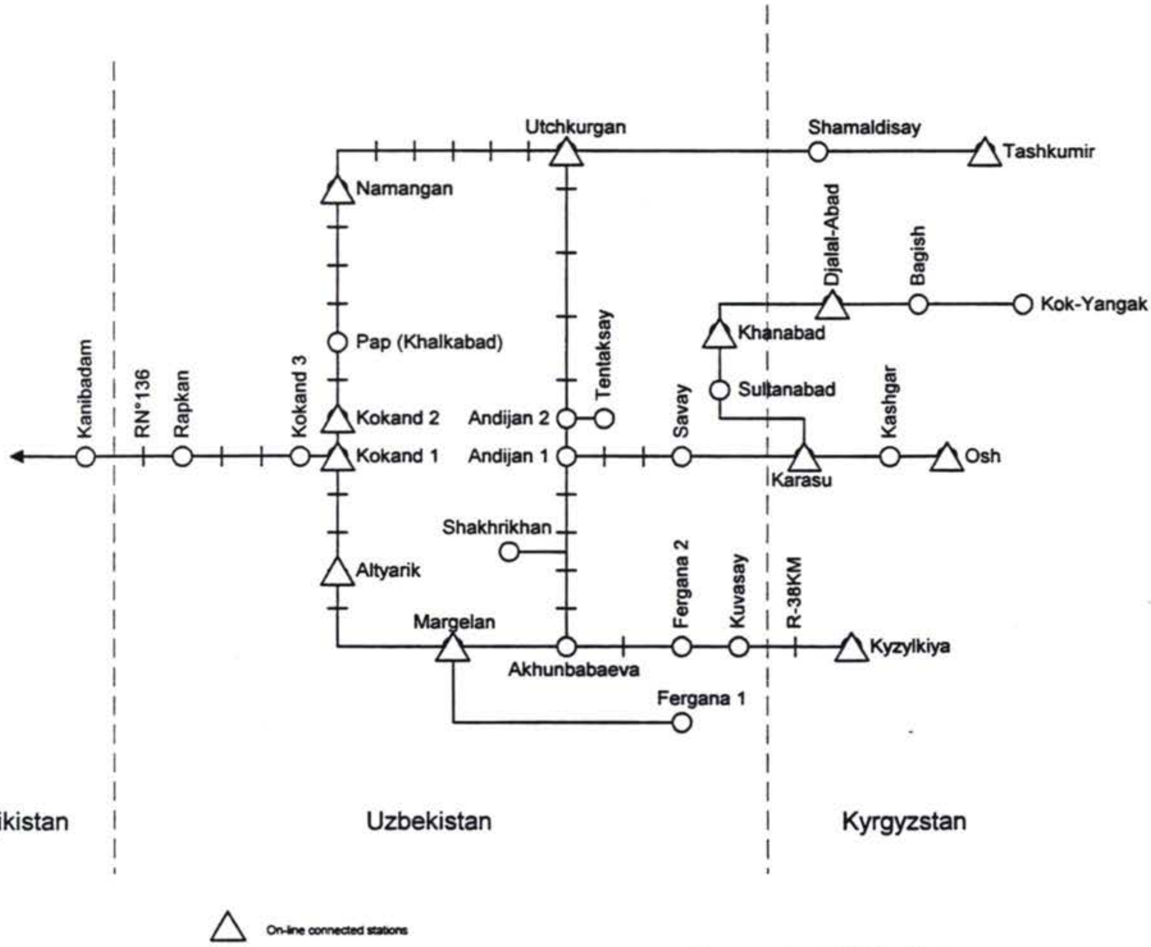


△ On-line connected stations

3.1.3.3.2

Uzbekistan
Computer system
Diagram

Appendix 2 - Electronic Data Interchange

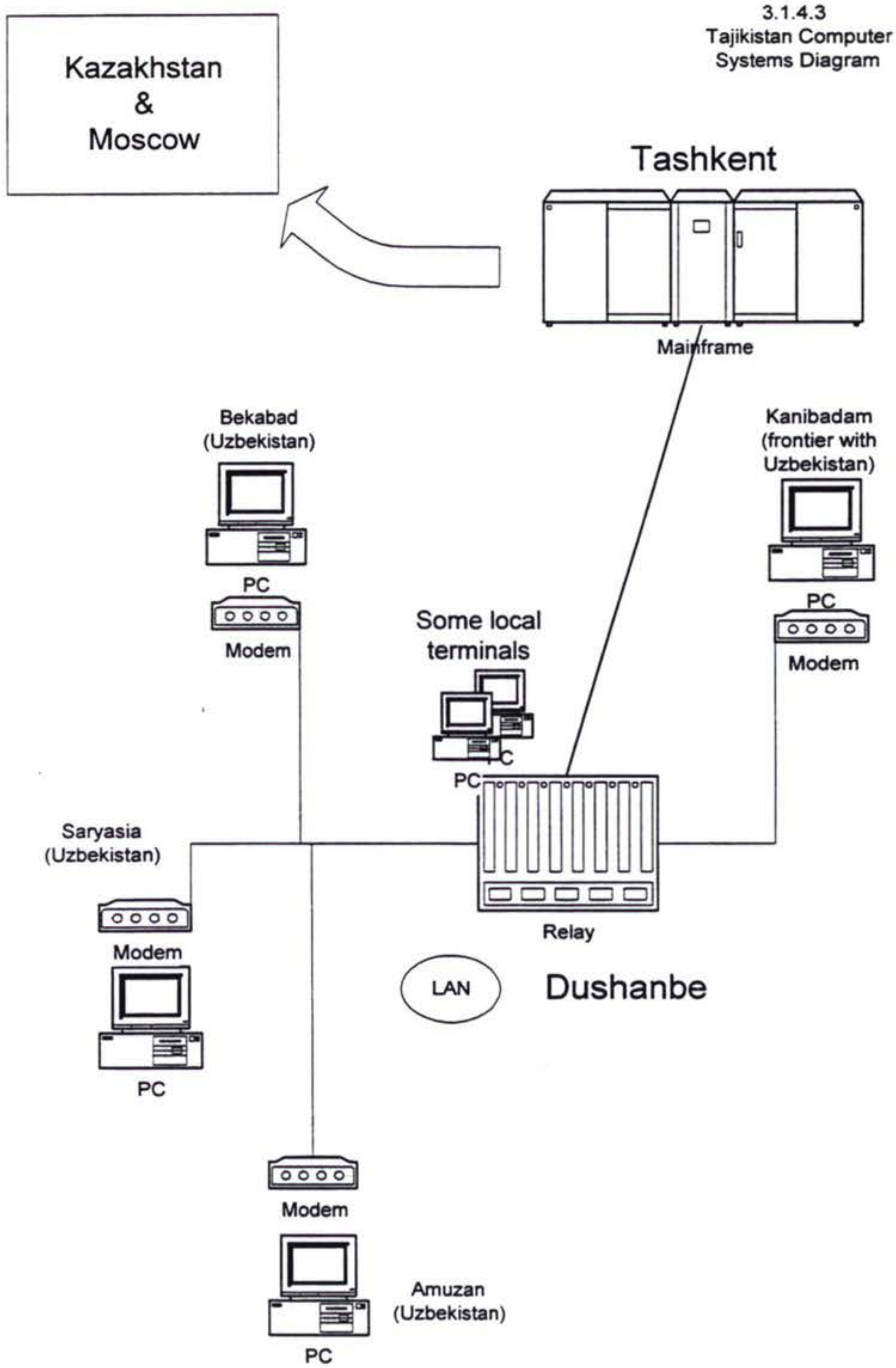


3.1.3.3.2

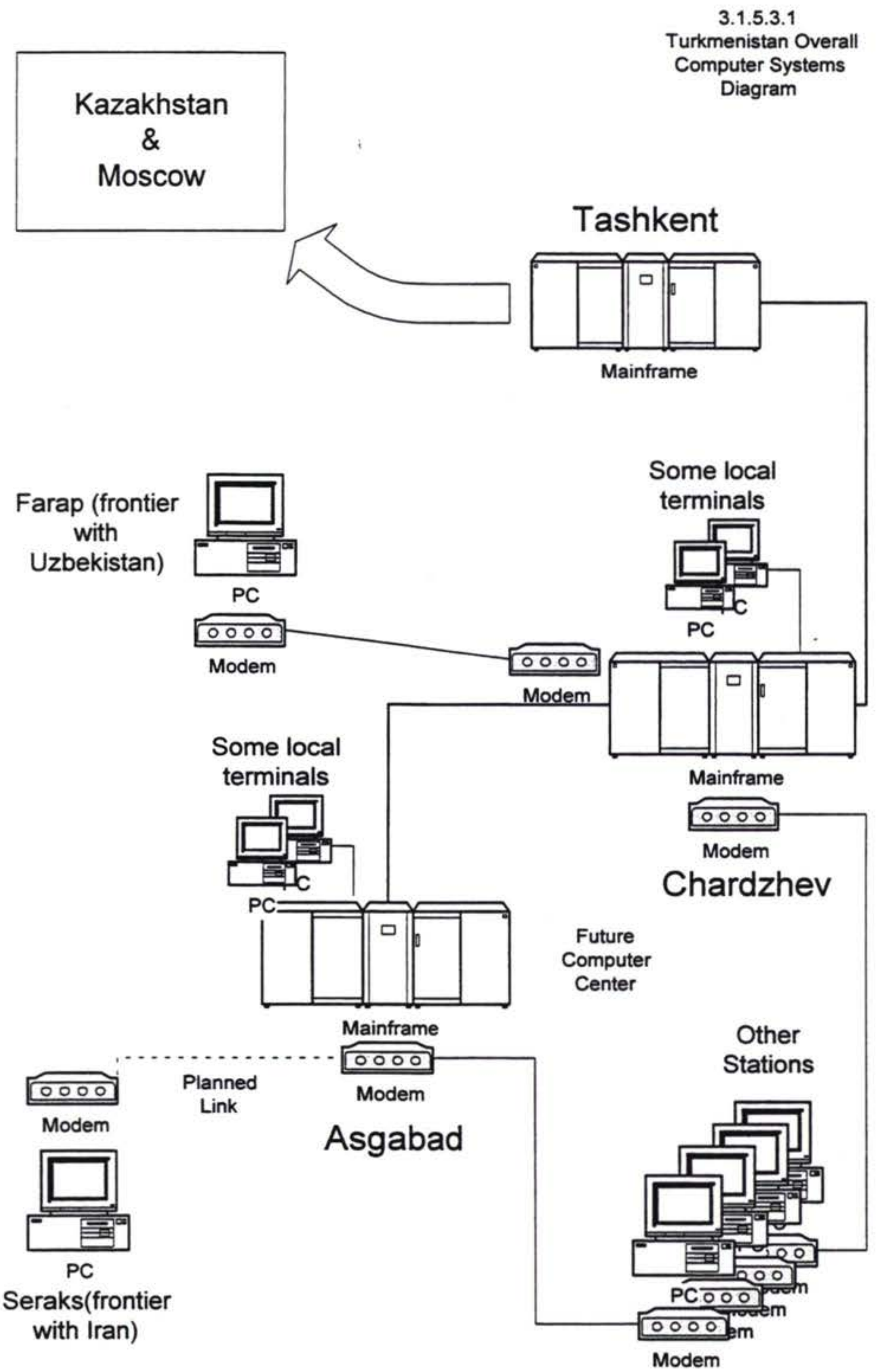
Kyrgyzstan & Uzbekistan
Computer system
Diagram

Appendix 2 - Electronic Data Interchange

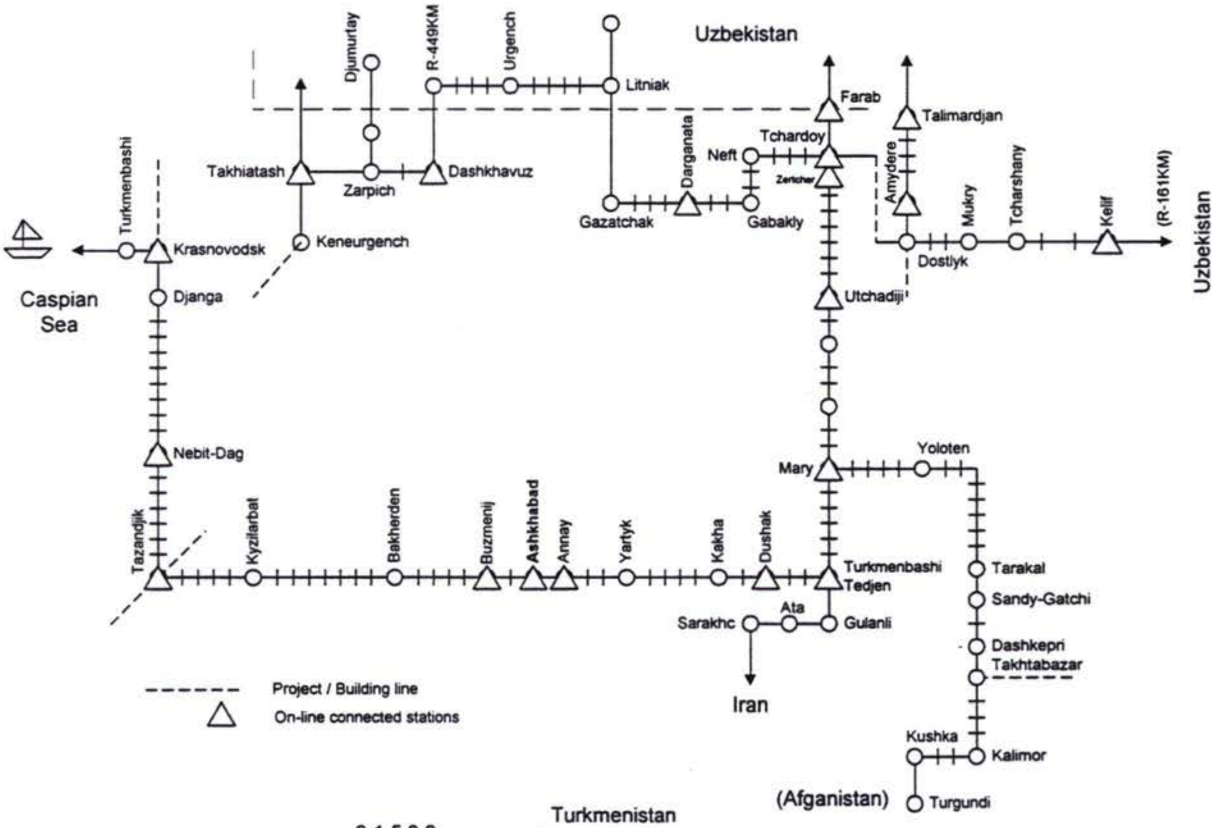
3.1.4.3
Tajikistan Computer Systems Diagram



Appendix 2 - Electronic Data Interchange



Appendix 2 - Electronic Data Interchange



3.1.5.3.2 Turkmenistan Computer system Diagram

Chapter 3

European systems presentation seminar

European systems presentation seminar

List of participants

	Railway/Company	Name	Position	Telephone	Fax
1.	TZD	Nozimow Aso Talbakowicz	Director of Telecommunications	3772/21 58 37	
2.		Ulugow Akram Nurmatowicz	Director of Investment	3772/21 88 57	3772/21 57 91
3.	KRG	Kashko Lyudmila	Director of the IT Centre	3312/249751	3312/253518
4.		Gorev Viktor	Director of Signalling and Telecommunications	3302/245731	3312/253518
5.	GR	Arweladze Gennadij Gerontiewicz	Director of Telecommunications	995/95 46 00	995/95 25 27
6.		Todua Tengiz Grigoirwicz	Director of the IT Centre	995/96 63 28	995/96 63 28
7.	ARM	Grigorian	Deputy Director of Telecommunications	3742/57 43 01	3742/57 38 25
8.		Saratikjan	Director of the IT Centre	3742/57 38 25	3742/57 38 25
9.	KSH	Siemion Siergejewicz Vieczislavovicz	Deputy Director of Telecommunications	7327/26 04 602	
10.		Imangaliev Galihan Dzarylkasynowicz	Deputy Director of the IT Centre	7327/26 05 318	7327/26 31 411
11.	UIC/PKP	Wieladek F. Adam	UIC Chairman	48.22/624 47 21	
12.	PKP	Janik Jan	Director General	48.22/624 44 00	
13.	PKP	Pawlowski Henryk	Centre Director	48.22/624 48 32	48.22/822 94 11
	Railway/Company	Name	Position	Telephone	Fax
14.	PKP	Frak Kazimierz	Director of Signalling and Telecommunications	48.22/624 43 50	48.22/624 48 02

European systems presentation seminar

	Railway/Company	Name	Position	Telephone	Fax
15.	PKP	Slupczynski Aleksander	Director of the IT Centre	48.22/25 30 45	48.22/25 08 56
16.	UIC	Michel André	Director of Administration	33.1/44 49 2009	33.1/44 49 21 40
17.	UIC	Kaczmarek Tadeusz	Director-Delegate	33.1/44 49 20 86	33.1/44 49 21 19
18.	UIC	Fazik Josef	Chargé de Mission	33.1/44 49 21 14	33.1/44 49 21.19
19	UIC	Jean-Michel Wiss	Charge de Mission	33.1/44 49 20 93	33.1/44 49 20 99
20.	UIC	Eric Phan-Kim	IT Expert		33.1/44 49 21 19
21.	UIC/Siemens	Hümmer	Director	49.531/226 24 68	49.531/226 40 26
22.	Austria	Graβl	Telekom		
23.	ZSR	Predac			
24.		Sutka			
25.		Kekenak			
26.	Deutsche Phonesat	Prof.Dr. Dieter Felske	Director General	49.3342/385 382	49.3342/385 359
27.		Klaus Baarss	Regional Director	49.3342/385 337	49.3342/377 399
28.	Kapsch	Miezielinska-Chmielewska	Kapsch telecom W-wa		
29.		Jozef Perkowski	Kapsch telekom W-wa	48.22/25 25 20	48.22/ 25 23 95
30.		Heinz Hammerschmid	Kapsch Wieden	43.1/811 11 1685	43.1/ 811 11 1551

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	Railway/Company	Name	Position	Telephone	Fax
33.	Alcatel	Thierry Demoy	Area Manager	33.1/41 49 89 74	33.1/41 49 86 03
34.		Thomas D'Agostins	Marketing Manager	34.1/330 59 54	34.1/330 50 33
35.		Bruno Herlicq	Railways Communications	34.1/582 400	34.1/358 41 88
36.	Alcatel	Heinz Wiedmann	Marketing Development	49.711/821 49157	49.711/821 43346
37.		Anna Dabrowska	Alcatel Polska	48.22/611 54 60	48.22/12 17 85
38.	AEG	Klaus Wittmann	Area Sales Manager	49/731 505 1499	49/731 505 1817
39.	INOMA	PompuraFrantisek	Director General INOMA	42.844/ 221 130	42.844/221 196
40.		Rynes Vladimir	Expert	42.844/ 221 256	42.844/221 196
41.	UIC	Igor Kawkazkij	Interpreter		
42.	UIC	Vladimr Ternavski	Interpreter		

European systems presentation seminar

TRACECA - TELECOMMUNICATIONS Seminar
Warsaw, 9 - 13 March 1998

9 March		**Moderator Mr.Kaczmarek**		
	14:00	Opening of seminar	Mr.Wieladek Mr. Janik Mr. Michel	
		Project presentation: - General context - Ground telecommunications issues - IT issues	 Mr.Kaczmarek Mr.Fazik Mr.Phan-Kim	
	15:00	Coffee break		
	15:30	Financing telecommunications networks in Europe	EBRD	
	16:00	Telecommunications networks and IT systems - example : PKP	PKP	
	17:00	Close of session		
	18:00	Cocktails		

European systems presentation seminar

TRACECA - TELECOMMUNICATIONS Seminar
Warsaw, 9 - 13 March 1998

10 March		Moderator Mr.Kaczmarek		
	10:00	European standards	Mr. Hümmer	
	10:30	Railway telecommunications strategy in Europe	Mr.Graβl Mr.Bidinger Mr. Predac Mr. Sutka Mr. Kekenak	
	11:30	Coffee break		
		Industrial telecommunications products		
	12:00	Presentation 1	Motorola	
	13:00	Lunch		
	14:30	Presentation 2	Ericsson	
	15:30	Coffee break		
	16:00	Presentation 3	Deutche Phonesat	
	17:00	Close of session		
	18:30	Dinner hosted by Ericsson		

European systems presentation seminar

TRACECA - TELECOMMUNICATIONS Seminar
Warsaw, 9 - 13 March 1998

11 March	10:00	Presentation 4	Alcatel	
	11:00	Coffee break		
	11:30	Presentation 5	Kapsch	
	13:00	Lunch		
	14:30	Presentation 6	AEG	
	15:30	Presentation 7	Siemens-Nixdorf	
	16:30	Coffee break		
	17:00	Presentation 8	INOMA	
	18:30	Dinner hosted by Alcatel		

12 March	7:00	Departure for Lodz		
	8:55	Arrival in Lodz - tour of a telecommunications centre - lunch - visit to the "Intertelecom" exhibition		
	16:35	Departure for Warsaw		
	18:32	Arrival in Warsaw		
	19:30	Dinner hosted by Kapsch		

European systems presentation seminar

TRACECA - TELECOMMUNICATIONS Seminar
Warsaw, 9 - 13 March 1998

13 March	8:00	Departure by bus to visit the IT Centre in Warsaw		
	9:00	Tour of the centre		
	11:00	Tour of Headquarters - Train Control		
	12:30	Departure for the Training Centre		
	13:00	Lunch		
	14:30	Conclusion of the seminar Final discussion		
	18:30	Dinner		

14 March		Departure of delegations		

Chapter 4

General recommendations and methodology

General recommendations and methodology

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1. General recommendations

The purpose of this chapter is to:

- specify the project context,
- outline the services to be provided,
- put forward a technical proposal, including a range of mandatory, recommendatory and informatory technical specifications,
- supply basic costs for products and systems.

1.1 Project context.

This project for linking the telecommunications systems in the TRACECA countries is part of the reconstruction of Central Asian railways. It constitutes Module E.

1.1.1 Project objectives

The aim of Module E is to examine the possibility of setting up an efficient telecommunications network within the TRACECA countries. It will also look at potential links with European railways.

Module E comprises:

- an analysis of existing telecommunications systems,
- a seminar to present the systems used in Europe,
- an action and investment plan,
- and perhaps, a training seminar on new telecommunications systems.

Chapter 5 contains a range of general recommendations for the action and investment plan.

In particular, it specifies:

- the general context of the project,
- the telecommunications services to be provided, a framework of generic technical specifications (of general application, not targeted towards a specific project).

1.1.2 General context.

1.1.2.1 Investment concept model.

All investment plans stem from a logical sequence beginning with an expression of needs and culminating in implementation.

The concepting for this project is presented in Figure 1.

It shows that project implementation has to be the best possible trade-off between the needs of the railway operator, expressed in terms of traffic and the corresponding installations, and investment possibilities.

The concept complies with the need for a strict separation of the tasks of project developer and prime contractor:

- The project developer has a particularly important role. He:
  - voices the needs of the end user,
  - manages the financial resources,
  - fixes the schedule of work.
- The prime contractor implements the project within the framework set by the project developer.
- The choice of prime contractor is crucial to the success of the project.

This point is explained in greater detail in Sections 1.1.5. and 1.3.3.3.1. of this chapter.

1.1.2.2 Uncertainty over needs.

Current and predicted levels of traffic have been analysed extensively in the other modules. They are relatively well defined.

The funding available and investment potential are known to some extent.

However, the translation of needs into railway installations is not precise enough. For example, should installations be repaired or replaced by their exact equivalent or should they be rationalised and adjusted in accordance with predicted traffic levels?

While such uncertainty does not seriously affect the main choices to be made regarding the architecture of the telecommunications networks and technologies, it does have a major impact on the Action Plan.

At all events, it is essential to consult the railway operators in order to achieve consensus on the needs of the programme of operating requirements and the corresponding technical requirements.

1.1.3 Financial context.

One of the most important parameters of a project is its funding. Investors play a crucial role because their involvement is contingent upon an in-depth analysis of the sums to be invested, the return on investment and the financial guarantees needed for the project.

The architecture of a telecommunications network is clearly a compromise between the needs expressed and funding possibilities:

- The needs depend on the state of the network (available telecommunications services, quality of service, ease of maintenance and obsolescence),
- Funding possibilities depend on income from rail traffic and investment potential, which may involve loans that have to be guaranteed by the railways. So funding depends on their solvency.

Financing railway infrastructure is a fast changing arena in Europe today as a result of EU directives requiring a separation, at least in accounting terms, between infrastructure managers and railway operators for passenger and freight, etc.

Funding is no longer systematically channelled via the State, and new forms of finance have resulted from structural changes such as the creation of subsidiaries and privatisation.

Thus, the relationship between railways and telecommunications operators can take one of the following, very diverse forms:

- concession of right of way on railway territory,
- co-funding of cable laying,
- laying of separate cables in railway ducts,
- laying of cables by one party and use of part of the cable by the other party,

- provision of bearer and end-to-end telecommunications services by one party for the other party,

- allocation of entire sections of a network (cables, transmission equipment, switches) by one party to the other party.

1.1.4 National legal context.

Prior to any proposal to develop telecommunications networks, it is crucial to make a careful examination of national regulations governing telecommunications and, more importantly, those pertaining to railway telecommunications.

This is particularly important as regards the possibilities of setting up subsidiaries or privatising, as mentioned in Section 1.1.3 "Financial Context".

1.1.5 Legal context of the project.

- The project is to be put out to tender on the basis of administrative, financial and technical specifications.

This procedure exceeds the framework of Module E, as does the scope of the invitation to tender (which may be national or multinational).

- It is strongly hoped that the specifications will be based on a detailed statement of needs and technical specifications which are both:

- precise as regards:
  - the environment and
  - interfaces between telecommunications networks in order to ensure interoperability,
- and flexible as regards:
  - technical solutions,
  - the network architecture and
  - the potential to expand the network as telecommunications needs grow.

- Bibliographical reference [1] advocates a "turnkey" contract, with the contracting party being supervised by an experienced consulting firm which must be selected on the basis of an invitation to tender.

We agree with this recommendation: it has the advantage of awarding general project management to one single entity and prevents the project developer from being involved in decisions for which the prime contractor should be responsible.

The prime contractor should be given free range to specify how the project is to be organised, decide on any sub-contracts and choose his/her staff.

Notwithstanding, the contract should specify that the railways' telecommunications employees are to be trained so that they can later maintain the installations.

- It is essential to set up a project organisation including railways representatives of all levels of responsibility.

1.2 Services to be provided.

On the whole, railways make extensive use of telecommunications services in all areas.

There are generally considered to be three categories of telecommunications services:

- railway signalling (train headway and protection of train running - signalling telecommunications).

- railway operation (traffic control, energy, stations, depots, etc. - railway operating telecommunications),

- applications (traffic supervision, passenger, freight, invoicing, maintenance, etc. - applications telecommunications).

General recommendations and methodology

1.2.1 Signalling telecommunications

Signalling is not actually part of Module E.

Nonetheless, it directly affects the type and capacity of telecommunications systems used, cables in particular.

For this reason, signalling can not be disregarded.

We found the report listed in bibliographical reference [4] to be of particular interest.

1.2.1.1 Train detectors.

- They detect the presence of rail traffic on a given track section.

- The most commonly used detector is the track circuit (this appears to be the case in Transcaucasian and Central Asian countries)

The use of track circuits for detection is limited by transmission attenuation in the rail and by railway operating considerations.

The maximum distance is about 2,200 m for frequency track circuits and roughly 2,800 m for pulse coded track circuits.

- Rail traffic may also be detected using an axle counter, which counts and counter-checks the number of axles in a moving train.

There is no maximum physical distance for the use of axle counters.

- In and around stations, track circuits are a necessity.

On open track, axle counters and track circuits are in competition and the choice made will depend on required line throughput and costs.

1.2.1.2 Block systems.

- Train spacing involves a succession of zones commonly called block sections.

The block is the system comprising all the equipment which guarantees this spacing.

- There are many types of block, requiring varying amounts of equipment and procedures.

- The resulting throughput (i.e. the number of trains circulating on the track per unit of time) varies according to the block type used.

- The block system also determines the safety level.

1.2.1.3 Types of block

The ideas outlined in this section are based on material taken from bibliographical reference [3].

They therefore correspond to the signalling systems used by SNCF, although the same underlying principles are generally applied on other railways.

- The block type is usually directly related to the importance of the line (on all counts: resources obtained from traffic, public service function, strategic importance, etc.).

Block types can be classified as follows:

- Manual telephone blocks .

The two signal boxes at either end of the block section are linked by telephone (cf. below, dedicated safety line - 1.2.2.1 and 1.2.2.2).

The signalman at the entry point releases the entry signal (which may only be a simple manual stop signal), once the signalman at the exit point informs him/her that the entire train has left that block section. This type of block involves exclusively the application of written regulations via telephone communications.

It is reserved for lightly trafficked lines (maximum of a few trains per day).

- Manual blocks per equipment or interlocked blocks.

The two signal boxes at either end of the block section are electrically connected and have electromechanical devices which are manually controlled but do have some interlocks (the lever of the entry signal is locked electro-mechanically on closure, when the block section is occupied; the release signal is activated manually from the downline signal box but sent electrically and generally used in conjunction with a treadle or some other form of electrical override device monitoring train movements).

This type of block also has a telephone link so that measures can be taken in the event of unusual operating conditions or disruptions.

Manual blocks are only used on lightly trafficked lines.

- Automatic blocks, i.e. where block sections are controlled automatically.

It is current practice today to distinguish between two types of automatic block

- the short-section permissive automatic colour-light block (ACLB), which is installed when daily traffic approaches or exceeds 100 trains for both directions for a double track line or 40 trains on a single-track line.

  The maximum block section length is 2,800 m so that a driver does not forget the order given him at the entry to the block section.
- the long-section partly permissive automatic block (PPAB) for lower throughput lines. Block sections are long (minimum 6 km).

1.2.1.4 Role of telecommunications.

- It is crucial to remember that the transmission of safety information must be failsafe

- In and around stations, the role of telecommunications is to transmit signalling information (status of track circuits, position of switches, etc.) needed for the train spacing and protection functions of the signal boxes.

- On the open track, the role of telecommunications is:

- either to send signalling information (status of track circuits, etc.) back to the signal boxes in order to guarantee headway (in an absolute block where an entire line is covered by the signal boxes),
- or to send signalling information (status of track circuits, etc.) back to the lineside equipment centres and to exchange signalling information between these centres (in a permissive block where the entire line is not covered by the signal boxes).

- Extensive use is still made of fully dedicated signalling cables.

1.2.2 Railway operating telecommunications.

1.2.2.1 Types of Service.

- The term "Railway operating telecommunications" covers all telecommunications services directly involved in running trains.

- **It is essential to bear in mind that it is railway operating modes that have shaped railway operating telecommunications**. A change in the technology used may alter a service and thus the operating mode. Such a change requires prior consultation with the operators (who therefore act as project developers in this regard) on all aspects including costs.

- These services provide various links for the operations and energy functions, i.e.:

- operating and energy control,
- signals, switches, level crossings, significant points,
- station-to-station dedicated telephone lines for safety,
- dedicated telephone lines for track works crews,
- relay of alarms, track and OHL maintenance,
- ground-to-train radio,
- shunting radio,
- maintenance, incidents and track site radio,
- local radio,

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- various lines,
- loud-speaker equipment at small stations,
- etc.

1.2.2.2 Types of communication.

- Most services are provided by telephone but data transmission is catching on for identification, vehicle location and emergency alarm purposes.

- Railway operations involve a wide range of voice communications services.

- They include:

- point to point,
- point to multi-point in a given geographical area (e.g. call from the traffic controller to all trains within a control block, a line section or the entire line),
- point to selective multi-point in a given geographical area (e.g. call from the traffic controller to all trains of a given type within a control block, a line section or the entire line.),
- broadcast (warning, loud-speaker equipment in small stations).

- Conventional switched telephone networks (STN) are essentially point-to-point systems, which means there is a certain amount of duality between railway operating telephone links and STN.

NB:

Some railways require services which involve the installation of lineside telephones or sockets at typical intervals of a few hundred metres (e.g. power alarm telephones on SNCF electrified lines, located every 500 m, or telephone sockets for the dedicated track works communication system on new SNCF lines).

At SNCF, these functional constraints are not due to traffic control as such.

Nowadays, for economic reasons, these services are based almost of necessity on the use of copper cables.

Other services required may have a similar impact on the technology used. It is therefore vital to consult with the railway operator (and other customers, such as the power supply division) in order to gain a precise idea of all services required.

This is a crucial step since it has an impact on whether or not copper cables will be used.

1.2.2.3 Performance criteria.

- An important characteristic of railway operating links is their performance levels and the high availability demanded by railway operators.

After safety, the operators' prime concern is to move their trains through at all costs.

- The access times required vary from a few hundred milliseconds to a maximum of a few seconds. This is because any wait or malfunction results in delays which directly affect customers and therefore undermines the operator's image.

- Very high availability is required on some links.

Consequently, the dedicated safety line is the last resort for moving a train from one station to another in the event of failure in the signalling system.

1.2.3 Applications telecommunications.

The past three decades have seen an explosive, sometimes uncontrolled development in computer applications for the transfer of data directly and indirectly linked to the railway business: traffic control, passenger and freight services, invoicing, maintenance, management information systems, etc.

In this, the rail mode is simply following a universal trend.

In the telecommunications area this has resulted in a move towards high transmission speeds and a proliferation of telecommunications installations.

At the same time, greater demands are being placed on transmission quality and network security.

To meet these demands, railways are applying a variety of solutions:

- use of the switched telephone network,
- X25 packet-transmission networks dedicated to railway data transmission applications,
- use of frame relay, or ATM (Asynchronous Transmission Mode),
- establishment of Local Area Networks (LAN) or Wide Area Networks (WAN),
- lease of circuits from the public operator,
- and perhaps in the future: Internet

The role of telecommunications is to make IT applications available and supply data transmission services with high throughputs and the requisite transmission quality.

1.3 Technical proposal.

1.3.1 Technological development.

1.3.1.1 A growth market.

- Generally speaking, telecommunications networks are developing at a rapid pace today, spurred by market demand for transmission of increasing volumes of information at ever faster speeds.

- This trend provides an incentive for technological development, one of the by-products of which is the rapid obsolescence of existing equipment.

1.3.1.2 Rapid renewal of equipment.

- It is now common for perfectly functional generations of equipment to be replaced by new, more sophisticated generations with lower life cycle costs (investment and use).

- Although such methods are the rule among telecommunications operators, they are somewhat of a culture shock for the railways who more are used to making their equipment last as long as possible.

- The railways must join the trend.

- This does not rule out the possibility of gradual migration or changes introduced on a stage-by-stage basis, with the discarded items being cascaded and used for spare parts, in particular in railway sectors less affected by the boom in requirements. A good case in point is railway operating telecommunications. Most railway companies today operate in this way if only out of financial motives.

1.3.1.3 Move towards digital technology.

- This has become an irreversible trend.

The productivity enhancements it allows and the resulting cost reductions, both for manufacturers and users, are such that it would be suicidal to envisage any solution other than digital technology.

1.3.1.4 Move towards optical fibre transmission media.

- Optical fibres are the only solution to meet demand for high transmission speeds.

- There are no problems with the use of optical fibres for :

- railway operating telecommunications,
- application telecommunications.

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- By contrast, where signalling telecommunications are concerned, their use needs to be subjected to closer examination

This matter will be dealt with later on in this report;

1.3.2 Telecommunications network architecture.

1.3.2.1 Principles.

- The architecture of the telecommunications networks of railways in Georgia, Azerbaijan and Armenia has already been studied in depth.

- Bibliographical reference [1] is of particular interest.

This refers to a critical analysis of the paper shown under bibliographical reference [5] and includes a number of proposals (cf. summary in Chapter 1);

In summary, on the Baku - Tbilisi - Poti and Tbilisi - Yerevan routes (i.e. 1,225 km):

- The TEWET company suggests laying a 12 optical fibre cable hosting 30 channels (30-channel PCM) i.e., a bit rate of 2 Mbit/s.
- In bibliographical reference [1], F.W. Krämer proposes immediate adoption of SDH architecture (synchronous digital hierarchy) with a 155 Mbit/s bit rate (i.e., a STM1) and an active capacity of 120 telephone channels.

- An analysis of railway telecommunications networks currently being set up (for example on SNCF, PKP and ÖBB) shows that these railways are opting in favour of a two-tier structure:

- the first of SDH type with 155/622 Mbit/s.
- the second of PDH type with 2/8 Mbit/s.

cf., for example, bibliographical reference [2].

- The final say as regards architecture will be given to the telecommunications network operator.

It would nevertheless seem clear that the best starting approach would be one based on an SDH "backbone" network, initially on a very small scale, (155 Mbit/s STM1), as a support for a 2 Mbit/s drop-and-insert PCM PDH network (cf. <u>Figure 2</u> for block diagram).

This solution is not only in tune with technological developments but also offers the necessary flexibility to provide a proper service in areas where railway installations are grouped heavily together (major centres) and to the smaller and medium-sized locations scattered along the various railway lines.

Bibliographical references [10] and [11] contain useful information about SDH technology.

1.3.2.2 Network back-up.

- Network back-up is a constant concern in the telecommunications sector.

It forms the leitmotiv of the TRACECA project with its telecommunications package (cf. references [1] and [4] for example).

- The need to ensure network back-up is largely dictated by <u>quality of service</u> considerations.

It is important to remember that quality of service standards is an indicator sine qua non for contracted telecommunications services.

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This is increasingly true, even between entities that are part of the same company, and therefore all the more so between entities belonging to different companies (or when the contract involves a railway operator and a telecommunications operator).

- Availability is the most commonly applied quality-of-service indicator.

Availability refers to the probability of a given system operating in a given environment being available at a given moment in time.

It may take different forms.

For example:

- In the early 90s the Swedish railway administration (BV) required an availability rate of virtually 100 % and a maximum outage time of less than 3 hours in a given 3-year period (a severe constraint requiring ring-shaped network back-up).

- In relation to its subsidiary "Télécom Développement" the SNCF will undertake a commitment only with regard to the following MTTR:

=< 6 hours for transmission equipment,

=< 18 hours for cables (a reasonable objective for a 36-fibre cable, far more difficult to attain for 144-fibre cables).

- The SNCF is committed to the following availability levels for the radiocommunications operator, SFR:

99.95 % for redundant circuits,

99.0 % for non redundant circuits.

- The most common type of redundancy is a ring-shaped structure. This consists of linking both ends of a transmission medium (in the broadest sense of the term) which means that it is possible to have access to transmission equipment via two different transmission links.

Back-up of this nature is not without cost and may require duplication of all transmission media, namely duplication of cables. Because of the cost, it is often necessary to proceed in two stages, with the back-up only being provided if the availability targets are made more stringent (cf. for example [1]).

By way of illustration, the block diagram in Figure 2 shows:

- a loop between the end D of the 2 Mbit/s circuit and input B on the following SDH equipment forms a ring-shaped structure (apart from the common failure modes of the cable).

- the link between D and A of the 2 Mbit/s circuit by means of a pair of additional fibres offers partial protection for this circuit (for all failures in the transmission equipment as such, with the exception of the common failure modes of the cable).

In conclusion:

- Telecommunications network back-up has to be a compromise between quality of service and financial considerations.
- The possibility of using redundant techniques for part of the network and moving gradually from non redundant to redundant circuits should not be rejected out of hand.

1.3.2.3 Flexibility.

- Telecom networks should be capable of expansion.

. One important criteria therefore in judging network architecture is its flexibility, in other words its ability to evolve rapidly over time and at the lowest possible cost to adapt to demand.

It is necessary therefore:

- to be able to move gradually from a 30-channel drop-and-insert PCM-only architecture to an SDH architecture. This is in line with the recommendations of [1] and [6].

- for the internal structure of digital transmission equipment to be modular to cater to increases in transmission capacity by simply adding other basic modules and parameter adjustments.

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1.3.3 Technical specifications.

These consist of:

- Mandatory specifications marked with (M) (Mandatory),
- Recommendatory specifications (R),
- Informatory specifications (I).

When it comes to telecommunications, it generally makes sense to follow the recommendations published by the telecommunications standardisation unit of the International Telecommunications Union (ITU-T) (M).

1.3.3.1. Signalling telecommunications.

1.3.3.1.1. The context is set out in § 1.2.1. **(I)**

1.3.3.1.2. One particular problem is that of theft of the copper used in signalling and telecommunications installations.

Should this be replaced by the same or should a new system be adopted perhaps even in a new railway operating context ?

One example:

- should track circuits and copper cables be replaced with the same ?
- or should a new block spacing system be used based on the use of optical fibre transmission, following rationalisation of railway installations - closure of a railway location: station, etc. ?

This is a technical and economic problem which goes far beyond the mere issue of technical specifications. A few examples may however be helpful:

1. For its new lines, the SNCF uses automatic block with short block sections but no wayside colour-light signals as a basis for TVM 300 and TVM 430-type ground-to-train transmission. This block system uses coded track circuits.

Two separate cables are employed:

- the first is a copper cable which serves to pass signalling data (status of track circuits, etc.) back to lineside equipment centres.

This solution is still the most economical today, in particular as regards its interfaces with signalling equipment and cable branches.

- The second cable is an optical fibre cable and is used to transmit:
  - signalling information between lineside signalling facilities, located every 12 km at the minimum).
  - railway operation telecommunications circuits,
  - telecommunications circuits used for applications,
  - other available telecommunication circuits which may be leased or may belong to telecommunications operators.

2. The Swedish Rail Administration (BV)(Banverket) envisaged the possibility in as early as 1991 of transmitting block information using optical fibres. Cf. bibliographical reference [7] in which 2 fibres are dedicated to this function.

The technique is now used for double track automatic block. By contrast, for single track lines, the transmission medium used for signalling is still the copper cable.

BV considers that copper cables remain the most economical solution for transmitting small volumes of data over short distances (typically the case with signalling installations in station areas and with short block spacing systems) and that optical fibres are the most cost-effective answer for major data flows over longer distances.

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3. The Danish Rail Administration (Banestyrelsen) uses a block system for train spacing based entirely on optical fibre transmissions (cf. bibliographical reference [12]).

A transmission system transmits data between the various sites using a dedicated pair of optical fibres. The bit rate is 2 Mbit/s. Interfaces are in compliance with ITU standard G 703/704.)

In addition to the headway function, the link acts as a host for 4 telephone channels available on each of the sites concerned. These telephone channels can be connected to a central PABX.

4. In a conversation with CIE-Consult concerning bibliographical reference [4], mention was made of the possibility of using a track circuit, not just to perform the standard function of detecting vehicle presence but also to ensure low speed transmission through the rails.

This is an interesting idea but it raises the problem of electrical separation joints and detection of broken rails. If this latter function is not required, track circuits may have greater scope, but:

- transmission power has to be increased (copper is needed for this),
- there is the risk of crosstalk between consecutive blocks (alternating A-B frequencies). An adequate buffer has to be provided and very carefully designed electrical joints.

N.B.: some countries do not require the broken rail detection function. In such cases, if the first break is not detected, a second break may result in a loss of transmission between the two breaks if track circuits are used. This constitutes a wrongside failure.

Another idea is to use pulse coded circuits rather than frequency circuits. These have a broader range but also have their limitations:

- because of their transmission power,
- because of the greater attenuation of the direct wave than of the backward wave, which places limitations on the discriminator.

The idea suggested by CIE-Consult will not subsequently be considered in that it falls outside the scope of the telecommunications study.

5. CIE-Consult also pointed out that from a cost angle, there would be a threshold at about 20 km, below which track circuits would be more advantageous and beyond which axle counters would have the edge. This threshold could be higher, however, for track circuits of Russian manufacture which are cheaper and less sophisticated.

In conclusion:

1.3.3.1.2.1. Transmission of signalling telecommunications must be fail-safe. **(M)**

The corresponding proof of safety shall apply to the whole of the signalling system: transmitter, transmission, receiver. **(M)**

1.3.3.1.2.2. For transmission of small volumes of signalling information over short distances, copper cables are the preferred solution **(R)**

1.3.3.1.2.3. Consideration should, however, be given to a block system based on optical fibre transmission which could prove an interesting alternative. **(R)**

1.3.3.1.2.4. For the transmission of large volumes of data over longer distances, the preferred transmission medium is optical fibre cables. **(R)**

General recommendations and methodology

1.3.3.1.2.5. The choice of transmission medium for signalling data depends on the cost of signalling and telecommunications equipment, equipment performance standards, their age, state of wear and tear and the risk of vandalism **(I)**

1.3.3.1.2.6. In cases where railway installations - and more particularly the block signalling system - are to be thoroughly overhauled, it is better to opt for interlocking signalling block sections (short-section automatic colour-light block system (ACLB), long-section partly permissive automatic block (PPAB), manual blocks per turnout or interlocked blocks).

Use of the manual telephone block should be the exception (lightly trafficked lines or downgraded operation of other types of block system). **(R)**

1.3.3.2. Railway operating telecommunications.

1.3.3.2.1 As explained in 1.2.2.1., some services used for railway operating telecommunications purposes may impose major constraints which require a solution based on the choice of copper transmission cables.

Discussions with operators are therefore essential to reach an "operating requirements - technical solution -cost" compromise. **(M)**

1.3.3.3. Transmission cables

This section deals exclusively with terrestrial cables. Underwater cables are discussed in another specific chapter.

1.3.3.3.1. Choice of prime contractor

1.3.3.3.1.1 The contractor selected must have excellent references for the manufacture, laying and connection of transmission cables in a railway environment. **(M)**

1.3.3.3.2 Type of cable.

1.3.3.3.2.1. Transmission using optical fibre cables is a speciality in itself. Detailed specifications for an optical fibre cable should contain a large number of parameters. It is worth consulting bibliographical reference [8] on this point. It is therefore a matter for professionals.

A minimum of requirements should however be set out. These are dealt with the following paragraphs. **(I)**

1.3.3.3.2.2. Leaving out the specific case of signalling telecommunications described in 1.3.3.1 and railway operating telecommunications described in 1.3.3.2, the obvious and imperative choice is optical fibre transmission cables. **(M)**

1.3.3.3.2.3. Optical fibres shall be of the single-mode variety and be capable of being set for transmission frequencies of 1,300 nm and 1,550 nm these being the frequencies most commonly used by industry. **(M)**

Conformity shall be sought with the ITU-T recommendation G 652 "Characteristics of a single-mode fibre cable" **(M)**

It is advocated that a WDM cable be used in so far as is possible.

1.3.3.3.2.4 The **type of cable** chosen will depend on the following constraints:

- railway line characteristics (topography, geology),
- the type of electrification used on the line (d.c. or a.c.), if relevant.
- weather conditions if the cable is not buried in the ground (range of temperatures, rainfall and humidity, maximum wind speeds),
- particularly environmental conditions if the cable is not buried (salty atmosphere, chemical pollution),
- the volume of information to be transmitted,

- the telecommunications services needed,
- the cable-laying technique.

There is therefore no one single solution.
The prime contractor must be obliged to justify the type of cable he chooses in relation to the above-mentioned factors. **(M)**

- ability to withstand high crush loads in accordance with the IEC-794-E3 standard,
- ability to withstand load voltages in accordance with the IEC-794-E1 standard
- operating temperature range of -30 to +70°C (storage at -40 to +70°C, installation between - 10 et +50°C),
- sufficient strength for laying in an environment as harsh as that of an embankment,
- adequate strength to withstand vibrations,
- suitability for the requisite laying technique,
- if necessary, bearing a marking on the outside to identify it and distinguish it from the other cables,
- completely dielectric under a d.c. electrified line (case of many lines on the Transcaucasian and Central Asian networks electrified to 3,000 V=),
- longitudinal impermeability.

All these features carry a mandatory weighting. **(M)**

1.3.3.3.2.5. In general, it is recommended that manufacturers' standard cables be selected. **(R)**

1.3.3.3.2.6. Fibre attenuation measured by means of a calibrated light source (laser) and a meter for measuring the power between the fibre contacts, including losses at the connector, shall not exceed:

- for a wave length of 1,550 nm:
    - 0.25 dB/km over long distances,
    - 0.30 dB/km over short distances,
- for a wave length of 1,300 nm:
    - 0.45 dB/km over long distances,
    - 0.45 dB/km over short distances. **(M)**

1.3.3.3.3 Cable laying.

1.3.3.3.3.1 Cabling is not just a matter of purchasing a cable and laying it as such. It is an operation which must be viewed as a whole and shall include the following phases. **(M)** :

- staking out (showing exactly where the cable is to go),
- supplies (cable and accessories),
- civil engineering,
- cable laying as such,
- connection.

Price quotations shall cover all these items. **(M)**

In the rest of this text, the word "laying" is used in the broadest sense of the term and covers all the above-mentioned aspects.

1.3.3.3.3.2 Cables may be installed in 4 different ways.

1.3.3.3.3.2.1 <u>Aerial cable under d.c. electrified line</u> (for example 3,000 V =) (<u>type A</u>).
The cable shall be dielectric. **(M)**
It is advisable for the cable to be protected as far as possible, for example against gun shots. **(R)**
The cable may be laid without de-energising the overhead contact line. **(I)**
This type of cable is vulnerable to wind and ice. **(I)**

1.3.3.3.3.2.2. <u>Aerial cable under a.c. electrified line</u> (25,000 V, 50 Hz) (<u>type B</u>).
The cable may also have a steel wire for tensioning purposes. **(I)**
It is advisable for the cable to be protected as far as possible, for example against gun shots. **(R)**

General recommendations and methodology

To lay the cable, power to the overhead line shall be cut off. As a result, the cost of installing the cable varies considerably, depending for the most part on the duration of the power cut. **(M)**
This type of cable is without a doubt vulnerable to wind and ice. **(I)**

1.3.3.3.3.2.3. <u>Cable laid in duct</u> (<u>type C</u>).
The problem of rodents must be borne in mind. **(M)**

1.3.3.3.3.2.4. <u>Buried cable</u> (<u>type D</u>).

For a longer life span (some 50 years), cable shall be buried 50 - 60 cm underground in temperate climates. A depth of 70 - 100 cm may be necessary in Nordic countries. **(M)**
This guarantees stability of performance. **(I)**
It should be possible for the cable to be buried directly in the soil.
The problem of rodents shall be borne in mind. **(M)**
In addition, the new cable shall be laid at least 30 cm away from existing cables **(M)**
A better solution is to lay the cable <u>in the soil in a tube</u> (for example a 27/33 tube for a 16.5 mm cable). **(R)**
By using self-lubricating tubes combined with suction it is possible to achieve service ranges of 2 x 2,400 m or as much as 9,600 m in future. **(R)**

1.3.3.3.3.3. <u>Choice of laying technique</u>.
- Railways have always preferred underground to aerial cables. **(I)**
Better reliability is achieved in this way **(I)** :

- absence of potential problems due to wind, ice, gun shots,
- less risks from civil engineering works,
- none of the potential risks of falling trees.

Conversely, there is the problem of rodents that shall be borne in mind. **(M)**
Cables have a longer life span as a result. **(I)**
As one of the speakers at the TRACECA seminar in Warsaw said **(I)** :
"a happy fibre is a cold dry fibre,
an unhappy fibre is a hot damp fibre"
- Increasingly however railways and telecommunications operators are prepared to take the risk of laying aerial optical fibre cables. **(I)**

In conclusion:

- **It is recommended that cables be buried wherever this is cost-effective.** Cost-effectiveness should be judged on the basis of paragraph 1.3.3.3.3.1 . **(R)**
- For crossing stations, it is better for cables to be buried or laid in ducts. **(R)**
- It is likely that the best solution may be a combination of the different laying techniques. Aerial cables would be best used in the open track and buried or ducted cables in station areas, on bridges, in tunnels, etc. **(I)**

1.3.3.3.3.4. Some 3 to 5 m of extra cable should be provided at all points to be served (now or later). These spare cable lengths should be left as a loop with a radius of at least 15 times the cable diameter (or other value to be specified by the manufacturer)

This shall also be done at specific points such as bridges, tunnels, transmission amplification points, maintenance points, etc. **(M)**

1.3.3.3.3.5. In general, cables are delivered on drums and are several km long.
Cable ends are then joined by splicing.
Splice attenuation must not exceed:

- 0.08 dB on average,
- 0.15 dB maximum. **(M)**

1.3.3.3.3.6. Price quotations shall cover the equipment needed to weld the fibres and the reflectometers to check the standard of the splice and pinpoint the source of any incident.

(M)

1.3.3.3.4 Cable connections.

1.3.3.3.4.1. As far as possible, user needs should include details of all places where transmission equipment is to be connected up to the cable. It is strongly recommended that cables be provided with drop-and-inserts at the time of laying rather than having to provide expensive connections later.
This should, in particular, be done in all stations designated by operators, even if the actual connection is not immediately required. **(R)**

1.3.3.3.4.2. A block diagram of a drop-and-insert arrangement is shown in Figure F3. The following remarks apply:

- It is better to group together the cable as a whole at the end of the optical cable in the station so that welds may be made before the cable end (Figure 3A), rather than at the junction box (Figure 3B). **(R)**
- When the connection is not immediately required, an optical connector should be fitted in accordance with Figure 3C. **(R)**

- In general, at the junction point, all the fibres of the cable in the same tube should be cut and those not used should be welded to the junction point. Cable tubes not concerned are not to be cut. **(I)**

1.3.3.3.5. Cable capacity.

1.3.3.3.5.1. This point is of paramount importance for the project, given that:

- it has enormous impact on the financial cost of the project,
- it reflects the strategy of the railway company in relation to its telecommunications requirements,
- it reflects the position of the project in relation to public and/or private telecom operators.

1.3.3.3.5.2. Various cable capacity examples could be given **(I)**:

- Bibliographical reference [5] proposes a cable with 12 optical fibres (o.f.) for the TRACECA project.
- The BV network (bibliographical reference [7]) has 24 optical fibres per cable.
- The Polish railways' telecom network (PKP) uses cables with 12 to 18 optical fibres (bibliographical reference [9]).
- Developments as regards the number of optical fibres in the transmission cables used by SNCF on its new lines (LN) are particularly revealing:
  - ON LN3 (Paris - Lille - Channel Tunnel portal - Belgian border) 8 o.f. were used (including 4 for drop-and-insert PCMs in each railway location, 2 for the intermediate 8 Mbit/s PDH and 2 for the 140 Mbit/s PDH). If the LN3 transmission network were to be designed from scratch today, there would be no intermediate 8 Mbit/s PDH and the 140 Mbit/s PDH would be replaced by a 155 Mbit/s STM1 SDH, i.e. a total of 6 o.f..

  - On LN5 currently under construction (Valence - Marseilles - Montpellier), two transmission cables are planned:
  - The first, a buried 36 o.f. cable, in which:
    - 12 fibres are for SNCF i.e.:
      - 6 o.f. for basic needs (as for LN3 if the decision were made today, it would be an SDH backbone network) plus 6 fibres in reserve:
        - 2 for the radio frequency/optical fibre (RF/OF) interfaces needed for the ground-to-train radio,
        - 2 for the future UIC cellular, digital, multiservice interoperable radio (still referred to as the railway GSM or GSM-R),
        - 2 o.f. in reserve.
    - 24 fibres for the needs of the SNCF "Télécoms Développement" subsidiary and CEGETEL.
  - The second cable is an aerial cable. It is in fact an Optical Aerial Protection Cable (CDPAO) and is used for earthing signalling, telecommunications and energy equipment. The cable has a steel core (electrification = 25,000 V - 50 Hz type). The

"telecommunications capacity" of this cable is 72 o.f., all for use by the subsidiary, "Télécoms Développement".

From these various examples a number of conclusions and the following recommendations may be drawn :

- a minimum of 12 fibres are necessary for the telecommunications requirements of railway companies, **(R)**
- a minimum of 12 further fibres are desirable to allow for sale of transmission capacity and added value service or for associations with public or private telecom operators, i.e. a total of **24 fibres**. This may be considered the preferred solution. **(R)**
- In the event of prospects for very close cooperation - financial in particular - with one or more public or private telecom operators, an additional 12 or 24 fibres - if not more - may be requested by the operators, i.e. a total of 36 to 48 fibres. **(R)**

1.3.3.4. Telecommunications network.

1.3.3.4.1. Digital transmission equipment.

1.3.3.4.1.1. A deliberate choice shall be made to adopt digital technology. **(M)**

1.3.3.4.1.2. The new telecom network shall be able to be built up progressively.
As far as possible, old analog transmission circuits should be able to be connected up to the new digital transmission equipment. **(M)**
This may require the use of telephone signal adapters.

1.3.3.4.1.3. The architecture proposed in Figure 2 is recommended.
It consists of an SDH 155 Mbit/s (STM1) backbone network supporting a PDH 2 Mbit/s network. **(R)**

If necessary, manufacturers may install PDH networks with a capacity of more than 2 Mbit/s **(R)**

1.3.3.4.1.4. In general, the standards and recommendations of the ITU-T, CCITT and ETSI (European Telecommunications Standards Institute) shall be applied. **(M)**

1.3.3.4.1.5. Some railway lines may be equipped with 2 Mbit/s PDH without immediately being connected up to the SDH equipment.
It shall be possible to migrate later from PDH to SDH, in accordance with the principle illustrated in Figure 4. **(M)**

1.3.3.4.1.6. One important factor is the range of digital equipment.
- At present, the maximum transmission distance without repeaters is approximately 200 km, which still needs a power booster. **(I)**
- In practice it is imperative to be able accurately to detect the position of a broken fibre by means of a reflectometer (N.B.: reflectometer accuracy diminishes with distance), whence the need for intermediary cutoff points. **(M)**
- A normal distance between consecutive PDH equipment is some 50 - 70 km, depending on the wave length used. **(R)**
- A normal distance between SDH equipment is some 70 - 100 km, depending on the wave length used. **(R)**
- The prime contractor shall indicate the attenuation (power budget) he guarantees (in accordance with recommendation G. 957 of ITU-T). **(M)**
By way of example, typical values are in the 25 to 30 dB range. **(I)**

1.3.3.4.2. Quality of service.

Quality of service shall be quantified on the basis of the ITU-T recommendation with the reference G.826:
"Error performance parameters and objectives for international constant bit rate digital paths at or above the primary rate" **(M)**

General recommendations and methodology

1.3.3.4.3. Network security.

1.3.3.4.3.1. Telecom network back-up is a compromise between quality of service objectives and financial constraints. **(I)**

1.3.3.4.3.2. It is recommended that telecom services and equipment be classified in relation to the required level of back-up, i.e.:

- no redundancy,
- partial redundancy,
- full redundancy. **(R)**

1.3.3.4.3.3. As far as possible, redundancy should be avoided or partial redundancy selected. **(R)**

1.3.3.4.3.4. When full circuit redundancy is required, rather than duplicating cables systematically, there should be no hesitation about using back-up circuits, or even replacement services provided by public or private operators. **(R)**

1.3.3.4.4. Network management.

1.3.3.4.4.1. Telecom networks need to be monitored from a central point. The telecom network provided by the prime contractor must have a Network Management System. **(M)**

1.3.3.4.4.2. The functions to be performed by the management system are set out in bibliographical reference [2].

They relate to:

- network management as such i.e.:
  - performance measurement:
    - traffic on the network,
    - quality of service indicators,
  - failure management:
    - network disruptions,
    - network failures,
    - errors in the network,
  - network security (activation of redundancy back-ups),
- network configuration management:
  - for equipment and when in and out of service,
  - as regards the parameters set for the equipment,
- charging for services.

All these functions shall be provided. **(M)**

1.3.3.4.4.3. The management system is usually a proprietary system.

For the most part, telecom systems to date have developed independently and a variety of different networks co-exist, each with or without their own management systems.

This is better than having no management system at all but it does make finding failure harder especially when several networks are affected at the same time (common failure modes).

Moreover, there must be two different managers: one for the backbone network (STMi), the other for the local networks. **(M)**

It is therefore recommended that a measure of integration be sought, namely through the use of Q type standard interfaces. As an example a Q3-type operating interface is recommended in bibliographical reference [10]. **(R)**

The prime contractor shall supply a detailed description of the management interface used. **(M)**

It should be remembered that an interface depends entirely on:

- its mechanical connections,
- the electric signals exchanged,
- the telegrams interchanged,
- the protocols used. **(I)**

Operating system software is proprietary. In the long term, it is advisable to use a QX interface enabling networks from a variety of manufacturers to be managed from a central supervisory point. **(R)**

1.3.3.4.4.4. Where network management is concerned, the pitfall of over-centralisation should be avoided at all costs. What is important at national level is not exactly the same as what is important at regional level. For large railway networks, it is therefore recommended to have not just a national network management centre with all the above-mentioned functions but also to have several simpler regional centres. **(R)**

1.3.3.4.4.5. Bibliographical reference [10] contains an example of a network management centre. **(I)**

1.3.3.4.5. Network synchronisation.

1.3.3.4.5.1. PDH and SDH type synchronous transmission requires a timer synchronisation function. **(I)**

1.3.3.4.5.2 The prime contractor shall provide full details of the different synchronisation mechanisms used in his network (PDH and SDH levels): timer, GPS, etc. **(M)**

1.3.3.4.5.3. The prime contractor shall propose a solution for the synchronisation of his SDH and PDH network with a SDH and PDH network supplied by another contractor. **(M)**

1.3.3.5. Dedicated or integrated telecommunications networks?

1.3.3.5.1. **(I)** This chapter has been drawn up in relation to a particular typology of functions to be performed. A distinction has therefore been made between: signalling telecommunications, railway operating telecommunications and application telecommunications.

Other typologies are possible, for example the one set out in bibliographical reference [2], viz:

- long distance operational telephone installations,
- switched telephone network,
- data transmission network,
- radiocommunications,
- information and public address installations.

1.3.3.5.2. **(I)** Whatever the typology selected, developments over the years have led to dedicated systems each evolving along separate lines.

In the future, the trend is bound to be towards network and service integration but this can only be achieved gradually.

The TRACECA project is an ideal opportunity to branch out in this direction.

This is clearly the case for the physical transmission medium and the digital transmission equipment which may be the same throughout, except for part of the signalling telecommunications equipment which need further consideration.

It is less obvious in the case of services hosted using the transmission network. Services connected with train movements are not the same as voice and data application services which are very similar or even identical to the services offered on public or private telecom operator networks.

Bibliographical reference [2] lists the differences between railway networks and public networks, i.e.:

- public networks typically have a star-shaped or meshed structure, and have point-to-point links, no concentration/distribution function, no broadcast mode and small nodes,
- railways have typically linear, meshed ring-shaped structures, with multiple point-to-point links,. a concentration/distribution function, broadcast mode and small nodes

Under these conditions, is it better to group all the installations together (for example, using the same switch for the switched telephone network and station or control centre railway telephony)?

It is recommended that this aspect be left open in invitations to tender and to leave it to the manufacturers to prove that they can offer all the services needed. **(R)**

1.3.3.5.3. Whatever the answer given to the above question, it is necessary for the railway telecommunications operator console to incorporate all the requisite services shown in section 1.2.2.1. as well as access to data transmission services. **(M)**

Products of this type are available on the market, cf. bibliographical reference [13]. **(I)**

1.3.3.5.4. Mention has been made on several occasions of the need for a smooth transition from old to new systems.

If this is not possible, the manufacturer must indicate the extra costs of having to replace the old systems. **(M)**

1.3.3.6. Power supply sources

1.3.3.6.1. Power supply is an integral part of the telecommunications network. **(I)**

1.3.3.6.2. The project developer shall indicate the primary source of energy provided for the prime contractor. **(M)**

1.3.3.6.3. The prime contractor must provide the secondary power supply to be used directly for the telecommunications network. **(M)**

1.3.3.6.4. The project developer shall specify the length of time for which the secondary supply is to be capable of running independently. **(M)**

1.3.3.6.5. The prime contractor must take all necessary steps to protect against power supply cuts and overvoltages in the primary power supply. **(M)**

1.3.3.6.6. It is accepted that elements of the telecommunications network may block in the event of overvoltages in the primary power supply or if capacity of the secondary supply is exceeded. **(M)**

1.3.3.6.7. Telecommunications installations shall restart automatically when the primary supply returns to its nominal level. **(M)**

1.3.3.6.8. Should the project developer fail to specify the primary power supply, the prime contractor must state the precise conditions under which the secondary power supply operates under nominal conditions, when blocked and for restart after blockage. He must also indicate the capacity of the secondary power supply system. **(M)**

General recommendations and methodology

1.3.3.6.9. A major factor is the loading on the power supply system. This factor is crucial to the reliability of the power supply system.

In this connection, it is recommended that the power supply operate to less than 50% of its nominal capacity (30 % is recommended for power components). **(R)**

1.3.3.7. Underwater cables

1.3.3.7.1. The TRACECA project contains sea sections: Black and Caspian Seas.
According to recent information, underwater cables should shortly be placed in service in the Black Sea between Poti and Varna (in 1998) and between Poti and Odessa (in 1999).
The link between Azerbaijan and Turkmenistan via the Caspian Sea, on the other hand, seems to have ground to a halt. **(I)**

1.3.3.7.2. Laying cables just for the TRACECA project cannot be justified. **(I)**

1.3.3.7.3. It is recommended, by contrast, that the use of underwater cables be given closer consideration for the following points:

- use of voice and data transmission for international railway applications (freight, wagon fleet management etc.),
- security of the transmission networks.

Underwater cables may in fact prove a financially viable option. **(R)**

1.3.3.8. Satellites

1.3.3.8.1. Obviously one or several satellites reserved for the TRACECA project alone could never be justified. **(I)**

1.3.3.8.2. Conversely, it is recommended that more thorough consideration be given to use of satellites for the following:

- use of voice and data transmission for international railway applications connected with trains and wagons (wagon fleet management, customer information etc.),
- transmission network redundancy,
- train location, or wagon location using the GPS tracking system plus data transmission via, for example the NAVSTAR satellite. Such services could be of interest to railways and their freight customers. **(R)**

Bibliographical reference [14] provides an illustration of these points.

1.3.3.9. Radiocommunications

1.3.3.9.1. Radiocommunications are at present in extensive use on the railways (cf. telecom and IT inventories in this report: ground-to-train radio, shunting radio, voice and data transmission via the HF radiocommunications system known as Codan). **(I)**

1.3.3.9.2. Radiocommunications frequently offer an interesting alternative to wired solutions:

- they offer a wide range of voice and data transmission services,
- they offer an adequate quality of service although not as good as a wired network (bit error rate in the region of 10^{-5} or better in the case of carefully designed radio coverage, as against error rates in the region of 10^{-10} to 10^{-12} or better with wired networks),
- they spare or reduce the extent of the wired network,
- they are easy to apply,
- they are often highly competitive in terms of price (in any calculation, account should be taken not just of investment costs but also of all other costs for use, maintenance, licences, etc.).

By contrast, the use of radiocommunications is as a rule subject to regulation, both as regards frequency allocation in the radioelectric spectrum and the approval of radioelectric equipment. This regulations are national although use of the radioelectric spectrum and definition of radiocommunications systems are coordinated and standardised at supranational level (Europe and world).**(I)**

1.3.3.9.3. Radiocommunications are an alternative that should be considered as a rapid solution to short and very short-term problems where only low data transmission rates are required. **(R)**

General recommendations and methodology

1.3.3.9.4. In the past the UIC standardised the ground-to-train radio system for voice communications between stations, control centres, drivers and track maintenance personnel. The system is an analog system operating in the 450-460 Mhz band. It may also to some extent be used for data transmission. The corresponding leaflet still applies (cf. bibliographical reference [15]).
Whilst waiting for the emergence of GSM-R (see below), this solution is still interesting. In particular it is more efficient than the present HF ground-to-train radio system in use in TRACECA countries. **(I)**

1.3.3.9.5. The UIC is currently working on standards for a digital, cellular, multiservice radiocommunications system - theoretically grouping together all the radiocommunications services at present in use in Europe on the railways. This future system is the GSM-Railways, called by this name because it is based on the GSM standard (extended to include additional services currently being standardised). It operates in the 900 Mhz band and should be available in the next 2 to 3 years.
It will then become mandatory for the European Union for reasons connected with interoperability.
It is therefore recommended that extra optical fibres already be set aside for the ground network of this system (cf. § 1.3.3.3.5. "Cable capacity"). **(R)**

1.3.3.9.6. Radiocommunications are a booming sector, in particular in the wake of efforts to obtain better use of the spectrum.
This explains why some people support other types of radiocommunication system such as:

- trunked radio networks (3RP) and the future TETRA standard which is to be derived from these (cf. bibliographical reference [2]). These networks are particularly well suited to station areas and direct mode (direct link between a radioelectric transmitter and receiver without onward relay),
- spread spectrum radio networks (CDMA) are particularly suitable for radioelectric propagation in difficult environments (for example remote control of leading and trailing locomotives in heavy-haul trains).

In theory all this should converge on a single universal standard called UMTS (Universal Mobile Telecommunication System) in the first decade of the next millennium. **(I)**

1.3.3.9.7. HF radiocommunication is not used by the railway enterprises of the European Union. By contrast it is widely used in TRACECA countries for train radios.

It is also used occasionally by the railways with the CODAN system, donated by the "World Food Program" to railway companies in Caucasian countries.
Propagation with this system is harder to control than with the VHF and especially UHF bands which are the preferred choice of railways in the European Union at the moment. Conversely, the range of this system is extensive, which may make it of interest in the case of seas or in very scarcely populated areas (with very few railway installations by definition).
In such cases, HF radio should not be summarily dismissed and more thorough studies should be carried out into the various possible technical solutions, in relation to actual needs and cost criteria. **(I)**

1.3.3.9.8. More specifically where the Codan HF radiocommunications system mentioned in the IT inventory part of this report is concerned, this could rapidly be used for exchanging data on trains worked across borders, thus compensating for the poor quality of the present cable networks. This should be considered as a very short-term solution. **(R)**

1.3.3.10 Environment

1.3.3.10.1 **(I)**
There are two approaches to dealing with environmental considerations:
- The environment is defined by its most extreme climatic, mechanical, electromechanical, electrostatic and physico-chemical constraints, which telecommunications network equipment must then withstand.
- The telecommunications network is composed of standard manufacturer's models, with no alterations whatsoever.

In this case, if external environmental constraints are tougher than those met by the manufacturer, the corresponding products must be isolated from the external environment and placed in:

- air-conditioned room
- ventilated, heated cabinets
- protective and earthing equipment
- etc.

Transmission and connecting cables fall into the former category, while as a rule, digital transmission devices, switching installations (telecom switches and railway operating telephone equipment) and power-supply sources come under the latter category.

1.3.3.10.2 **(I)**
The environmental constraints to be borne in mind are:

- climatic:
  - -- temperature,
  - -- rainfall,
  - -- wind,
  - -- ice, etc.
- mechanical:
  - -- vibrations,
  - -- impacts,
- electromagnetic:
  - -- electromagnetic compatibility (EMC)
  - -- high altitude nuclear electromagnetic pulses (HEMP),
- electrostatic,
- physico-chemical:
  - -- corrosion,
  - -- contact potentials, etc.

1.3.3.10.3 **(M)**
Transmission cables must comply with the environmental constraints listed in paragraph 1.3.3.3.2.4, Chapter 4.

1.3.3.10.4 (M)
Equipment (transmission cables and installations) must be properly protected and earthed.

1.3.3.10.5 (M)
Staff must be properly protected against:

- temperature extremes,
- electromagnetic radiation,
- electric discharges,
- laser-generated light rays.

1.3.3.11 Maintenance

1.3.3.11.1 Network maintenance shall be organised in accordance with the recommendations of series M of the ITU-T. **(M)**

1.4 Cost factors

1.4.1 General.

1.4.1.1. The cost factors referred to below are examples only.

1.4.1.2. The utmost caution should be exercised in relation to prices. In general prices can vary greatly for many reasons :

- assessment of customer requirements,
- technological progress,
- product/system study and manufacture costs,
- product and system installation costs,
- transport costs,
- labour costs,
- risk evaluation,
- corporate strategy.

Ultimately, prices can only be gauged well by calling for tenders (and carrying out the related negotiations).
Nonetheless, the approximate prices involved in a project do need to be correctly estimated, despite the difficulties involved in such an exercise.
Hence this section has been compiled.

1.4.2 Optical fibre cable.

1.4.2.0. Although copper cables are not considered in this study, it is helpful to have a reference price for that cable type.

MD4 is a copper wire type, with a 15 to 20 km range, widely used by SNCF.
For information, the cost of a 7-quad MD4 is some **15632 Ecus**, laying and supplies included.

1.4.2.1. The cost of cable does not stop at the procurement cost. It includes all items from supplies through to provision of the cable ready for use, i.e.:
- supplies,
- staking out and connecting,
- civil engineering and laying (including labour).

1.4.2.2. Experience show that substantial variation in investment costs is to be expected.

1.4.2.3. The following table gives the percentages for the various items listed above for the various types of solution described in section "1.3.3.3.3 Cable laying", i.e.:
solution A: aerial cable under d.c. OHL (e.g. 3000 V=),
solution B: aerial cable under a.c. OHL (25000 V, 50 Hz),
solution C: cable laid in duct,
solution D: buried cable.

Solution	A	B	C	D
Staking out and connecting	25 %	25 %	15 %	20 %
Supplies	30 %	30-40 %	15 %	20 %
Civil engineering and laying (including labour)	25-45 %	25-45 %	70 %	60 %

N.B.: Solution D is based on 50% buried cable and 50% cable laid in ducts. In reality, a cable is never totally buried: it is run through ducts in buildings, and on structures, etc.

Solutions A, B, C and D correspond thus to the following price ranges:
- solution A : 11825 - 19892 Ecu / km
- solution B : 11825 - 22092 Ecu / km
- solution C : 22092 - 29517 Ecu / km
- solution D : 14758 - 22092 Ecu / km

First of all it should be noted that the various solutions overlap. The overlap and variability are due to geology, railway line access, the impact of work on rail traffic (cost of track possession), etc.

1.4.2.4. At the TRACECA seminar in Warsaw, K. Frak [9] gave a value of 18333 Ecu / km for buried cables with 12 to 18 optical fibres. This value tallies with section 1.4.2.3.

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1.4.2.5. In 1997, the operator Télécoms Développement laid 1800 km of buried fibre optic cable in France at a mean cost of 21212 Ecu / km. That figure also tallies with section 1.4.2.3.

1.4.2.6. It is interesting to compare the lower figure for solution A (i.e. 11825 Ecu / km) and the figures given in the bibliographical references [4], i.e.:

- 3208 Ecu / km for supply of a cable with 12 optical fibres,
- 916 Ecu / km for laying and installation,

thus a total cost of 4125 Ecu / km.

The high differential between the two values needs to be investigated.

It is possible that the second figure does not take account of items such as civil engineering and connecting or does not include labour costs.

1.4.2.7. Another interesting parameter is the incremental cost of the cable the greater the number of fibres.

The differential is approximately 50 % per additional group of 12 fibres, in other words a 10 to 15% differential for a complete cable-laying operation.

1.4.2.8. In light of the above, the rest of the study is based on the following preferential hypotheses:

- The capacity of the fibre optic cable (f.o.) has been determined as follows:
  -- 2 f.o. for the SDH,
  -- 2 f.o. for the distribution networks,
  -- 2 f.o. for border crossing and to handle other special cases,
  -- 2 f.o. partial network back-up,
  -- 2 f.o. reserved for the signalling applications,
  -- 2 f.o. reserved for ground to train radio applications,

Thus a total of 12 f.o. for railway requirements.

It is advantageous in economic terms to make provision for "dark" fibres for one or more telecommunications operators. Rentals of between 1.2 and 3 Ecus / m / year can be levied for those fibres.

The economics study already carried out takes account of that option.

It is proposed that 12 "dark" f.o. be reserved for telecommunications operators.

In other words a cable with an aggregate capacity of 24 optical fibres is proposed.

- Solution D: cable buried or laid in a duct at an average price of: **18636 Ecus / km**

In the following sections (4 and 5) the cost will be broken down into two parts:

- Costs covered by the European Union or by an EBRD loan:
  - Cable and supplies used in laying
  - Supervision of staking out
  - Cable connections
  - Transmission equipment
  - Energy supply
  - Spares
  - Training
- Costs covered by the railways
  - Staking out

- Civil engineering
- Laying

The sum involved has been estimated at ten times lower than the cost of the job in western Europe owing to the difference in labour costs.

1.4.3 Digital transmission equipment.

1.4.3.1. The average price of PCM 30-channel digital terminal equipment (DTE) is in the region of **11000 Ecu.**

1.4.3.2. The average price of SDH STM1 end multiplexers, standard version, is some **29333 Ecu.**
The prices vary from 22000 to 41250 Ecu for the basic (no back-up) and higher-level versions.

1.4.3.3. The mean price of SDH STM1 add-drop multiplexers, standard version, is in the region of **22000 Ecu.**

1.4.4 Network management.

- The SDH network management system costs **106060 Ecu**.

- The average cost of the distribution network management system is **15150 Ecu.**
(N.B.: a simplified version costs 7333 Ecu).

- Bibliographical reference [4] contains a price of **183333 Ecu.**

1.4.5 Switching equipment.

1.4.5.1. This covers switches in the conventional telephone switched network (STN) and telephone equipment for railway operations (see section 1.3.3.5. "Dedicated or integrated telecommunications networks?").

1.4.5.2. In the case of automatic telephone switches, as a rule of thumb a conventional subscriber's link (point to point only) is priced at **147 Ecu**, on the basis of 100 subscriber links minimum.

Below that figure, the fixed charge rises. Thus, for 50 subscriber links, the cost of the switch is in the region of 11733 Ecu.

In the case of the proposed PABX (see paragraph 2), it should be noted that the cost is **303 Kecus**, which breaks down as follows:

- Cost of the telecom switch itself, equipped for 1200 subscribers: **212.1 KEcus**
- Cost of the control room (complete environment, power supply and management system included):
90.9 KEcus.

1.4.5.3. The telephone equipment used for railway operations generally has less capacity. However it provides the various services described in section 1.2.2 "Telecommunications and Railway Operations".

A degree of variability is given by the number of station operators (signalman, traffic manager, etc.) and control offices (traffic controllers, etc.) linked up to the installation.

The following figures may serve as a guide:

- low capacity equipment (for example dedicated to new lines) (1 operator, up to 8 lines) :
7333 Ecu i.e. **917 Ecu/line**
- modest capacity equipment (1 to 2 operators, up to 30 lines) :
36850 Ecu i.e. **1228 Ecu/line**

- medium capacity equipment (1 to 4 operators, up to 60 lines) :
  56100 Ecu i.e. **935 Ecu/line**
- high capacity equipment (4 to 12 operators, over 100 lines) :
  125400 Ecu i.e. **1256 Ecu/line**

It is interesting to note that bibliography reference [4] gives a price of **45833 Ecu** per station (without specifying what is understood by the term station).

In this instance too, it is important to be very cautious in drawing comparisons (for example to establish whether digital transmission equipment - SDH or PDH - is included in the figures stated or not).

1.4.6 Power supply sources.

Three types of power supply are considered:
1.4.6.1 Power supply to a complete control room - in the case of a large centre including, for instance, the PABX, an STM1 and the control office installations. The make-up of such a control room is defined in the Methods part. The corresponding figure is: **90.9 KEcus** (see 1.4.5.2).

1.4.6.2 Medium capacity power supply - in the case of an STM1 grouping plus ADM plus medium capacity station control centre or indeed an ADM group providing control centre back-up. The figure for this is **10.9 KEcus.**

1.4.6.3 Modest capacity power supply - in the case of an ADM plus small station. The figure here is **2.3 KEcus**.

1.4.7 Satellites.

1.4.7.1. Various cost figures were quoted at the TRACECA seminar in Warsaw (bibliography reference [14]), i.e.:
- cost of a fixed station: **45833 Ecu** to **91667 Ecu,**
- cost of a mobile unit: **3677 Ecu** to **4583 Ecu,**
- cost of one minute of voice, fax and data transmission: **0.92 Ecu**
- cost of hiring a permanent 64 kbit/s duplex channel: **1833 Ecu / month**.

1.4.7.2. One of the speakers at the TRACECA seminar in Warsaw stated that a minute of communication with INMARSAT cost **3.7 to 5.5 Ecu.**

This also demonstrates a degree of variation in costs which needs to be investigated. It is definitely due in part to differences in subscription and pricing formulae in the sector.

1.4.8 Spares

1.4.8.1 Provision is made for spares equivalent to **10 %** of the investment in equipment.

1.4.9 Training

1.4.9.1 Training as described in the "Method" section requires an investment budget of **94.6 KEcu.**

1.4.10 Provision for contingencies

1.4.10.1 This sum is traditionally included in a preliminary project study as a contingency fund. It is calculated on the basis of the aggregate investment.

1.4.10.2 Currently the chosen percentage is **5 %** at SNCF (some years ago it was 10 %).
That value is also advocated by F.W. Krämer, in his report " TRACECA - Communication Network for the Caucasian Railways. Feasibility Study. (1/10/1997)" (bibliography reference 1 in the Progress Report).

1.4.11 Maintenance

- In western Europe, annual maintenance of installations is estimated at **4 %** of the total investment.
This cost includes all basic costs: personnel, measuring equipment, logistics, etc.

- Annual maintenance of the cable and the line (ducts, etc...) is estimated at **0.15 Ecu/m.**

2. Method and general technical options selected

The purpose of this section is to provide details of the method used to define the future network and assess the corresponding investment.

- The principles selected for telecom network architecture are set out in the following chapter on "block diagrams"

- The method adopted is based on the following concepts:

  - In the telecom architecture proposed considerable importance is attached to specific railway telecom services, in particular for railway operating purposes and ensuring the safety of rail vehicle movements.
  This requires a system of collection and distribution between the Control Centre, which is in charge of the regulation of traffic over one or several railway lines and the stations dotted along this (or these) line(s).
  It is therefore somewhat different to conventional telecom networks.

  - The approach adopted is exclusive to the railways.
  Network architecture may vary if the private operator of a telecom network, other than the railway, is involved.
  The proposal would then need to be adapted to take account of the strategy of this private operator.

  - The proposed modernisation of the telecom network is based on the use of optical fibre cables and digital transmission equipment.
  It is not recommended that additional copper cables be used, although this would be possible on an occasional basis for purposes of network harmony and maintenance.
  For the same reasons, it is not being suggested that new analog transmission equipment be added.
  N.B.:
    - It is important that a detailed check be made of the condition of existing copper cables and analog transmission equipment.
    - From an investment angle, it is highly desirable to keep those installations that are still in good working order.

  - In the study account is not taken of dedicated signalling cables, which are treated as local cables.
  2 optical fibres have however been set aside in the optical fibre cable for any necessary signalling applications.

  - Similarly the study does not take account of local telecommunications cables..

  - The proposed telecom network architecture conforms to ITU standard T G-803:
  "Architecture of transport networks based on synchronous digital hierarchy". (cf. section 3).

  - The study strategy finally selected is in two parts, i.e.:

    -- Establishment of a "backbone" network taking account of the points from which lines branch out and all the stations on this backbone,

    -- Completion of the whole network including the secondary lines.

  - The method may be broken down into the following successive stages:
    -- Installation of the SDH network,
    -- Installation of the distribution network,

-- Installation of the PABX,
-- Installation of telephone equipment at the control centre (PC) and in the stations,
-- Installation of the SDH network management system,
-- Installation of the management systems of the distribution networks,
-- Network synchronisation,
-- Network back-up,
-- Decision on spares requirements,
-- Calculation of training requirements.

- An **investment table** has been drawn up for each of the Caucasus countries on this basis (Georgia, Azerbaijan and Armenia) and for the following options:
-- Network without back-up,
-- Network with partial back-up.

In the following details are given of the method for each of the stages shown above.

2.1 Installation of the SDH network

- Here account is taken of:
-- the size of urban centres,
-- the size of railway junctions,
-- the position and size of existing switches,
-- the number of transmission channels per link,
-- the distance between SDH nodes,
-- the number of stations between SDH nodes.

- All SDH nodes and the physical links between them go to make up the "SDH backbone" or, by extension, the "backbone".

- Railway branch lines connecting to the main lines have been analysed separately.
Depending on the circumstances, it is possible either to:
-- set up an additional SDH node at the point where the branch joins the main line,
-- lay extra o.f. cable to serve a station close to the backbone and connect it to the nearest SDH node.

- SDH nodes are equipped with 155 Mbit/s throughput STM1.

2.2 Installation of distribution networks.

- These are essentially for links between the Control Centres and the railway locations directly involved in ensuring the safety of rail vehicle movements (stations, signal boxes, sub-stations, etc.).

- Links between SDH nodes are achieved by means of a drop-and-insert type PCM network.
- A distribution link should not serve more than 5 points to avoid immediate saturation (some 30% spare capacity should be kept free on commissioning).
- The number of links between SDH nodes will equal the number of stations served divided by 5 and rounded up to the nearest whole integer.

- Distribution nodes will have 2 Mbit/s add/drop multiplexers (ADM) on 2 or 8 Mbit/s transmission medium.

- If there is more than 1 link, use will be made of 2 Mbit/s ADM over a 8 Mbit/s transmission medium.
If there is one link only, 2 Mbit/s ADM will suffice.

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N.B.: given the flexibility of existing ADM equipment- easy transfer from a 2 Mbit/s ADM to a 2 Mbit/s ADM over a 8 Mbit/s transmission medium- and the minimal cost differentials between these types, it could be advisable to go for the same option throughout for maintenance reasons.

- As the SDH backbone stops at the national borders, services up to and across these borders are covered by a separate study.

- Since circuits start at the Control Centre (PC) controlling the stations, this centre needs to have as many ADM as there are links served.

2.3 Installation of PABX

- These switches are the crux of the Switched Telephone Network. They handle all communications **other** than those of the traffic control centres and railway establishments directly involved in ensuring the safety of rail vehicle movements.

N.B.: A distinction may be made between 3 types of switches:
- those only handling transit traffic with, on average some 4 or 5 bundles,
- those handling transit traffic and providing some limited local services,
- those handling transit traffic, limited local services and with possibilities for extension.

- It is proposed that a PABX be installed in each of the capital cities of the republics in the Caucasus and Central Asia.
The role of this switch will be:
- to handle communications between the republics in the Caucasus and Central Asia,
- to handle communications with Europe.
The switch will be a transit switch, also handling limited local traffic and with possibilities for extension.
This means that an extra hierarchical level is added to each of the national interconnected automatic networks.

Depending on requirements and the age of existing telecom switches, a master plan should be drafted outlining the deployment of new switches.

- **A PABX software module should be developed to adapt the signalling protocols and enable connection of the existing switches.**

2.4 Installation of telephone equipment at the control centre (PC) and in stations

- As already stated in § 1.2 "Installation of distribution networks", links between control centre and stations rely on a drop-and-insert PCM distribution network which houses the dedicated services required for railway operations.
In this respect, the distribution and concentration functions of the drop-and-insert PCM are used to a very large extent (cf. block diagrams).

- The distinctive feature of this equipment is its different levels of capacity for connecting telephone calls (high capacity for the control centre, medium for major stations, low for other stations).

2.5 Installation of the SDH network management system

- One SDH management system is to be installed per country.

2.6 Installation of the management systems of the distribution networks

- One or several management systems are to be installed for the distribution networks (with add/drop multiplexer equipment) per country (normally as many as there are local telecom control centres).

- The distribution network management system (ADM) is to be separate from the SDH network management system.

- At a later stage, the possibility of having a supervisor to combine management of the SDH network with that of the distribution networks may be envisaged.

2.7 Network synchronisation

- A network is to be set up to synchronise the SDH network to set the timer for the SDH nodes from a single atomic clock at network and SSU synchronisation unit level.
It is proposed that a GPS-type system be used as back-up for the network synchronisation system.

2.8 Network back-up

- Full active back-up (two separate sets of cables and digital transmission equipment) has been ruled out because of the cost of the corresponding investment.

- Back- up using a flattened transmission loop is recommended both for the backbone SDH network and for the drop-and-insert PCM distribution networks, since this provides partial redundancy against all other failures than a complete break in the cable whilst only requiring two of the optical fibres in the optical fibre cable.

- Where the safety of train movements more particularly is concerned (dedicated links between control centre and stations), the idea of partial back-up has been considered, in which case the control centre transmission equipment would be duplicated.

This duplicated equipment would be installed on the backbone network, geographically as far as possible from the control centre and accessible to an outside network used to provide a bridge between the duplicated equipment and the control centre.

- Naturally back-up comes in many different forms (public telecom network, satellite links, underwater cables, microwave links, etc.).
Back-up arrangements will, therefore, need to be studied in closer detail by the designer of the future network, in relation to the quality objectives set out in the list of requirements and in relation to local circumstances (existence of an outside network, local geography).

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2.9 Environment (Power supply)

- This is an important item which includes:
  -- power supply,
  -- protection against overvoltage, lightning,
  -- earthing,
  -- technical facility equipment,
  -- air-conditioning in technical facilities,
  -- distribution frames, etc.

- The following approach was adopted in this study:
  -- **The environmental item as a whole** was considered separately for the PABX advocated for international connections, and for the control centre equipment.
  -- For the digital transmission equipment for lines and stations, power supply sources were treated separately.
  The rest of this item was considered to be included in the cost of the equipment.

- On the subject of **power supply** as such, the following approach was adopted:
  -- Power supply to the PABX and control centre equipment (1 STM and as many ADM as links) is incorporated in the technical facilities.
  -- Medium capacity power supply is used for major stations (1 STM, 1 ADM, 1 medium capacity telephone equipment for railway operations).
  -- Low capacity is used for small stations (1 ADM, 1 low capacity telephone equipment for railway operations).
  -- Medium capacity power supply is used for partial redundancy for the control centre function (as many extra ADM as extra links).

N.B.:

Power supply systems need to have a permanent management interface to allow remote monitoring from a management centre.
The power supply systems deliver contact loops that can be incorporated in the ADM equipment.
Spare bits in the time slots serve to report the status of these contacts to the control centre where they are transferred to a dedicated manager.
In addition, in view of the choice of partial network back-up, it is essential to have a system for supervising power supply.
The extra cost is trivial by comparison with the total cost of the project. It has, at all events, been included in the investment tables shown elsewhere.

2.10 Training

- This item is fundamental to the working of the network.
- It is recommended that the manufacturer selected should train **instructors** who will then train the telecom staff of the railways concerned.

- Training should include the following:

  -- Training in transmission equipment maintenance:
    --- Basic training in digital transmission: 2 weeks
    --- Practical training: 1 week

  -- Training in operating the management control centre: 1 week

  -- Training in the maintenance control centre:
    --- Basic training: 2 weeks
    --- Specific training for drop-and-insert PCM: 1 week
    --- Specific training for SDH: 3 weeks.

-- Cable maintenance training:
   --- Basic training: 1 week
   --- Practical training: 1 week

-- Special training in station telephone equipment: 1 week

-- Training in electric power supply systems and miscellaneous equipment: 1 week

N.B.: Training for the PABX is included in the price of the switch (equipment and management)

i.e. total training: 14 weeks.

- A training programme internal to the railways should then be drawn up in relation to the maintenance scheduling principles of each of the countries concerned.

2.11 Spares.

Spares are provided as part of investment

3 Block diagrams

3.1 Introduction

- The purpose of this explanation is to set out the principles selected for the structure of the telecom networks of the three Caucasian countries: Georgia, Azerbaijan and Armenia.

- By definition the block diagrams are generic in nature.
They have a general value and are not specifically related to the particular cases under study.

3.2 **Architectural concept** (Block diagram SP1)

- Telecom network architecture is based on ITU-T G 803 recommendation:
"Architecture of Transport Networks based on the Synchronous Digital Hierarchy"

- This includes three network layers:
  - layer 1: "Optical fibre or microwave transmission support layer",
  - layer 2: "SDH channel layer network with VC12 or VC3" containers,
  - layer 3: "Circuit switching, packet switching networks with dedicated links

- For the purposes of this study, the "drop-and-insert PCM distribution network" has been added in layer 3, this having the particular feature of being supported by both layer 1 and layer 2.

- The main advantages expected of recommendation G 803 are:
  -- Simple design and operation of separate layers,
  -- Each layer has its own operating and maintenance capacities,
  -- Changes or additions to a layer have no effect on the other layers from an architectural point of view.

3.3 **Basic components** (Block diagram SP2)

- This diagram shows the basic components used in the other block diagrams as well as the symbols used in them (STM1, ADM2, ADM2/8, DTE).

- It also shows the different types of audio-frequency interface and data available for the 64 Kbits channels. Examples of terminal equipment are given by way of illustration.

3.4 Backbone and distribution networks (Block diagram SP3)

3.4.1 Backbone network

- The backbone is the central core of the telecommunications network.

SDH technology has been selected for the backbone network.

-Given the present transmission load in terms of the number of channels revealed by the progress report study of existing networks, the nodes of the backbone network are to have a minimum configuration, hence STM1.

- The reasons for the choice of STM1 are the following:
  - Transmission capacity of an STM1 is 155 Mbit/s.
  - 63 x 2 Mbit/s channels are available to users.
  - In the case of the Caucasian countries, the maximum load is in their respective capitals.
  It is one channel maximum for the PABX and 17 channels for the distribution networks (Georgia). This gives a total of 18 channels.
  If spare capacity is provided with a view to a 30 % increase, the number of channels would be 20 in use or in spare capacity.
  43 channels are therefore available for potential negotiations with public or private telecom operators (i.e. about 2/3 of capacity in terms of channels used).

- The STM1 are located in major areas: capitals and major railway establishments (stations and marshalling yards).
Siting depends essentially on two factors:
  - the number of existing switches with at least about one hundred subscribers (cf. interim report),
  - a maximum distance in the 70 - 100 Km bracket between consecutive STM1.

3.4.2 Distribution network

- The distribution network makes use of drop-and-insert pulse coded modulation (PCM).
Transmission equipment is of the Add Drop Multiplexer (ADM) type.

- The distribution network serves basically to ensure the safety of railway traffic. It involves a Control Centre connected in linear fashion to the different stations.
The Control Centre must be connected to an STM1.

- The distribution network carries the 2 Mbit/s links between the control centre and the stations along the line.

- Each station has an ADM.

- For operating reasons the number of these ADM per link is, in principles, limited to 5.

- As a result, a simple rule can apply for estimating the number of links between consecutive STM1:
  -- the number of links is equal to the quotient of the number of stations divided by 5, if necessary rounded up to the next integer.

- Given that in almost 50 % of cases it will be necessary to have more than one link between 2 STM1, the distribution nodes have been equipped with 2 Mbit/s Add/Drop Multiplexers (ADM) on an 8 Mbit/s transmission support (shown as ADM8 in the block diagrams).
The corresponding ends at control centre level are, by contrast, equipped with 2 Mbit/s ADM on a 2 Mbit/s transport support (shown as ADM2 in the block diagrams).
Block diagram SP2 shows the details of ADM2 and ADM8.

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3.5 Partial back-up of the backbone and distribution networks

(1) Principle of the flattened loop (Block diagram SP4)

- Full back-up for the telecom network solely for railway purposes seems unrealistic in view of the cost factor.

- It is however possible to provide partial back-up for the system as follows:

-- The backbone network can be provided with back-up by establishing a loop between the most remote STM1 and the originating STM1 (e.g. in the control centre) by means of 2 additional optical fibres in the same optical fibre cable.
This forms a flattened loop.
In fact, the intermediate nodes are spread over the loop to avoid too great a distance between the originating STM1 and the STM1 the furthest away.

-- The end of the distribution network is connected to the next STM1. This creates a ring at distribution network level.

- This type of back-up using a flattened loop is effective against all potential network failure modes with the exception of a failure common to all the optical fibres concerned in the optical fibre cable (e.g. if the cable is completely severed by earthworks machinery).

3.6 Partial back-up for the backbone and distribution networks

(1) Simultaneous transmission of time slots (Block diagram SP5)

- This diagram shows network operation with flattened loop back-up:

-- For a transmission channel requiring back-up, use is made of two time slots (TS) which are transmitted simultaneously eastwards and westwards.

-- The "eastern" TS arrives directly at the ADM (add/drop multiplexer) to which it is addressed.

-- Should this ADM detect a break in the eastern link, a reflex switch cuts in to transfer the ADM to the western link.

-- The ADM addressed will then be able to receive the western TS which transits via and the ADM from which the connection originated.

3.7 Interconnection of networks at the border (Block diagram SP6)

- The problem of interconnections at borders may be illustrated by taking the example of the border between Georgia and Azerbaijan.

- Since the telecom networks are national, the backbone networks are not connected directly from one STM1 to another and the distribution networks come to a halt at Gardabani and Beyuk-Kasik respectively.

- Interconnection is via an extra pair of dedicated optical fibre between the STM1 at Tbilissi and at Akstafa. The following are installed:
Either a:
- 2 Mbit/s OLTE (Optical Link DTE) at the output from the G703 interface in the STM1 multiplexer

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This means that a 2 Mbit/s channel is provided between the two capitals: Tbilissi and Baku.
- STM1 tributaries cards in the STM1 multiplexers
This means that 63 2 Mbit/s channels are provided between the capitals of the two countries, Tbilisi and Bakou. This solution is preferable so that this capacity can be leased to other parties.

- It is possible to have local links between Gardabani and Beyuk-Kasik for reasons of convenience if necessary, using an additional pair of dedicated optical fibres and the Digital Terminal Equipment (DTE) for the purpose.

3.8 Management of distribution networks (Block diagram SP7)

- This is achieved through a central manager and his operator consol in the control centre.

- The dedicated control centre interfaces for managing the ADM are connected to the central manager via a management bus.

- The control centre ADM are the "master" and are connected to the remote ADM via an operating and maintenance channel using the spare bits of the PCM frame.

3.9 Management of the backbone network (Block diagram SP8)

- This is achieved through a central manager and one or several operator consoles (PEX) in the control centre.

- QB3, the dedicated management interface of the control centre STM1 is connected with the central manager via the local IT network.

- The backbone operating channel, managed by the control centre STM1, operates in one direction only (because of management constraints in the routing tables in the STM1).
In the event of a break in the optical fibres, the operating channel will be out of service for part of the network.
To overcome this difficulty, the central manager needs two points of access to the backbone network.
To this end, the dedicated management interface, QB3, of the STM1 located at the furthest distance from the control centre is connected to the control centre central manager by means of an X25 link and routers connected to the corresponding local IT networks.

- Transit over an X25 network independent of the railway network is recommended for the back-up function.

- If the public operator or private operators cannot provide an X25 service, there are two solutions:
  -- not to provide back-up for the operating channel, which would make repairs to the network more difficult in the event of failure.
  -- to use a dedicated 64 Kbit/s link between routers.

3.10 Network synchronisation (Block diagram SP9)

- When using the SDH, it is essential to ensure synchronisation between the various networks.

- This is done via the control centre.

General recommendations and methodology

- A reference 10^{-11} stability clock (CPR) controls a 10^{-9} stability clock Synchronization Supply Unit (SSU).
The stability of the CPR and SSU must conform to the recommendations of ITU-T G 811 and G 812 respectively.
The SSU sets off a timer which then enables the 2 Mbits/s clock signals to be distributed to the control centre equipment (STM1, PABX, ADM2).
The timer signals are then transmitted on to the other STM1 in the backbone network using the transport frames; this sets the timing at equipment level.

- Back-up should be provided for the synchronisation system at the end of the backbone network. This should be based, for example, on the GPS and one SSU.

- Timing is synchronised on the basis of a synchronisation plan, including back-up by GPS.

- The network used for synchronisation requires central control in conjunction with the management of the SDH.

3.11 Connection of the PABX (Block diagram SP10)

- The PABX located in the capitals are responsible for handling traffic between the various TRACECA countries and Europe.

- International links with railways in Europe can be established via a bundle of dedicated links scaled to take account of the volume of traffic to be handled.

- A software module needs to be developed for connecting the existing switches (adaptation of the signalling protocols).

- It is recommended that use be made of the QSIG signalling protocol between the PABX, rather than CCITT n° 7, for the following reasons:
    -- QSIG is a standard developed by ECMA (European Computer Manufacturers Association) and ETSI (European Telecom Standards Institute),
    -- QSIG developments are harmonised between ECMA and ETSI,
    --QSIG has been chosen by UIC for connecting the automatic trunk networks of railways in western Europe,
    -- QSIG gives access to a variety of suppliers.

- A new numbering scheme and a new routing scheme need to be established to take account of the possibility of international access via the PABX.

3.12 Connection with existing switches (Block diagram SP11)

- The diagram shows how switches are connected in the following circumstances:

    -- connection between remote user and his automatic switch over the same 2 Mbit/s channel of the same distribution network,

    -- connection between two existing switches via different 2 Mbit/s channels on the same distribution network,

    -- connection between two existing switches depending on two different STM1 (one connected at control centre level, the other at distribution network level).

3.13 Connection of IT applications (Block diagram SP12)

- The diagram shows how IT applications are connected in the following cases:

-- connections between two computers on different 2 Mit/s channels on the same distribution network via the backbone and the originating control centre.

-- connection of two local computer networks via routers, each depending on a different STM1.

3.14 Connection of IT applications to a computer centre (Block diagram SP13)

- The diagram shows how a stand-alone computer can be connected to the local IT network and to the computer centre in Tbilissi. The principles of diagram SP12 also apply.

3.15 Control Centre operation (Block diagram SP14)

- The diagram shows the voice communications between the control centre and the stations for a traffic control type circuit.

- Using broadcasting and collection amplifiers, the control centre can communicate with one or several or all of the stations on the network as a whole;
The control centre has as many such amplifiers as there are distribution networks.
The microphones and receivers needed for voice communications are connected to the ADM by means of audio cards.

- the call signal (not shown in the diagram) is transmitted in voice frequency over the control centre transmission pair.

3.16 Time Slot (TS) allocation on a distribution network (Block diagram SP15)

- This diagram shows one example of how time slots may be allocated between the control centre and stations (or other railway locations)

- The TS1 (traffic control), TS2 (energy control) and TS15 (ground-to-train radio) are of the broadcasting/collection type, in view of the fact that the control centre must be able to call one, several or all stations on the distribution network.

- TS3 is reserved for the safety bus. Since this only involves links between adjacent stations, the same TS is used throughout the distribution network..

- TS4 to 8 are allocated to the other automatic telephone links. These links are of the point-to-point type.

- TS9 to 13 are allocated to IT applications. These are also of the point-to-point type.

- TS14 (maintenance conferencing) is used for dialogue between all link users.

General recommendations and methodology

- It will be noted that in the example given, only half of the TS (15) have been allocated of a possible total of 30.
This spare capacity is sufficient for a large number of stations and other locations.

3.17 Control centre back-up (Block diagram SP16)

- Assuming the principles for partial back-up of the backbone and distribution networks to have been agreed (cf. Sections **5** and **6**) block diagram SP16 shows how voice communications links between control centre and stations are provided with back-up.
It is important to realise that if communications break down completely between the control centre and the stations, this will disrupt operating of the railway network and lead to delays, cancelled trains, etc.

- Under these circumstances, it is advisable to provide greater back-up for the main links (for example, traffic control, energy supply).

- The steps taken are similar to those in section **6.** i.e.:

  -- ADM and redundant broadcasting/collection amplifiers which are a mirror image of the control centre, are connected to the STM1 the furthest away from that of the control centre.

  -- a reflex redundant system is installed in stations. Should the easterly link fail, the system automatically switches over to the western link.
  The redundant broadcasting/collection amplifiers are connected to those of the control centre via an external network using a dedicated telephone link (300 - 3400 Hz).

3.18 Network of secondary railway lines (Block diagram SP17)

- Where the telecom networks of secondary railway lines are concerned, SDH technology is not used but only PCM drop and insert.

- An originating ADM manages the link. Additional ADM are initially added to demultiplex the 2 Mbit/s channels not demultiplexed by the original ADM.

- In the block diagram proposed, the ADM are of the ADM8 type.
The originating ADM8 demultiplexes one of the 4 channels directly (for example, Channel A).
If necessary, the other channels (B, C and D) are demultiplexed by the additional ADM2 situated at the originating end.

- In the case of small secondary railway lines with only one link, it is possible to use only ADM2.

3.19 Administrative telephone network (Block diagram SP18)

- Replacement of existing switches with PABX based on digital technology.

- Small PABX (50 and 500 users) are configured as remote units of the master PABX in the major stations. Master PABX have a manager to control remote units.

- Signals between master PABX are QSIG, as they are between the PABX in the national capitals.

- Signalling between PABX and the remote units is not necessarily by QSIG

- Each remote unit will be connected by a 2Mbits/s channel.

- Links between PABX are estimated at one 2Mbits/s channel (i.e. 20 erlangs as an annual average) for each group of 500 users.

3.20 Computer links between the two SDH networks (Block diagram SP19)

If the rail network topology is such that not one but several SDH transmission networks are advocated, it may be that the computer centre is not located at the intersection of these networks.
To allow stations situated along SDH networks other than that serving the computer centre to communicate with said centre, data multiplexers should be installed to interconnect the SDH networks for data transmission.

Chapter 4

General recommendations and methodology
Appendix 1 - Bibliography and diagrams

Appendix 1 - Bibliography and diagrams

Bibliography

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1

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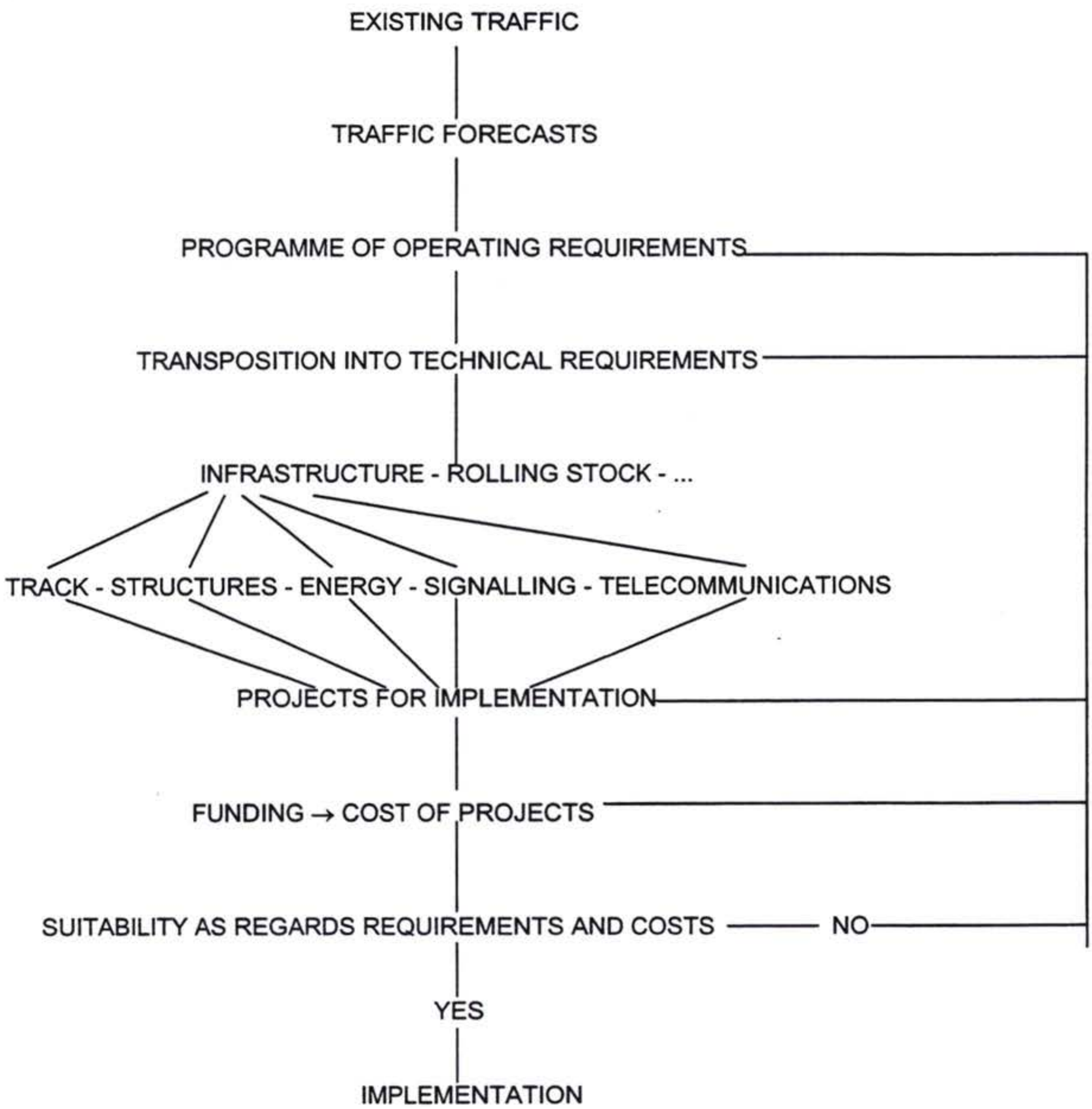
Appendix 1 - Bibliography and diagrams

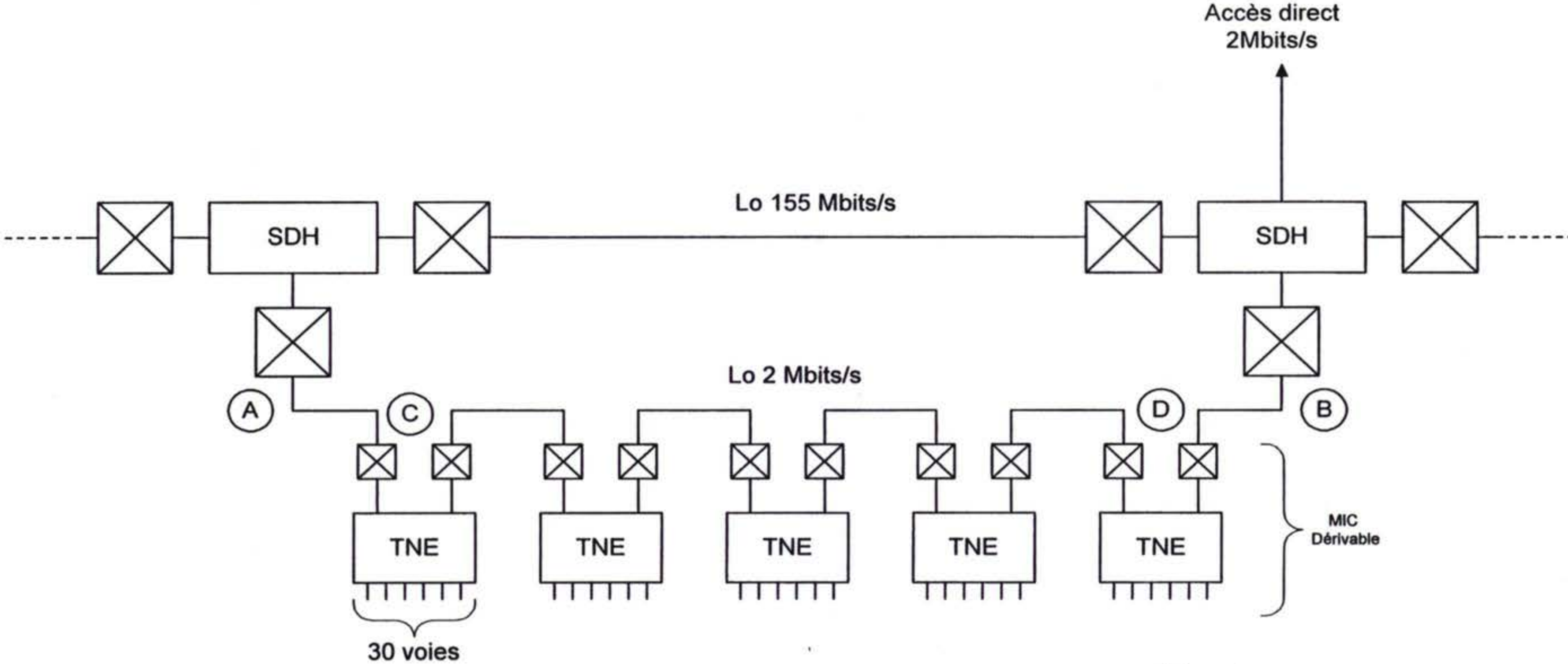
INVESTMENT CONCEPT MODEL Diagram 1



Appendix 1 - Bibliography and diagrams

Architecture du réseau de Télécommunications Schéma de principe

Figure 2



Légende

SDH Synchronous Digital Hierarchy
☒ Terminal Numérique de Ligne Optique
TNE Terminal Numérique d'Extrémité

Appendix 1 - Bibliography and diagrams

Diagram 3A

Connection of optical fibre cable
Recommended solution

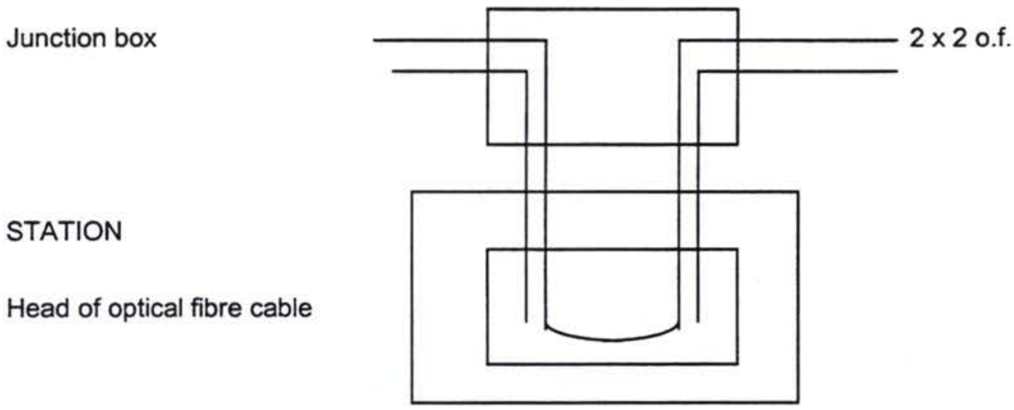
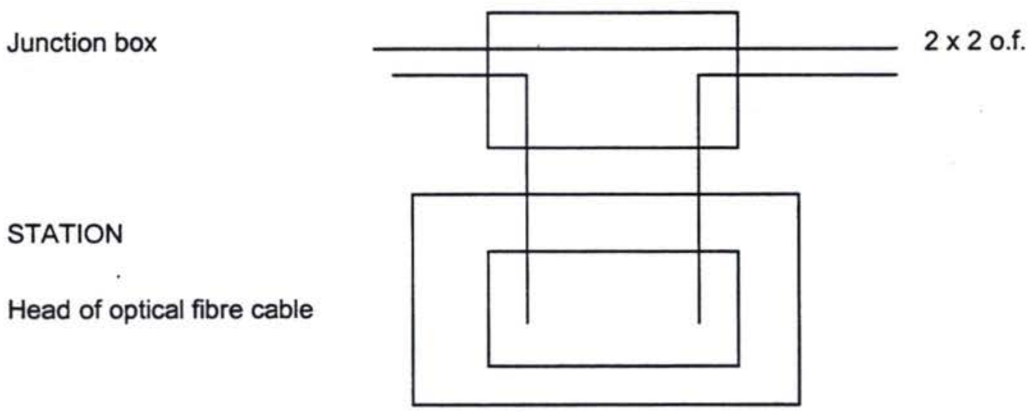


Diagram 3B

Connection of optical fibre cable
Solution not recommended



Appendix 1 - Bibliography and diagrams

Diagram 3C

Connection of optical fibre cable
Holding solution (optical connector)

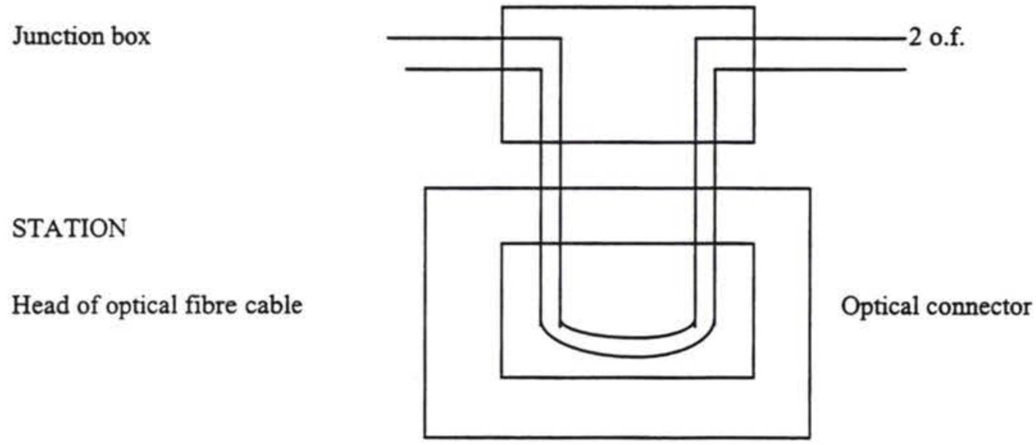
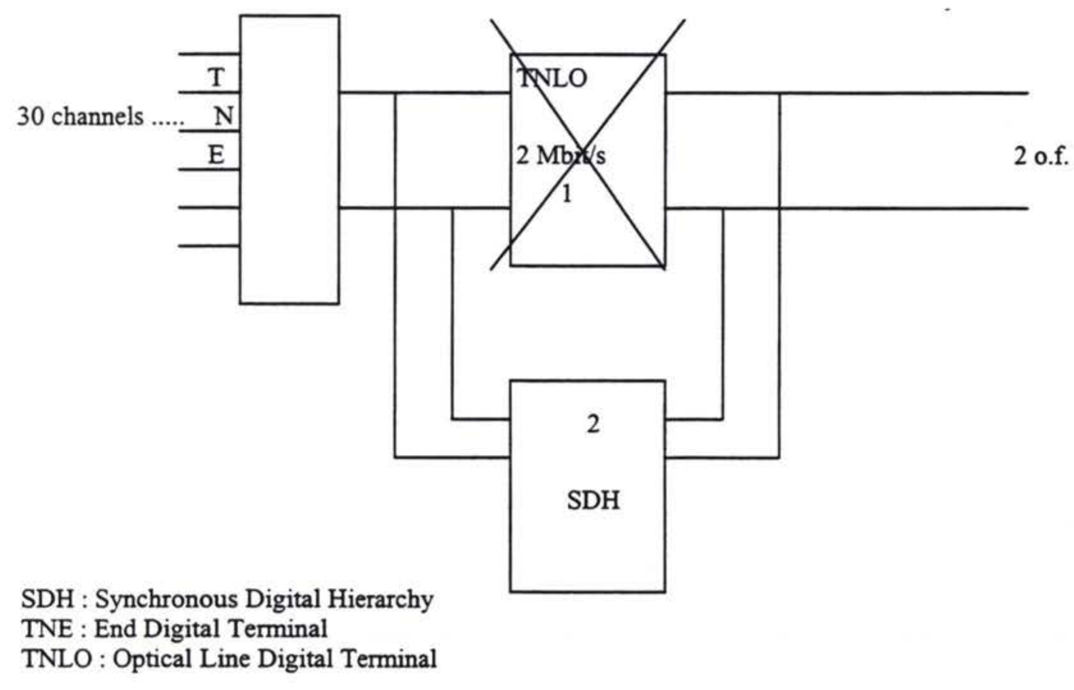


Diagram 4

Migration from PDH to SDH



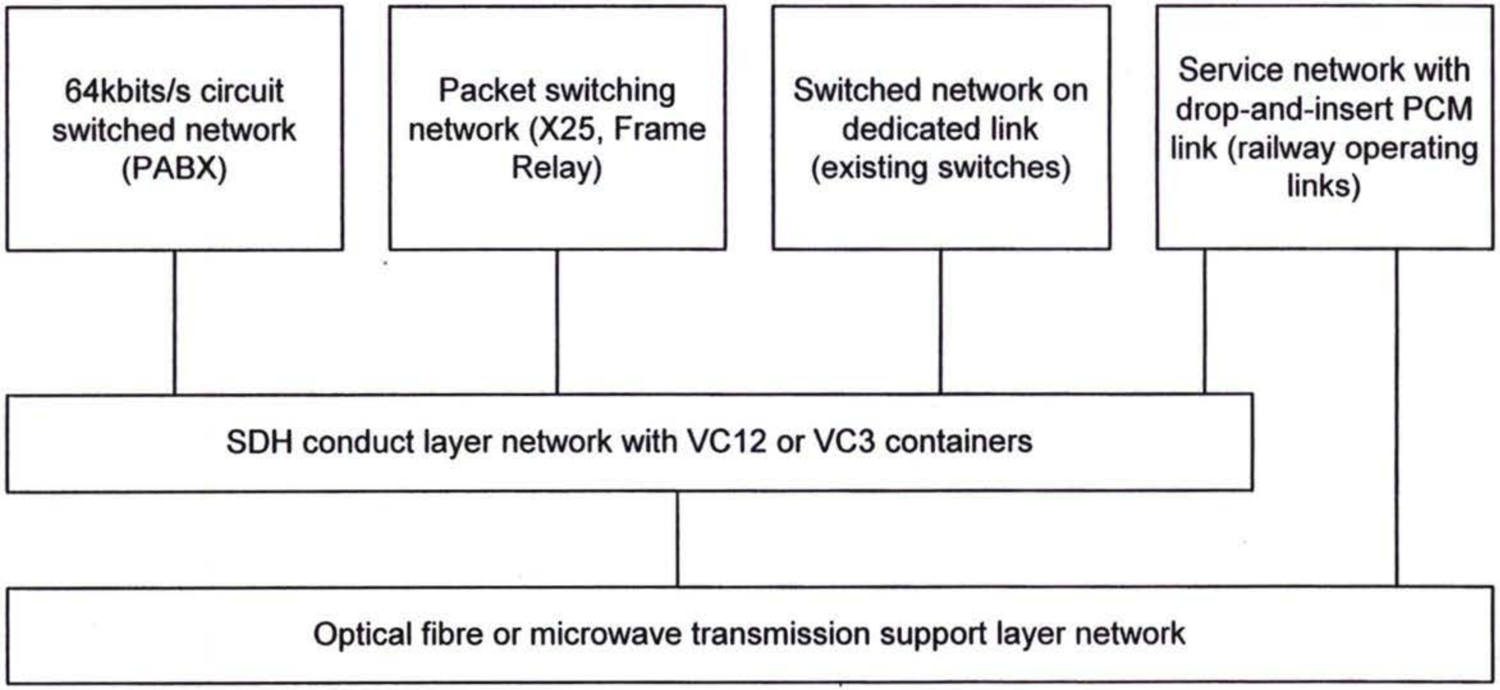
SDH : Synchronous Digital Hierarchy
TNE : End Digital Terminal
TNLO : Optical Line Digital Terminal

Chapter 4

General recommendations and methodology
Appendix 2 - Bloc diagrams

Appendix 2 - Bloc diagrams

- This architechture is based on ITU recommendation G-803 "Architecture of transport networks with synchronous digital hierarchy (SDH), with the "circuit layer" extended to the PCM drop-and-insert distribution network

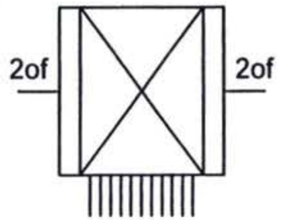


Architechtural concept selected

Diagram SP-1

Appendix 2 - Bloc diagrams

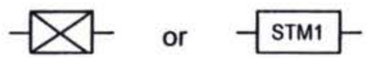
(1)



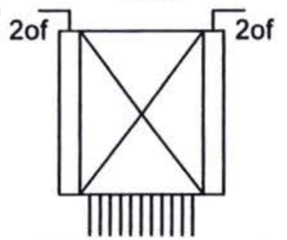
M 2 Mbits/s Tributaries
M≤63

STM1 Multiplexer by extension STM1 (equivalent to ADM 155 Mbits/s)

Symbol selected:



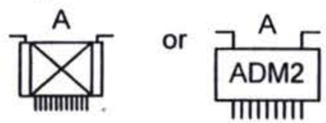
(2)



N 64 kbit/s channels
N≤30

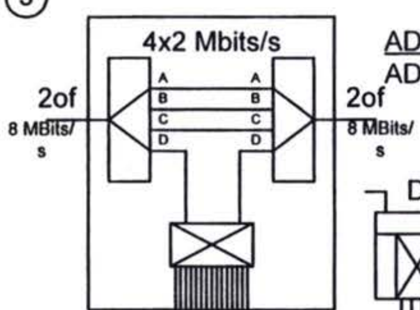
ADM 2 Mbits/s by extension ADM2

Symbol selected:



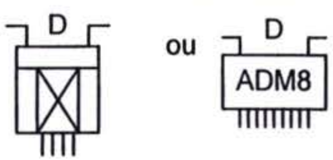
A: 2 Mbits/s channel drop-and-insert

(3)



ADM 2 / link 8 Mbits/s by extension ADM8

Symbol selected:



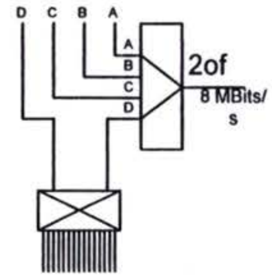
D: 2 Mbits/s channel drop-and-insert

Logical representation ADM2/8 A B C D (D being the 2 Mbits/s drop-and-insert)

Basic components

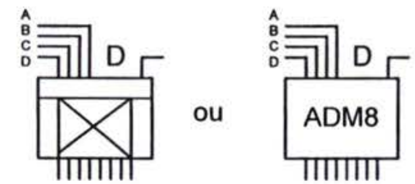
Diagram SP-2 1/2

(4)



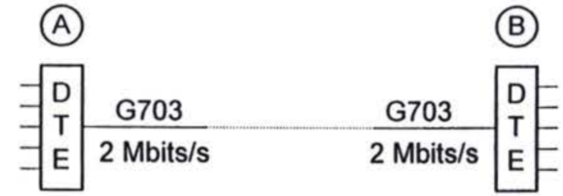
ADM 2 / 8 used at the end

Symbol selected:

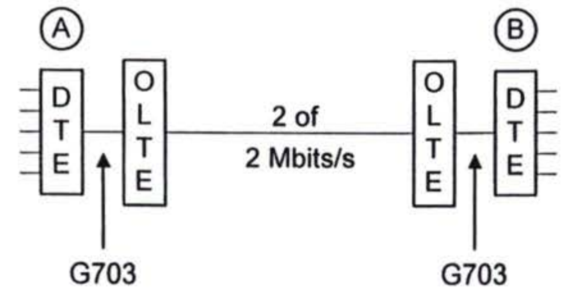


(5) Digital Terminal Equipment (DTE)

(5.1)



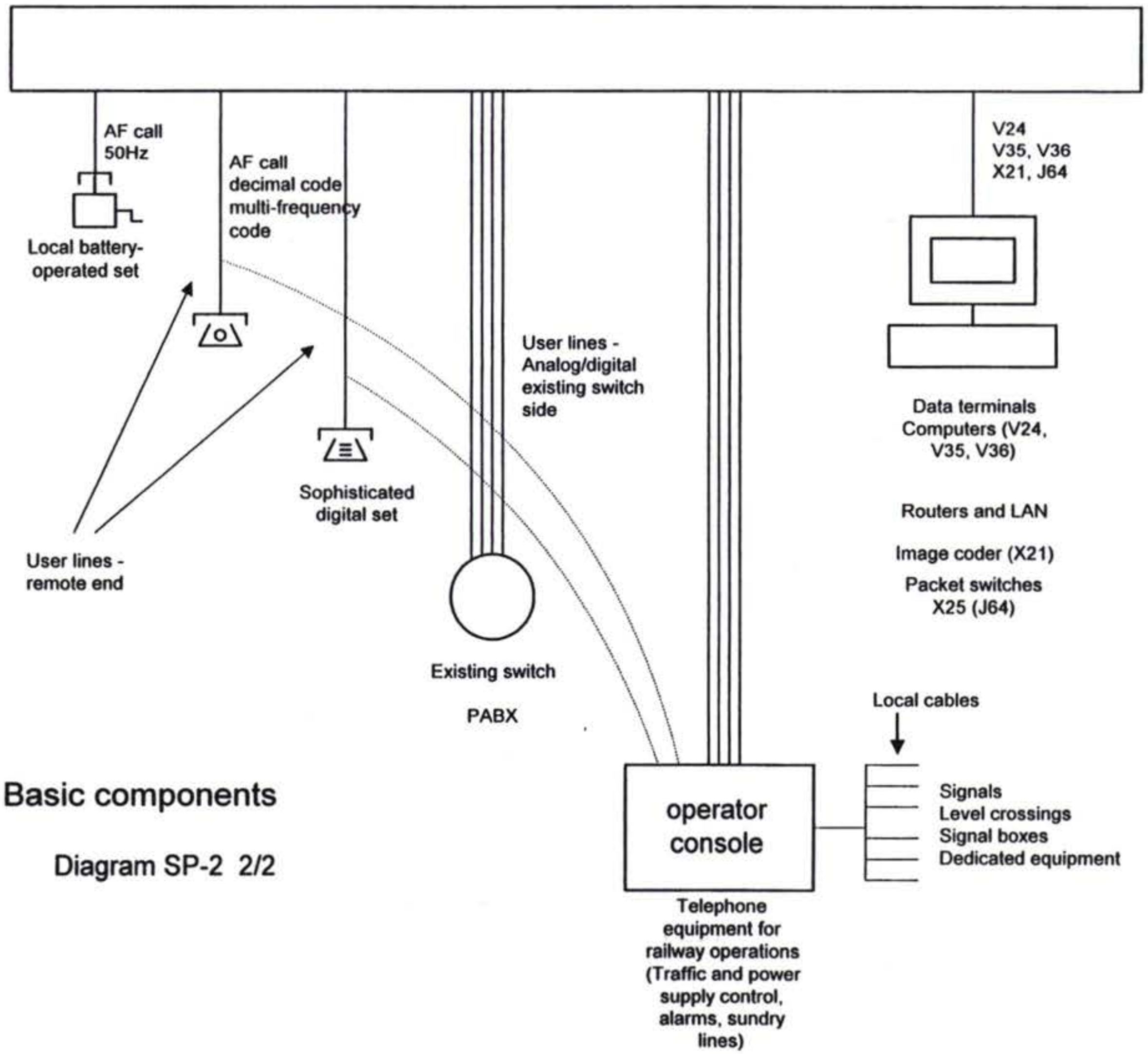
(5.2)



One DTE provides a 2Mbits/s point-to-point link between two points A and B in accordance with diagrams 5.1 and 5.2. The link may be electrical (conforming with G703) or optical. In the latter case, Optical Line Terminal Equipment (OLTE) shall be used for the fibre interface)

Appendix 2 - Bloc diagrams

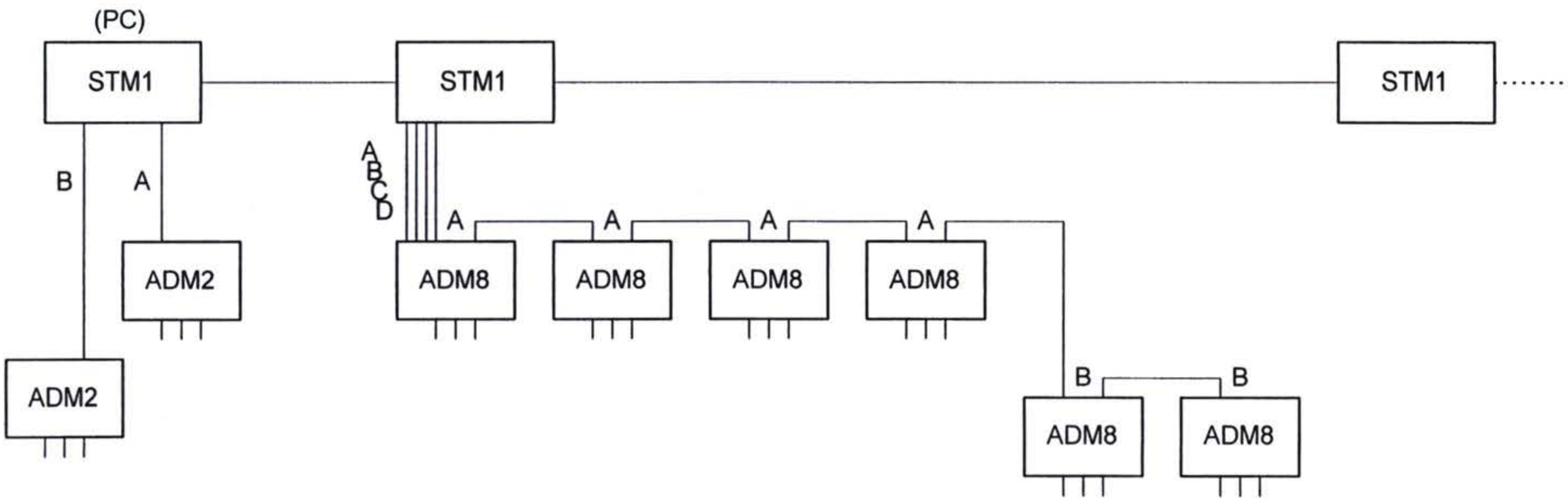
⑥ <u>Interfaces available:</u> audio frequency (analog) and data for 64kbits/s channels



Basic components

Diagram SP-2 2/2

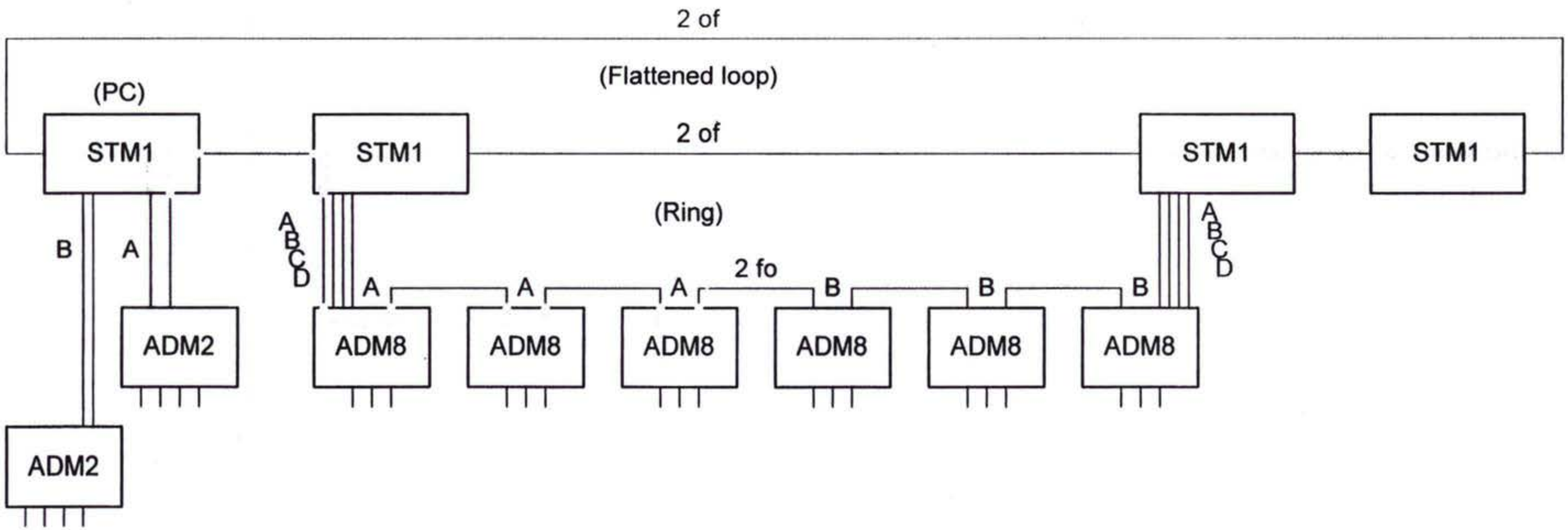
Appendix 2 - Bloc diagrams



Backbone and distribution network

Diagram SP-3

Appendix 2 - Bloc diagrams



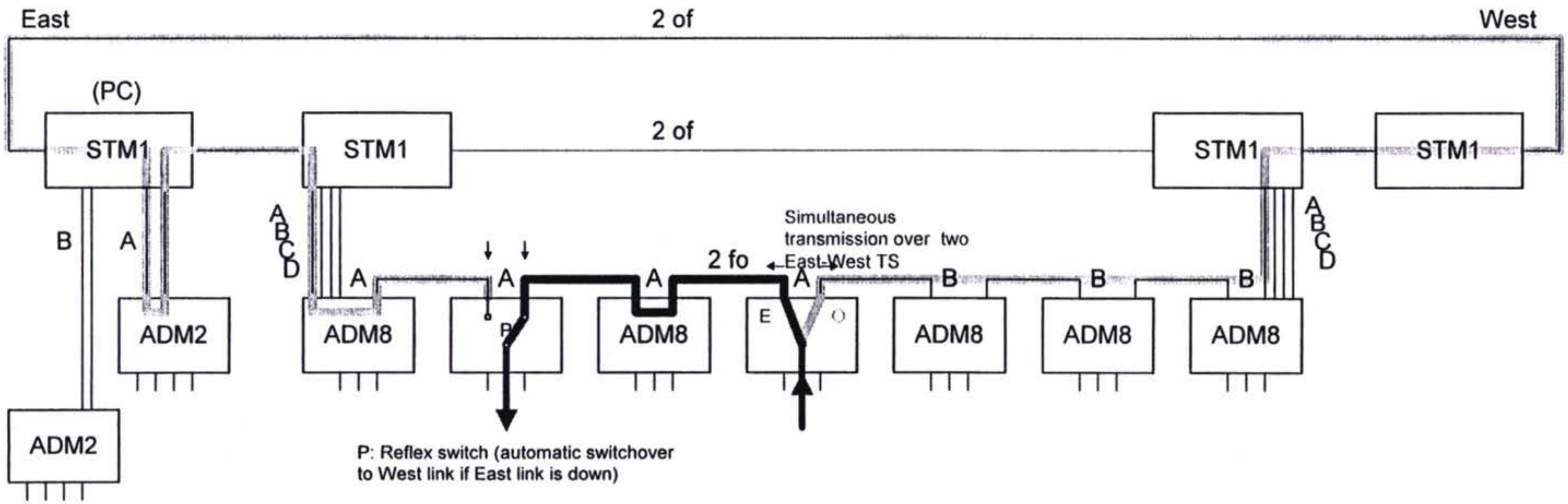
NB:

- The part highlighted in yellow is the 2Mbits/s "A" loop with back-up.
- The distribution network may be equated with a ring on a flattened loop.
- The 3x2 of are in the <u>same</u> optical fibre cable.

Partial redundancy for backbone and distribution networks
(flattened loop)

Diagram SP-4

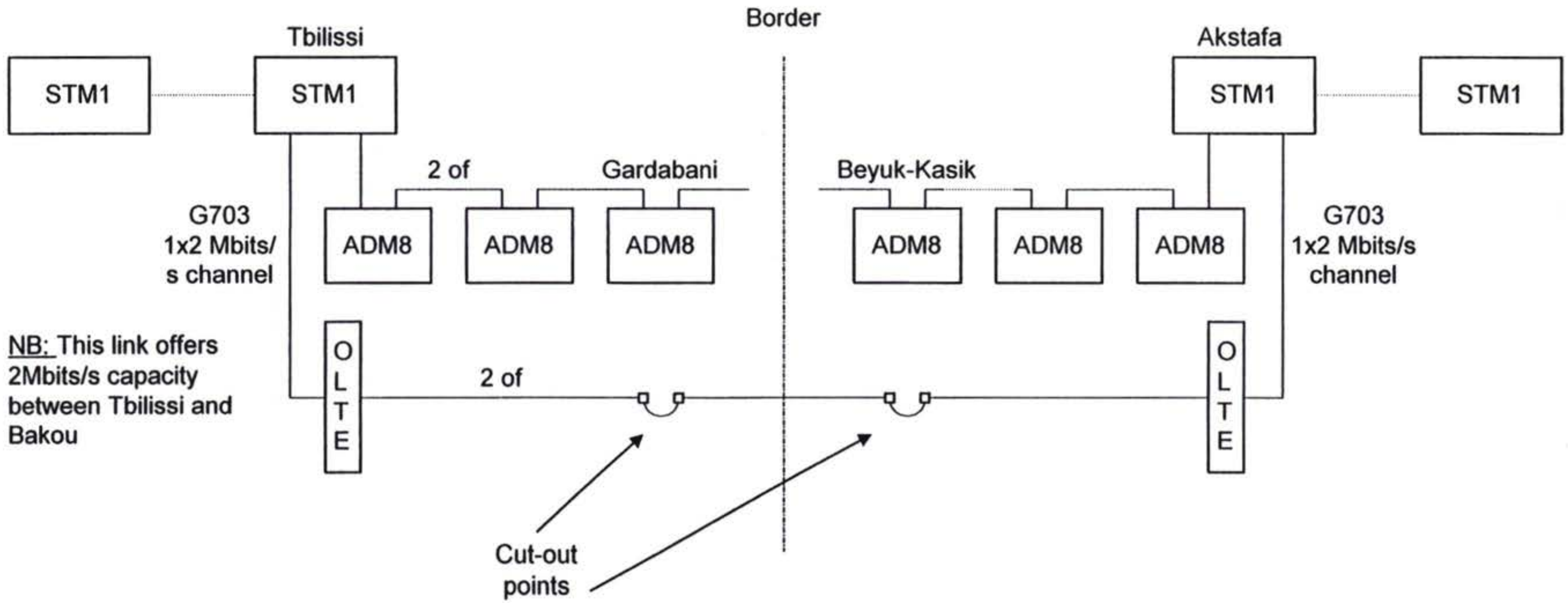
Appendix 2 - Bloc diagrams



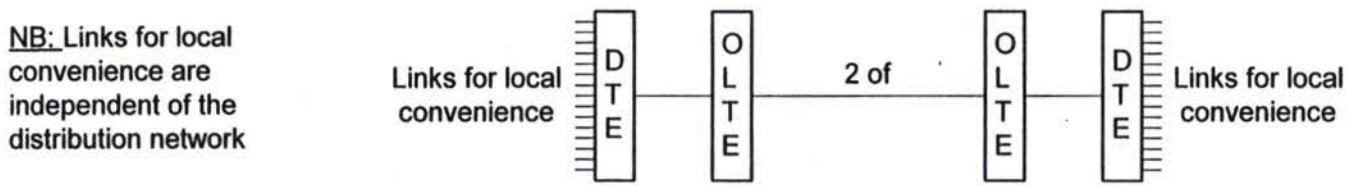
Partial redundancy for backbone and distribution networks (2)
(Simultaneous transmission over two Time Slots (TS))

Diagram SP-5

Appendix 2 - Bloc diagrams



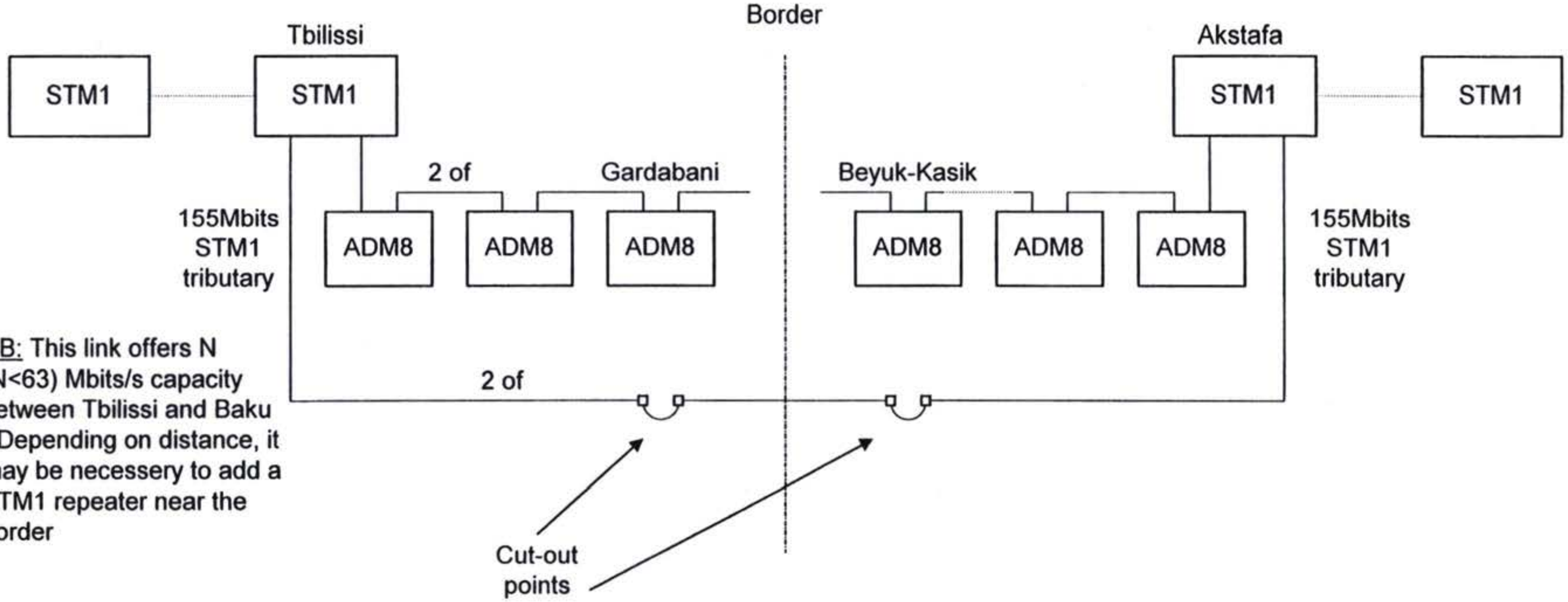
Direct local links between Gardabani and Beyuk-Kasik



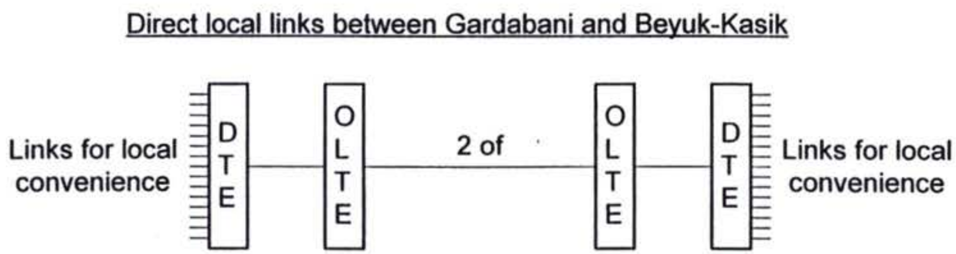
Interconnexion of networks at the borders

Diagram SP-6 1/2

Appendix 2 - Bloc diagrams



NB: This link offers N (N<63) Mbits/s capacity between Tbilissi and Baku - Depending on distance, it may be necessery to add a STM1 repeater near the border

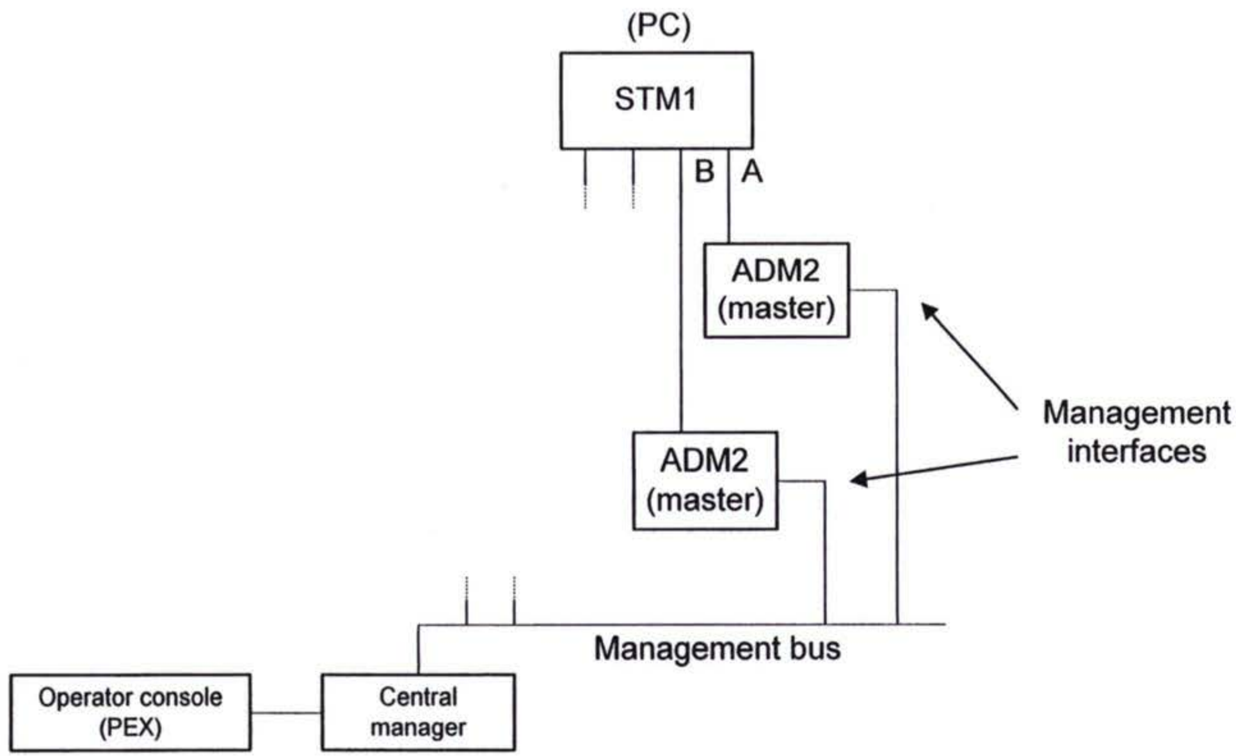


NB: Links for local convenience are independent of the distribution network

Interconnexion at 155Mbits/s of networks at the borders

Diagram SP-6 2/2

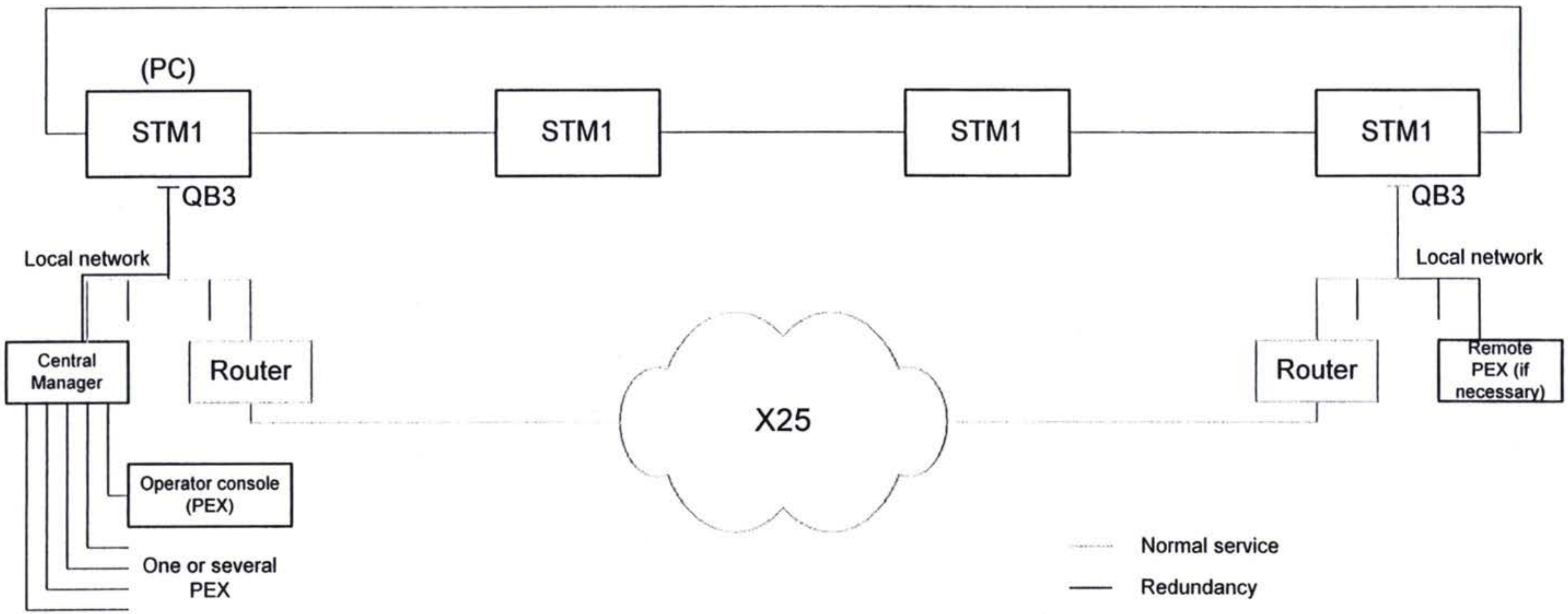
Appendix 2 - Bloc diagrams



Distribution network managed from control centre

Diagram SP-7

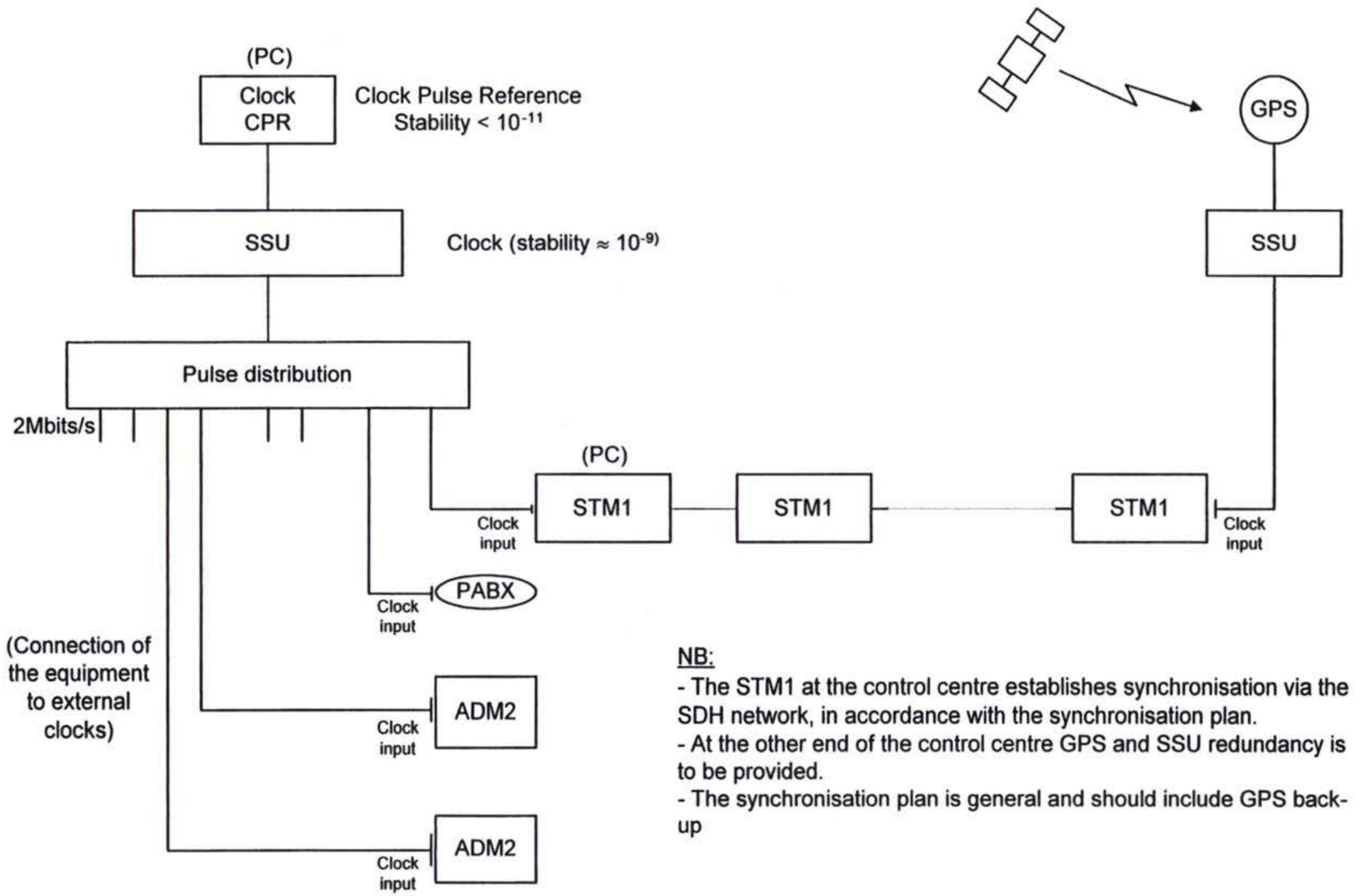
Appendix 2 - Bloc diagrams



Network Management

Diagram SP-8

Appendix 2 - Bloc diagrams

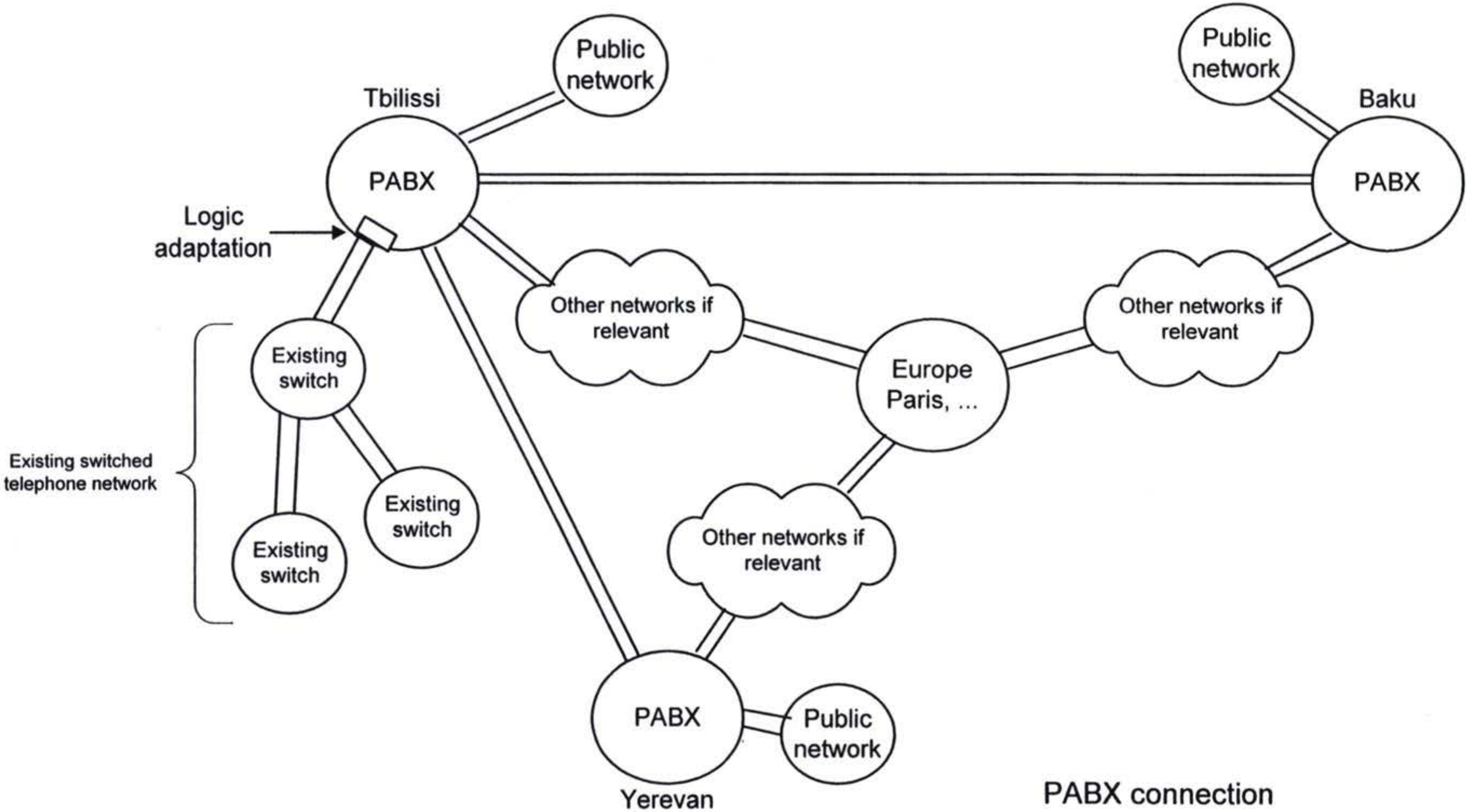


NB:
- The STM1 at the control centre establishes synchronisation via the SDH network, in accordance with the synchronisation plan.
- At the other end of the control centre GPS and SSU redundancy is to be provided.
- The synchronisation plan is general and should include GPS back-up

Network synchronisation

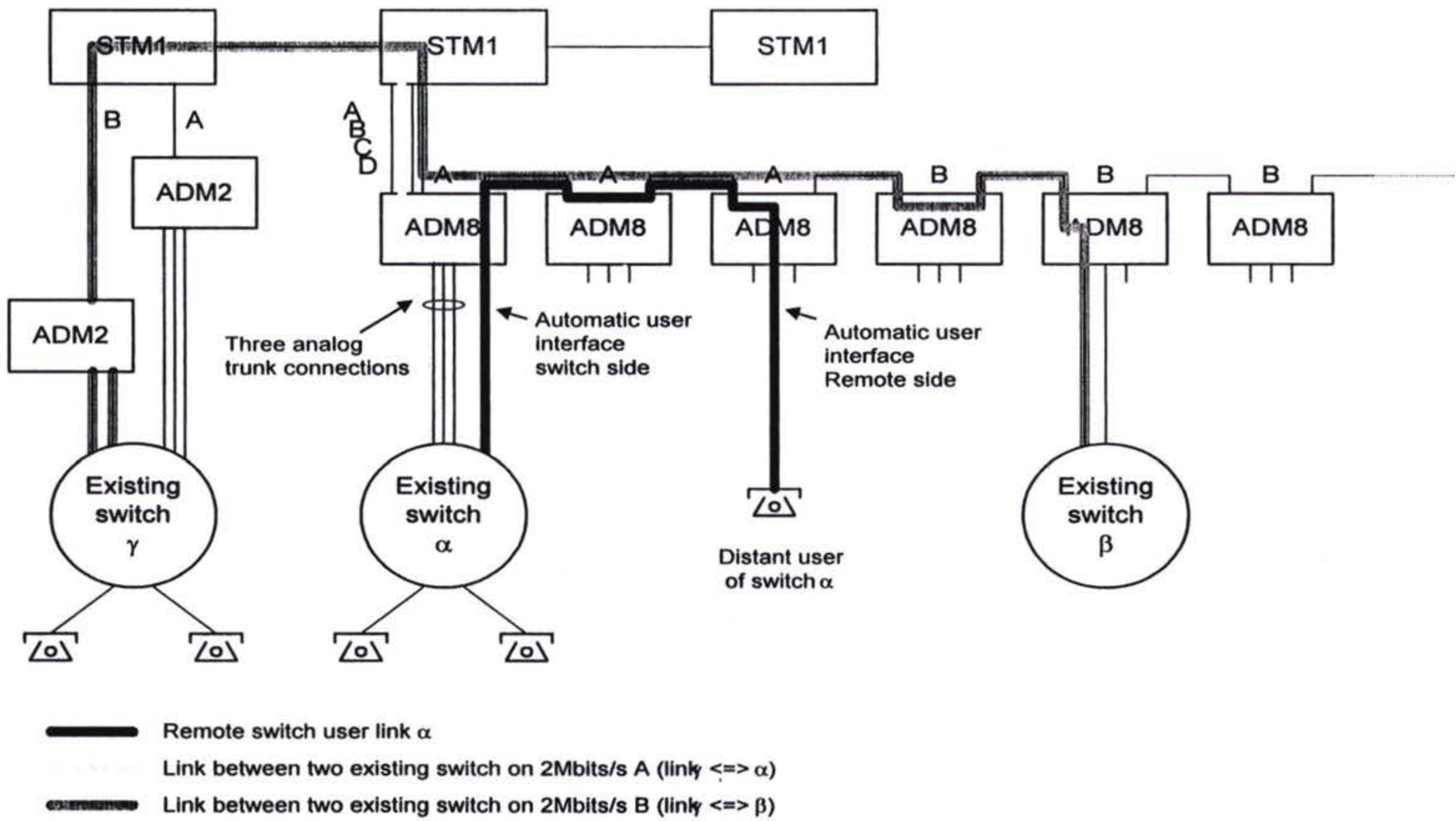
Diagram SP-9

Appendix 2 - Bloc diagrams



PABX connection
Diagram SP-10

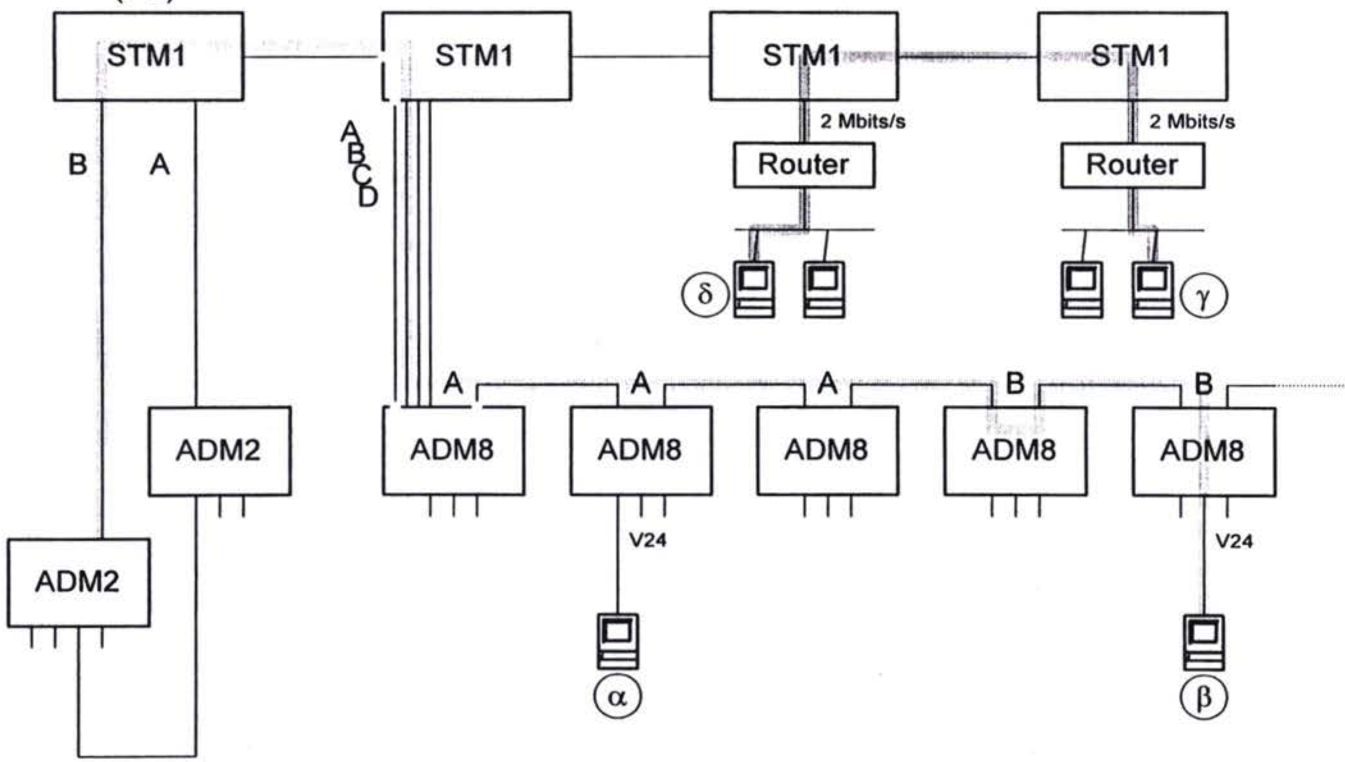
Appendix 2 - Bloc diagrams



Existing switch connection

Diagram SP-11

Appendix 2 - Bloc diagrams



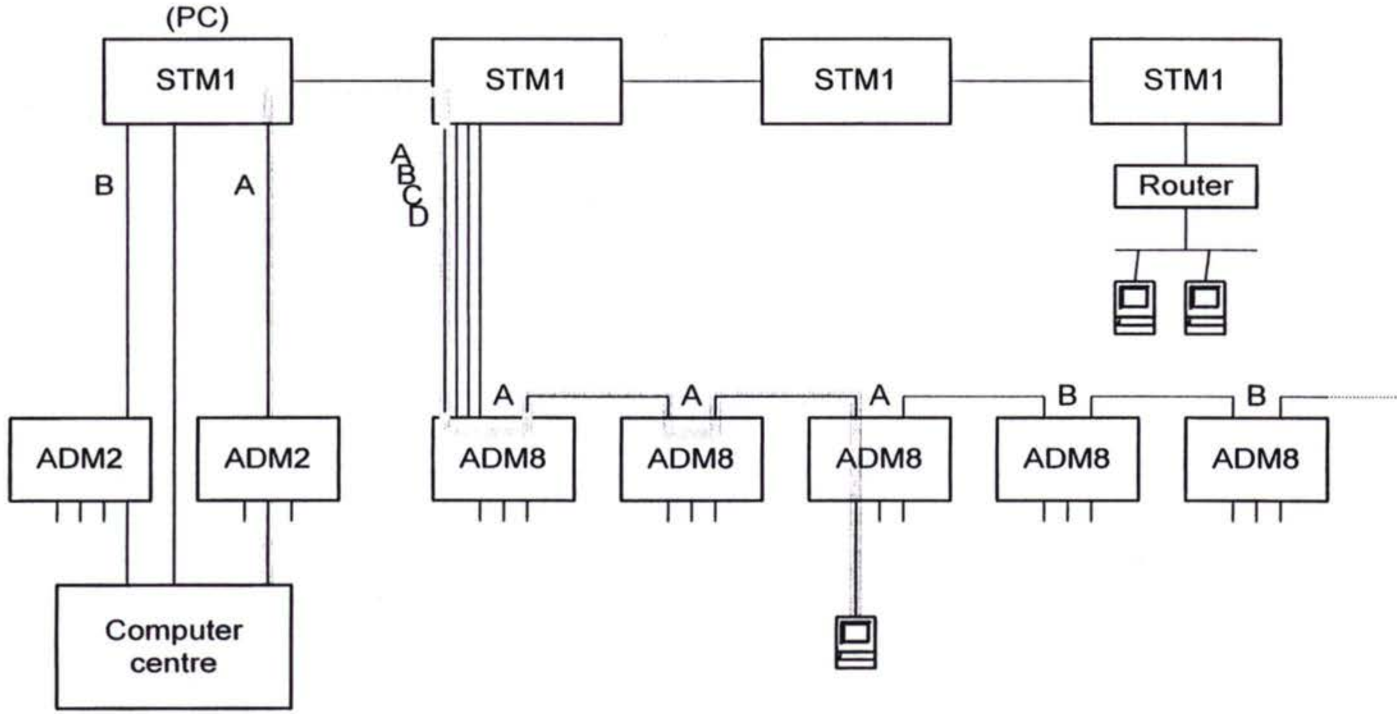
Connection between two computers α et β via the distribution and SDH networks

Connection between two local networks γ et δ via the SDH network

Connection of IT applications

Diagram SP-12

Appendix 2 - Bloc diagrams



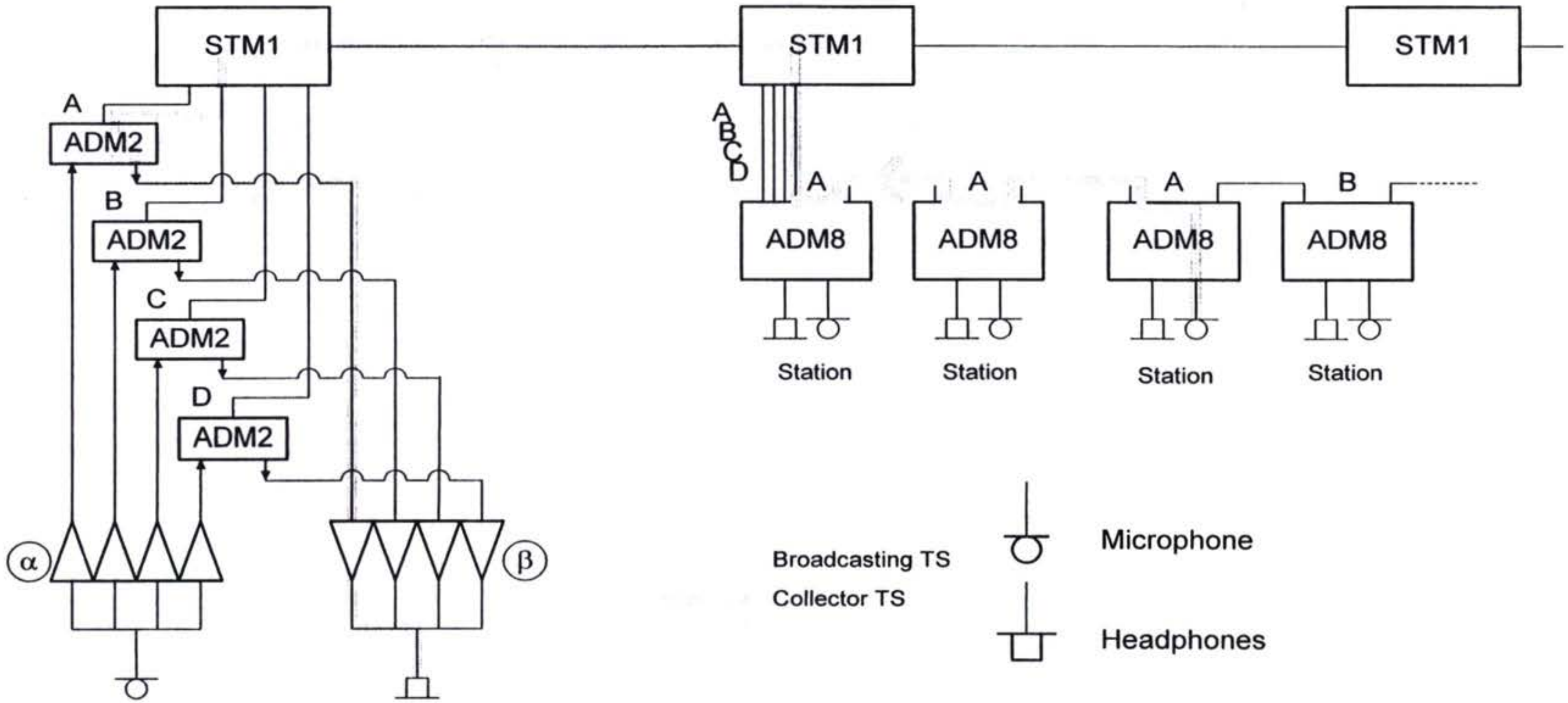
Link between a local network and the computer centre via the SDH network

Link between a computer and the computer centre via the distribution and SDH networks

Connection of an IT computer centre

Diagram SP-13

Appendix 2 - Bloc diagrams

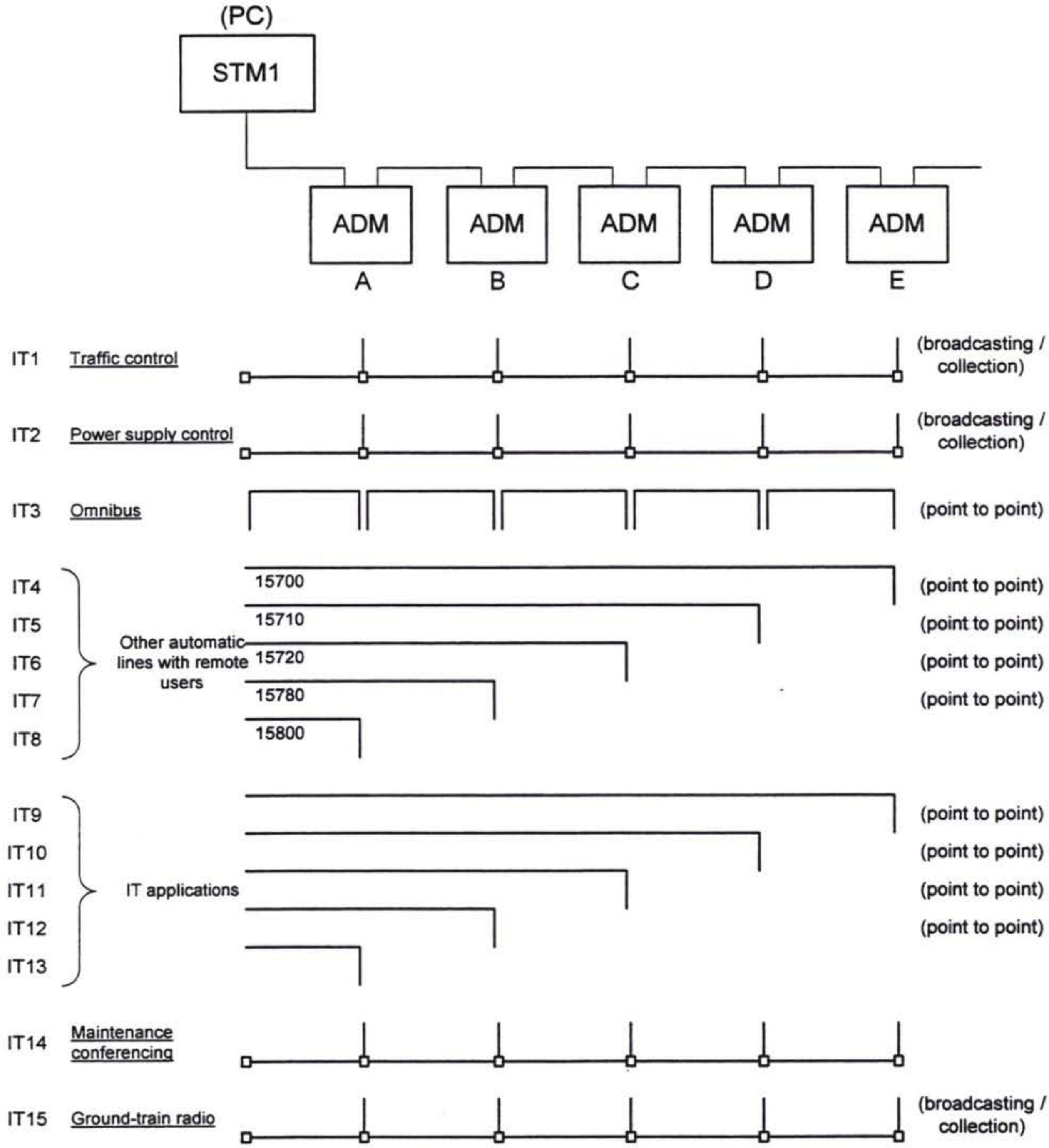


NB: - Use of broadcasting amplifiers α et collector amplifiers β (as many as there are drop-and-inserts)
- Call receivers are not shown but the paths followed are identical
- Input/outputs in the ADM is by audiocard

Control centre operation

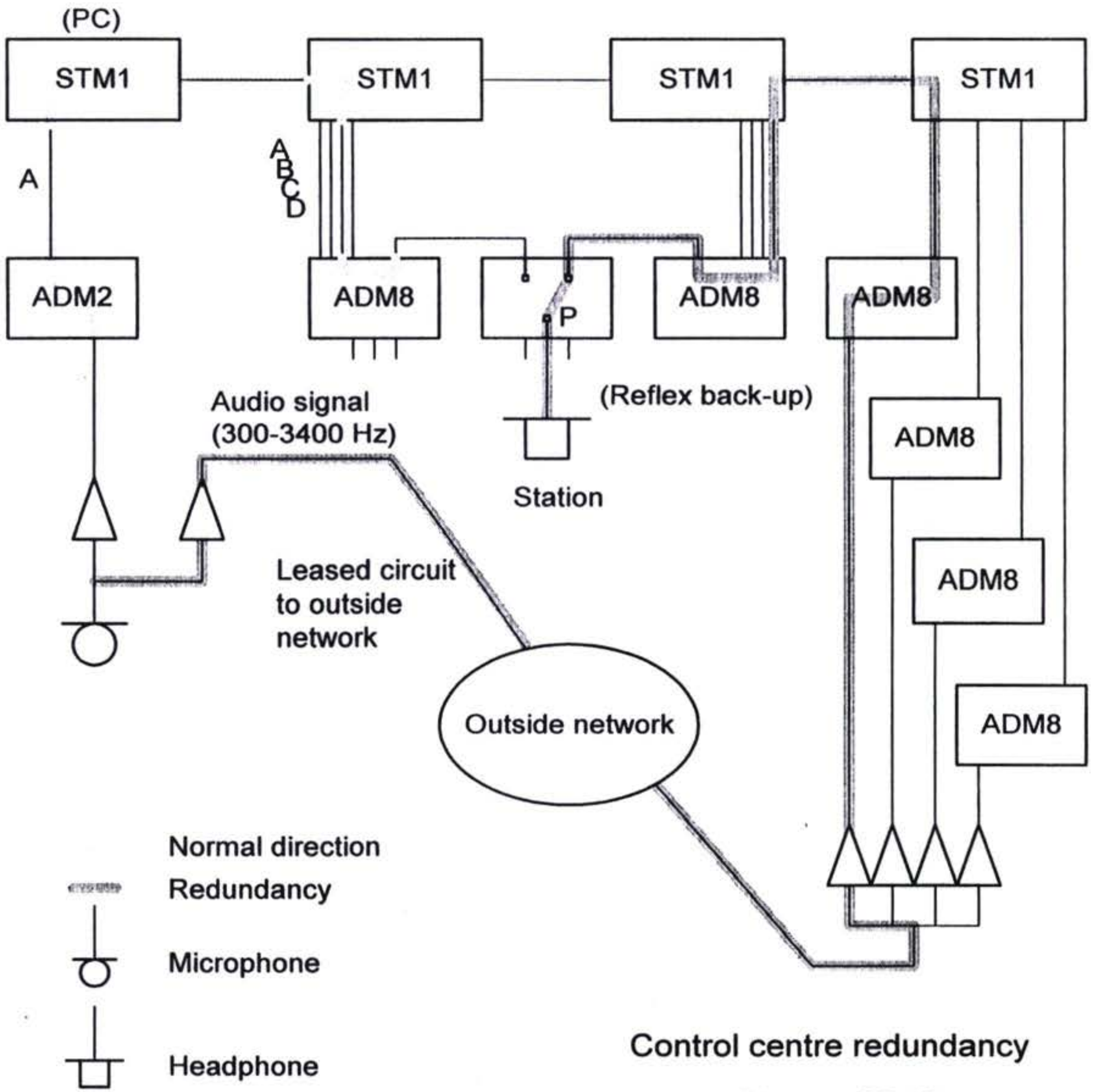
Diagram SP-14

Appendix 2 - Bloc diagrams



Allocation of Time Slots (TS) PCM on control centre to stations distribution network (example)
Diagram SP-15

Appendix 2 - Bloc diagrams

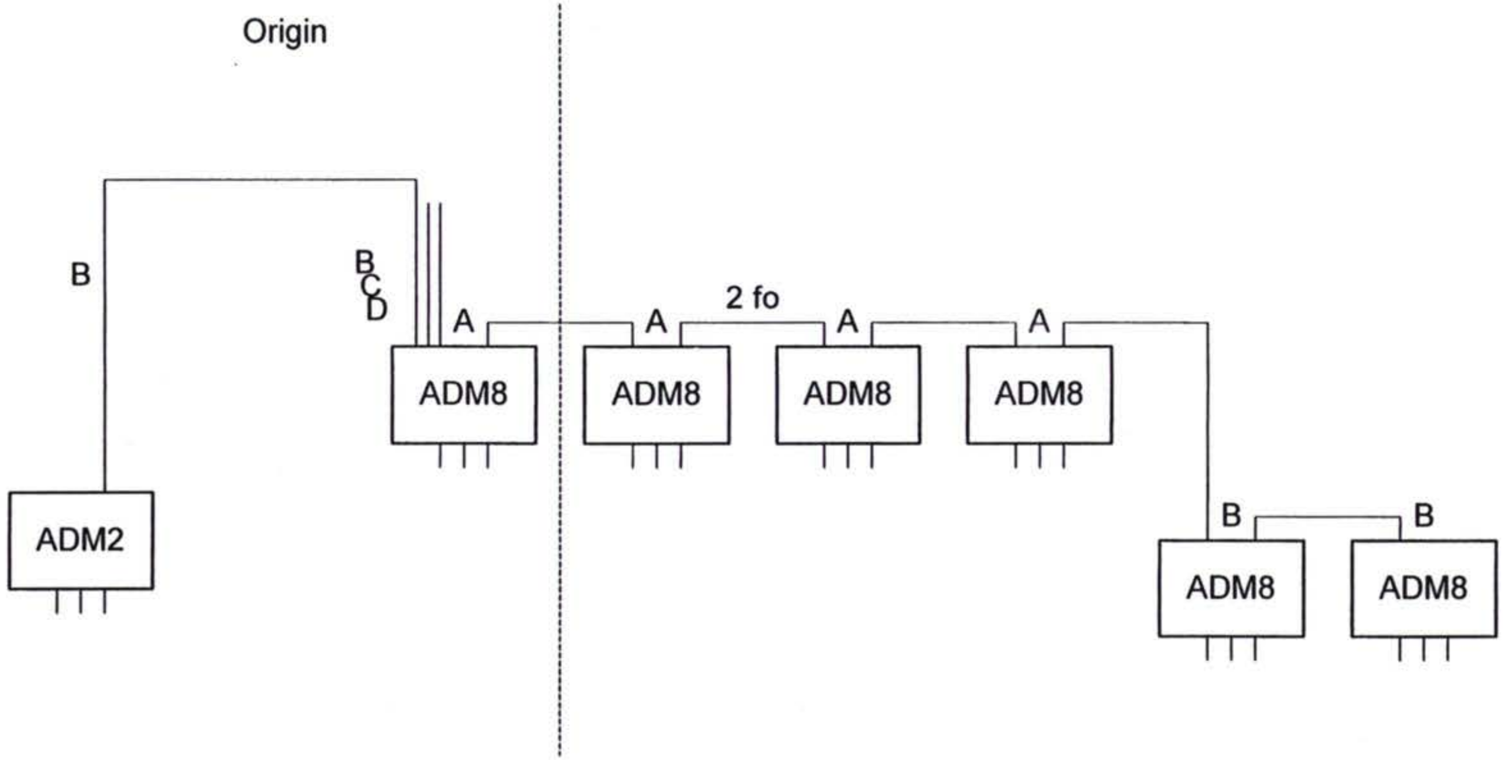


NB:
Redundancy shown over a single link in one direction only (control centre -> station)

Control centre redundancy

Diagram SP-16

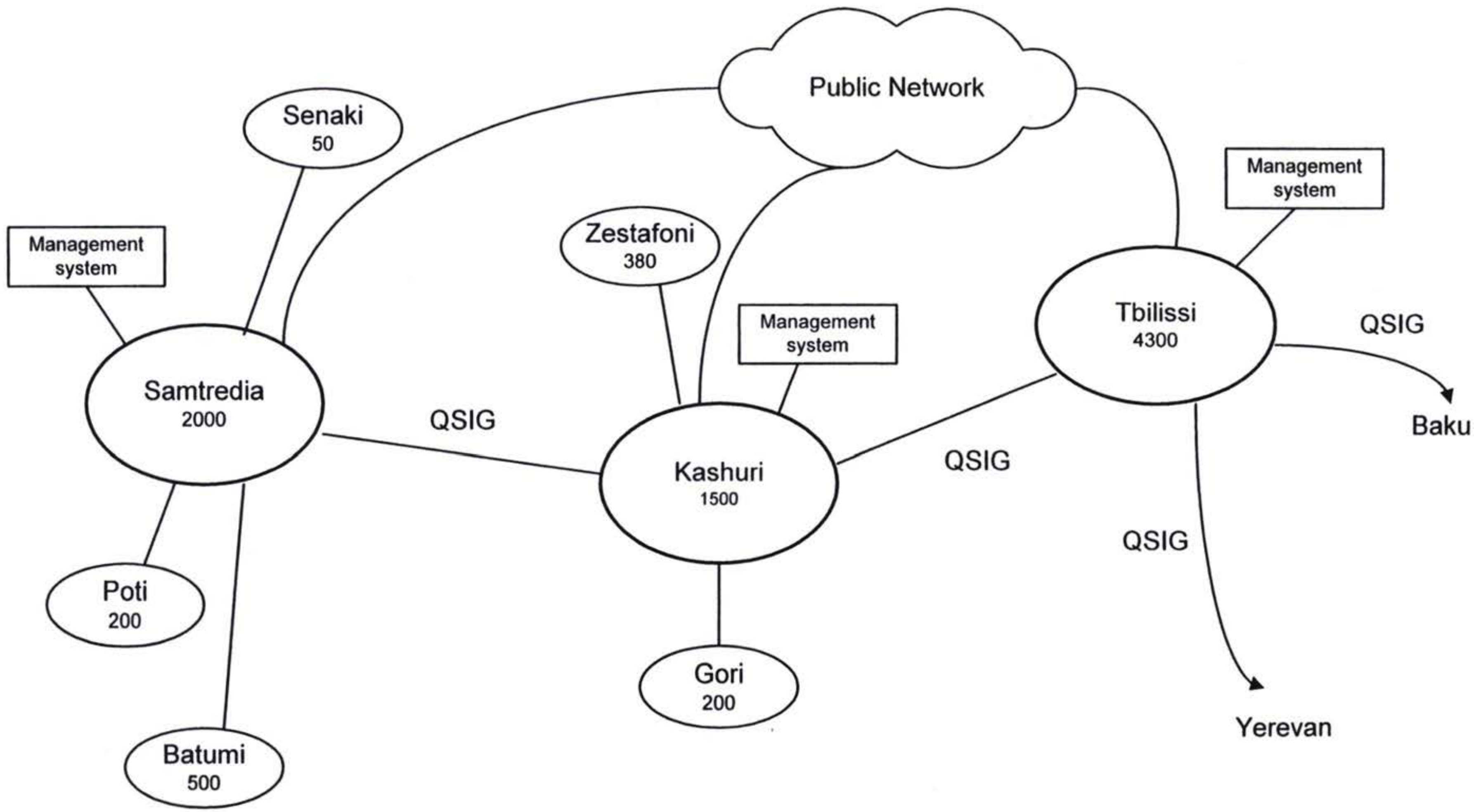
Appendix 2 - Bloc diagrams



Network of secondary railway lines

Diagram SP-17

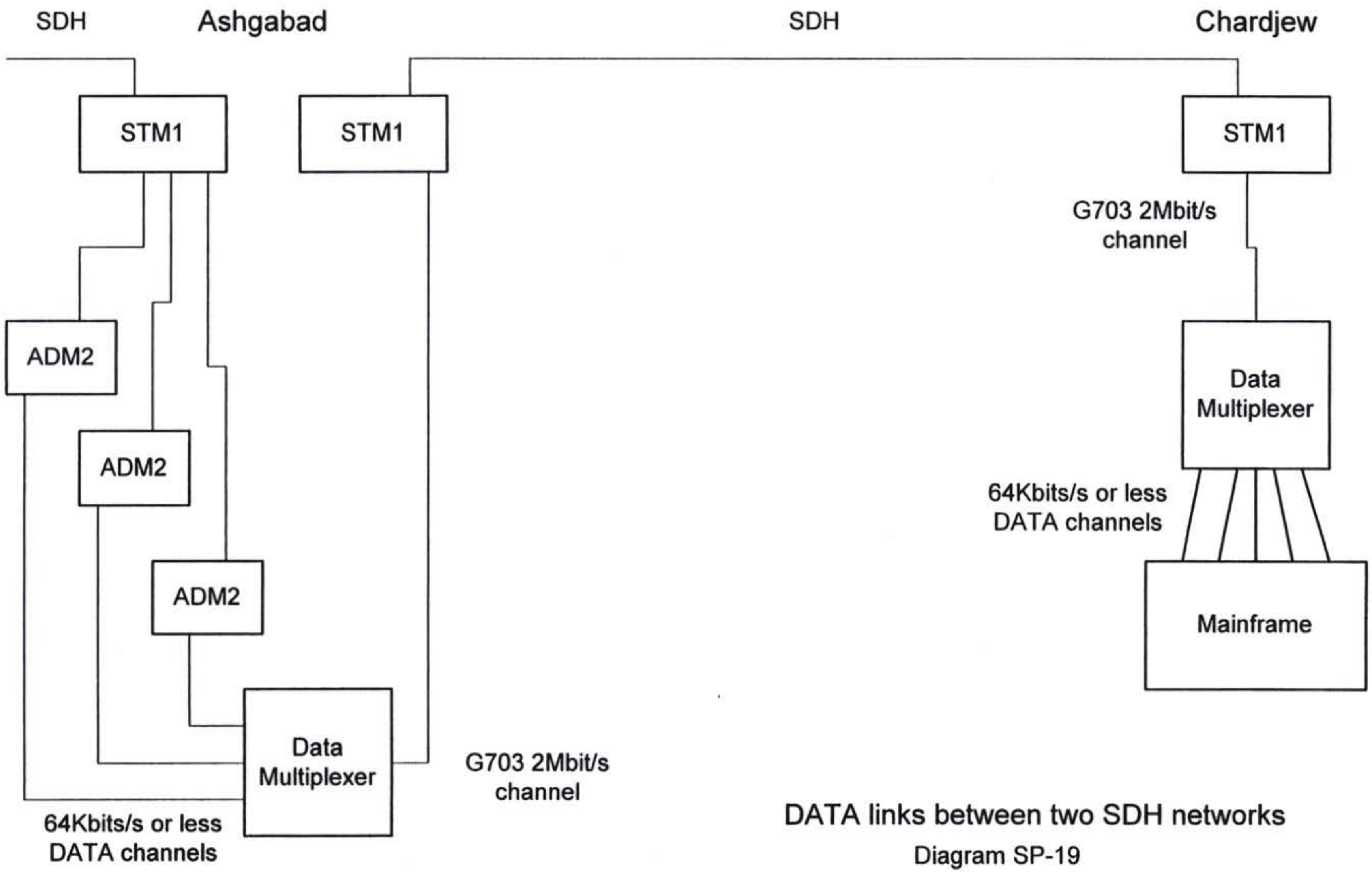
Appendix 2 - Bloc diagrams



Administrative telephone network

Diagram SP-18

Appendix 2 - Bloc diagrams



DATA links between two SDH networks
Diagram SP-19

Chapter 5

Caucasus - Recommendations and economic study

Caucasus - Recommendations and economic study

Contents

Caucasus - Recommendations and economic study

1. Telecommunications

The material enclosed contains the action and investment plan for Module E of the TRACECA project for the countries in the Caucasian area: Georgia, Azerbaijan and Armenia.

It consists of a technical study and an economic study.

1.1 Summary

1.1.1 Preface

1.1.1.1 Context and strategy

In Chapter 2, section 1 the **context** of the study is set out and in section 2, the **method** selected and the **general technical options** underlying the study of telecommunications network architecture.

The **context** is essentially as follows:

- Independent railway telecom networks have been envisaged for each country, with PABX being used to interconnect these countries with each other and with Europe.

- Major importance has been attached to specific railway telecom facilities used for railway operations and ensuring the safety of railway movements. In particular, these require a process of collection-distribution between the Control Centre, which is in charge of the supervision of railway lines as a whole, and the stations dotted along the line.

The **study strategy** selected is based on a distinction between a backbone telecom network, and a secondary telecom network, the backbone being for main railway trunk lines and the spokes being for the secondary lines branching off from these main line routes.

1.1.1.2 Block diagrams

Explanations and a set of **block diagrams** are provided in support of the general technical options selected and describe the rules for positioning the various parts that go to make up a telecom network. These constitute Chapter 2, section 3.

1.1.1.3 Financial data

Financial data given in Chapter 2, section 1.4 provides details of and a justification for the basic costs of the different parts of the telecom networks.

1.1.2 Technical study

The general recommendations of Chapter 2, applied to the railways in the Caucasian area, culminate in the following recommendations.

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1.1.2.1 Backbone network

A **proposal for a backbone network** is given for each of the three countries in the Caucasian area. These consist of:

- a document setting out the reasons for the specific options selected for a particular country,
- the general architecture of the backbone network (Appendix 1),
- **investment tables** (Appendix 2) for two different network configurations:
  -- without back-up of incoming railway control centre circuits,
  -- with partial back-up of incoming railway control centre circuits.

This data will subsequently be used as a basis for the economic study.

The backbone includes the following sections:
In Armenia: Ayrum (Georgian border) - Yerevan - Razdan, i.e. 369 km.
In Azerbaijan: Beyuk-Kasik (Georgian border) - Baku, i.e. 503 km.
In Georgia: Poti/Batumi - Tbilisi - Sadakhlo (Armenian border)/Gardabani (Azerbaijan border), i.e. 550 km.

1.1.2.2 Secondary network

A **simplified proposal for railway secondary networks** completes the technical study. This is organised along similar lines to the backbone network proposal (justification of solutions selected, general diagrams, investment tables). The corresponding diagrams and appendices are given as Appendices 3 and 4.

1.1.2.3 Conclusions

The following are the main **conclusions**:

- It is recommended that a firm decision be made to opt for **optical fibre cables** and **digital transmission** techniques.
Where the backbone telecom network is concerned, it is recommended that use be made of cables with 24 optical fibres, 12 of which would be employed for railway applications and 12 by possible future telecom operators. This cable will be buried to ensure reliability and a long life cycle.

Comparison of laying methods for optical fibre cable :

Method of laying	Aerial		Buried	
	Pro	Con	Pro	Con
Ease of laying	X		X (earth)	X (rocks)
Mechanical protection		X	X	
Sensitivity to wind, trees, snow, etc.		X	X	
Risk of vandalism		X	X	
Effects of catenary poles condition		X	X	
Bullet-proof tests		X	X	
Price of cable		X	X	
Speed of laying	X			X
Laying price	X			X

- It is recommended that the basis of the backbone network should be SDH technology (synchronous 155 Mbit/s STM1 add/drop multiplexers) supplemented by telecom distribution networks using drop-and-insert PCM (2 Mbit/s add/drop multiplexers with an 8 Mbit/s ADM8 transport medium and 2 Mbit/s add/drop multiplexers with a 2 Mbit/s ADM2 transport medium).
These telecom networks are linear and in this respect they reflect the topology of the railway networks.

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- It is recommended that telecom networks be provided at least partially with back-up, without seeking full redundancy for all the various installations, this not being economically justified. The solution whereby incoming control centre circuits are provided with back-up would be preferable but seems unfeasible, given that the public telecom operators do not appear to be able to supply the necessary external cables.

- It would also be advisable to replace the automatic administrative telephone switches with digital equipment.

- The technology to be adopted for the railway secondary networks should consists of a 6-fibre cable and drop-and-insert PCM.
Given the high cost of investment, it is not recommended that secondary networks be systematically equipped but rather that this be done in relation to actual operating needs. However it should be borne in mind that the equipment recovered when replacing the backbone will be available for use in maintaining these secondary lines and this will make it possible to defer investments for them.

1.1.3 Investment

1.1.3.1 Budget for the recommendations

The recommendation that an optical fibre network be installed with SDH and PCM multiplexers, operational telephony and administrative telephone switches would give the following budget:

	EU Investment (MECU)	Railway Investment (MECU)
Total	18.33	2.55

European Union investment covers:

- the cable and its fittings
- supervision of staking out operations and cable laying
- cable connections
- transmission equipment
- PABX
- power supply
- spares
- training

The railways' investment covers:

- staking out
- civil engineering
- cable laying
- rewiring buildings and installing subscriber telephones

The cost calculated is ten times lower than that of similar work in western Europe because of manpower cost differences.

1.1.3.2 Pilot Project

In order to focus on top priority investments that are vital to the railways, and to quickly initiate a preliminary project which would demonstrate the viability of the whole project, a pilot project should be set up.

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The pilot project should focus on the main line linking Baku to Poti (through Tbilisi) and to Yerevan, thus entailing the knock-on effects on the backbone proposal :

- Omission of the Samtredia/Batumi section in Georgia
- Omission of the Yerevan/Razdan section in Armenia
- Completion of the whole backbone whilst only installing equipment in 70% of small stations (in relation to the categories in the UIC technical study).
- Inclusion of all PABX but with only 75% of the original capacity

N.B.: not renewing the equipment in 30 to 50% of stations was already a recommendation in the CIE-Consult report on Georgia for the EBRD.

The pilot backbone network takes in the following sections:

In Armenia : Ayrum (Georgian border) - Yerevan, i.e. 309 km.
In Azerbaïjan : Beyuk-Kasik (Georgian border) - Bakou, i.e. 503 km.
In Georgia : Poti - Tbilisi - Sadakhlo (Armenian border)/ Gardabani (Azerbaijani border), i.e. 444 km.

The amount of investment would be as follows:

	EU Investment (MECU)	Railway Investment (MECU)
Total	14.8	2.2

There is quite a substantial degree of uncertainty in the Railway investment figure, as it mainly covers civil engineering which will depend on local costs. And this figure only approximate the work that would be done by the railways themselves. If the civil engineering is undertaken by an external company and paid by the railways, the amount may be much higher.

1.1.4 Economic study

The economic study is composed of a comparison between two scenarios over 20 years.

- Reference scenario, in which the project does not go ahead. The current maintenance budget continues to apply, with an increase of 2% per annum. Locomotives are procured to offset delays caused by telecommunications failures (5 minutes per 6.4 km section per day for all trains in the country concerned).

- Project scenario, in which the project is implemented in each of the countries concerned within a twelve-month period. Operating costs amount to 2% of investment in equipment and maintenance is 1FRF/m of cable laid. Cables have a useful life of 50 years and equipment of 20 years.

  Revenue may be expected from hiring out surplus system capacity to telecom operators. This revenue is taken into account in Armenia from the second year, since the law already allows for this eventuality. In Azerbaijan and in Georgia, the necessary legal framework does not yet exist and as a result revenue is only expected to be earned six years after the start of the project.

The following table shows the corresponding rates of return:

	Overall	Armenia	Azerbaijan	Georgia
IRR	21 %	19 %	32 %	16 %

Results will be heavily dependent on revenue earned from hire of excess system capacity. Among the many advantages of this investment, only this revenue has been able to be estimated. But the

internal benefits would be sufficient in themselves to justify the project as part of the railway restructuring process.
Despite the rather pessimistic assumptions and a reference situation where the cost of maintenance has probably been underestimated, the internal rates of return of the projects proposed are high (about 20%). They would require changes in the telecommunications legislation in Georgia and Azerbaijan in the next five years.

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1.2 Technical study

The diagrams and investment tables are given in Appendices 1 and 2.

1.2.1 Backbone Network, Armenia

1. The backbone network consists of the Ayrum-Yerevan-Razdan line.

5 STM1 are located on the line in:
- Vanadzor, Gyumri, Macis, Erevan et Razdan.

A 14 km local loop is located on the Yerevan-Macis section.

2. The total length of the Ayrum-Yerevan-Razdan backbone is 369 km (including local loop).

3. The PABX is located in Yerevan.

4. There is a total of 40 stations, which may be broken down as follows:
   - 8 large or medium-size stations, warranting telephone equipment suitable for an average stations. These are:
     -- Ayrum, Samain, Vanadzor, Gyumri, Masis, Yerevan-Fret, Yerevan-Passagers and Razdan,
   - 32 less-important stations, warranting telephone equipment suitable for a small station.

5. The traffic and energy (sub-systems, OHL) control room is located in Yerevan.

6. A single technical facilities room (including power supply, air conditioning, protection systems, wiring racks, etc.) is located in Yerevan for the control room station equipment, the PABX and the digital transmission equipment - STM1 and ADM.

7. The distribution networks are made up of 8 Mbits/s ADM (drop-and-insert PCM add/drop multiplexers).
(See Chapter 2, section 2 : Method)

From the rules in the Method sub-section and figure AIP.1, it may be extrapolated that 10 links need to be set up for the distribution network, i.e. the following ADM distribution:
- 40 for the stations,
- 10 to the Yerevan control room.

Thus a total of 50 ADM for a network without back-up of links between control centres and stations.

8. An SDH network management unit (STM1) is located in Yerevan.

9. Two distribution network management units (ADM) are each located in Yerevan and in Gyumri respectively, which are considered the telecom centres of excellence of Armenia.

10. As regards power supply:
   - power supply to the PABX, STM1 and ADM of the Yerevan control room is included in the technical facilities room,
   - the 8 large stations listed under point 4 and the corresponding STM1 and ADM are fed by 8 medium capacity power supply lines,
   - the 32 small stations listed under point 4 and the corresponding ADM are fed by 32 modest capacity power supply lines.

11. Back-up

It is assumed that there is a flattened transmission loop providing partial back-up in every case.

Total back-up for the main rail operating links (operations control and power control) on the Yerevan-Vanadzor line can be provided by an external network (for example the public network). That arrangement would involve installing 10 additional ADM in Vanadzor.
It also requires 1 additional medium capacity power supply line in Vanadzor.

1.2.2 Backbone Network, Azerbaijan

1. The backbone network consists of 9 STM1 located in:
- Akstafa, Gyandja, Evlakh, Udzari, Kyurdamir, Kazi-Magomed, Alyatl, Baladjari and Bakou
The backbone network runs from Beyuk-Kasik (border with Georgia) to Bakou.

A 9 km local loop is located in Bakou.

2. The total length of the backbone is 503 km (including the local loop).

3. The PABX is located in Bakou.

4. There is a total of 50 stations, which may be broken down as follows:
   - 12 large and medium-size stations, warranting telephone equipment suitable for an average station. These are:
     -- Beyuk-Kasik, Akstafa, Gyandja, Evlakh, Udzari, Kyurdamir, Kazi-Magomed, Alyatl, Baladjari and 3 x Bakou.
   - 38 less important stations, warranting telephone equipment suitable for a small station.

5. The traffic and energy (sub-stations, OHL) control room is located in Bakou.

6. A single technical facilities room (including power supply, air conditioning, protection systems, wiring racks, etc.) is located in Bakou for the control room station equipment, the PABX and the digital transmission equipment - STM1 and ADM.

7. The distribution networks are made up of 8 Mbits/s ADM (drop-and-insert PCM add/drop multiplexers).
(See Chapter 2, section 2 : Method)

From the rules in the Method sub-section and figure AIP.2, it may be extrapolated that 14 links need to be set up for the distribution network, i.e.; the following ADM distribution:
   - 50 for the stations,
   - 14 to the Bakou control room.
Thus a total of 64 ADM for a network without back-up of links between control centres and stations.

8. An SDH network management unit (STM1) is located in Bakou.

9. Two distribution network management units (ADM) are located in Bakou and in Gyandja respectively, which are considered the telecom centres of excellence of Azerbaijan.

10. As regards power supply:
   - power supply to the PABX, STM1 and ADM of the Bakou control room is included in the technical facilities room.
   - the 12 large stations listed under point 4 and the corresponding STM1 and ADM are fed by 12 medium capacity power supply lines.
   - the 38 small stations listed under point 4 and the corresponding ADM are fed by 38 modest capacity power supply lines.

11. Back-up

It is assumed that there is a flattened transmission loop providing partial back-up in every case.

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Total back-up for the main rail operating links (operations control and energy control) on the Bakou-Gyandja line can be provided by an external network (for example the public network). That arrangement would involve 14 additional ADM being installed in Gyandja.
It also requires 1 additional medium capacity power supply line in Gyandja.

1.2.3 Backbone Network, Georgia

1. The backbone network consists of 7 STM1 installed in:
   - Poti, Batumi, Samtrediya, Zestafoni, Khashuri, Gori and Tbilisi.

Apart from the Poti-Tbilisi main line and the Batumi-Samtrediya secondary line, the network includes secondary lines running to the borders with Azerbaijan and Armenia, i.e. the Tbilisi-Gardabani and Tbilisi-Sadakhlo lines.

A 9 km local loop is located in Tbilisi.

2. The total length of the backbone is 550 km (including the local loop).

3. The PABX is located in Tbilisi.

4. There is a total of 69 stations, which may be broken down as follows:
   - 15 large and medium-size stations, warranting telephone equipment suitable for an average stations. These are:
     -- Poti, Senaki, Batumi, Samtredyia, Kutasi, Zestafoni, Khashuri, Gori, 3 x Tbilisi (-UZL., -PASS. and -SORT.), Marauli, Sadakhlo, Rustavi and Gardabani.
   - 54 less important stations, warranting telephone equipment suitable for a small station.

5. The traffic and energy (sub-stations, OHL) control room is located in Tbilisi.

6. A single technical facilities room (including power supply, air conditioning, protection systems, wiring racks, etc.) is located in Tbilisi for the control room station equipment, the PABX and the digital transmission equipment - STM1 and ADM.

7. The distribution networks are made up of 8 Mbits/s ADM (drop-and-insert PCM add/drop multiplexers).
(See Chapter 2, section 2: Method)

From the rules in the Method sub-section and figure AIP.1, it may be extrapolated that 17 links need to be set up for the distribution network, i.e. the following ADM distribution:
   - 69 for the stations,
   - 17 to the Tbilisi control room.
Thus a total of 86 ADM for a network without back-up of links between control centres and stations.

8. An SDH network management unit (STM1) is located in Tbilisi.

9. Two distribution network management units (ADM) are located in Tbilisi and in Samtredyia respectively, which are considered the telecom centres of excellence of Georgia.

10. As regards power supply:
   - power supply to the PABX, STM1 and ADM of the Tbilisi control room is included in the technical facilities room.
   - the 15 large stations listed under point 4 and the corresponding STM1 and ADM are fed by 15 medium capacity power supply lines.
   - the 54 small stations listed under point 4 and the corresponding ADM are fed by 54 small capacity power supply lines.

11. Back-up

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It is assumed that there is a flattened transmission loop providing partial back-up in every case.

Total back-up for the main rail operating links (operations control and energy control) on the Tbilisi-Samtredyia line can be provided by an external network (for example the public network). That arrangement would involve 17 additional ADM in Samtredyia.
It would also require 1 additional medium capacity power supply line in Samtredyia.

1.2.4 Telecom switches for office telephones

In order to enhance the impact of the renovation of the telecommunications network, it is proposed to replace all or some of the telecom switches serving office telephones.

The telecom switches (PABX) involved and the number of subscribers in each case are:

In Armenia :

Yerevan	2 000
Masis	200
Gyumri	1 500
Sananin	200
Ayrum	100
Vanadzor	200

In Azerbaïjan

Baku	3 000
Alyat	100
Kazi Magomed	200
Kyurdamir	200
Baladjari	2 100
Gyandja	2 300

In Georgia

Tbilisi	4 300
Kashuri	1 500
Zestafoni	380
Gori	200
Samtredia	2 000
Senaki	50
Poti	200
Batumi	500

The PABX for the capitals (Yerevan, Baku and Tbilisi) will replace the PABX advocated for the Backbone part.

PABX covering over 500 telephones need the same type of control room as that advocated for the PABX in the Backbone part.

Inter-PABX links are based on channels carrying 2Mbits/s.

Inter-PABX links (channels @ 2Mbits/s)			
	Armenia	**Azerbaïjan**	**Georgia**
Number of channels	7	12	12

The investment tables are given in Appendix 5.

1.2.5 Railway secondary line architecture and investment

The diagrams and investment tables figure in Appendices 3 and 4.

1.2.5.1 General

- Figures AIP.4 to AIP.6 illustrate the railway secondary line networks in Georgia, Azerbaijan and Armenia.

- The kilometre length and number of stations is stated for each line.

- The following table summarises the main characteristics for the secondary network and the same characteristics for the backbone network:

	Secondary lines			Backbone	
	Number of secondary lines	Kilometres	Number of stations	Kilometres	Number of stations
Georgia	9	934	92	550	69
Azerbaïjan	8	1 354	113	503	50
Armenia	5	409	26	369	40
Total	**22**	**2 697**	**231**	**1 422**	**159**

It is thus evident that the figures for line length and station numbers are substantially higher for the secondary lines than for the backbone networks.

1.2.5.2 Architecture of secondary line telecommunications networks

- Unlike the architecture of the backbone network, that of the secondary line telecom networks has not been studied in detail. The proposal made should be seen as a preliminary outline.

- The secondary lines have been dealt with separately from the backbone networks. Integration in the backbone network could be looked into later, depending on actual operating needs. There is in any case no impact on investment.

- A cable with 6 optical fibres has been chosen (2 for the distribution network, 2 for any back-up or another service, 2 spare fibres), procuring a 15 % saving across the board on the cost of type D cable laying (buried).

- The basic architecture is a linear PCM drop-and-insert network, in line with block diagram SP17.

- ADM network management specifically for the secondary line is installed for secondary lines over 90 km long.
There are no plans to install network management equipment on site at the beginning of the line for shorter secondary lines. Instead, maintenance engineers will work using a portable computer.

- Station installations and medium capacity power supply lines are provided at origin points considered important (major railway hubs and/or long secondary lines). In all other cases, equipment suitable for small stations and low capacity power supply lines are installed.

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- It has been decided not to provide back-up for secondary line control circuits.

1.2.5.3 Investment

- An approximate estimate of the cost of equipping all the secondary lines with fibre optic cables and digital transmission equipment in each country is given in the secondary line **investment tables**.

N.B.: As stated above, no detailed technical study has been carried out for each secondary line. The quantities stated should be considered as rough estimates.

- The following table summarises the estimated investment figures and shows the investment figures for backbone networks without back-up.

Investment summary table (EU)

	Secondary lines	Backbone (without back-up of links between control centres and stations)	Backbone (with back-up of links between control centres and stations)	Total (with back-up of links between control centres and stations)
Armenia	2.55	3.90	4.04	6.59
Azerbaïjan	7.80	5.03	5.22	13.02
Georgia	5.76	5.79	6.02	11.78
Total (MECU)	**16.11**	**14.73**	**15.28**	**31.39**

Investment summary table (railway)

	Secondary lines	Backbone (without back-up of links between control centres and stations)	Backbone (with back-up of links between control centres and stations)	Total (with back-up of links between control centres and stations)
Georgia	0.46	0.53	0.53	0.99
Azerbaïjan	1.54	0.72	0.72	2.26
Armenia	1.06	0.79	0.79	1.85
Total (MECU)	**3.06**	**2.04**	**2.04**	**5.1**

1.2.5.4 Conclusion

It is absolutely clear that the scope of the TRACECA project pilot phase in the Caucasus is not to cover the investment on all secondary lines and that secondary line upgrading will have to be carried out step by step as circumstances allow.

1.3 Economic study

1.3.1 Introduction

This section outlines the economic and financial evaluation of the project to install telecommunications networks serving the Caucasian railways of Armenia, Azerbaijan and Georgia. A commonly used alternative for the project title is: "Caucasus Telecom Railways Line (CTRL)".

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First an explanation is given as to the method applied followed by a run-down of the different scenarios, the results of internal rate of return (IRR) calculations and an analysis of IRR variations.

The support received from Mr Roussel (Systra) throughout this study has been particularly appreciated.

The data used in the analyses are taken from existing Tacis/Traceca reports and from two studies completed by CIE-Consult for the EBRD.

1.3.1.1 Direct benefits

These benefits, some of which are quantified in this economic study, comprise:

- improvement of rail traffic safety levels, in particular in Armenia and Georgia,
- stripping away of some speed restrictions on certain sections,
- practical elimination of the numerous telecommunications-related delays,
- optimal use of rolling stock,
- installation of powerful communications links between railways in the region,
- better maintenance,
- creation of a new revenue source, i.e. leasing of excess capacity in the telecommunications network.

1.3.1.2 Indirect benefits

Although it is difficult to quantify such advantages, they constitute key factors in reviving the railways in question, in particular with respect to competition. They include:

- creation of the infrastructure required for the installation of MIS systems (essential basis for restructuring),
- creation of the infrastructure necessary to fit the real-time freight tracking systems requested by customers
- provision of a basis for creating interfaces with other transport providers
- regional and international co-operation project.

1.3.2 Method

The economic evaluation was carried out for a period of 20 years in $ US (constant values). The approach taken was to compare the current situation (the reference situation) without the investment project with the situation if the project is implemented (project situation). In each case, income and expenditure are compared and the internal rate of return from the project is estimated for each country.

1.3.3 Reference situation: project not implemented

The reference situation is defined by calculating current telecommunications maintenance and operating costs and the investment required to reduce traffic delays caused by telecommunications incidents. The solution envisaged to lessen these delays is to purchase additional locomotives.

1.3.3.1 Maintenance and operating costs

These are calculated on the basis of available data regarding the current situation at the various railways in the countries examined. The main items taken were salary payments and costs, expenditure on materials and repairs and any other telecommunications and signalling costs. In the absence of a breakdown per sector, it was assumed that 40% of telecom and signalling department staff and costs are employed solely for telecommunications purposes.

The figures used for Armenia ('97 staff and '96 costs) and Georgia ('96 costs) are taken from the Tewet study (Joint venture for the Caucasian railways), and the (ADDY) source used for those relating

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to Azerbaijan ('96 staff and costs) is the CIE-Consult study (EBRD Project Identification report, Azerbaijan Railways.

Costs in US $ 1,000	ARMENIA	AZERBAIJAN	GEORGIA
salaries and operating costs	80	1,250	508
materials	32	251	61
repairs(*)	27		396
other costs	4	914	36
Total	**144**	**2,415**	**1,002**

(*) no information available for the Azerbaijan 'repairs entry

These amounts correspond to investments for one kilometre of cable and it is assumed that 40% of staff work purely on telecommunications activities.

	ARMENIA	AZERBAIJAN	GEORGIA
Line length in km	798	2,117	1,575
Km of cable invested	309	503	444
Telecommunications + signalling staff	304	2,086	1,100
Telecommunications staff	122	834	440

Annual maintenance and operating expenditure is given in the following table in US $1,000.

	ARMENIA	AZERBAIJAN	GEORGIA
Maintenance and operating costs	27	230	113

These costs seem to be too low for the material fitted, most likely because available funds for repairs are lacking and certain outdated spare parts cannot be replaced.

The age-related increase in costs was estimated to be 2% per annum.

1.3.3.2 Delays

Delays are caused by obsolete material.

According to the CIE-Consult Study on Georgia (EBRD Project identification report, Georgian railways), the delay observed (aggregate for all trains) is 5 minutes per day and per 6.4 km section. This statistic was applied to each country and adjusted by annual rates of increase in daily delays corresponding to the specific features of the three countries selected for the study.

	ARMENIA	AZERBAIJAN	GEORGIA
Rate of increase in delays	5%	2%	3%

The (book) life of an electric locomotive was set as 25 years, and the residual value is brought to account in the final year of the study (2019).

The following estimates were taken from various past studies in order to gauge the number of hours for which a locomotive is worked annually:

	ARMENIA	AZERBAIJAN	GEORGIA
km/year/locomotive	70,000 km	100,000 km	100,000 km
mean speed	40 km/h	40 km/h	40 km/h
hrs/year /locomotive	1,750	2,500	2,500

Locomotive requirements are gauged on the basis of annual delays recorded for each country and annual operating hours per locomotive.

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The tables are presented in full in Appendix 6.

Locomotive requirements per country are as follows:

ARMENIA

Investment years	2000	2011
Number of locomotives	1	1
Cost (US$ m)	3	3
Residual value (US$ m)	0.72	2.04

AZERBAIJAN

Investment year	2000
Number of locomotives	2
Cost (US$ m)	6
Residual value (US$ m)	1.44

GEORGIA

Investment years	2000	2006
Number of locomotives	1	1
Cost (US$ m)	3	3
Residual value (US$ m)	0.72	1.44

1.3.4 The project

The project situation is determined by investments, operating and maintenance costs and income from leasing of excess capacity in the telecommunications network (PCM channels and dark fibres).

1.3.4.1 Investments

The amount taken corresponds to aggregate investments funded by the EU and the railways, scheduled for disbursement in 2000.

in millions of US $	ARMENIA	AZERBAIJAN	GEORGIA	Total
Aggregate investment	**4.47**	**7.18**	**7.06**	**18.70**
EU share of total investment	3.90	6.22	6.17	**16.29**

A full breakdown is given in Appendices 2 and 5.

Lifespan is assumed to be 50 years for cables and 20 years for equipment.

1.3.4.2 Maintenance and operating costs

Maintenance and operating costs were estimated as follows:

- equipment: 2 % of total investment in equipment (the corresponding figure for western Europe is 4%),
- cables: 1 FRF/m of laid cable.

The results are set out in the tables below:

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in millions of US $	ARMENIA	AZERBAIJAN	GEORGIA
Cable length in km	309	503	444
Total investment	4.47	7.17	7.06
% thereof for equipment	2.04	3.21	3.41
Operating costs (O)	0.04	0.06	0.07
Cable maintenance (M)	0.05	0.08	0.07
Total M+O	**0.09**	**0.15**	**0.14**

1.3.4.3 Revenue from lease of excess transmission capacity

The technical recommendations specified a level of capacity superior to the needs of the railways alone, thus creating a leasing option.

There are two types of excess capacity:

- the SDH/STM-1 installations comprising 63 PCM channels operating at 2Mbits/s.
- twelve fibres (six pairs) reserved for telecom needs (dark fibres).

1.3.4.3.1 PCM capacity

This type of capacity is likely to be of most interest to GSM operators and companies wishing to create IT links between different locations.

Tariff estimates are based on France Télécom rates and calculated for a 2Mbits/s link over 150km, i.e. 0.054 million US $/year. In order to create a realistic scenario, this rate was divided by four, producing 0.014 million US $/year for this study.

The technical recommendations include installing STM-1 equipment providing sixty-three 2Mbits/s channels. The following table summarises railway needs and the number of channels available for leasing.

	Armenia	Azerbaïjan	Georgia
recommended no. of channels	11	15	18
links between PABX systems	7	12	12
with 50% spare capacity	27	41	45
Total available	**63-27= 36**	**63-41= 22**	**63-45= 18**

Given that existing telecommunications legislation in Armenia has already been adapted accordingly, leasing revenue is accounted for as of 2003. In the other two countries, no income is calculated before 2005 to allow time for legislation to be altered.

In the first year, it is assumed that 10% of total capacity is leased with an additional 10% being added each year.

1.3.4.3.2 Dark fibres

This type of capacity will be of use to European and worldwide telecommunications operators who, while reluctant to invest in cables, will have the means and opportunity to install the electronic technology necessary to use the optical fibres surplus to railway needs.

Of the 24 fibres specified in the technical recommendation, 6 will be put to use immediately, 6 will be reserved for future railway needs and 12 will be set aside for leasing.

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The income estimates are based on the rates charged by RATP and French motorways, i.e. 8 to 20 FRF/m/year (6FRF = 1US$) per fibre pair. More realistic rates were taken for this study, i.e.:

- 0.5 US $/m/year for Armenia (which feeds the Europe/Asia link)
- 1 US $/m/year for the other two countries (which are on the Europe/Asia link).

Leasing commences in 2007, with two pairs of fibres being leased in the first year and another two pairs being added biennially.

1.3.4.3.3 Telecom switches (PABX)

It would appear that some of the subscribers served by the railway telecom switches are third parties, e.g. forwarding agents, who must pay a subscription for this service. However, given the poor quality of lines, subscription fees are no longer charged.

The same service is provided to the homes of railway employees free of charge, although it is likely that a subscription fee will be levied as part of the move towards a market economy.

Hence, replacing the PABX systems would generate revenue which unfortunately can not be quantified for want of exact data.

1.3.5 Results

Based on the two distinct scenarios developed above the following internal rates of return may be calculated per country:

	Overall	Armenia	Azerbaijan	Georgia
IRR	21 %	19 %	32 %	16 %

The results are given in tabular form in Appendix 6.

1.3.6 Rate of variation

It is interesting to note how the rates of return are affected by a +/- 10 % variation in project investment

The reference situation remains unchanged, with only operating and maintenance costs (and the residual value) varying in response to an adjustment in investment).

	Overall	Armenia	Azerbaijan	Georgia
IRR (inv +10%)	18 %	17 %	25 %	15 %
IRR (inv -10%)	25%	23 %	52 %	18 %

The tables used for the calculations are given in Appendix 6.

1.3.7 Economic study based solely on telecommunications revenue

The internal rates of return calculated on the basis of revenue from dark fibre and PCM channel leasing alone are as follows:

	Overall	Armenia	Azerbaijan	Georgia
IRR	10%	8%	11%	9%
IRR (inv + 10%)	11%	7%	11%	15%
IRR (inv -10%)	13%	9%	12%	19%

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The income generated by leasing excess telecommunications network capacity alone justifies the project. However, it is vital that:

- the governments of Azerbaijan and Georgia undertake to amend telecommunications legislation to enable the railways to compete against the existing national operator;
- agreements be signed apace with telecommunications operators and with companies managing the underwater cables in the Black and Caspian Seas.

1.3.8 Sensitivity to revenue variation

Given the project's heavy reliance upon revenue generated by leasing excess telecommunications network capacity, the following results illustrate the project's sensitivity to their variations :

	Overall	Armenia	Azerbaïjan	Georgia
IRR (revenues +10%)	22 %	20 %	33 %	17 %
IRR (revenues -10%)	20 %	18 %	31 %	15 %

The tables used for the calculations are given in Appendix 6.

1.3.9 First Year Benefit Ratio

The First Year Benefit Ratio (FYBR) is an indicator for gauging most opportune period for project implementation. The FYBR is defined as the ratio of the discounted benefits of the project in the first year of normal operation, divided by the total discounted project costs from project start to the first year of normal operation.

The table below summarises the FYBR for the three countries involved in the optical cable project. Provided the implementation starts in 2000, the project will become fully operational (i.e. dark fibres are leased out) in 2007.
The discount rate applicable to the Caucasus is 8 %.

	Overall	Armenia	Azerbaïjan	Georgia
FYBR	19 %	10.5 %	72.2 %	12.8 %

The very high rate for Azerbaïjan is explained by the significantly lower maintenance costs in the project scenario (S1) as compared to the reference scenario (S0).

From these FYBR figures, it appears that the Caucasian telecommunications market is ready to absorb the optical cable's spare transmission capacity. From a market point of view, the project implementation should therefore not be delayed.

1.3.10 Conclusion

The results obtained rely heavily upon revenue generated by leasing excess telecommunications network capacity. While there are many benefits to be derived from such investment, leasing revenue is the only one which can be quantified, although other internal spin-offs would suffice to justify implementing the project as part of the restructuring of the three railways.

Although experience has shown that this type of project can be expected to bring about savings in maintenance expenditure, the assumption does not hold true here. Current expenditure is most likely underestimated and/or maintenance work neglected for want of spare parts.

The project is expected to produce lower operating costs and increased revenue (freight and passenger) by enhancing train punctuality.

2. Electronic data interchange

2.1 Project context

2.1.1 Project objectives

This section of Module E aims to enhance electronic data interchange between the railways and their partners.
The partners include:

- other railways,
- customs authorities,
- police et immigration officials,
- major customers,
- freight forwarders,
- shipping companies.

The goals are to:

- boost productivity at the railways by cutting down on formalities and the number of forms to be filled in and monitoring goods throughout the journey,
- shorten freight transit times by simplifying formalities, particularly customs procedures at borders,
- allow customers direct access to information regarding the status of their goods,
- improve communication with shipping companies, thus ensuring continuous tracking of goods,
- enhance passenger traffic,
- and generally increase railway satisfaction ratings amongst customers.

2.1.2 General context

The level of computerisation at Caucasian railways is relatively low, and only stations located at borders or in the capitals are equipped with IT facilities. All three railways have a computer link with Moscow.

The Armenian customs authorities, and more recently their Georgian counterparts, have adopted UNCTAD's IT customs system, Asycuda. Although the pilot phase has been completed, the system has yet to be installed across-the-board owing to a shortage of funds. Azerbaijan's customs procedures are being upgraded on the basis of an in-house system.

Freight forwarders are generally quite well equipped with computer facilities, albeit to a lesser extent in Armenia.

The Baku-based Caspian Shipping Company is computerised, but there does not seem to be any IT facilities in Georgian ports.

There is currently no electronic data interchange between the above-mentioned parties, although they are willing to redress this situation. Good cases in point are plans to connect freight forwarders in Armenia and Georgia with their respective customs authorities. Implementation is subject to availability of sufficient telecommunications resources.
(The information concerning customs authorities, customers, freight forwarders and ports has been taken from the report on "Traceca - Trade Facilitation - Computer Systems Report". Some details regarding Asycuda were supplied directly by UNCTAD).

2.1.3 Legal context

CIS states do not seem to have any legislation governing electronic data interchange.
It is advocated that OSJD lend these electronic messages the same official and irrefutable status accorded to the hard-copy forms currently used.

It is strongly recommended that bilateral, or preferably multilateral, interchange agreements be signed, possibly taking the following texts as reference:

- "Commission recommendation of 19 October 1994 relating to the legal aspects of electronic data interchange" and the "European Model EDI Agreement" (Official Journal of the European Communities, 28 December 1994, No.L338, page 98),
- "Trade data interchange by teletransmission - UNCID" (International Chamber of Commerce, 22 September 1987)
- "UNCITRAL model law on electronic commerce" (29^{th} session: 28 May - 14 June 1996).

UNCID: Uniform Rules of conduct for interchange of trade data by teletransmission
UNCITRAL: United Nations Commission for International Trade Law

2.2 Services to be provided

2.2.1 Data interchange with other Traceca railways

It is imperative that freight and passenger data be exchanged electronically between the railways. This task is indirectly performed by the existing system, which is centralised in Moscow. Whatever changes take place in railway IT facilities in the Caucasian countries, it is vital that this electronic exchange of data continues.

2.2.2 Data interchange with administrative bodies

Since the railways have information on goods passing through customs quite some time before the actual border-crossing, they should be able to forward this data electronically to the central customs office and/or the border station. This should considerably reduce train stoppage times at borders.

2.2.3 Data interchange with customers

The target should be to enable customers to access the railways on-line to:

- book wagons,
- input information on their goods,
- obtain tariff details,
- find out the status and location of their goods,
- be notified when the goods arrive,
- secure statistics,
- receive reference timetables.

2.2.4 Interconnecting Traceca railways with Europe

Since there is already electronic data interchange between the Traceca railways, it is recommended that the information exchanged be passed on to railways in the European countries bordering the corridor :

- Bulgaria,
- Romania,
- Ukraine,

and via Ukraine :
- Hungary,
- Moldavia,
- Poland,
- and Slovakia.

This data shall then be transferred via existing European IT systems, e.g. the Hermes network systems (European railway IT network).

Slovakia is currently hooked up to the Hermes network and links with Hungary, Romania and Poland are in the pipeline.
Bulgaria and Romania intend to install UNCTAD's railway IT network Acis, and there are also plans afoot to incorporate a Hermes interface module into Acis.

2.2.5 Data interchange with the shipping companies

In order to ensure continuity in the data chain, the ultimate goal being to provide uninterrupted coverage while the goods are in transit, electronic communication should be set up with the shipping companies.

Such a move would:
- speed up data transfer between railways and shipping companies,
- eliminate the need for paper forms,
- minimise the time required before loading the goods,
- extend the scope of freight tracking and tracing systems.

2.3 Recommendations

2.3.1 Telecommunications

Before considering electronic data interchange, it must be stressed that reliable and powerful telecommunications links are a prerequisite. Efficient communications facilities are particularly important for IT centres, major passenger and freight stations, marshalling yards, border points, port stations and control centres.

The availability of quality transmission lines between the countries will pave the way for a regional information system.

2.3.2 In-house IT facilities

Caucasian railways' IT systems are extremely basic and hence in need of upgrading.
Restructuring studies being carried out by CIE-Consult are likely to produce MIS recommendations, at least as far as finance and management are concerned.

As regards freight and passenger IT facilities, it is recommended that, in addition to the border stations and headquarters currently equipped, computers be installed in major stations and marshalling yards using the same system. In this way, instead of data being available at border crossings only, it may be obtained directly upon departure of freight or passengers, in intermediate marshalling yards or, at the very latest, at the final marshalling yard.
Having early access to such information is the main advantage of exchanging data electronically with railway partners.

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2.3.3 Data interchange between the railways

In general, it should be noted that setting up electronic data interchange facilities often triggers changes in working methods. It would be advisable to combine such a move with restructuring.

2.3.3.1 Central Asian railways

The recommendations set out in the joint CIE-Consult/Systra Central Asian railways restructuring studies (Modules A, B, C and D of this study) underlined the need to retain the existing ASSOUP freight and Express 2 passenger applications for at least five years. Furthermore, they advised decentralising regional data processing, which is currently carried out at the Moscow computer centre.

2.3.3.2 Caucasian railways

2.3.3.2.1 Passenger IT systems

This area does not seem to be a priority for the time being. However, in the long term, assuming that ridership figures rise, particularly towards other CIS countries, it would be advisable to install the Express 2 software or the Express 3 upgrade.

2.3.3.2.2 Freight IT systems

Each of the Caucasian railways currently has its own PC, which is connected to the Russian railway's computer centre, providing it with access to information on trains crossing borders.
The railways mainly use this link to enter the requisite data into the wagon hire compensation system.

The Caucasian railways have also indicated a wish to:
- be able to process regional data locally
- have a system with more functions, particularly customer freight tracking.

There are several options for complying with these requests:
- Installing the UNCTAD ACIS system in each country,
- Setting up an RCC (Regional Computer Centre) in the Caucasus region.

2.3.3.2.2.1 ACIS

The ACIS system, which was developed by UNCTAD, is perfectly suited to railway requirements in countries with a low level of computerisation as it is based on PC networks. Consignment management is real-time and quite detailed, breaking information down to the goods level.

It consists of the following modules:
- RailTraffic
- RailStats
- RailTelecom
- RailMaintenance
- RailSliding
- Wagon distribution
- RailTerminal
- RailCommercial
- RailClient
- RailInterchange
- RailTutorial

Moreover, ACIS can easily be interconnected with the Asycuda customs system.

For more information on ACIS, see the appendix dealing with the European systems presentation seminar held in Warsaw in March 1998.

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The system was subjected to an unsuccessful pilot test in Uzbekistan, the main reason for the failure being that Uzbekistan Railways already have an RCC and interconnecting ACIS and mainframe-based systems is quite a complicated task, which would have required developing a special programme.

The Caucasus region seems to be a better candidate for ACIS, provided that the Caucasian railways' current ASSOUP operations, in particular concerning management of wagon compensations, can be carried out by automatically extracting the data or via a gateway to ASSOUP.

The system would be installed nationwide and later interconnected between the countries.

2.3.3.2.2.2 Caucasus RCC

Another option would be to build on the CIS and Baltic railway's IT network to create an RCC in the Caucasus region.
This variant would involve installing an IBM mainframe, the simplest and most economical model being the 4381 (second-hand), which is already used in the Central Asian RCCs.

2.3.4 Data interchange with administrative bodies

The three countries share borders and there tend to be two stations located at a short distance from each other on either side of the border, e.g. Beyuk-Kassik/Gardabani between Azerbaïjan and Georgia, and Ayrum/Sadarkhlo between Armenia and Georgia. To reduce train stoppage times, it would be advisable to carry out formalities at one station only, which would be used by representatives of both countries.

2.3.4.1 With customs officials

2.3.4.1.1 Armenia and Georgia

Customs offices in both countries use the UNCTAD Asycuda system.

2.3.4.1.1.1 ACIS

If the railways decide to install the ACIS system, it should be quite easy to communicate with the IT customs system, Asycuda, currently used in the two countries, as the option is already available in the corresponding software programmes, both systems having being developed by UNCTAD.

2.3.4.1.1.2 RCC

If the railways opt for an RCC, similar to the one already used in other CIS Traceca countries, communicating with Asycuda would require:
- either a tailored programme in Asycuda or ASSOUP
- or the installation of an EDI translator to translate the messages between the systems.

2.3.4.1.2 Azerbaijan

Azerbaijan customs authorities plan to computerise their offices, however it is unclear whether the facilities used will be of Russian origin or developed in-house. The budget allocation is US$ 12.5 million.

In any case, a gateway or software adaptation will be needed to allow for communication between the railways and the new IT customs system. This matter should be examined more closely once the customs authorities have chosen their new system.

2.3.4.2 With the police

Data interchange with the police would be in relation to international passenger traffic and does not seem to be a priority for the time being.

2.3.5 Data interchange with customers and freight forwarders

2.3.5.1 ASSOUP

At present, ASSOUP has no module allowing access to customers and freight forwarders, although this may be redressed in an upgraded version. If not, a special programme will be required.

2.3.5.2 ACIS

ACIS contains a RailClient module for this purpose. Customers and freight forwarders simply require a PC directly connected to the railways via a modem or one with Internet access.

2.3.6 Data interchange with shipping companies

2.3.6.1 Black Sea / Azerbaïjan

Shipping companies in Poti and Batumi have no IT facilities.
Pending installation of an IT system, they should have at least one terminal hooked up to the Azerbaijan Railways' IT system.

2.3.6.2 Caspian Sea / Georgia

The Caspian Shipping Company is equipped with an IT system based on IBM 4381.
There are two options for connecting the company's system with the railways:

1) Supply the railways with one or several terminals with access to this system.
The problem is that this would lead to double input (and hence the likelihood of errors occurring and a double workload) and the risk of limited acceptance of the system.

2) Interconnect the company's server with that of the railways.
This would entail creating interface software modules between the two servers.

The Caspian Shipping Company's IT staff seem to be highly qualified in creating IBM 4381 software. Incidentally, the "Trade and Customs Facilitations" study advocates that they write the interfaces with Asycuda.

2.3.7 Interconnecting the Traceca railways with Europe

2.3.7.1 Passengers

The Express 2 system already has a link with western Europe, between Moscow and Frankfort, with the gateway between Express 2 and Kurs 90 (the DB system) located in Moscow. A connection between Moscow and Helsinki and Moscow and Warsaw is in the pipeline.

2.3.7.2 Freight

As was the case for Express 2, it is feasible to develop a gateway between the Hermes freight applications (see list in Appendix 2) and ASSOUP. At present, the centralisation of functions at the Moscow IT system would entail the gateway being installed there.
However, if functions are actually decentralised in line with Traceca railways' requests and as approved by OSJD decisions, the gateway could be installed in the Caucasus region and/or in Central Asia.

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2.4 Action plan

The timeframe for options A (ACIS - RailTracker) and B (RCC) are set out below. Option A is preferable mainly because it:

- suits the needs of small railways,
- interfaces efficiently with customs and customers,
- employs the latest developments in information technology.

2.4.1 Timeframe

2.4.1.1 Option A (ACIS - RailTracker)

Phase 1 : Information
Organise information and training seminars on the advantages and limitations of electronic data interchange, inviting IT and administration managers at the railways and shipping companies. Although freight forwarders and customs offices have already attended this type of seminar as part of the project "Traceca - Trade and custom facilitation/ Scott Wilson Kirkpatrick", they should also be invited so as to facilitate the creation of working parties at a later stage.

Phase 2 : ACIS installation

- Install ACIS RailTracker in each of the three countries

Phase 3 : Interconnection

- Interconnect the three national RailTracker systems
- Interconnect with shipping companies
- Interconnect with customs offices
- Interconnect with freight forwarders
- Interconnect with major customers

Phase 4 : Passenger IT systems

- Install Express 2 terminals

Phase 5 : Optional

- Interconnect with police stations

2.4.1.2 Option B (RCC, ASSOUP & Express)

Phase 1 : Information
Organise information and training seminars on the advantages and limitations of electronic data interchange, inviting IT and administration managers at the railways and shipping companies. Although freight forwarders and customs offices have already attended this type of seminar as part of the project "Traceca - Trade and custom facilitation/ Scott Wilson Kirkpatrick", they should also be invited so as to facilitate the creation of working parties at a later stage.

Phase 2 : Pilot phase

- Set up a regional computer centre (RCC) equipped with ASSOUP and Express 2/3 software
- Partially interconnect with customs services

Phase 3 : Initial installation wave

- Raise the level of in-house computerisation, mainly in freight stations and marshalling yards
- Fully interconnect with the customs system
- Interconnect with shipping companies

Phase 4 : Second installation wave

- Interconnect with freight forwarders

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- Interconnect with major customers

Phase 5 : Optional
- Interconnect with police stations

2.4.2 Organisation

To ensure that the project runs smoothly, a steering committee should be set up in each country, comprising:
- a team of two European consultants (EDI and management) selected following an invitation to tender; the same team would work on a part-time basis in all three countries,
- in each country, a group of high-level managers drawn from each of the bodies concerned (railways, customs, etc.).

2.5 Investment

The investment requirement to implement the recommendations of this report is as follows:

Given the imprecise nature of available data, phase 2-5 budgets are merely estimates.
It is assumed that special programmes such as gateway software to interface with customs systems will be developed locally.
The timeframe for implementation is taken to be two years.

2.5.1 Supervision (for all three countries)

48 weeks /person for the European consultants	300 000 ECU

2.5.2 Option A

Phase 1 - Information

Organise three 2-day seminars	30 000 ECU

Phase 2 - Installation

Install ACIS RailTracker in each of the three countries	550 000 ECU

Phase 3 - Interconnection

Interconnect the three national RailTracker systems	100 000 ECU
Interconnect with customs offices	100 000 ECU
Interconnect with shipping companies	100 000 ECU
Interconnect with freight forwarders	50 000 ECU
Interconnect with major customers	50 000 ECU

Phase 4 - Passenger IT systems

Install Express 2 terminals	100 000 ECU

Phase 5 - Optional

Interconnect with police stations	200 000 ECU

Total (minus optional extra)	1 080 000 ECU

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2.5.3 Option B

Phase 1 - Information

Organise three 2-day seminars	30 000 ECU

Phase 2 - Pilot project

Purchase and install a second-hand IBM 4381. Install terminals. Launch Assoup and Express 2	300 000 ECU
Interconnect with customs offices	200 000 ECU

Phase 3 - Initial installation wave

Increase the number of computerised stations	100 000 ECU
Fully interconnect with customs offices	100 000 ECU
Interconnect with shipping companies	100 000 ECU

Phase 4 - Second installation wave

Interconnect with freight forwarders	200 000 ECU
Interconnect with major customers	200 000 ECU

Phase 5 - Optional

Interconnect with police stations	200 000 ECU

Total (minus optional extra)	1 230 000 ECU

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Appendices

1) List of Hermes nodes

Company	Node	Country
Association of Train Operating Companies	Nottingham	Great Britain
CD	Prague	Czech Republic
Danish State Railways (DSB)	Copenhagen	Denmark
Deutsche Bahn (DB)	Frankfurt	Germany
Italian State Railways (FS)	Rome	Italy
Netherlands Railways (NS)	Amsterdam	Netherlands
Austrian Federal Railways (OeBB)	Vienna	Austria
Spanish National Railway Network (RENFE)	Madrid	Spain
Swiss Federal Railways (SBB/CFF/FFS)	Bern	Switzerland
Swedish Railways (SJ)	Stockholm	Sweden
Belgian National Railways Company (SNCB)	Brussels	Belgium
French National Railways Company (SNCF)	Paris	France
Slovenian Railways (SZ)	Ljubljana	Slovenia
Railways of the Slovak Republic (ZSR)	Bratislava	Slovak Republic

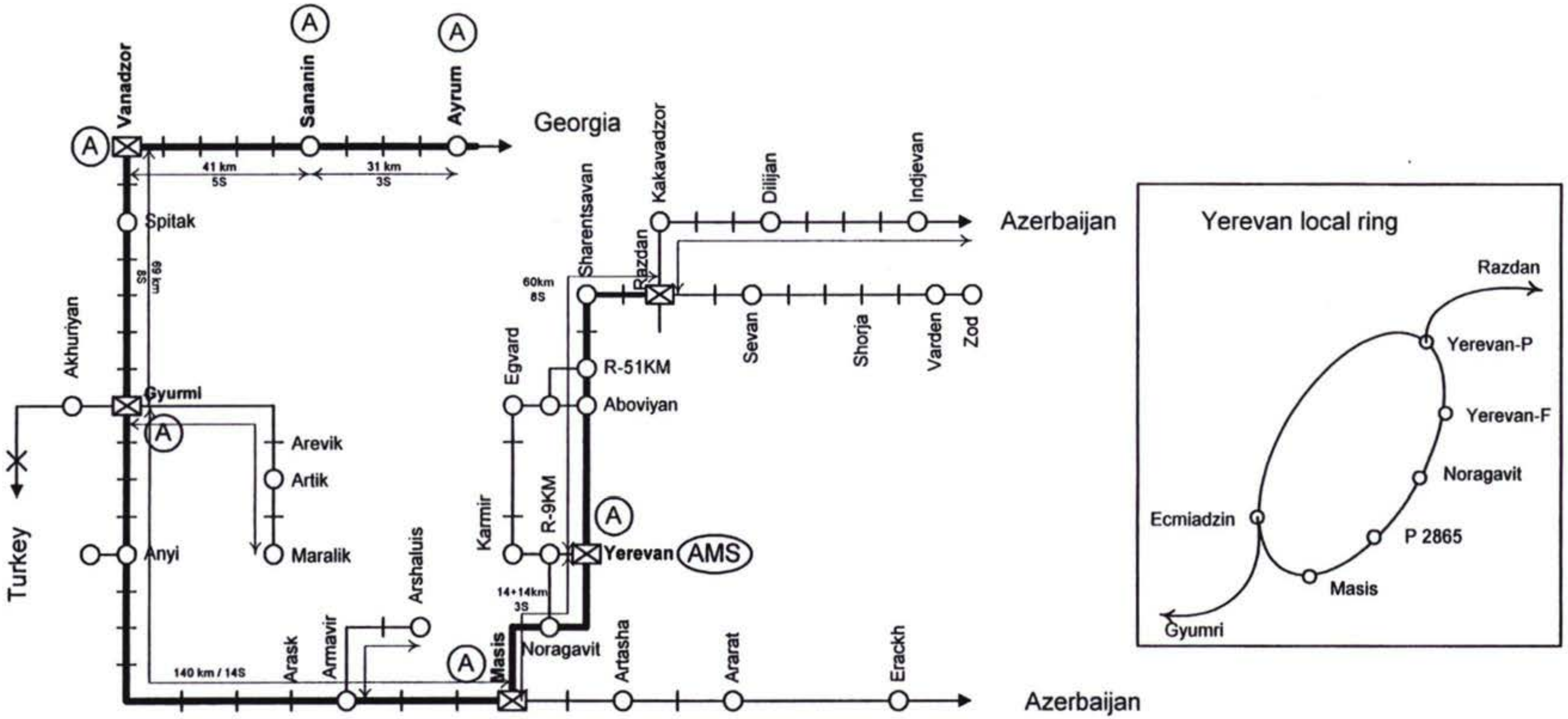
2) List of Hermes freight applications

- Advance notification of train consists
- ENEE : Railway locations database (FGE)
- EUROP
- GOETHE : Wagons worked abroad
- DAMOCLES : Dangerous goods database
- TEI : International block trains
- RIV exchange
- Wagon search
- Frontier crossing
- Incidents in transit
- Advice of dispatch
- Advice of arrival

Chapter 5

Caucasus - Recommendations and economic study
Appendix 1 - Backbone network diagrams

Appendix 1 - Backbone network diagrams



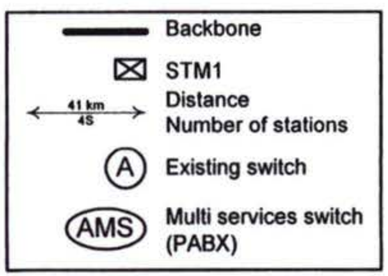


Diagram AIP.3

Armenia Telecommunication Backbones

Appendix 1 - Backbone network diagrams

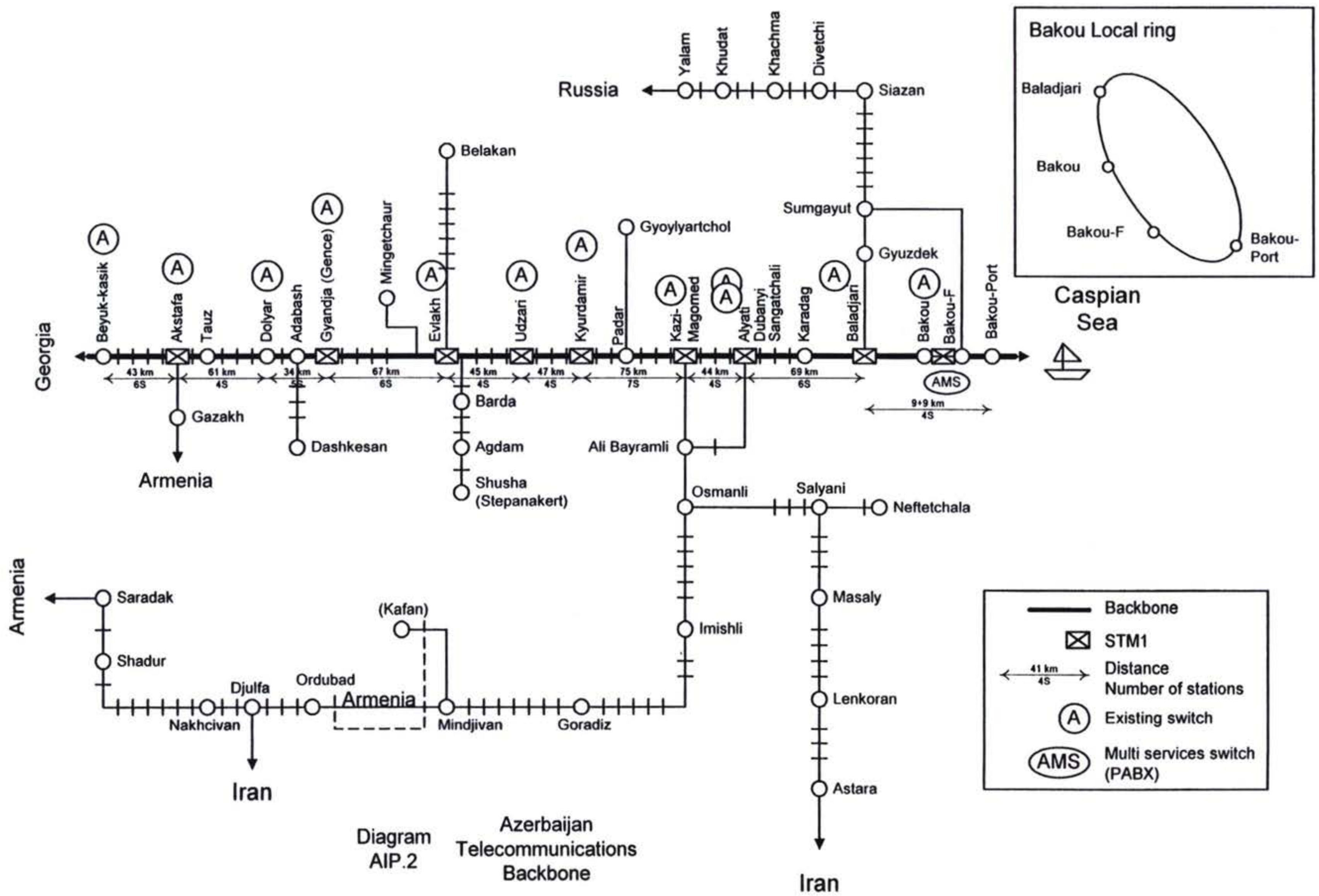


Diagram AIP.2

Azerbaijan Telecommunications Backbone

Appendix 1 - Backbone network diagrams

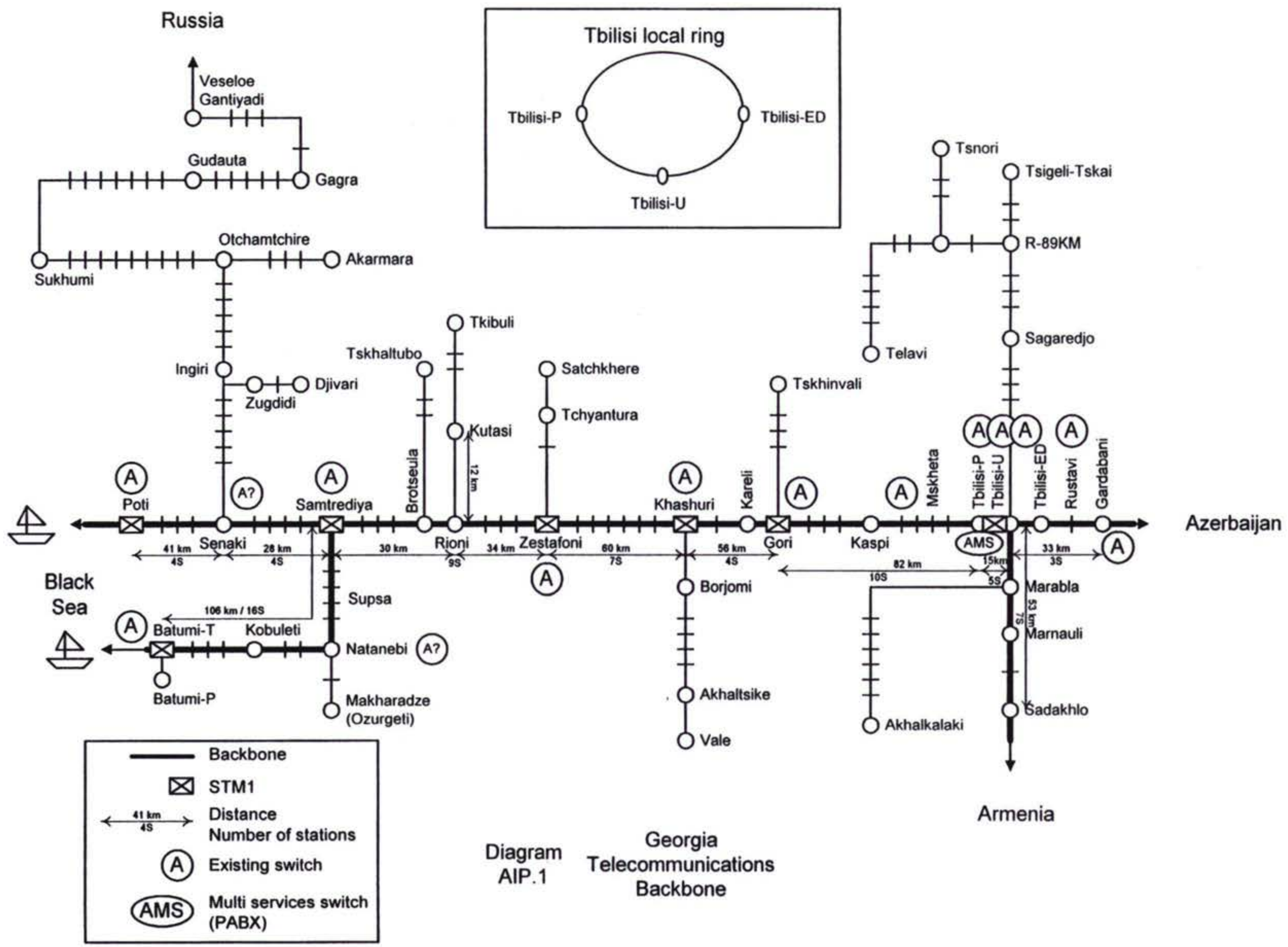


Diagram AIP.1

Georgia Telecommunications Backbone

Chapter 5

Caucasus - Recommendations and economic study
Appendix 2
Investment tables for the backbone networks

Pilot project - Backbone network - Summary - 26/02/99

	EU Investment (Millions of ECU)	Railway investment (Millions of ECU)	Total
Armenia	3,15	0,44	3,60
Azerbaijan	4,72	0,72	5,44
Georgia	4,53	0,64	5,17
Total	**12,40**	**1,81**	**14,21**

Pilot project - Backbone network, ARMENIA
(V0.8 26/02/99)

Item No.	Item description	Comments	Length	Number	Unit price	Total	EU total	Total railway investment (adjusted to reflect local labour costs)
			in km	of units	(in thousands of FRF)	(millions of FRF)	(millions of ECU)	(millions of ECU)
	cabling	supplies	309		20,5	6,33	0,96	
	cabling	supervision of staking-out work	309		2	0,62	0,09	
	cabling	installing links	309		4	1,24	0,19	
	cabling	staking out, civil engineering and laying (including labour)	309		95	29,36		0,44
1	total expenditure on cabling				121,5	37,54	1,24	0,44
	large and medium-sized stations			7				
	smaller stations			17				
	total stations			24				
	number of links	(distribution network)		6				
	number of SDH nodes			4				
2.1	STM1 equipment			4	130	0,52	0,08	
2.2	hooking up STM1 equipment			4	14	0,06	0,01	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			30	64	1,92	0,29	
5.2	hooking up ADM equipment			30	8	0,24	0,04	
6	ADM management			2	100	0,20	0,03	
7.1	AMS (PABX)	(equipment and management)		1	1400	1,40	0,21	
7.2	AMS (PABX)	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		17	15	0,26	0,04	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		7	72	0,50	0,08	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		7	220	1,54	0,23	
11.2	hooking up	(30 lines)		7	21	0,15	0,02	
12.1	small station equipment	(6 lines)		17	44	0,75	0,11	
12.2	hooking up	(6 lines)		17	4	0,07	0,01	
13	spares	(10% of items (2-12)				0,99	0,15	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				49,17	3,00	0,44
15	provision for contingencies	5% of aggregate investment (items 1-14)				2,46	0,15	
		AGGREGATE TOTAL of items 1-15				51,63	3,15	0,44

Pilot project - Backbone network, AZERBAIJAN
(V0.8 26/02/99)

Item No.	Item description	Comments	Length	Number	Unit price	Total	EU total	Total railway investment (adjusted to reflect local labour costs)
			in km	of units	(in thousands of FRF)	(millions of FRF)	(millions of ECU)	(millions of ECU)
	cabling	supplies	503		20,5	10,31	1,56	
	cabling	supervision of staking-out work	503		2	1,01	0,15	
	cabling	installing links	503		4	2,01	0,30	
	cabling	staking out, civil engineering and laying (including labour)	503		95	47,79		0,72
1	total expenditure on cabling				121,5	61,11	2,02	0,72
	large and medium-sized stations			12				
	smaller stations			27				
	total stations			39				
	number of links	(distribution network)		10				
	number of SDH nodes			9				
2.1	STM1 equipment			9	130	1,17	0,18	
2.2	hooking up STM1 equipment			9	14	0,13	0,02	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			49	64	3,14	0,48	
5.2	hooking up ADM equipment			49	8	0,39	0,06	
6	ADM management			2	100	0,20	0,03	
7.1	AMS (PABX)	(equipment and management)		1	1400	1,40	0,21	
7.2	AMS (PABX)	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		27	15	0,41	0,06	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		12	72	0,86	0,13	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		12	220	2,64	0,40	
11.2	hooking up	(30 lines)		12	21	0,25	0,04	
12.1	small station equipment	(6 lines)		27	44	1,19	0,18	
12.2	hooking up	(6 lines)		27	4	0,11	0,02	
13	spares	(10% of items (2-12)				1,41	0,21	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				77,45	4,50	0,72
15	provision for contingencies	5% of aggregate investment (items 1-14)				3,87	0,22	
		AGGREGATE TOTAL of items 1-15				81,33	4,72	0,72

Pilot project - Backbone network, GEORGIA
(V0.8 26/02/99)

Item No.	Item description	Comments	Length	Number	Unit price	Total	EU total	Total railway investment (adjusted to reflect local labour costs)
			in km	of units	(in thousands of FRF)	(millions of FRF)	(millions of ECU)	(millions of ECU)
	cabling	supplies	444		20,5	9,10	1,38	
	cabling	supervision of staking-out work	444		2	0,89	0,13	
	cabling	installing links	444		4	1,78	0,27	
	cabling	staking out, civil engineering and laying (including labour)	444		95	42,18		0,64
1	total expenditure on cabling				121,5	53,95	1,78	0,64
	large and medium-sized stations			14				
	smaller stations			27				
	total stations			41				
	number of links	(distribution network)		10				
	number of SDH nodes			6				
2.1	STM1 equipment			6	130	0,78	0,12	
2.2	hooking up STM1 equipment			6	14	0,08	0,01	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			51	64	3,26	0,49	
5.2	hooking up ADM equipment			51	8	0,41	0,06	
6	ADM management			2	100	0,20	0,03	
7.1	AMS (PABX)	(equipment and management)		1	1400	1,40	0,21	
7.2	AMS (PABX)	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		27	15	0,41	0,06	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		14	72	1,01	0,15	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		14	220	3,08	0,47	
11.2	hooking up	(30 lines)		14	21	0,29	0,04	
12.1	small station equipment	(6 lines)		27	44	1,19	0,18	
12.2	hooking up	(6 lines)		27	4	0,11	0,02	
13	spares	(10% of items (2-12)				1,44	0,22	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				70,66	4,31	0,64
15	provision for contingencies	5% of aggregate investment (items 1-14)				3,53	0,22	
		AGGREGATE TOTAL of items 1-15				74,19	4,53	0,64

Investment in backbone networks (Caucasus) - without back-up of the links between control centre and stations - Summary - 26/02/99

	EU Investment (Millions of ECU)	Railway investment (Millions of ECU)	Total
Armenia	3,90	0,53	4,43
Azerbaijan	5,03	0,72	5,75
Georgia	5,79	0,79	6,59
Total	**14,73**	**2,05**	**16,77**

Investment in backbone network, ARMENIA (without back-up of the links between control centre and stations)
(V0.8 26/02/99)

Item No.	Item description	Comments	Length	Number	Unit price	Total	EU total	Total railway investment (adjusted to reflect local labour costs)
			in km	of units	(in thousands of FRF)	(millions of FRF)	(millions of ECU)	(millions of ECU)
	cabling	supplies	369		20,5	7,56	1,15	
	cabling	supervision of staking-out work	369		2	0,74	0,11	
	cabling	installing links	369		4	1,48	0,22	
	cabling	staking out, civil engineering and laying (including labour)	369		95	35,06		0,53
1	total expenditure on cabling				121,5	44,83	1,48	0,53
	large and medium-sized stations			8				
	smaller stations			32				
	total stations			40				
	number of links	(distribution network)		10				
	number of SDH nodes			5				
2.1	STM1 equipment			5	130	0,65	0,10	
2.2	hooking up STM1 equipment			5	14	0,07	0,01	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			50	64	3,20	0,48	
5.2	hooking up ADM equipment			50	8	0,40	0,06	
6	ADM management			2	100	0,20	0,03	
7.1	AMS (PABX)	(equipment and management)		1	1400	1,40	0,21	
7.2	AMS (PABX)	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		32	15	0,48	0,07	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		8	72	0,58	0,09	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		8	220	1,76	0,27	
11.2	hooking up	(30 lines)		8	21	0,17	0,03	
12.1	small station equipment	(6 lines)		32	44	1,41	0,21	
12.2	hooking up	(6 lines)		32	4	0,13	0,02	
13	spares	(10% of items (2-12)				1,26	0,19	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				59,58	3,72	0,53
15	provision for contingencies	5% of aggregate investment (items 1-14)				2,98	0,19	
		AGGREGATE TOTAL of items 1-15				62,56	3,90	0,53

Investment in backbone network, AZERBAIJAN (without back-up of the links between control centre and stations)
(V0.8 26/02/99)

Item No.	Item description	Comments	Length	Number	Unit price	Total	EU total	Total railway investment (adjusted to reflect local labour costs)
			in km	of units	(in thousands of FRF)	(millions of FRF)	(millions of ECU)	(millions of ECU)
	cabling	supplies	503		20,5	10,31	1,56	
	cabling	supervision of staking-out work	503		2	1,01	0,15	
	cabling	installing links	503		4	2,01	0,30	
	cabling	staking out, civil engineering and laying (including labour)	503		95	47,79		0,72
1	total expenditure on cabling				121,5	61,11	2,02	0,72
	large and medium-sized stations			12				
	smaller stations			38				
	total stations			50				
	number of links	(distribution network)		14				
	number of SDH nodes			9				
2.1	STM1 equipment			9	130	1,17	0,18	
2.2	hooking up STM1 equipment			9	14	0,13	0,02	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			64	64	4,10	0,62	
5.2	hooking up ADM equipment			64	8	0,51	0,08	
6	ADM management			2	100	0,20	0,03	
7.1	AMS (PABX)	(equipment and management)		1	1400	1,40	0,21	
7.2	AMS (PABX)	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		38	15	0,57	0,09	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		12	72	0,86	0,13	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		12	220	2,64	0,40	
11.2	hooking up	(30 lines)		12	21	0,25	0,04	
12.1	small station equipment	(6 lines)		38	44	1,67	0,25	
12.2	hooking up	(6 lines)		38	4	0,15	0,02	
13	spares	(10% of items (2-12)				1,58	0,24	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				79,40	4,79	0,72
15	provision for contingencies	5% of aggregate investment (items 1-14)				3,97	0,24	
		AGGREGATE TOTAL of items 1-15				83,37	5,03	0,72

Investment in backbone network, GEORGIA (without back-up of the links between control centre and stations)
(V0.8 26/02/99)

Item No.	Item description	Comments	Length	Number	Unit price	Total	EU total	Total railway investment (adjusted to reflect local labour costs)
			in km	of units	(in thousands of FRF)	(millions of FRF)	(millions of ECU)	(millions of ECU)
	cabling	supplies	550		20,5	11,28	1,71	
	cabling	supervision of staking-out work	550		2	1,10	0,17	
	cabling	installing links	550		4	2,20	0,33	
	cabling	staking out, civil engineering and laying (including labour)	550		95	52,25		0,79
1	total expenditure on cabling				121,5	66,83	2,21	0,79
	large and medium-sized stations			15				
	smaller stations			54				
	total stations			69				
	number of links	(distribution network)		17				
	number of SDH nodes			7				
2.1	STM1 equipment			7	130	0,91	0,14	
2.2	hooking up STM1 equipment			7	14	0,10	0,01	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			86	64	5,50	0,83	
5.2	hooking up ADM equipment			86	8	0,69	0,10	
6	ADM management			2	100	0,20	0,03	
7.1	AMS (PABX)	(equipment and management)		1	1400	1,40	0,21	
7.2	AMS (PABX)	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		54	15	0,81	0,12	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		15	72	1,08	0,16	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		15	220	3,30	0,50	
11.2	hooking up	(30 lines)		15	21	0,32	0,05	
12.1	small station equipment	(6 lines)		54	44	2,38	0,36	
12.2	hooking up	(6 lines)		54	4	0,22	0,03	
13	spares	(10% of items (2-12)				1,90	0,29	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				88,67	5,52	0,79
15	provision for contingencies	5% of aggregate investment (items 1-14)				4,43	0,28	
		AGGREGATE TOTAL of items 1-15				93,10	5,79	0,79

Investment in backbone networks (Caucasus) - with back-up of the links between control centre and stations - Summary - 26/02/99

	EU Investment (Millions of ECU)	Railway investment (Millions of ECU)	Total
Armenia	4,04	0,53	4,57
Azerbaijan	5,22	0,72	5,94
Georgia	6,02	0,79	6,81
Total	**15,28**	**2,05**	**17,33**

Investment in backbone network, ARMENIA (with back-up of the links between control centre and stations)
(V0.8 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Total railway investment (adjusted to reflect local labour (millions of ECU)
	cabling	supplies	369		20,5	7,56	1,15	
	cabling	supervision of staking-out work	369		2	0,74	0,11	
	cabling	installing links	369		4	1,48	0,22	
	cabling	staking out, civil engineering and laying (including labour)	369		95	35,06		0,53
1	total expenditure on cabling				121,5	44,83	1,48	0,53
	large and medium-sized stations			8				
	smaller stations			32				
	total stations			40				
	number of links	(distribution network)		10				
	number of SDH nodes			5				
2.1	STM1 equipment			5	130	0,65	0,10	
2.2	hooking up STM1 equipment			5	14	0,07	0,01	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			60	64	3,84	0,58	
5.2	hooking up ADM equipment			60	8	0,48	0,07	
6	ADM management			2	100	0,20	0,03	
7.1	AMS (PABX)	(equipment and management)		1	1400	1,40	0,21	
7.2	AMS (PABX)	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		32	15	0,48	0,07	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		9	72	0,65	0,10	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		8	220	1,76	0,27	
11.2	hooking up	(30 lines)		8	21	0,17	0,03	
12.1	small station equipment	(6 lines)		32	44	1,41	0,21	
12.2	hooking up	(6 lines)		32	4	0,13	0,02	
13	spares	(10% of items (2-12)				1,34	0,20	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				60,46	3,85	0,53
15	provision for contingencies	5% of aggregate investment (items 1-14)				3,02	0,19	
		AGGREGATE TOTAL of items 1-15				63,48	4,04	0,53

Investment in backbone network, AZERBAIJAN (with back-up of the links between control centre and stations)
(V0.8 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Total railway investment (adjusted to reflect local labour (millions of ECU)
	cabling	supplies	503		20,5	10,31	1,56	
	cabling	supervision of staking-out work	503		2	1,01	0,15	
	cabling	installing links	503		4	2,01	0,30	
	cabling	staking out, civil engineering and laying (including labour)	503		95	47,79		0,72
1	total expenditure on cabling				121,5	61,11	2,02	0,72
	large and medium-sized stations			12				
	smaller stations			38				
	total stations			50				
	number of links	(distribution network)		14				
	number of SDH nodes			9				
2.1	STM1 equipment			9	130	1,17	0,18	
2.2	hooking up STM1 equipment			9	14	0,13	0,02	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			78	64	4,99	0,76	
5.2	hooking up ADM equipment			78	8	0,62	0,09	
6	ADM management			2	100	0,20	0,03	
7.1	AMS (PABX)	(equipment and management)		1	1400	1,40	0,21	
7.2	AMS (PABX)	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		38	15	0,57	0,09	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		13	72	0,94	0,14	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		12	220	2,64	0,40	
11.2	hooking up	(30 lines)		12	21	0,25	0,04	
12.1	small station equipment	(6 lines)		38	44	1,67	0,25	
12.2	hooking up	(6 lines)		38	4	0,15	0,02	
13	spares	(10% of items (2-12)				1,69	0,26	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				80,59	4,97	0,72
15	provision for contingencies	5% of aggregate investment (items 1-14)				4,03	0,25	
		AGGREGATE TOTAL of items 1-15				84,62	5,22	0,72

Investment in backbone network, GEORGIA (with back-up of the links between control centre and stations)
(V0.8 26/02/99)

Item No.	Item description	Comments	Length	Number	Unit price	Total	EU total	Total railway investment (adjusted to reflect local labour
			in km	of units	(in thousands of FRF)	(millions of FRF)	(millions of ECU)	(millions of ECU)
	cabling	supplies	550		20,5	11,28	1,71	
	cabling	supervision of staking-out work	550		2	1,10	0,17	
	cabling	installing links	550		4	2,20	0,33	
	cabling	staking out, civil engineering and laying (including labour)	550		95	52,25		0,79
1	total expenditure on cabling				121,5	66,83	2,21	0,79
	large and medium-sized stations			15				
	smaller stations			54				
	total stations			69				
	number of links	(distribution network)		17				
	number of SDH nodes			7				
2.1	STM1 equipment			7	130	0,91	0,14	
2.2	hooking up STM1 equipment			7	14	0,10	0,01	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			103	64	6,59	1,00	
5.2	hooking up ADM equipment			103	8	0,82	0,12	
6	ADM management			2	100	0,20	0,03	
7.1	AMS (PABX)	(equipment and management)		1	1400	1,40	0,21	
7.2	AMS (PABX)	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		54	15	0,81	0,12	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		16	72	1,15	0,17	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		15	220	3,30	0,50	
11.2	hooking up	(30 lines)		15	21	0,32	0,05	
12.1	small station equipment	(6 lines)		54	44	2,38	0,36	
12.2	hooking up	(6 lines)		54	4	0,22	0,03	
13	spares	(10% of items (2-12)				2,03	0,31	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				90,10	5,73	0,79
15	provision for contingencies	5% of aggregate investment (items 1-14)				4,50	0,29	
		AGGREGATE TOTAL of items 1-15				94,60	6,02	0,79

Chapter 5

Caucasus - Recommendations and economic study
Appendix 3 - Network of secondary railway lines

Appendix 3 - Network of secondary lines

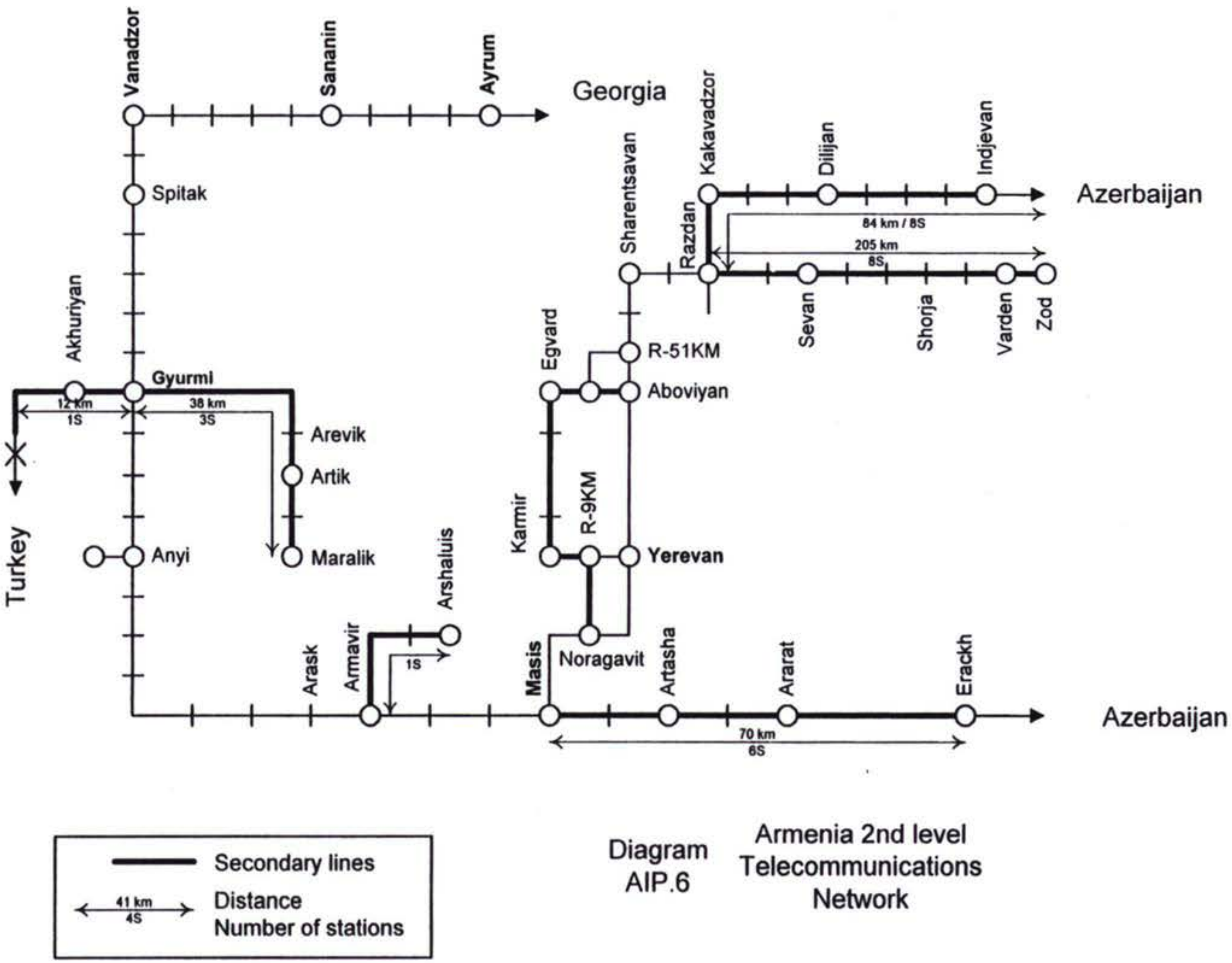


Diagram AIP.6

Armenia 2nd level Telecommunications Network

Appendix 3 - Network of secondary lines

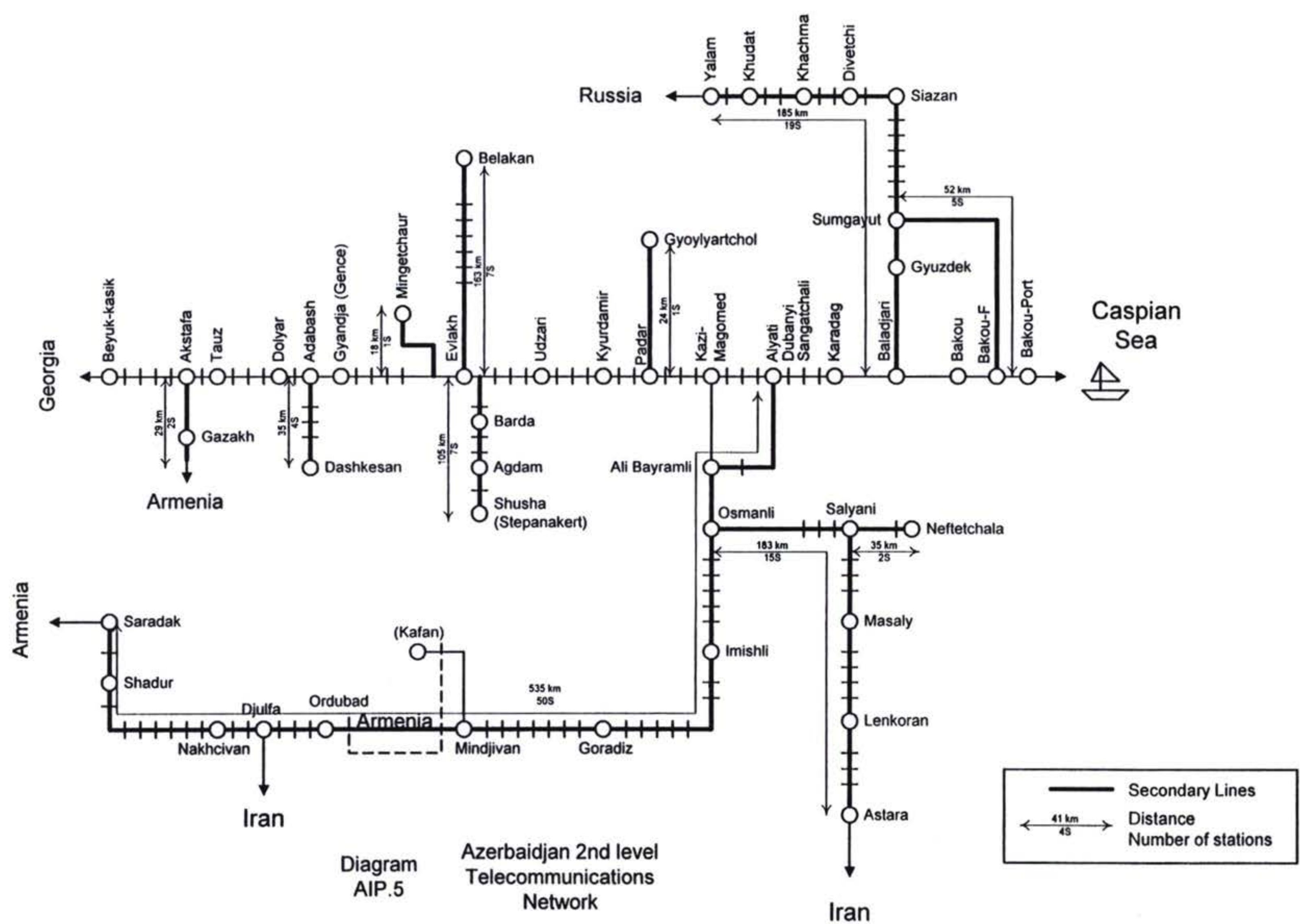


Diagram AIP.5

Azerbaidjan 2nd level Telecommunications Network

Appendix 3 - Network of secondary lines

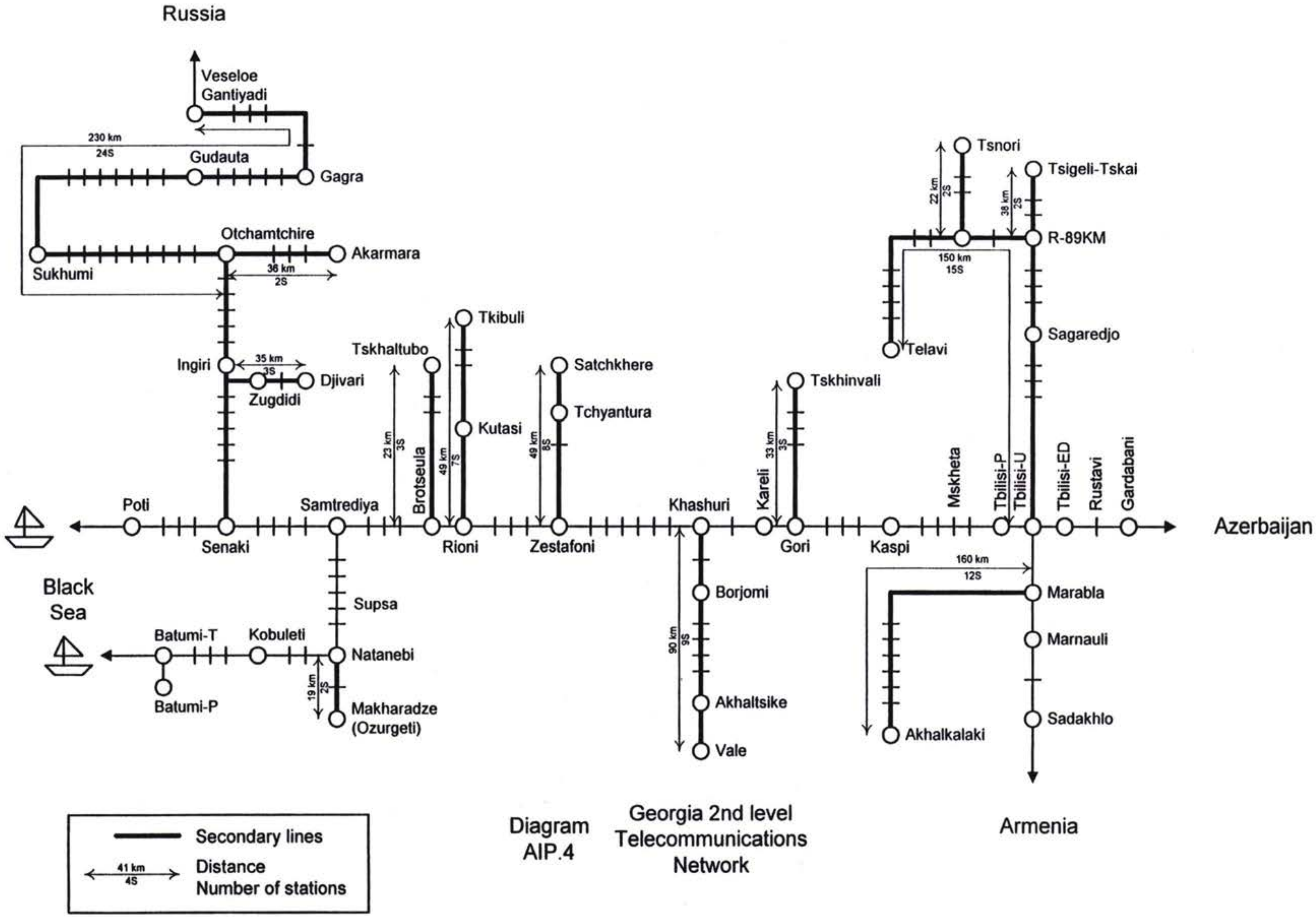


Diagram AIP.4

Georgia 2nd level Telecommunications Network

Chapter 5

Caucasus - Recommendations and economic study Appendix 4 - Investment tables for the network of secondary railway lines

Investment in the secondary network, Caucasus -Summary - 26/02/99

	EU Investment (Millions of ECU)	Railway investment (Millions of ECU)
Armenia	2,55	0,46
Azerbaijan	7,80	1,54
Georgia	5,76	1,06
Total	**16,11**	**3,06**

Investment in the secondary network, ARMENIA
(V0.4 26/02/99)

Item No.	Item description	Comments	Length	Number	Unit price	Total	EU total	Total railway investment (adjusted to reflect local labour costs)
			in km	of units	(in thousands of FRF)	(millions of FRF)	(millions of ECU)	(millions of ECU)
	cabling	supplies	409		17	6,95	1,05	
	cabling	supervision of staking-out work	409		2	0,82	0,12	
	cabling	installing links	409		4	1,64	0,25	
	cabling	staking out, civil engineering and laying (including labour)	409		75	30,68		0,46
1	**total expenditure on cabling**					40,08	**1,43**	**0,46**
	large and medium-sized stations	(Razdan, Masis, Gyumri)		3				
	smaller stations			23				
	total stations			26				
	number of links			8				
2.1	**ADM equipment**			31	64	1,98	0,30	
2.2	**hooking up ADM equipment**			31	8	0,25	0,04	
3	**ADM management**			1	100	0,10	0,02	
4.1	**low-capacity power supply**	(ADM, low-capacity station centre)		23	15	0,35	0,05	
5.1	**medium-capacity energy supply**	(STM1, medium-capacity station centre)		3	72	0,22	0,03	
6.1	**medium station equipment**	(30 lines)		3	217	0,65	0,10	
6.2	**hooking up**	(30 lines)		3	25	0,08	0,01	
7.1	**small station equipment**	(6 lines)		23	44	1,01	0,15	
7.2	**hooking up**	(6 lines)		23	4	0,09	0,01	
8	**spares**	(10% of items (2-7)				0,46	0,07	
		Total of items (1-8)				45,27	2,21	0,46
9	**provision for contingencies**	5% of aggregate investment (items 1-9)				2,26	0,34	
		AGGREGATE TOTAL of items 1-9				47,53	**2,55**	**0,46**

Investment in the secondary network, AZERBAIJAN
(V0.4 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Total railway investment (adjusted to reflect local labour costs) (millions of ECU)
	cabling	supplies	1354		17	23,02	3,49	
	cabling	supervision of staking-out work	1354		2	2,71		
	cabling	installing links	1354		4	5,42		
	cabling	staking out, civil engineering and laying (including labour)	1354		75	101,55		1,54
1	**total expenditure on cabling**					132,69	**3,49**	**1,54**
	large and medium-sized stations	(Bakou-F., Baladjari, Alyati, Osmanli, Evlakh)		9				
	smaller stations			104				
	total stations			113				
	number of links			27				
2.1	**ADM equipment**			131	64	8,38	1,27	
2.2	**hooking up ADM equipment**			131	8	1,05	0,16	
3	**ADM management**			1	100	0,10	0,02	
4.1	**low-capacity power supply**	(ADM, low-capacity station centre)		104	15	1,56	0,24	
5.1	**medium-capacity energy supply**	(STM1, medium-capacity station centre)		9	72	0,65	0,10	
6.1	**medium station equipment**	(30 lines)		9	217	1,95	0,30	
6.2	**hooking up**	(30 lines)		9	25	0,23	0,03	
7.1	**small station equipment**	(6 lines)		104	44	4,58	0,69	
7.2	**hooking up**	(6 lines)		104	4	0,42	0,06	
8	**spares**	(10% of items (2-7)				1,85	0,28	
		Total of items (1-8)				153,45	6,63	1,54
9	**provision for contingencies**	5% of aggregate investment (items 1-9)				7,67	1,16	
		AGGREGATE TOTAL of items 1-9				161,12	**7,80**	**1,54**

Investment in the secondary network, GEORGIA
(V0.4 26/02/99)

Item No.	Item description	Comments	Length	Number	Unit price	Total	EU total	Total railway investment (adjusted to reflect local labour costs)
			in km	of units	(in thousands of FRF)	(millions of FRF)	(millions of ECU)	(millions of ECU)
	cabling	supplies	934		17	15,88	2,41	
	cabling	supervision of staking-out work	934		2	1,87		
	cabling	installing links	934		4	3,74		
	cabling	staking out, civil engineering and laying (including labour)	934		75	70,05		1,06
1	**total expenditure on cabling**					91,53	**2,41**	**1,06**
	large and medium-sized stations	(Tbilissi, Marabla, Kashuri, Zestafoni, Rioni, Senaki)		6				
	smaller stations			86				
	total stations			92				
	number of links			23				
2.1	**ADM equipment**			109	64	6,98	1,06	
2.2	**hooking up ADM equipment**			109	8	0,87	0,13	
3	**ADM management**			1	100	0,10	0,02	
4.1	**low-capacity power supply**	(ADM, low-capacity station centre)		86	15	1,29	0,20	
5.1	**medium-capacity energy supply**	(STM1, medium-capacity station centre)		6	72	0,43	0,07	
6.1	**medium station equipment**	(30 lines)		6	217	1,30	0,20	
6.2	**hooking up**	(30 lines)		6	25	0,15	0,02	
7.1	**small station equipment**	(6 lines)		86	44	3,78	0,57	
7.2	**hooking up**	(6 lines)		86	4	0,34	0,05	
8	**spares**	(10% of items (2-7)				1,49	0,23	
		Total of items (1-8)				108,27	4,94	1,06
9	**provision for contingencies**	5% of aggregate investment (items 1-9)				5,41	0,82	
		AGGREGATE TOTAL of items 1-9				113,69	**5,76**	**1,06**

Chapter 5

Caucasus - Recommendations and economic study
Appendix 5 - Telecom switches

Pilot Project, PABX systems, Caucasus - Summary

	EU Investment (Millions of ECU)	Railway investment (Millions of ECU)	Total
Armenia	0,39	0,07	0,46
Azerbaijan	0,94	0,14	1,08
Georgia	1,08	0,16	1,25
Total	**2,41**	**0,38**	**2,79**

Pilot project, PABX systems, ARMENIA - V0.2 26/02/99 - EPK

		number of telephones	telephones to be fitted	unit price (FRF)	Total (FRF)	Total EU investment (ECU)	Total railway investment (ECU)
Yerevan							
	PABX	2 000	1 500	1 000	1 500 000	227 273	
	service to subscribers	2 000	1 500	150	225 000		34 091
	AMS savings	1	1	-1 400 000	-1 400 000	-212 121	
Masis					0		
	PABX	200	150	1 000	150 000	22 727	
	service to subscribers	200	150	150	22 500		3 409
Gyumri					0		
	PABX	1 500	1 125	1 000	1 125 000	170 455	
	service to subscribers	1 500	1 125	150	168 750		25 568
	technical facilities	1	1	500 000	500 000	75 758	
Sananin					0		
	PABX	200	150	1 000	150 000	22 727	
	service to subscribers	200	150	150	22 500		3 409
Ayrum					0		
	PABX	100	75	1 500	112 500	17 045	
	service to subscribers	100	75	225	16 875		2 557
Vanadzor					0		
	PABX	200	150	1 000	150 000	22 727	
	service to subscribers	200	150	150	22 500		3 409
Training						25 000	
Contingencies						18 580	3 622
Total						**390 170**	**72 443**

		number of telephones	telephones to be fitted	unit price (FRF)	Total (FRF)	Total EU investment (ECU)	Total railway investment (ECU)
Baku							
	PABX	3 000	2 250	1 000	2 250 000	340 909	
	service to subscribers	3 000	2 250	150	337 500		51 136
	AMS savings	1	1	-1 400 000	-1 400 000	-212 121	
Alyat					0		
	PABX	100	75	1 500	112 500	17 045	
	service to subscribers	100	75	225	16 875		2 557
Kazi Magomed					0		
	PABX	200	150	1 000	150 000	22 727	
	service to subscribers	200	150	150	22 500		3 409
Kyurdamir					0		
	PABX	200	150	1 000	150 000	22 727	
	service to subscribers	200	150	150	22 500		3 409
Baladjari					0		
	PABX	2 100	1 575	1 000	1 575 000	238 636	
	service to subscribers	2 100	1 575	150	236 250		35 795
	technical facilities	1	1	500 000	500 000	75 758	
Gyandja					0		
	PABX	2 300	1 725	1 000	1 725 000	261 364	
	service to subscribers	2 300	1 725	150	258 750		39 205
	technical facilities	1	1	500 000	500 000	75 758	
Training						50 000	
Contingencies						44 640	6 776
Total						**937 443**	**142 287**

Pilot project, PABX systems, GEORGIA - V0.2 26/02/99 - EPK

	number of telephones	telephones to be fitted	unit price (FRF)	Total (FRF)	Total EU investment (ECU)	Total railway investment (ECU)
Tbilissi						
PABX	4 300	3 225	1 000	3 225 000	488 636	
service to subscribers	4 300	3 225	150	483 750		73 295
AMS savings	1	1	-1 400 000	-1 400 000	-212 121	
Kashuri				0		
PABX	1 500	1 125	1 000	1 125 000	170 455	
service to subscribers	1 500	1 125	150	168 750		25 568
technical facilities	1	1	500 000	500 000	75 758	
Zestafoni				0		
PABX	380	285	1 000	285 000	43 182	
service to subscribers	380	285	150	42 750		6 477
Gori				0		
PABX	200	150	1 000	150 000	22 727	
service to subscribers	200	150	150	22 500		3 409
Samtredia				0		
PABX	2 000	1 500	1 000	1 500 000	227 273	
service to subscribers	2 000	1 500	150	225 000		34 091
technical facilities	1	1	500 000	500 000	75 758	
Senaki				0		
PABX	50	38	1 500	56 250	8 523	
service to subscribers	50	38	225	8 438		1 278
Poti				0		
PABX	200	150	1 000	150 000	22 727	
service to subscribers	200	150	150	22 500		3 409
Batumi				0		
PABX	500	375	1 000	375 000	56 818	
service to subscribers	500	375	150	56 250		8 523
Training					50 000	
Contingencies					51 487	7 803
Total					**1 081 222**	**163 854**

Investment in PABX systems, Caucasus - Summary

	EU Investment (Millions of ECU)	Railway investment (Millions of ECU)	Total
Armenia	0,56	0,10	0,66
Azerbaijan	1,25	0,19	1,44
Georgia	1,45	0,22	1,66
Total	**3,26**	**0,50**	**3,76**

Telecom switches, ARMENIA - V0.2 26/02/99 - EPK

		number of telephones	telephones to be fitted	unit price (FRF)	Total (FRF)	Total EU investment (ECU)	Total railway investment (ECU)
Yerevan							
	PABX	2 000	2 000	1 000	2 000 000	303 030	
	service to subscribers	2 000	2 000	150	300 000		45 455
	AMS savings	1	1	-1 400 000	-1 400 000	-212 121	
Masis					0		
	PABX	200	200	1 000	200 000	30 303	
	service to subscribers	200	200	150	30 000		4 545
Gyumri					0		
	PABX	1 500	1 500	1 000	1 500 000	227 273	
	service to subscribers	1 500	1 500	150	225 000		34 091
	technical facilities	1	1	500 000	500 000	75 758	
Sananin					0		
	PABX	200	200	1 000	200 000	30 303	
	service to subscribers	200	200	150	30 000		4 545
Ayrum					0		
	PABX	100	100	1 500	150 000	22 727	
	service to subscribers	100	100	225	22 500		3 409
Vanadzor					0		
	PABX	200	200	1 000	200 000	30 303	
	service to subscribers	200	200	150	30 000		4 545
Training						25 000	
Contingencies						26 629	4 830
Total						**559 205**	**96 591**

		number of telephones	telephones to be fitted	unit price (FRF)	Total (FRF)	Total EU investment (ECU)	Total railway investment (ECU)
Baku							
	PABX	3 000	3 000	1 000	3 000 000	454 545	
	service to subscribers	3 000	3 000	150	450 000		68 182
	AMS savings	1	1	-1 400 000	-1 400 000	-212 121	
Alyat					0		
	PABX	100	100	1 500	150 000	22 727	
	service to subscribers	100	100	225	22 500		3 409
Kazi Magomed					0		
	PABX	200	200	1 000	200 000	30 303	
	service to subscribers	200	200	150	30 000		4 545
Kyurdamir					0		
	PABX	200	200	1 000	200 000	30 303	
	service to subscribers	200	200	150	30 000		4 545
Baladjari					0		
	PABX	2 100	2 100	1 000	2 100 000	318 182	
	service to subscribers	2 100	2 100	150	315 000		47 727
	technical facilities	1	1	500 000	500 000	75 758	
Gyandja					0		
	PABX	2 300	2 300	1 000	2 300 000	348 485	
	service to subscribers	2 300	2 300	150	345 000		52 273
	technical facilities	1	1	500 000	500 000	75 758	
Training						50 000	
Contingencies						59 697	9 034
Total						**1 253 636**	**189 716**

Telecom switches, GEORGIA - V0.2 26/02/99 - EPK

		number of telephones	telephones to be fitted	unit price (FRF)	Total (FRF)	Total EU investment (ECU)	Total railway investment (ECU)
Tbilissi							
	PABX	4 300	4 300	1 000	4 300 000	651 515	
	service to subscribers	4 300	4 300	150	645 000		97 727
	AMS savings	1	1	-1 400 000	-1 400 000	-212 121	
Kashuri					0		
	PABX	1 500	1 500	1 000	1 500 000	227 273	
	service to subscribers	1 500	1 500	150	225 000		34 091
	technical facilities	1	1	500 000	500 000	75 758	
Zestafoni					0		
	PABX	380	380	1 000	380 000	57 576	
	service to subscribers	380	380	150	57 000		8 636
Gori					0		
	PABX	200	200	1 000	200 000	30 303	
	service to subscribers	200	200	150	30 000		4 545
Samtredia					0		
	PABX	2 000	2 000	1 000	2 000 000	303 030	
	service to subscribers	2 000	2 000	150	300 000		45 455
	technical facilities	1	1	500 000	500 000	75 758	
Senaki					0		
	PABX	50	50	1 500	75 000	11 364	
	service to subscribers	50	50	225	11 250		1 705
Poti					0		
	PABX	200	200	1 000	200 000	30 303	
	service to subscribers	200	200	150	30 000		4 545
Batumi					0		
	PABX	500	500	1 000	500 000	75 758	
	service to subscribers	500	500	150	75 000		11 364
Training						50 000	
Contingencies						68 826	10 403
Total						**1 445 341**	**218 472**

Chapter 5

Caucasus - Recommendations and economic study
Appendix 6 - Economic tables

Hypothesis

	Armenia	Azerbaijan	Georgia	France
Length of cable laid (in km)	309	503	444	
PCM Cost in US$	0,014	0,014	0,014	0,057
Black Fibre Cost in US$	0,0005	0,001	0,001	0,0013 à 0,0033
km loco / year	100000	70000	100000	
Delays growth rate	1,05	1,02	1,03	

TRI

INV	Armenia	Azerbaijan	Georgia	Overall
+0%	19%	32%	16%	21%
+10%	17%	25%	15%	18%
-10%	23%	52%	18%	25%

TRI

REVENUES	Armenia	Azerbaijan	Georgia	Overall
+10%	20%	33%	17%	22%
-10%	18%	31%	15%	20%

(In millions of US $) ARMENIA AZERBAIJAN GEORGIA

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,365	0,372	0,3794	0,387	0,395	0,403	0,411	0,419	0,427	0,436	0,445	0,453	0,463	0,472	0,481	0,491	0,501	0,511	0,521	0,531
Inv Loco	12	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0
Residual Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Cash flow	-12,365	-0,372	-0,379	-0,387	-0,395	-0,403	-3,411	-0,419	-0,427	-0,436	-0,445	-3,453	-0,463	-0,472	-0,481	-0,491	-0,501	-0,511	-0,521	5,829
Project case : S1																				
Investments	18,70																			
Maintenance cost	0,38	0,38	0,3825	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38
Residual Value	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	4,52
PCM revenues	0,00	0,00	0,00	0,05	0,10	0,21	0,31	0,42	0,53	0,63	0,74	0,85	0,95	1,01	1,06	1,06	1,06	1,06	1,06	1,06
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,10	1,10	2,20	2,20	3,30	3,30	4,41	4,41	5,51	5,51	6,61	6,61	6,61
Cash flow	-19,08	-0,38	-0,38	-0,33	-0,28	-0,18	-0,07	1,14	1,25	2,45	2,56	3,77	3,87	5,03	5,09	6,19	6,19	7,29	7,29	11,81
S1-S0	-6,72	-0,01	0,00	0,05	0,11	0,23	3,34	1,56	1,67	2,89	3,00	7,22	4,34	5,50	5,57	6,68	6,69	7,80	7,81	5,98

IRR 21%

Locomotive cost	3		VR	
Maintenance cost increase		1,02	0	1
			1 PCM revenues	
REVENUE			1 Black fibres revenues	

revenues -10 %		
revenues +10 %		
Number of free 2Mb/s PCM channels	76	
Average 2Mb/s PCM cost	0,014	
Number of black fibres	36	0,02
Average black fibre cost		
Number of km	1256	

(In millions of US $) ARMENIA

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,022	0,023	0,023	0,024	0,024	0,025	0,025	0,026	0,026	0,027	0,027	0,028	0,028	0,029	0,029	0,030	0,031	0,031	0,032	0,032
Inv Loco	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,8
Cash flow	**-3,022**	**-0,023**	**-0,023**	**-0,024**	**-0,024**	**-0,025**	**-0,025**	**-0,026**	**-0,026**	**-0,027**	**-0,027**	**-3,028**	**-0,028**	**-0,029**	**-0,029**	**-0,030**	**-0,031**	**-0,031**	**-0,032**	**2,728**
Project case : S1																				
Investments	4,47																			
Maintenance cost	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09
Residual Value	0																			1,115
PCM revenues	0,00	0,00	0,00	0,05	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,15	0,15	0,31	0,31	0,46	0,46	0,62	0,62	0,77	0,77	0,93	0,93	0,93
Cash flow	**-4,56**	**-0,09**	**-0,09**	**-0,04**	**0,01**	**0,06**	**0,11**	**0,31**	**0,36**	**0,57**	**0,62**	**0,82**	**0,88**	**1,03**	**1,03**	**1,18**	**1,18**	**1,34**	**1,34**	**2,45**
S1-S0	**-1,54**	**-0,07**	**-0,07**	**-0,02**	**0,03**	**0,08**	**0,13**	**0,34**	**0,39**	**0,60**	**0,65**	**3,85**	**0,90**	**1,06**	**1,06**	**1,21**	**1,21**	**1,37**	**1,37**	**-0,27**

IRR **19%**

Locomotive cost	3		VR	
Maintenance cost increase		1,02	0	1
			1 PCM revenues	
REVENUE			1 Black fibres revenues	

Number of free 2Mb/s PCM channels	36
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,0005
Number of km	309

(In millions of US $) AZERBAIJAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,23	0,23	0,24	0,24	0,25	0,25	0,26	0,26	0,27	0,27	0,28	0,29	0,29	0,30	0,30	0,31	0,32	0,32	0,33	0,33
Inv Loco	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,4
Cash flow	-6,23	-0,234	-0,239	-0,244	-0,248	-0,253	-0,258	-0,264	-0,269	-0,274	-0,280	-0,285	-0,291	-0,297	-0,303	-0,309	-0,315	-0,321	-0,328	1,106
Project case : S1																				
Investments	7,17																			
Maintenance cost	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15
Residual Value	0,00																			1,808
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,03	0,06	0,09	0,12	0,15	0,18	0,22	0,25	0,28	0,31	0,31	0,31	0,31	0,31	0,31
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,50	1,01	1,01	1,51	1,51	2,01	2,01	2,52	2,52	3,02	3,02	3,02
Cash flow	-7,32	-0,15	-0,15	-0,15	-0,15	-0,12	-0,09	0,45	0,48	1,01	1,04	1,58	1,61	2,14	2,17	2,67	2,67	3,18	3,18	4,99
S1-S0	-1,09	0,09	0,09	0,10	0,10	0,14	0,17	0,71	0,75	1,29	1,32	1,86	1,90	2,44	2,47	2,98	2,99	3,50	3,51	3,88

IRR 32%

Locomotive cost	3	
Maintenance cost increase		1,02

VR

0 1

1 PCM revenues

1 Black fibres revenues

REVENUE

Number of free 2Mb/s PCM channels	22
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,001
number of km	503

(In millions of US $) GEORGIA

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,113	0,115	0,117	0,120	0,122	0,125	0,127	0,130	0,132	0,135	0,138	0,140	0,143	0,146	0,149	0,152	0,155	0,158	0,161	0,165
Inv Loco	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2
Cash flow	**-3,11**	**-0,12**	**-0,12**	**-0,12**	**-0,12**	**-0,12**	**-3,13**	**-0,13**	**-0,13**	**-0,13**	**-0,14**	**-0,14**	**-0,14**	**-0,15**	**-0,15**	**-0,15**	**-0,16**	**-0,16**	**-0,16**	**2,00**
Project case : S1																				
Investments	7,06																			
Maintenance and operating cost	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14
Residual Value	0,00																			1,60
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,03	0,05	0,08	0,10	0,13	0,15	0,18	0,20	0,23	0,25	0,25	0,25	0,25	0,25	0,25
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,44	0,44	0,89	0,89	1,33	1,33	1,78	1,78	2,22	2,22	2,66	2,66	2,66
Cash flow	**-7,20**	**-0,14**	**-0,14**	**-0,14**	**-0,14**	**-0,12**	**-0,09**	**0,38**	**0,40**	**0,87**	**0,90**	**1,37**	**1,39**	**1,86**	**1,89**	**2,33**	**2,33**	**2,77**	**2,77**	**4,37**
S1-S0	**-4,09**	**-0,03**	**-0,02**	**-0,02**	**-0,02**	**0,01**	**3,04**	**0,51**	**0,53**	**1,01**	**1,03**	**1,51**	**1,53**	**2,01**	**2,03**	**2,48**	**2,48**	**2,93**	**2,94**	**2,38**

IRR **16%**

Locomotive cost 3
Maintenance cost increase 1,02

VR
0 1
1 PCM revenues
1 Black fibres revenues

REVENUE

Number of free 2Mb/s PCM channels	18
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,001
number of km	444

(In millions of US $)		ARMENIA		AZERBAIJAN			GEORGIA													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,365	0,372	0,379	0,387	0,395	0,403	0,411	0,419	0,427	0,436	0,445	0,453	0,463	0,472	0,481	0,491	0,501	0,511	0,521	0,531
Inv Loco	12	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0
Residual Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Cash flow	-12,365	-0,372	-0,379	-0,387	-0,395	-0,403	-3,411	-0,419	-0,427	-0,436	-0,445	-3,453	-0,463	-0,472	-0,481	-0,491	-0,501	-0,511	-0,521	5,829
Project case : S1																				
Investments	20,57																			
Maintenance cost	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40
Residual Value	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	4,97
PCM revenues	0,00	0,00	0,00	0,05	0,10	0,21	0,31	0,42	0,53	0,63	0,74	0,85	0,95	1,01	1,06	1,06	1,06	1,06	1,06	1,06
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,10	1,10	2,20	2,20	3,30	3,30	4,41	4,41	5,51	5,51	6,61	6,61	6,61
Cash flow	-20,97	-0,40	-0,40	-0,35	-0,30	-0,19	-0,09	1,12	1,23	2,44	2,54	3,75	3,86	5,01	5,07	6,17	6,17	7,27	7,27	12,25
S1-S0	-8,61	-0,03	-0,02	0,04	0,10	0,21	3,32	1,54	1,66	2,87	2,99	7,20	4,32	5,49	5,55	6,66	6,67	7,78	7,79	6,42

IRR 18%

Locomotive cost	3		VR
Maintenance cost increase		1,02	0 1
			1 PCM revenues
			1 Black fibres revenues

Number of free 2Mb/s PCM channels	76
Average 2Mb/s PCM cost	0,014
Number of black fibres	36
Average black fibre cost	
Number of km	1256

(In millions of US $)   ARMENIA

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,022	0,023	0,023	0,024	0,024	0,025	0,025	0,026	0,026	0,027	0,027	0,028	0,028	0,029	0,029	0,030	0,031	0,031	0,032	0,032
Inv Loco	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,8
Cash flow	**-3,022**	**-0,023**	**-0,023**	**-0,024**	**-0,024**	**-0,025**	**-0,025**	**-0,026**	**-0,026**	**-0,027**	**-0,027**	**-3,028**	**-0,028**	**-0,029**	**-0,029**	**-0,030**	**-0,031**	**-0,031**	**-0,032**	**2,728**
Project case : S1																				
Investments	4,91																			
Maintenance cost	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096	0,096
Residual Value	0,00																			1,23
PCM revenues	0,00	0,00	0,00	0,05	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,15	0,15	0,31	0,31	0,46	0,46	0,62	0,62	0,77	0,77	0,93	0,93	0,93
Cash flow	**-5,01**	**-0,10**	**-0,10**	**-0,05**	**0,00**	**0,05**	**0,11**	**0,31**	**0,36**	**0,57**	**0,62**	**0,82**	**0,87**	**1,03**	**1,03**	**1,18**	**1,18**	**1,33**	**1,33**	**2,56**
S1-S0	**-1,99**	**-0,07**	**-0,07**	**-0,02**	**0,03**	**0,08**	**0,13**	**0,34**	**0,39**	**0,59**	**0,64**	**3,85**	**0,90**	**1,05**	**1,06**	**1,21**	**1,21**	**1,37**	**1,37**	**-0,17**

IRR **17%**

Locomotive cost	3		VR		
Maintenance cost increase		1,02		0	1
				1 PCM revenues	
				1 Black fibres revenues	

Number of free 2Mb/s PCM channels	36
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,0005
Number of km	309

(In millions of US $) **AZERBAIJAN**

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,23	0,23	0,24	0,24	0,25	0,25	0,26	0,26	0,27	0,27	0,28	0,29	0,29	0,30	0,30	0,31	0,32	0,32	0,33	0,33
Inv Loco	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,4
Cash flow	-6,23	-0,234	-0,239	-0,244	-0,248	-0,253	-0,258	-0,264	-0,269	-0,274	-0,280	-0,285	-0,291	-0,297	-0,303	-0,309	-0,315	-0,321	-0,328	1,106
Project case : S1																				
Investments	7,89																			
Maintenance cost	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15
Residual Value	0,00																			1,99
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,03	0,06	0,09	0,12	0,15	0,18	0,22	0,25	0,28	0,31	0,31	0,31	0,31	0,31	0,31
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,50	1,01	1,01	1,51	1,51	2,01	2,01	2,52	2,52	3,02	3,02	3,02
Cash flow	-8,04	-0,15	-0,15	-0,15	-0,15	-0,12	-0,09	0,44	0,47	1,01	1,04	1,57	1,60	2,13	2,17	2,67	2,67	3,17	3,17	5,16
S1-S0	-1,81	0,08	0,08	0,09	0,09	0,13	0,17	0,70	0,74	1,28	1,32	1,86	1,89	2,43	2,47	2,98	2,98	3,49	3,50	4,06

IRR **25%**

Locomotive cost 3
Maintenance cost increase 1,02

VR
0 1
1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels	22
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,001
number of km	503

(In millions of US $) GEORGIA

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,113	0,115	0,117	0,120	0,122	0,125	0,127	0,130	0,132	0,135	0,138	0,140	0,143	0,146	0,149	0,152	0,155	0,158	0,161	0,165
Inv Loco	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2
Cash flow	**-3,11**	**-0,12**	**-0,12**	**-0,12**	**-0,12**	**-0,12**	**-3,13**	**-0,13**	**-0,13**	**-0,13**	**-0,14**	**-0,14**	**-0,14**	**-0,15**	**-0,15**	**-0,15**	**-0,16**	**-0,16**	**-0,16**	**2,00**
Project case : S1																				
Investments	7,77																			
Maintenance and operating cost	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15
Residual Value	0,00																			1,76
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,03	0,05	0,08	0,10	0,13	0,15	0,18	0,20	0,23	0,25	0,25	0,25	0,25	0,25	0,25
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,44	0,44	0,89	0,89	1,33	1,33	1,78	1,78	2,22	2,22	2,66	2,66	2,66
Cash flow	**-7,92**	**-0,15**	**-0,15**	**-0,15**	**-0,15**	**-0,12**	**-0,10**	**0,37**	**0,40**	**0,86**	**0,89**	**1,36**	**1,38**	**1,85**	**1,88**	**2,32**	**2,32**	**2,77**	**2,77**	**4,52**
S1-S0	**-4,80**	**-0,03**	**-0,03**	**-0,03**	**-0,03**	**0,00**	**3,03**	**0,50**	**0,53**	**1,00**	**1,03**	**1,50**	**1,53**	**2,00**	**2,03**	**2,47**	**2,48**	**2,93**	**2,93**	**2,53**

IRR **15%**

Locomotive cost 3
Maintenance cost increase 1,02

VR
0 1
1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels 18
Average 2Mb/s PCM cost 0,014
Number of black fibres 12
Average black fibre cost 0,001 /km
number of km 444

(In millions of US $)		ARMENIA		AZERBAIJAN			GEORGIA													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,365	0,372	0,379	0,387	0,395	0,403	0,411	0,419	0,427	0,436	0,445	0,453	0,463	0,472	0,481	0,491	0,501	0,511	0,521	0,531
Inv Loco	12	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0
Residual Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Cash flow	**-12,365**	**-0,372**	**-0,379**	**-0,387**	**-0,395**	**-0,403**	**-3,411**	**-0,419**	**-0,427**	**-0,436**	**-0,445**	**-3,453**	**-0,463**	**-0,472**	**-0,481**	**-0,491**	**-0,501**	**-0,511**	**-0,521**	**5,829**
Project case : S1																				
Investments	16,83																			
Maintenance cost	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37
Residual Value	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	4,07
PCM revenues	0,00	0,00	0,00	0,05	0,10	0,21	0,31	0,42	0,53	0,63	0,74	0,85	0,95	1,01	1,06	1,06	1,06	1,06	1,06	1,06
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,10	1,10	2,20	2,20	3,30	3,30	4,41	4,41	5,51	5,51	6,61	6,61	6,61
Cash flow	**-17,20**	**-0,37**	**-0,37**	**-0,31**	**-0,26**	**-0,16**	**-0,05**	**1,16**	**1,26**	**2,47**	**2,58**	**3,78**	**3,89**	**5,05**	**5,10**	**6,21**	**6,21**	**7,31**	**7,31**	**11,38**
S1-S0	**-4,83**	**0,01**	**0,01**	**0,07**	**0,13**	**0,24**	**3,36**	**1,58**	**1,69**	**2,91**	**3,02**	**7,24**	**4,35**	**5,52**	**5,59**	**6,70**	**6,71**	**7,82**	**7,83**	**5,55**

IRR **25%**

Locomotive cost	3	
Maintenance cost increase		1,02

VR
0 1
1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels	76
Average 2Mb/s PCM cost	0,014
Number of black fibres	36
Average black fibre cost	
Number of km	1256

(In millions of US $) ARMENIA

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,022	0,023	0,023	0,024	0,024	0,025	0,025	0,026	0,026	0,027	0,027	0,028	0,028	0,029	0,029	0,030	0,031	0,031	0,032	0,032
Inv Loco	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,8
Cash flow	-3,022	-0,023	-0,023	-0,024	-0,024	-0,025	-0,025	-0,026	-0,026	-0,027	-0,027	-3,028	-0,028	-0,029	-0,029	-0,030	-0,031	-0,031	-0,032	2,728
Project case : S1																				
Investments	4,02																			
Maintenance cost	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09
Residual Value	0,00																			1,00
PCM revenues	0,00	0,00	0,00	0,05	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,50	0,50	0,50	0,50	0,50	0,50	0,50
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,15	0,15	0,31	0,31	0,46	0,46	0,62	0,62	0,77	0,77	0,93	0,93	0,93
Cash flow	-4,11	-0,09	-0,09	-0,04	0,01	0,06	0,11	0,32	0,37	0,57	0,62	0,83	0,88	1,03	1,03	1,19	1,19	1,34	1,34	2,35
S1-S0	-1,09	-0,07	-0,06	-0,01	0,04	0,09	0,14	0,34	0,39	0,60	0,65	3,86	0,91	1,06	1,06	1,22	1,22	1,37	1,37	-0,38

IRR	23%			
			VR	
Locomotive cost	3		0	1
Maintenance cost increase		1,02		

1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels	36
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,0005
Number of km	309

(In millions of US $) AZERBAIJAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,23	0,23	0,24	0,24	0,25	0,25	0,26	0,26	0,27	0,27	0,28	0,29	0,29	0,30	0,30	0,31	0,32	0,32	0,33	0,33
Inv Loco	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,4
Cash flow	-6,23	-0,234	-0,239	-0,244	-0,248	-0,253	-0,258	-0,264	-0,269	-0,274	-0,280	-0,285	-0,291	-0,297	-0,303	-0,309	-0,315	-0,321	-0,328	1,106
Project case : S1																				
Investments	6,45																			
Maintenance cost	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142	0,142
Residual Value	0,00																			1,63
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,03	0,06	0,09	0,12	0,15	0,18	0,22	0,25	0,28	0,31	0,31	0,31	0,31	0,31	0,31
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,50	1,01	1,01	1,51	1,51	2,01	2,01	2,52	2,52	3,02	3,02	3,02
Cash flow	-6,60	-0,14	-0,14	-0,14	-0,14	-0,11	-0,08	0,45	0,48	1,02	1,05	1,58	1,61	2,15	2,18	2,68	2,68	3,18	3,18	4,81
S1-S0	-0,37	0,09	0,10	0,10	0,11	0,14	0,18	0,72	0,75	1,29	1,33	1,87	1,90	2,44	2,48	2,99	3,00	3,51	3,51	3,71

IRR 52%

Locomotive cost 3

Maintenance cost increase 1,02

VR

0 1

1 PCM revenues

1 Black fibres revenues

Number of free 2Mb/s PCM channels	22
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,001
number of km	503

(In millions of US $)   GEORGIA

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,113	0,115	0,117	0,120	0,122	0,125	0,127	0,130	0,132	0,135	0,138	0,140	0,143	0,146	0,149	0,152	0,155	0,158	0,161	0,165
Inv Loco	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2
Cash flow	-3,11	-0,12	-0,12	-0,12	-0,12	-0,12	-3,13	-0,13	-0,13	-0,13	-0,14	-0,14	-0,14	-0,15	-0,15	-0,15	-0,16	-0,16	-0,16	2,00
Project case : S1																				
Investments	6,36																			
Maintenance and operating cost	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135	0,135
Residual Value	0,00																			1,44
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,03	0,05	0,08	0,10	0,13	0,15	0,18	0,20	0,23	0,25	0,25	0,25	0,25	0,25	0,25
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,44	0,44	0,89	0,89	1,33	1,33	1,78	1,78	2,22	2,22	2,66	2,66	2,66
Cash flow	-6,49	-0,14	-0,14	-0,14	-0,14	-0,11	-0,08	0,38	0,41	0,88	0,90	1,37	1,40	1,87	1,89	2,34	2,34	2,78	2,78	4,22
S1-S0	-3,38	-0,02	-0,02	-0,02	-0,01	0,01	3,04	0,51	0,54	1,01	1,04	1,51	1,54	2,01	2,04	2,49	2,49	2,94	2,94	2,22

IRR **18%**

VR

Locomotive cost 3   0   1
Maintenance cost increase 1,02

1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels	18
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,001 /km
number of km	444

(In millions of US $)		ARMENIA		AZERBAIJAN			GEORGIA													
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Base case : SO																				
Maintenance and operating cost	0,365	0,372	0,3794	0,387	0,395	0,403	0,411	0,419	0,427	0,436	0,445	0,453	0,463	0,472	0,481	0,491	0,501	0,511	0,521	0,531
Inv Loco	12	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0
Residual Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Cash flow	**-12,365**	**-0,372**	**-0,379**	**-0,387**	**-0,395**	**-0,403**	**-3,411**	**-0,419**	**-0,427**	**-0,436**	**-0,445**	**-3,453**	**-0,463**	**-0,472**	**-0,481**	**-0,491**	**-0,501**	**-0,511**	**-0,521**	**5,829**
Project case : S1																				
Investments	18,70																			
Maintenance cost	0,38	0,38	0,3825	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38
Residual Value	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	4,52
PCM revenues	0,00	0,00	0,00	0,06	0,11	0,23	0,34	0,46	0,58	0,70	0,81	0,93	1,05	1,11	1,17	1,17	1,17	1,17	1,17	1,17
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,21	1,21	2,42	2,42	3,63	3,63	4,85	4,85	6,06	6,06	7,27	7,27	7,27
Cash flow	**-19,08**	**-0,38**	**-0,38**	**-0,33**	**-0,27**	**-0,15**	**-0,04**	**1,29**	**1,41**	**2,74**	**2,85**	**4,18**	**4,30**	**5,57**	**5,63**	**6,85**	**6,85**	**8,06**	**8,06**	**12,58**
S1-S0	**-6,72**	**-0,01**	**0,00**	**0,06**	**0,12**	**0,25**	**3,37**	**1,71**	**1,84**	**3,17**	**3,30**	**7,64**	**4,76**	**6,04**	**6,12**	**7,34**	**7,35**	**8,57**	**8,58**	**6,75**

IRR **22%**

Locomotive cost	3		VR	
Maintenance cost increase		1,02	0	1
			1 PCM revenues	
REVENUE+10%			1 Black fibres revenues	
revenues -10 %				
revenues +10 %				
Number of free 2Mb/s PCM channels		76		
Average 2Mb/s PCM cost		0,0154		
Number of black fibres		36		0,02
Average black fibre cost				
Number of km		1256		

(In millions of US $) ARMENIA

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,022	0,023	0,023	0,024	0,024	0,025	0,025	0,026	0,026	0,027	0,027	0,028	0,028	0,029	0,029	0,030	0,031	0,031	0,032	0,032
Inv Loco	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,8
Cash flow	**-3,022**	**-0,023**	**-0,023**	**-0,024**	**-0,024**	**-0,025**	**-0,025**	**-0,026**	**-0,026**	**-0,027**	**-0,027**	**-3,028**	**-0,028**	**-0,029**	**-0,029**	**-0,030**	**-0,031**	**-0,031**	**-0,032**	**2,728**
Project case : S1																				
Investments	4,47																			
Maintenance cost	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09
Residual Value	0																			1,115
PCM revenues	0,00	0,00	0,00	0,06	0,11	0,17	0,22	0,28	0,33	0,39	0,44	0,50	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,17	0,17	0,34	0,34	0,51	0,51	0,68	0,68	0,85	0,85	1,02	1,02	1,02
Cash flow	**-4,56**	**-0,09**	**-0,09**	**-0,04**	**0,02**	**0,07**	**0,13**	**0,35**	**0,41**	**0,64**	**0,69**	**0,92**	**0,97**	**1,14**	**1,14**	**1,31**	**1,31**	**1,48**	**1,48**	**2,60**
S1-S0	**-1,54**	**-0,07**	**-0,07**	**-0,01**	**0,04**	**0,10**	**0,15**	**0,38**	**0,44**	**0,66**	**0,72**	**3,94**	**1,00**	**1,17**	**1,17**	**1,34**	**1,34**	**1,51**	**1,51**	**-0,13**

IRR **20%**

Locomotive cost 3
Maintenance cost increase 1,02

VR
0 1
1 PCM revenues
1 Black fibres revenues

REVENUE+10%

Number of free 2Mb/s PCM channels	36
Average 2Mb/s PCM cost	0,0154
Number of black fibres	12
Average black fibre cost	0,00055
Number of km	309

(In millions of US $) AZERBAIJAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,23	0,23	0,24	0,24	0,25	0,25	0,26	0,26	0,27	0,27	0,28	0,29	0,29	0,30	0,30	0,31	0,32	0,32	0,33	0,33
Inv Loco	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,4
Cash flow	-6,23	-0,234	-0,239	-0,244	-0,248	-0,253	-0,258	-0,264	-0,269	-0,274	-0,280	-0,285	-0,291	-0,297	-0,303	-0,309	-0,315	-0,321	-0,328	1,106
Project case : S1																				
Investments	7,17																			
Maintenance cost	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15
Residual Value	0,00																			1,808
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,03	0,07	0,10	0,14	0,17	0,20	0,24	0,27	0,30	0,34	0,34	0,34	0,34	0,34	0,34
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,55	0,55	1,11	1,11	1,66	1,66	2,21	2,21	2,77	2,77	3,32	3,32	3,32
Cash flow	-7,32	-0,15	-0,15	-0,15	-0,15	-0,11	-0,08	0,51	0,54	1,13	1,16	1,75	1,78	2,37	2,40	2,96	2,96	3,51	3,51	5,32
S1-S0	-1,09	0,09	0,09	0,10	0,10	0,14	0,18	0,77	0,81	1,40	1,44	2,03	2,07	2,67	2,71	3,27	3,27	3,83	3,84	4,21

IRR **33%**

Locomotive cost	3		VR	
Maintenance cost increase		1,02	0	1
			1	PCM revenues
REVENUE+10%			1	Black fibres revenues

Number of free 2Mb/s PCM channels	22
Average 2Mb/s PCM cost	0,0154
Number of black fibres	12
Average black fibre cost	0,0011
number of km	503

(In millions of US $) **GEORGIA**

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,113	0,115	0,117	0,120	0,122	0,125	0,127	0,130	0,132	0,135	0,138	0,140	0,143	0,146	0,149	0,152	0,155	0,158	0,161	0,165
Inv Loco	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2
Cash flow	**-3,11**	**-0,12**	**-0,12**	**-0,12**	**-0,12**	**-0,12**	**-3,13**	**-0,13**	**-0,13**	**-0,13**	**-0,14**	**-0,14**	**-0,14**	**-0,15**	**-0,15**	**-0,15**	**-0,16**	**-0,16**	**-0,16**	**2,00**
Project case : S1																				
Investments	7,06																			
Maintenance and operating cost	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14
Residual Value	0,00																			1,60
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,03	0,06	0,08	0,11	0,14	0,17	0,19	0,22	0,25	0,28	0,28	0,28	0,28	0,28	0,28
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,49	0,49	0,98	0,98	1,47	1,47	1,95	1,95	2,44	2,44	2,93	2,93	2,93
Cash flow	**-7,20**	**-0,14**	**-0,14**	**-0,14**	**-0,14**	**-0,11**	**-0,09**	**0,43**	**0,46**	**0,97**	**1,00**	**1,52**	**1,54**	**2,06**	**2,09**	**2,58**	**2,58**	**3,07**	**3,07**	**4,66**
S1-S0	**-4,09**	**-0,03**	**-0,02**	**-0,02**	**-0,02**	**0,01**	**3,04**	**0,56**	**0,59**	**1,11**	**1,14**	**1,66**	**1,69**	**2,21**	**2,24**	**2,73**	**2,73**	**3,22**	**3,23**	**2,67**

IRR **17%**

Locomotive cost	3	
Maintenance cost increase		1,02

VR

0 1
1 PCM revenues
1 Black fibres revenues

REVENUE+10%

Number of free 2Mb/s PCM channels	18
Average 2Mb/s PCM cost	0,0154
Number of black fibres	12
Average black fibre cost	0,0011
number of km	444

(In millions of US $)		ARMENIA		AZERBAIJAN			GEORGIA													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,365	0,372	0,3794	0,387	0,395	0,403	0,411	0,419	0,427	0,436	0,445	0,453	0,463	0,472	0,481	0,491	0,501	0,511	0,521	0,531
Inv Loco	12	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0
Residual Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Cash flow	-12,365	-0,372	-0,379	-0,387	-0,395	-0,403	-3,411	-0,419	-0,427	-0,436	-0,445	-3,453	-0,463	-0,472	-0,481	-0,491	-0,501	-0,511	-0,521	5,829
Project case : S1																				
Investments	18,70																			
Maintenance cost	0,38	0,38	0,3825	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38	0,38
Residual Value	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	4,52
PCM revenues	0,00	0,00	0,00	0,05	0,09	0,19	0,28	0,38	0,47	0,57	0,67	0,76	0,86	0,91	0,96	0,96	0,96	0,96	0,96	0,96
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,99	0,99	1,98	1,98	2,97	2,97	3,97	3,97	4,96	4,96	5,95	5,95	5,95
Cash flow	-19,08	-0,38	-0,38	-0,34	-0,29	-0,20	-0,10	0,99	1,08	2,17	2,27	3,35	3,45	4,49	4,54	5,53	5,53	6,52	6,52	11,04
S1-S0	-6,72	-0,01	0,00	0,05	0,10	0,21	3,31	1,41	1,51	2,61	2,71	6,81	3,91	4,96	5,02	6,02	6,03	7,03	7,04	5,22

IRR **20%**

Locomotive cost 3
Maintenance cost increase 1,02

VR
0 1
1 PCM revenues
1 Black fibres revenues

REVENUE-10%

revenues -10 %
revenues +10 %
Number of free 2Mb/s PCM channels 76
Average 2Mb/s PCM cost 0,0126
Number of black fibres 36 0,02
Average black fibre cost
Number of km 1256

(In millions of US $) ARMENIA

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,022	0,023	0,023	0,024	0,024	0,025	0,025	0,026	0,026	0,027	0,027	0,028	0,028	0,029	0,029	0,030	0,031	0,031	0,032	0,032
Inv Loco	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,8
Cash flow	**-3,022**	**-0,023**	**-0,023**	**-0,024**	**-0,024**	**-0,025**	**-0,025**	**-0,026**	**-0,026**	**-0,027**	**-0,027**	**-3,028**	**-0,028**	**-0,029**	**-0,029**	**-0,030**	**-0,031**	**-0,031**	**-0,032**	**2,728**
Project case : S1																				
Investments	4,47																			
Maintenance cost	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09
Residual Value	0																			1,115
PCM revenues	0,00	0,00	0,00	0,05	0,09	0,14	0,18	0,23	0,27	0,32	0,36	0,41	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,14	0,28	0,28	0,42	0,42	0,56	0,56	0,70	0,70	0,83	0,83	0,83
Cash flow	**-4,56**	**-0,09**	**-0,09**	**-0,05**	**0,00**	**0,04**	**0,09**	**0,27**	**0,32**	**0,50**	**0,55**	**0,73**	**0,78**	**0,92**	**0,92**	**1,06**	**1,06**	**1,20**	**1,20**	**2,31**
S1-S0	**-1,54**	**-0,07**	**-0,07**	**-0,02**	**0,02**	**0,07**	**0,11**	**0,30**	**0,35**	**0,53**	**0,58**	**3,76**	**0,81**	**0,95**	**0,95**	**1,09**	**1,09**	**1,23**	**1,23**	**-0,42**

IRR **18%**

Locomotive cost	3		VR
Maintenance cost increase		1,02	0 1
			1 PCM revenues
REVENUE-10%			1 Black fibres revenues

Number of free 2Mb/s PCM channels	36
Average 2Mb/s PCM cost	0,0126
Number of black fibres	12
Average black fibre cost	0,00045
Number of km	309

(In millions of US $) AZERBAIJAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,23	0,23	0,24	0,24	0,25	0,25	0,26	0,26	0,27	0,27	0,28	0,29	0,29	0,30	0,30	0,31	0,32	0,32	0,33	0,33
Inv Loco	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,4
Cash flow	-6,23	-0,234	-0,239	-0,244	-0,248	-0,253	-0,258	-0,264	-0,269	-0,274	-0,280	-0,285	-0,291	-0,297	-0,303	-0,309	-0,315	-0,321	-0,328	1,106
Project case : S1																				
Investments	7,17																			
Maintenance cost	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15
Residual Value	0,00																			1,808
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,03	0,06	0,08	0,11	0,14	0,17	0,19	0,22	0,25	0,28	0,28	0,28	0,28	0,28	0,28
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,45	0,45	0,91	0,91	1,36	1,36	1,81	1,81	2,26	2,26	2,72	2,72	2,72
Cash flow	-7,32	-0,15	-0,15	-0,15	-0,15	-0,12	-0,09	0,39	0,42	0,90	0,92	1,40	1,43	1,91	1,94	2,39	2,39	2,85	2,85	4,65
S1-S0	-1,09	0,09	0,09	0,10	0,10	0,13	0,17	0,65	0,68	1,17	1,20	1,69	1,72	2,21	2,24	2,70	2,71	3,17	3,17	3,55

IRR **31%**

Locomotive cost	3		VR		
Maintenance cost increase		1,02		0	1
				1 PCM revenues	
REVENUE-10%				1 Black fibres revenues	

Number of free 2Mb/s PCM channels	22
Average 2Mb/s PCM cost	0,0126
Number of black fibres	12
Average black fibre cost	0,0009
number of km	503

(In millions of US $) **GEORGIA**

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,113	0,115	0,117	0,120	0,122	0,125	0,127	0,130	0,132	0,135	0,138	0,140	0,143	0,146	0,149	0,152	0,155	0,158	0,161	0,165
Inv Loco	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2
Cash flow	**-3,11**	**-0,12**	**-0,12**	**-0,12**	**-0,12**	**-0,12**	**-3,13**	**-0,13**	**-0,13**	**-0,13**	**-0,14**	**-0,14**	**-0,14**	**-0,15**	**-0,15**	**-0,15**	**-0,16**	**-0,16**	**-0,16**	**2,00**
Project case : S1																				
Investments	7,06																			
Maintenance and operating cost	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14
Residual Value	0,00																			1,60
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,02	0,05	0,07	0,09	0,11	0,14	0,16	0,18	0,20	0,23	0,23	0,23	0,23	0,23	0,23
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,40	0,40	0,80	0,80	1,20	1,20	1,60	1,60	2,00	2,00	2,40	2,40	2,40
Cash flow	**-7,20**	**-0,14**	**-0,14**	**-0,14**	**-0,14**	**-0,12**	**-0,10**	**0,33**	**0,35**	**0,77**	**0,79**	**1,22**	**1,24**	**1,66**	**1,68**	**2,08**	**2,08**	**2,48**	**2,48**	**4,08**
S1-S0	**-4,09**	**-0,03**	**-0,02**	**-0,02**	**-0,02**	**0,01**	**3,03**	**0,46**	**0,48**	**0,91**	**0,93**	**1,36**	**1,38**	**1,81**	**1,83**	**2,23**	**2,24**	**2,64**	**2,64**	**2,08**

IRR **15%**

Locomotive cost	3	
Maintenance cost increase		1,02

VR

0 1
1 PCM revenues
1 Black fibres revenues

REVENUE-10%

Number of free 2Mb/s PCM channels	18
Average 2Mb/s PCM cost	0,0126
Number of black fibres	12
Average black fibre cost	0,0009
number of km	444

Chapter 6

Central Asia - Recommendations and economic study

Central Asia - Recommendations and economic study

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1 Telecommunications

This section constitutes the action and investment plan of the Traceca project, Module E for the Central Asian countries: Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan, Turkmenistan.

It consists of a technical study and an economic study.

1.1 Summary

1.1.1 Preface

1.1.1.1 Context and strategy

In Chapter 4, section 1 the **context** of the study is set out and in section 2, the **method** selected and the **general technical options** underlying the study of telecommunications network architecture.

The **context** is essentially as follows:

- Independent railway telecom networks have been envisaged for each country, with PABX being used to interconnect these countries with each other, with the Caucasus region and with Europe.

- Major importance has been attached to specific railway telecom facilities used for railway operations and ensuring the safety of railway movements. In particular, these require a process of collection-distribution between the control centre, which is in charge of the supervision of railway lines as a whole, and the stations dotted along the line.

The **study strategy** selected is based on a distinction between a backbone telecom network, and a secondary telecom network, the backbone being for main railway trunk lines and the spokes being for the secondary lines branching off from these main line routes.

1.1.1.2 Block diagrams

Explanations and a set of **block diagrams** are provided in support of the general technical options selected and describe the rules for positioning the various parts that go to make up a telecom network. These constitute Chapter 4, section 3.

1.1.1.3 Financial data

Financial data given in Chapter 4, section 1.4 provides details of and a justification for the basic costs of the different parts of the telecom networks.

1.1.2 Technical study

The general recommendations of Chapter 4, applied to the railways in the Central Asian area, culminate in the following recommendations.

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1.1.2.1 Backbone network

A **proposal for a backbone network** is given for each of the five countries in the Central Asian area. These consist of:

- a document setting out the reasons for the specific options selected for a particular country,
- the general architecture of the backbone network (Appendix 1),
- **investment tables** (Appendix 2) for two different network configurations:
  -- without back-up of incoming railway control centre circuits,
  -- with partial back-up of incoming railway control centre circuits.

This data will subsequently be used as a basis for the economic study.

The backbone network takes in the following sections:

- In Kazkhstan :
  - Tchengeldy - Almaty - Droujba, i.e. 1808 km.
- In Kyrgyzstan :
  - Lugovaya (Kazakhstan) - Bishkek - Balyktchi, i.e. 327 km.
- In Uzbekistan:
  - Tchengeldi (Kazakhstan) - Tashkent - Bekabad -> Tajikistan
    Talimardjan - > Turkmenistan
    Farab -> Turkmenistan
  - R-161km / Termez / Sariasiya / Amuzang, i.e. a total of 1454 km.
- In Tajikistan:
  - Bekabad (Uzbekistan) - Nay - Kafurov,
  - Saryasia (Uzbekistan) - Pakhtabad - Dushanbe - Yangi-Bazar
  - Amuzan (Uzbekistan) - Ayvadji - Kurgan-Tjube - Kulyab - Yavan, i.e. a total of 509 km.

- In Turkmenistan :
  - Krasnodovsk (near Turkmenbashi - Caspian Sea) - Ashgabad - Farab (border with Uzbekistan)
  - Talimardjan/R-161km, i.e. a total of 1364 km.

1.1.2.2 Secondary network

A **simplified proposal for secondary railway networks** rounds off the technical study. This is organised along similar lines to the backbone network proposal (justification of options selected, general diagrams, investment tables).
The corresponding diagrams and appendices are given as Appendices 3 and 4.

1.1.2.3 Conclusions

The following are the main **conclusions**:

- It is recommended that a firm decision be made to opt for **optical fibre cables** and **digital transmission** techniques.
Where the backbone telecom network is concerned, it is recommended that use be made of cables with 24 optical fibres, 12 of which would be employed for railway applications and 12 by possible future telecom operators. This cable will be buried to ensure reliability and a long life cycle.

- It is recommended that the basis of the backbone telecom network should be SDH technology (synchronous 155 Mbit/s STM1 add/drop multiplexers) supplemented by telecom distribution networks using drop-and-insert PCM (2 Mbit/s add/drop multiplexers with an 8 Mbit/s ADM8 transport medium and 2 Mbit/s add/drop multiplexers with a 2 Mbit/s ADM2 transport medium).

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These telecom networks are linear and in this respect they reflect the topology of the railway networks.
- It is recommended that telecom networks be provided at least partially with back-up, without seeking full redundancy for all the various installations, this not being economically justified. The solution whereby incoming control centre circuits are provided with back-up would be preferable but seems unfeasible, given that the public telecom operators do not appear to be able to supply the necessary external cables.

- It would also be advisable to replace the automatic administrative telephone switches with digital equipment.

- The technology to be adopted for the secondary railway telecom networks should be:
- for railway branch lines: a 6-fibre cable and drop-and-insert PCM
- for other railway lines: same equipment as for the backbone network.

Given the high cost of investment, it is not recommended that secondary networks be systematically equipped but rather that this be done in relation to actual operating needs. However it should be borne in mind that the equipment recovered when replacing the backbone will be available for use in maintaining these secondary lines and this will make it possible to defer investments for them.

1.1.3 Investment

1.1.3.1 Budget for the recommendations

1.1.3.1.1 Transmission network

The recommendation that an optical fibre network be established with SDH and PCM multiplexers and operational telephony would give the following budget:

	EU Investment (MECU)	Railway Investment (MECU)	Total
Kazakhstan	15.33	2.60	17.93
Kyrgyzstan	3.38	0.47	3.85
Uzbekistan	12.13	2.09	14.22
Tajikistan	3.74	0.73	4.47
Turkmenistan	11.00	1.96	12.97
Total	**45.58**	**7.86**	**53.44**

European Union investment covers:
- the cable and its fittings
- supervision of staking out operations and cable laying
- cable connections
- transmission equipment
- power supply
- spares
- training

The railways' investment covers:
- staking out
- civil engineering
- cable laying

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The cost calculated is ten times lower than that of similar work in western Europe because of manpower cost differences.

1.1.3.1.2 Automatic administrative telephone switches (PABX)

The supplementary option of replacing the automatic administrative telephone switches would require the following budget:

	EU Investment (MECU)	Railway Investment (MECU)	Total
Kazakhstan	0.17	0.02	0.19
Kyrgyzstan	0.00	0.00	0.00
Uzbekistan	0.55	0.05	0.61
Tajikistan	0.00	0.00	0.00
Turkmenistan	0.00	0.00	0.00
Total	**0.72**	**0.08**	**0.80**

The cost of rewiring buildings and installing subscriber telephones would be borne by the railways.

1.1.4 Economic study

The economic study is composed of a comparison between two scenarios over 20 years.

- Reference scenario, in which the project does not go ahead. The current maintenance budget continues to apply, with an increase of 2% per annum. Locomotives are procured to offset delays caused by telecommunications failures.
- Project scenario, in which the project is implemented in each of the countries concerned within a twelve-month period. Operating costs amount to 2% of investment in equipment and maintenance is 1FRF/m of cable laid.
  Cables have a useful life of 50 years and equipment of 20 years.

  Revenue may be expected from hiring out surplus system capacity to telecom operators. This revenue is taken into account in Kazakhstan from the second year, since the law already allows for this eventuality. In the other countries, the necessary legal framework does not yet exist and as a result revenue is only expected to be earned six years after the start of the project. Tajikistan has been omitted from the economic study for want of sufficient data.

The following table shows the rates of return observed:

	Kazakhstan	Kyrgyzstan	Uzbekistan	Turkmenistan
IRR	20%	18%	19%	20%

Results will be heavily dependent on revenue earned from hire of excess system capacity. Among the many advantages of this investment, only leasing revenue has been able to be estimated. But the internal benefits would be sufficient in themselves to justify the project as part of the railway restructuring process.

Despite the rather pessimistic assumptions and a reference situation where the cost of maintenance has probably been underestimated, the internal rates of return of the projects proposed are high (about 20%). They would require changes in national telecommunications legislation over the coming years.

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1.2 Technical study

The diagrams and investment tables are given in Appendices 1 and 2.

1.2.1 Backbone networks

1.2.1.1 Backbone network, Kazakhstan

1. Due to insufficient data, only the corridor section between Tchengeldy and Droujba has been examined.
The backbone network originates in Tchengeldy near Tashkent and continues towards Droujba.
To increase the network's capacity to deal with failures, it has been split at Alma-Ata.

The backbone network comprises 26 SDH/STM1 multiplexers located in:
- Tchengeldy, Arys, Tchimkent, Tyoulkubas, Tchokpak, Djamboul, Akyr-Tyoube, Lougovaya, Tchu, Tchokpar, Otar, Ouzoun-Agatch, Alma-Ata 1,
- Alma-Ata 1, Kaptchagan, X1, Sary-Ozek, Koksou, Ouch-Tobe, Mataï, Lepsy, Aktogaï, X2, Beskol, X3, Droujba.

To provide flattened transmission loop, 22 repeaters are also positioned at:
- Arys, Tchimkent, Tyoulkubas, Tchokpak, Djamboul, Akyr-Tyoube, Lougovaya, Tchu, Tchokpar, Otar, Ouzoun-Agatch,
- Kaptchagan, X1, Sary-Ozek, Koksou, Ouch-Tobe, Mataï, Lepsy, Aktogaï, X2, Beskol, X3.

A 20 km local loop is located at Alma-Ata.

Since nodes are often spaced more than 100 km apart, intermediate nodes X1 to X3 have been inserted. The exact location of X1 to X3 will have to be agreed with the railways when issuing invitations to tender.
Even with the intermediate nodes, the distance generally exceeds the range of 1300nm laser aggregates. For the sake of standardisation and, most importantly, efficient maintenance, it is advocated that solely 1550nm aggregates be used.

2. The total length of the backbone network is 1808 km (including the local loop).

3. A PABX is located at Alma-Ata. It was designed to replace the existing switch.

4. There is a total of 141 stations, which may be broken down as follows:
- 27 large and medium size stations, warranting telephone equipment suitable for an average station. These are
  -- Tchengeldy, Arys, Tchimkent, Tyoulkubas, Tchokpak, Djamboul, Akyr-Tyoube, Lougovaya, Tatty, Tchu, Berlik 1, Kermer, Tchokpar, Otar, Ouzoun-Agatch, Alma-Ata 1 (i.e. 16 stations),
  -- Alma-Ata 1, Kaptchagan, Sary-Ozek, Koksou, Ouch-Tobe, Moulaly, Mataï, Lepsy, Aktogaï, Beskol, Droujba (i.e. 11 stations).

- 114 less-important stations warranting telephone equipment suitable for a small station.
  -- 77 on the Tchengeldi/Alma-Ata line.
  -- 37 on the Alma-Ata/Droujba line.

5. The main traffic and energy (sub-stations, OHL) control centre is located at Alma-Ata, and there are two others located at Tchimkent and Djamboul.

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6. A single technical facilities room (including power supply, air conditioning, protection systems, wiring racks, etc.) is located at Alma-Ata housing the control centre station equipment, PABX and the digital transmission equipment (STM1 and ADM).

7. The distribution networks consist of 8Mbits/s ADMs (drop-and-insert PCM add/drop multiplexers). (See Chapter 4, section 2 : Method).

From the rules in the Method section and Figure AIP.1 (Chapter 4), it may be extrapolated that the following number of links need to be set up:
- 19 for the distribution network on the Tchengeldy/Alma-Ata route,
- 17 for the distribution network on the Alma-Ata/Droujba route,

corresponding to the following ADM breakdown:
- Tchengeldy/Alma-Ata :
  - 77+16 = 93 for stations (point 4),
  - 19 divided up amongst the control centres at Tchimkent, Djamboul and Alma-Ata.
- Alma-Ata/Droujba
  - 37+11 = 48 for stations (point 4),
  - 17 in Alma-Ata.

In other words, an aggregate of 177 ADM for a network without back-up of links between control centres and stations.

8. An SDH network management unit (STM1) is located in Alma-Ata.

9. Three distribution network management units (ADM) are respectively located in Tchimkent, Djamboul and Alma-Ata, which are considered the telecom centres of excellence in Kazakhstan.

10. As regards power supply:
- power supply to the PABX, STM1 and ADM in the control centre in Tchimkent, Djamboul and Alma-Ata is included in the technical facilities room.
- equipment at the 27 large stations listed under point 4 and the corresponding STM1 and ADM devices are fed by 27 medium capacity power supply lines.
- equipment at the 114 small stations listed under point 4 and the corresponding ADM devices are fed by 114 low capacity power supply lines.

11. Back-up
It is assumed that there is a flattened transmission loop providing partial back-up in every case.

Total back-up for the the main rail operating links (operations control and energy control) on the Tchengeldy/Alama-Ata/Droujba line can be provided by an external network (for example, the public network). The arrangement would involve installing 19 additional ADMs between Tchengeldy and Alama-Ata and 17 in Droujba.

12. Training
Due to the size of the network, the budget is double that given in the Chapter 4 recommendations.

1.2.1.2 Backbone network, Kyrgyzstan

1. The backbone network comprises 5 SDH/STM1 multiplexers located in:
- Lugovaya, Karabalta, Bishkek 1, Bystrovka, Balyktchi.

To provide flattened transmission loop, 3 repeaters are also positioned at:
- Karabalta, Bishkek 1, Bystrovka.

The network originates in Lugovaya (Kazakhstan) and ends in Balyktchi
Note : although the Lugovaya / Kaindy section runs through Kazakh territory, it is managed by Kyrgyzstan Railways.

A 15 km local loop is located at Bishkek.

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Since the SDH nodes are spaced more than 50 km apart, 1550nm aggregates are necessary.

2. The total length of the backbone network is 327 km (including the local loop).

3. A PABX is located in Bishkek. It was designed to replace the existing switches at Biskek 1 and Biskek 2

4. There is a total of 27 stations, which may be broken down as follows:
   - 6 large and medium-size stations, warranting telephone equipment suitable for an average station. These are:
     -- Lugovaya, Karabalta, Bishkek 1 , Bishkek 2, Alamedin, Balyktchi
   - 21 less-important stations, warranting telephone equipment suitable for a small station.

5. The main traffic and energy (sub-stations, OHL) control centre is located at Bishkek 1.

6. A single technical facilities room (including power supply, air conditioning, protection systems, wiring racks, etc.) is located at Bishkek 1 housing the control centre station equipment, PABX and the digital transmission equipment (STM1 and ADM).

7. The distribution networks consist of 8Mbits/s ADMs (drop-and-insert PCM add/drop multiplexers). (See Chapter 4, section 2 : Method).

From the rules in the Method section and Figure AIP.1 (Chapter 4), it may be extrapolated that the following number of links need to be set up:
- 6 for the distribution network,

corresponding to the following ADM breakdown:
- 21+6 =27 for stations (point 4),
- 6 at the Bishkek control centre.

In other words, an aggregate of 33 ADMs for a network without back-up of links between control centres and stations.

8. An SDH network management unit (STM1) is located in Bishkek.

9. A distribution network management unit (ADM) is located in Bishkek.

10. As regards power supply:
   - power supply to the PABX, STM1 and ADM in the control centre at Bishkek 1 is included in the technical facilities room.
   - equipment at the 6 large stations listed under point 4 and the corresponding STM1 and ADM devices are fed by 6 medium capacity power supply lines.
   - equipment at the 21 small stations listed under point 4 and the corresponding ADM devices are fed by 21 low capacity power supply lines.

11. Back-up

It is assumed that there is a flattened transmission loop providing partial back-up in every case.

Total back-up for the main rail operating links (operations control and energy control) on the Lugovaya-Bishkek-Balyktchi line can be provided by an external network (for example, the public network). The arrangement would involve installing 3 additional ADMs in Lugovaya and Balyktchi.

1.2.1.3 Backbone network, Uzbekistan

1. The backbone network originates in Tchengeldi (Kazakhstan), near Tashkent and heads towards:
- Bekabad, continuing on towards Tajikistan

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- Talimardjan, continuing on towards Turkmenistan
- Farab, continuing on towards Turkmenistan

Note : although the Tchengeldi / Tashkent section runs on Kazakh territory between Salar and Tchengeldi, it is managed by Uzbekistan Railways.

The R-161km / Termez / Sariasiya / Amuzang section between Turkmenistan and Tajikistan is also taken into account.

The backbone network comprises 17 SDH/STM1 multiplexers located in:
- Buchara, Navoi, X1, Samarkand, X2, Karshi, Talimardjan, X3, Djizak, X4, Khavast, Mekhnat, Tashkent and Tchengeldi
- Termez, Kumkurgan and Sariasya.

The following nodes are also equipped with tributary STM1 optical cards (5 in all) because of topology or border links :
- Buchara, Samarkand, Talimardjan, Khavast
- Termez.

To provide flattened transmission loop, 11 repreaters are positioned at:
- Navoi, X1, Samarkand, X2, Karshi, X3, Djizak, Mekhnat and Tashkent.
- Kumkurgan and Sariasya.

A 15 km local loop is located at Tashkent.

Since nodes are often spaced more than 100 km apart, intermediate nodes X1 to X3 have been inserted. The precise location of X1 to X3 will have to be agreed with the railways when issuing invitations to tender.
Even with the intermediate nodes, the distance generally exceeds the range of 1300nm laser aggregates. For the sake of standardisation and, most importantly, efficient maintenance, it is advocated that only 1550nm aggregates be used.

2. The total length of the backbone network is 1454 km (including the local loop).

3. A PABX is located at Tashkent. It was designed to replace the existing switch.

4. There is a total of 115 stations, which may be broken down as follows:
   - 18 large and medium size stations, warranting telephone equipment suitable for an average station. These are
     -- Farab, Buchara, Navoi, Samarkand, Karshi, Talimardjan, Djizak, Khavast, Bekabad, Djetisai, Mekhnat, Tashkent, Salar, Tchengeldi (i.e. 14 stations)
     -- Termez, Kumkurgan, Sariasiya, Amuzang (i.e. 4 stations).
   - 97 less-important stations warranting telephone equipment suitable for a small station..
     -- 82 on the Tchengeldi/Tachkent/Buchara/Farab line.
     -- 15 in and around Termez.

5. The main traffic and energy (sub-stations, OHL) control centre is located in Tashkent.

6. A single technical facilities room (including power supply, air conditioning, protection systems, wiring racks, etc.) is located at Tashkent, housing the control centre station equipment, PABX and the digital transmission equipment (STM1 and ADM).

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7. The distribution networks consist of 8Mbits/s ADMs (drop-and-insert PCM add/drop multiplexers). (See Chapter 4, section 2 : Method).

From the rules in the Method section and Figure AIP.1 (Chapter 4), it may be extrapolated that the following number of links need to be set up:
- 21 for the distribution network on the Tchengeldi/Farab route,
- 5 for the distribution network around Termez,

corresponding to the following ADM breakdown:
- Tchengeldi/Farab:
  - 82+14 = 96 for stations (point 4),
  - 21 for the Tashkent control centre.
- Termez
  - 15+4 = 19 for stations (point 4),
  - 5 in Termez.

In other words, an aggregate of 141 ADM for a network without back-up of links between control centres and stations.

8. An SDH network management unit (STM1) is located in Tashkent.

8b. A primary clock, SSU and GPS are located in Tashkent to synchronise the entire SDH network. Termez also has an SSU and GPS

9. Two distribution network management units (ADM) are located in Tashkent and Buchara respectively, and are considered the telecom centres of excellence in Uzbekistan. A third unit is installed at Termez.

10. As regards power supply:
- power supply to the PABX, STM1 and ADM in the control centre in Tashkent is included in the technical facilities room.
- equipment at the 18 large stations listed under point 4 and the corresponding STM1 and ADM devices are fed by 18 medium capacity power supply lines.
- equipment at the 96 small stations listed under point 4 and the corresponding ADM devices are fed by 96 low capacity power supply lines.

11. Back-up
It is assumed that there is a flattened transmission loop providing partial back-up in every case.

Total back-up for the the main rail operating links (operations control and energy control) on the Tashkent/Buchara line can be provided by an external network (for example, the public network). The arrangement would involve installing 21 additional ADMs in Buchara.

12. Training
Due to the size of the network, the budget is double that given in the Chapter 4 recommendations.

1.2.1.4 Backbone network, Tajikistan

1. The following sections have been considered :
- (Bekabad) - Nay - Kafurov
- (Saryasia) - Pakhtabad - Dushanbe - Yangi-Bazar
- (Amuzan) - Ayvadji - Kurgan-Tjube - Kulyab - Yavan

Brackets indicate that the station is located in Uzbekistan and are only mentioned to set the geographical context.

Given that there are few stations, there is no need to install SDH nodes on all sections. Hence, the backbone network comprises:
- SDH/STM1 multiplexers located in Pakhtabad and Dushanbe

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- 8 Mbits/s ADM (drop-and-insert PCM add/drop multiplexers) on the other two line sections
SDH nodes should be installed in liaison with Uzbekistan Railways.

There is an STM1 repeater located in Pakhtabad to ensure flattened transmission loop.

A 15 km local loop is located at Dushanbe.

2. The total length of the backbone is 509 km (including the local loop).

3. A PABX is located at Dushanbe. It was designed to replace the existing switch.

4. There is a total of 22 stations, which may be broken down as follows:
   - 3 large and medium size stations, warranting telephone equipment suitable for an average station. These are Kafurov, Dushanbe and Kurgan-Tjube.
   - 19 less-important stations warranting telephone equipment suitable for a small station.

5. The main traffic and energy (sub-stations, OHL) control centre is located in Dushanbe.

6. A single technical facilities room (including power supply, air conditioning, protection systems, wiring racks, etc.) is located at Dushanbe, housing the control centre station equipment, PABX and the digital transmission equipment (STM1 and ADM).

7. From the rules in the Method section and Figure AIP.1 (Chapter 4), it may be extrapolated that the following number of links need to be set up:
- 5 for the distribution network,
corresponding to the following ADM breakdown:
- 19+3 = 22 for stations (point 4),
- 5 for the Dushanbe control centre.
In other words, an aggregate of 27 ADMs for a network without back-up of links between control centres and stations.

The (Bekabas)/Kafurov and (Amuzan)/Kulyab sections will be linked to the Dushanbe control centre either via channels currently leased from the telecommunications ministry or on the basis of an agreement with Uzbekistan Railways.

8. The SDH nodes at Dushanbe and Pakhtabad will be controlled in liaison with Uzbekistan Railways.

9. One distribution network management unit (ADM) is located in Dashanbe.

10. As regards power supply:
   - power supply to the PABX, STM1 and ADM in the control centre at Dushanbe 1 is included in the technical facilities room.
   - equipment at the 3 large stations listed under point 4 and the corresponding ADM devices are fed by 3 medium capacity power supply lines.
   - equipment at the 19 small stations listed under point 4 and the corresponding ADM devices are fed by 19 low capacity power supply lines.

11. Back-up

It is assumed that there is a flattened transmission loop providing partial back-up in every case.

1.2.1.5 Backbone network, Turkmenistan

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1. The backbone network originates in Krasnodovsk, near Turkmenbashi port (Caspian Sea) and runs towards Farab (border with Uzbekistan).
A second line section is covered : Talimardjan/R-161km.

The network comprises 21 SDH/STM1 multiplexers located at:
- Krasnovodsk, X1, Nebit-Dag, X2, Tazandjik, Kizilarbat, Bami, Bakherden and Ashgabad,
- Ashgabad, X3, Dushak, Tejden, Karabata, Mary, Bayram-Ali, Utchadiji, X4 and Tchardjou,
- Amydere and Kelif.

The following nodes are also equipped with tributary STM1 optical cards (3 in all) because of topology or border links:
- Tchardjou,
- Amydere and Kelif.

To provide flattened transmission loop, 15 repeaters are positioned at:
- X1, Nebit-Dag, X2, Tazandjik, Kizilarbat, Bami, Bakherden,
- X3, Dushak, Tejden, Karabata, Mary, Bayram-Ali, Utchadiji and X4.

To increase the network's capacity to deal with failures, the Krasnovodsk/Tchardjoy line splits at Ashgabad.

A 15 km local loop is located at Ashgabad.

Since nodes are often spaced more than 100 km apart, intermediate nodes X1 to X4 have been inserted. The precise location of X1 to X4 will have to be agreed with the railways when issuing invitations to tender.
Even with the intermediate nodes, the distance generally exceeds the range of 1300nm laser aggregates. For the sake of standardisation and, most importantly, efficient maintenance, it is advocated that only 1550nm aggregates be used.

2. The total length of the backbone is 1364 km (including the local loop).

3. A PABX is located at Ashgabad. It was designed to replace the existing switch.

4. There is a total of 84 stations, which may be broken down as follows:
- 18 large and medium size stations, warranting telephone equipment suitable for an average station. These are:
  -- Krasnovodsk, Nebit-Dag, Tazandjik, Kizilarbat, Bami, Bakherden, Buzmenij, Ashgabad (i.e. 8 stations)
  -- Annay, Dushak, Tejden, Karabata, Mary, Bayram-Ali, Utchadiji, Tchardjou (i.e. 8 stations)
  -- Amyere, Kelif (i.e. 2 stations).
- 66 less-important stations warranting telephone equipment suitable for a small station.
  -- 30 on the Krasnovodsk/Ashgabad line..
  -- 26 on the Ashgabad/Farab line.
  -- 10 between Talimardjan and R-161km.

5. The main traffic and energy (sub-stations, OHL) control centre is located at Ashgabad.

6. A single technical facilities room (including power supply, air conditioning, protection systems, wiring racks, etc.) is located at Ashgabad, housing the control centre station equipment, PABX and the digital transmission equipment (STM1 and ADM).
7. The distribution networks consist of 8Mbits/s ADMs (drop-and-insert PCM add/drop multiplexers). (See Chapter 4, section 2 : Method).

From the rules in the Method section and Figure AIP.1 (Chapter 4), it may be extrapolated that the following number of links need to be set up:
- 9 for the distribution network on the Krasnovodsk/Ashgabad route,
- 10 for the distribution network on the Ashgabad/Farab route,

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- 3 for the Talimardjan and R-161 km distribution network.

corresponding to the following ADM breakdown:

- Krasnovodsk/Ashgabad :
  - 30+8 = 38 for stations (point 4),
  - 9 at the Ashgabad control centre.
- Ashgabad/Farab
  - 26+8 = 34 for stations (point 4),
  - 10 at the Ashgabad conrol centre.
- Talimardjan and R-161km
  - 10+2 = 12 for stations (point 4),
  - 3 at Amydere.

In other words, an aggregate of 106 ADM for a network without back-up of links between control centres and stations.

8. An SDH network management unit (STM1) is located in Ashgabad.

8b. A primary clock, SSU and GPS are located in Ashgabad to synchronise the entire SDH network. Amydere also has an SSU and GPS

9. Two distribution network management units (ADM) are located in Ashgabad and Tchardjou respectively, and are considered the telecom centres of excellence in Turkmenistan. There is a third unit at Amydere.

10. As regards power supply:
   - power supply to the PABX, STM1 and ADM in the Ashgabad control centre is included in the technical facilities room.
   - equipment at the 18 large stations listed under point 4 and the corresponding STM1 and ADM devices are fed by 18 medium capacity power supply lines.
   - equipment at the 66 small stations listed under point 4 and the corresponding ADM devices are fed by 66 low capacity power supply lines.

11. Back-up
It is assumed that there is a flattened transmission loop providing partial back-up in every case.

Total back-up for the the main rail operating links (operations control and energy control) on the Krasnovodsk/Ashgabad/Tchardjou line can be provided by an external network (for example, the public network). The arrangement would involve installing 9 additional ADMs in Krasnovodsk and 10 in Tchardjou.

12. Training
Due to the size of the network, the budget is double that given in the Chapter 4 recommendations.

1.2.1.6 Investment summary

The following tables provide an overview of backbone network investment, respectively without and with control circuit back-up.

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Backbone investment summary table (without control circuit back-up)

	EU Investment (MECU)	Railway Investment (MECU)	Total
Kazakhstan	15.33	2.60	17.93
Kyrgyzstan	3.38	0.47	3.85
Uzbekistan	12.13	2.09	14.22
Tajikistan	3.74	0.73	4.47
Turkmenistan	11.00	1.96	12.97
Total	**45.58**	**7.86**	**53.44**

Backbone investment summary table (with control circuit back-up)

	EU Investment (MECU)	Railway Investment (MECU)	Total
Kazakhstan	15.78	2.60	18.38
Kyrgyzstan	3.46	0.47	3.93
Uzbekistan	12.46	2.09	14.55
Tajikistan	3.80	0.73	4.53
Turkmenistan	11.28	1.96	13.24
Total	**46.78**	**7.86**	**54.64**

1.2.2 Telecom switches for office telephones

In order to enhance the impact of telecommunications network renovation, it is proposed to underpin the installation of PABXs in the capitals by replacing some of the switches serving office telephones.

Although the technology used is outdated, the bulk of the telecom switches installed by Central Asian railways are relatively recent additions.

It is advocated that only pre-1980 switches be replaced:
These are:

In Kazakhstan :

Station	Number of subscribers	Year inaugurated
Sary-Ozek	700	1971
Beskol	200	1959

In Kyrgyzstan
Included in the PABX section of the backbone.

In Uzbekistan

Station	Number of subscribers	Year inaugurated
Samarkand	1000	1965
Karshi	1300	1975

In Tajikistan
Included in the PABX section of the backbone.

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In Turkmenistan
Included in the PABX section of the backbone.

The inter-PABX links are carried on 2Mbits/s channels.

inter-PABX links (2Mbits/s channels)									
	Kazakhstan		Kyrgyzstan	Uzbekistan		Tajikistan	Turkmenistan		
	A	B		C	D		E	F	G
Number of channels Operations telephones	19	17	6	21	5	2	9	10	3
Number of channels Office telephones	22	11	12	16	4	2	11	16	2
Number of channels used (with 50% redundancy)	62 (21)*	42	27	56	14	6	30	39	8
Number of free channels on the SDH	**42**	**21**	**36**	**7**	**49**	**57**	**33**	**24**	**55**

A: Between Tchengeldi and Alma-Ata
B: Between Alma-Ata and Droujba
C: Main network
D: Around Termez
E: Between Krasnovodsk and Ashgabad
F: Between Ashgabad and Farab
G: Around Amydere and Kelif

* It is assumed that the number of channels between Tchengeldi and Alma-Ata are divided up equally between the three control centres located at Alma-Ata, Tchimkent and Djamboul.

A breakdown of the investment figures is given in Appendix 5.

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1.2.3 Secondary railway line architecture and investment

1.2.3.1 General

This report supplements the study of the transmission backbone to be installed along the entire Traceca corridor.

A distinction shall be drawn between two types of railway line:
- branch lines (i.e. terminal sections),
- other lines lying outside the Traceca corridor but not constituting branch lines.

Diagrams and investment tables are given in Appendices 3 and 4.

1.2.3.2 Architecture selected

- Unlike the architecture of the backbone networks, that of the secondary line telecommunication network has not been studied in detail. The proposal should be viewed as a preliminary outline.

- Branch lines have been fitted with 8 Mbits/s drop-and-insert PCM.
Other lines not belonging to the Traceca corridor but constituting loops with said corridor or with other countries have been equipped with SDH/STM1 served by drop-and-insert PCM (as the backbone network).

- The following have been selected:
- For the branch lines, a 6 optical fibre buried cable (2 for distribution, 2 for possible redundancy or another service, 2 spare).
- For the other lines, the same type of cable as for the backbone network (24 buried fibres).

- The basic architecture for the branch line equipment is a linear PCM drop-and-insert network as illustrated in block diagram SP17. The architecture for other lines is the same as for the backbone network.

- Network management: the SDH and PCM installations are controlled by the management systems installed during the backbone phase.

- It has been decided not to provide back-up for branch line control circuits.

1.2.3.3 Breakdown per country

1.2.3.3.1 Kazakhstan

Owing to a lack of sufficient data, only the Tchengeldy/Droujba line is dealt with here.

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The branches on this line are :

Section	Length in km	Number of stations	Equipment
Tchimkent / Lenger	29	4	PCM
Koksu / Tekeli / Taldy-Kurgan	93	5	PCM
Total	**122**	**9**	

1.2.3.3.1.1 Koksu / Tekeli / Taldy-Kurgan

This is a railway branch line served by drop-and-insert PCM from Koksu onwards.
One station; Taldy-Kurgan, has been categorised as medium-size.

1.2.3.3.1.2 Tchimkent / Lenger

This is a railway branch line served by drop-and-insert PCM from Tchimkent onwards.

1.2.3.3.2 Uzbekistan

The sections involved are :

Section	Length in km	Number of stations	Equipment
Navoi / Utchkuduk / Muruntau	343	14	PCM
Buchara / Karshi / Kitab	157	10	SDH & PCM
Tashkent / Khodjikent	64	11	PCM
Tashkent / Angren	114	11	PCM
Total	**678**	**46**	

1.2.3.3.2.1 Navoi / Utchkuduk / Muruntau

This is a railway branch line served by drop-and-insert PCM from Navoi onwards.
Three stations, Utchkuduk, Kizilkuduk and Muruntau, have been categorised as medium-size.

1.2.3.3.2.2 Buchara / Karshi / Kitab

Between Buchara and Karshi, the SDH installations have been fitted in such a way as to form a loop with the existing SDH network (a repeater and two optical STM1 aggregates).
Two stations, Kitab and Guzar, have been categorised as medium-size.

1.2.3.3.2.3 Tashkent / Khodjikent

This is a railway branch line served by drop-and-insert PCM from Tashkent onwards.
One station, Khodjikent, has been categorised as medium-size.

1.2.3.3.2.4 Tashkent / Angren

This is a railway branch line served by drop-and-insert PCM from Tashkent onwards.
One station, Angren, has been categorised as medium-size.

1.2.3.3.3 Turkmenistan

The sections involved are :

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Section	Length in km	Number of stations	Equipment	Remarks
Tejden / Sarakhs	132	3	SDH & PCM	continues on towards Iran
Mary / Turgundy	322	25	SDH & PCM	continues on towards Afganistan
Total	**454**	**28**		

1.2.3.3.3.1 Tejden / Sarakhs

This line links Turkmenistan to Iran, its length and international dimension being the reasons why it is fitted with SDH equipment, i.e.an STM1 multiplexer and an STM1 optical aggregate.
Two stations, Sarakhs and Gulanli, have been categorised as medium-size.

1.2.3.3.3.2 Mary / Turgundy

The line links Turkmenistan to Iran, this international dimension being the reason why it is fitted with SDH equipment, i.e. four STM1 multiplexers, three STM1 repeaters and an STM1 optical aggregate.
Five stations - Yoloten, Sandy-Gatchi, Kalimor, Kushka and Turgundy - have been categorised as medium-size.

1.2.3.3.4 Fergana valley

Owing to the structure of the rail network in this region, an independent telecommunications network is indispensable, with investment and maintenance costs being split between Kyrgyzstan, Uzbekistan and Tajikistan Railways.
Indeed the most suitable course of action would be to set up a joint telecommunications company, which would subsequently be responsible for operating the valley's railway telecommunications network.

There are 64 stations, scattered across 728 kilometres.

Given the lines's size and international coverage, it has been viewed as an independent telecommunications network. It is equipped with SDH.
Seven STM1 multiplexers are located at:
- Kafurov, Kanibadab, Koland 1, Mangelan, Andijan 1, Utchkurgan and Namangan.

Two STM1 repeaters at
- Kanibadab and Koland 1.

An optical aggregate card at:
- Kafurov.

Nine stations - Kafurov (Leninabad) , Kanibadam, Kokand 1, Andijan 1, Fergana 1, Karasu, Osh, Djalal-Abad and Namangan - have been categorised as medium-size.

A PABX is located at Andijan 1. It was designed to replace the existing switch.

An SDH network management unit (STM1) is located at Andijan 1.

A distribution network management unit (ADM) is located at Andijan 1.

The training budget is twice the figure set out in the Chapter 4 recommendations.

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1.2.3.3.5 Tchardjou / Urgench / Beijneu line

Owing to the structure of the rail network in this region, an independent telecommunications network is indispensable, with investment and maintenance costs being split between Kyrgyzstan, Uzbekistan and Tajikistan Railways.
Indeed the most suitable course of action would be to set up a joint telecommunications company, which would subsequently be responsible for operating the valley's railway telecommunications network.

There are 55 stations, scattered across 1148 kilometres.

Given the line's size and international coverage and the fact that it links two stations on the backbone network (Tchardjou and Bejneu), it is equipped with SDH.

13 STM1 multiplexers are located at:
- Neft, Gabakly, Darganta, Gazatchak, Urgench, Dashkavuz, Khodjeili, kungrad, Y2, Jaslik, Y3, Karakalpakia and Beijneu.

12 STM1 repeaters at:
- Neft, Gabakly, Darganta, Gazatchak, Urgench, Dashkavuz, Khodjeili, kungrad, Y2, Jaslik, Y3, and Karakalpakia.

An optical aggregate card at:
- Tchardjou.

Nodes Y2 and Y3 have been inserted primarily to cut down the distance separating their neighbouring nodes. Their exact location must be agreed with the railways.

Nine stations - Neft , Gazatchak, Urgench, Dashkhavuz, Khodjeili, Houkous, Kungrad, Jaslik and Beijneu - have been categorised as medium-size.

A PABX is located at Urgench. It was designed to replace the existing switch.

An SDH network management unit (STM1) is located at Urgench.

A distribution network management unit (ADM) is located at Urgench.

The training budget is double the figure given in the Chapter 4 recommendations.

1.2.3.4 Investment

- Rough estimates for installing optical fibre cables and digital transmission equipment on all secondary lines are set out in the **"Secondary line investment tables"**, which are broken down per country. They are given in Appendix 4.

Note: as mentioned above, an in-depth technical examination has not been carried out for each of the secondary lines. The figures given should therefore be taken to be approximate.

- The table overleaf sums up the selected investment figures and recaps on the investment requirements for the backbone networks (with no control centre circuit redundancy).

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Summary table of branch and other line investment requirements

	EU Investment (MECU)	Railway Investment (MECU)	Total
Kazakhstan	0.84	0.18	1.02
Uzbekistan	4.24	0.98	5.22
Turkmenistan	3.36	0.65	4.02
Fergana Valley	6.11	1.05	7.16
Tchardjou/Beijneu	8.07	1.65	9.73
Total	**22.64**	**4.51**	**27.14**

Summary table of investment requirements for backbone networks with no control centre circuit back-up

	EU Investment (MECU)	Railway investment (MECU)	Total
Kazakhstan	15.33	2.60	17.93
Kyrgyzstan	3.38	0.47	3.85
Uzbekistan	12.13	2.09	14.22
Tajikistan	3.74	0.73	4.47
Turkmenistan	11.00	1.96	12.97
Total	**45.58**	**7.86**	**53.44**

1.2.3.5 Conclusion

Substantial investment is required for the Fergana Valley and the Tchardjou/Beijneu line and implementation is subject to agreement between the countries involved and close cooperation. Hence, such investment should not be envisaged until the telecommunications backbone networks are operational.

However, in Kazakhstan (as far as the section examined here is concerned), Uzbekistan and Turkmenistan, the investment requirements for secondary lines are merely 5%, 34% and 30% respectively of the backbone budgets. In so far as funds are available, it is advocated that the investment projects be implemented in one batch.

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1.3 Economic Study

1.3.1 Introduction

This section outlines the economic and financial evaluation of the project to install telecommunications networks serving the Central Asian railways of Kazakhstan, Kyrgyzstan, Uzbekistan and Turkmenistan.
First an explanation is given as to the method applied followed by a run-down of the different scenarios, the results of internal rate of return (IRR) calculations and an analysis of IRR variations.

The data used in the analyses are taken from studies carried out by CIE-Consult/Systra, "Traceca - Central Asia Railways Restructuring", Modules A-D.

Owing to a lack of economic data on Tajikistan Railways, the company has been omitted from this study. Furthermore, Tacis activities in the country are on hold for the time being and the second part of the Module D report (focusing on Tajikistan) has not been published.

1.3.1.1 Direct benefits

Such benefits, some of which are quantified in this economic study, comprise:

- improvement of rail traffic safety,
- stripping away of some speed restrictions on certain sections,
- practical elimination of the numerous telecommunications-related delays,
- optimal use of rolling stock,
- installation of powerful communications links between railways in the region,
- better maintenance, lower maintenance costs,
- creation of a new revenue source, i.e. leasing of excess capacity in the telecommunications network.

1.3.1.2 Indirect benefits

Although it is difficult to quantify such advantages, they constitute key factors in reviving the railways in question, in particular with respect to competition. They include:

- creation of the infrastructure required for the installation of MIS systems (essential basis for restructuring),
- creation of the infrastructure necessary to fit the real-time freight tracking systems requested by customers
- provision of a basis for creating interfaces with other transport providers
- regional and international co-operation project.

1.3.2 Method

The economic evaluation was carried out for a period of 20 years in $ US (constant values). The approach taken was to compare the current situation (the reference situation) without the investment project with the situation if the project is implemented (project situation). In each case, income and expenditure are compared and the internal rate of return from the project is estimated for each country.

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1.3.3 Reference situation: project not implemented

The reference situation is defined by calculating current telecommunications maintenance and operating costs and the investment required to reduce traffic delays caused by telecommunications incidents. The solution envisaged to lessen these delays is to purchase additional locomotives.

Since the railways in question have little or no electrification on the lines covered by this study, prices and lifespans are calculated for diesel locomotives.

1.3.3.1 Maintenance and operating costs

These are calculated on the basis of available data regarding the current situation at the various railways in the countries examined. The main items taken were salary payments and costs, expenditure on materials and repairs and any other telecommunications and signalling costs. In the absence of a breakdown per sector, it was assumed that 40% of telecom and signalling department staff and costs are employed solely for telecommunications purposes.

The statistics have been taken from the "Traceca - Central Asia Railways Restructuring" reports.

Costs in US $ 1,000	**Kazakhstan**	**Kyrgyzstan**	**Uzbekistan**	**Turkmenistan**
salaries and operating costs	21 693	219	3 925	1 367
materials	2 627	48	396	309
repairs(*)	0	0	676	0
other costs	6 120	176	2 803	1 041
Total	**30 440**	**443**	**7 800**	**2 717**

* information is available for the Uzbekistan repairs entry only

The proportion of these expenses ascribable to the cable section selected for investment is calculated and it is assumed that 40% of staff work purely on telecommunications activities.

	Kazakhstan	**Kyrgyzstan**	**Uzbekistan**	**Turkmenistan**
Line length in km	13 280	427	3 655	2 313
Km of cable invested	1 808	327	1 454	1 364
Telecommunications + signalling staff	11 190	245	3 290	1 790
Telecommunications staff	**4 476**	**98**	**1 316**	**716**

Annual maintenance and operating expenditure for the sections involved is given in the following table in US $1,000.

	Kazakhstan	**Kyrgyzstan**	**Uzbekistan**	**Turkmenistan**
Maintenance and operating costs	**1 658**	**136**	**1 241**	**641**

It is assumed that ageing equipment causes a 2% increase in costs per annum.

1.3.3.1 Delays

Delays are caused by obsolete telecommunications material.

According to the CIE-Consult/Systra study on Central Asia (Modules A-D), telecommunications - related delays are as follows:

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	Kyrgyzstan	Uzbekistan	Turkmenistan
Train delays caused by telecommunications problems (hrs/year)	1 655	6 474	6 000

It is assumed that delays in Kazakhstan are approximately the same as in Uzbekistan.

The annual increase in delays is taken to be 3%

The (book) life of a diesel locomotive was set as 20 years, and the residual value is brought to account in the final year of the study (2019).
Part of the network being examined in Kazakhstan and Uzbekistan comprises electrified lines. Nonetheless, the ratio of electrified to non-electrified lines is so low that diesel locomotives have been selected for the study.

The following estimates were taken from various past studies in order to gauge the number of hours for which a locomotive is worked annually:

	Kazakhstan	Kyrgyzstan	Uzbekistan	Turkmenistan
km/year/locomotive	144 000	71 000	110 000	80 000
mean speed	40	40	40	40
hrs/year /locomotive	3 600	1 775	2 750	2 000

Locomotive requirements are gauged on the basis of annual delays recorded for each country and annual operating hours per locomotive.
The tables are presented in full in Appendix 6.

Locomotive requirements per country are as follows:

Kazakhstan

Investment years	2000	2004	2017
Number of locomotives	1	1	1
Cost (US$ m)	2.2	2.2	2.2
Residual value (US$ m)	0.11	0.55	1.98

Kyrgyzstan

Investment years	2000	2012
Number of locomotives	1	1
Cost (US$ m)	2.2	2.2
Residual value (US$ m)	0.11	1.43

Uzbekistan

Investment years	2000	2003
Number of locomotives	1	1
Cost (US$ m)	2.2	2.2
Residual value (US$ m)	0.11	0.44

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Turkmenistan

Investment years	2000	2005	2018
Number of locomotives	2	1	1
Cost (US$ m)	4.4	2.2	2.2
Residual value (US$ m)	0.22	0.66	2.09

1.3.4 The project

The project situation is determined by investments, operating and maintenance costs and income from leasing of excess capacity in the telecommunications network (PCM channels and dark fibres).

1.3.4.1 Investments

The amount taken corresponds to aggregate investments funded by the EU and the railways, scheduled for disbursement in 2000.

in millions of US $	Kazakhstan	Kyrgyzstan	Uzbekistan	Turkmenistan
Backbone	19.72	4.24	15.64	14.26
PABX	0.21	0.00	0.67	0.00
Aggregate investment	**19.93**	**4.24**	**16.31**	**14.26**
EU share of total investment	**17.04**	**3.72**	**13.95**	**12.10**

A full breakdown is given in Appendices 2 and 5.

Lifespan is assumed to be 50 years for cables and 20 years for equipment.

1.3.4.2 Maintenance and operating costs

Maintenance and operating costs were estimated as follows:

- equipment: 2 % of total investment in equipment (the corresponding figure for western Europe is 4%),
- cables: 1 FRF/m of laid cable.

The results are set out in the tables below:

in millions of US $	Kazakhstan	Kyrgyzstan	Uzbekistan	Turkmenistan
Cable length in km	1808	327	1454	1364
Total investment	20.41	4.32	16.70	14.62
% thereof for equipment	7.27	1.80	5.96	4.79
Operating costs (O)	0.15	0.04	0.12	0.10
Cable maintenance (M)	0.30	0.05	0.24	0.23
Total M+O	**0.45**	**0.09**	**0.36**	**0.32**

1.3.4.1 Revenue from lease of excess transmission capacity

The technical recommendations specified a level of capacity superior to the needs of the railways alone, thus creating a leasing option.

There are two types of excess capacity:

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- the SDH/STM-1 installations comprising 63 PCM channels operating at 2Mbits/s.
- twelve fibres (six pairs) reserved for telecom needs (dark fibres).

1.3.4.3.1 PCM capacity

This type of capacity is likely to be of most interest to GSM operators, companies hoping to compete against the existing national operator and companies wishing to create IT links between different locations.

Tariff estimates are based on France Télécom rates and calculated for a 2Mbits/s link over 150km, i.e. 0.054 million US $/year. In order to create a realistic scenario, this rate was divided by four, producing 0.014 million US $/year for this study.

The technical recommendations include installing STM-1 equipment providing sixty-three 2Mbits/s channels. The following table summarises railway needs and the number of channels available for leasing.

Use of 2 Mbits/s channels								
	Kazakhstan		Kyrgyzstan	Uzbekistan		Turkmenistan		
	A	B		C	D	E	F	G
Number of channels Operations telephones	19	17	6	21	5	9	10	3
Number of channels Office telephones	22	11	12	16	4	11	16	2
Number of channels used (with 50% redundancy)	62 (21)*	42	27	56	14	30	39	8
Number of free channels on the SDH	**42**	**21**	**36**	**7**	**49**	**33**	**24**	**55**

A: Between Tchengeldi and Alma-Ata
B: Between Alma-Ata and Droujba
C: Main network
D: Around Termez
E: Between Krasnovodsk and Ashgabad
F: Between Ashgabad and Farab
G: Around Amydere and Kelif

* It is assumed that the number of channels between Tchengeldi and Alma-Ata are divided up equally between the three control centres located at Alma-Ata, Tchimkent and Djamboul.

Since regions D and G are somewhat remote, the number of channels made available for lease will probably be limited to 20 owing to a lack of demand.

Hence, the aggregate number of channels available for lease per country is as follows:

	Kazakhstan	Kyrgyzstan	Uzbekistan	Turkmenistan
Number of channels	63	36	27	77

Since prevailing telecommunications legislation in Kazakhstan has already been altered to allow for this eventuality, leasing revenue is accounted for as of 2003. The corresponding date for the other three countries is 2005, allowing time for legislative amendments.

In the first year, it is assumed that 10% of total capacity is leased with an additional 10% being added each year.

1.3.4.3.2 Dark fibres

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This type of capacity will be of use to European and worldwide telecommunications operators who, while reluctant to invest in cables, will have the means and opportunity to install the electronic technology necessary to use the optical fibres surplus to railway needs.

Of the 24 fibres specified in the technical recommendation, 6 will be put to use immediately, 6 will be reserved for future railway needs and 12 will be set aside for leasing.

The income estimates are based on the rates charged by RATP and French motorways, i.e. 8 fibres at 20 FRF/m/year (6FRF = 1US$) per fibre pair. More realistic rates were taken for this study, i.e.:

- 0.5 US $/m/year for Kyrgyzstan (which feeds the Europe/Asia link)
- 1 US $/m/year for the other three countries (which are on the Europe/Asia link).

Leasing commences in 2007, with two pairs of fibres being leased in the first year and another two pairs being added biennially.

1.3.4.3.3 Telecom switches (PABX)

It would appear that some of the subscribers served by the railway telecom switches are third parties, e.g. forwarding agents, who must pay a subscription for this service. However, given the poor quality of lines, subscription fees are no longer charged.

The same service is provided to the homes of railway employees free of charge, although it is likely that a subscription fee will be levied as part of the move towards a market economy.

Hence, replacing the PABX systems would generate revenue which unfortunately can not be quantified for want of precise data.

1.3.5 Results

Based on the two distinct scenarios developed above the following internal rates of return may be calculated per country:

	Kazakhstan	Kyrgyzstan	Uzbekistan	Turkmenistan
IRR	20%	18%	19%	20%

Tables setting out the results are given in Appendix 6.

1.3.6 Rate of variation

1.3.6.1 Investment variation

It is interesting to note how the rates of return are affected by a +/- 10 % variation in project investment

The reference situation remains unchanged, with only operating and maintenance costs (and the residual value) varying in response to an adjustment in investment.

	Kazakhstan	Kyrgyzstan	Uzbekistan	Turkmenistan
IRR (inv +10%)	19%	16%	18%	18%
IRR (inv -10%)	22%	21%	21%	22%

The tables used for the calculations are given in Appendix 6.

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1.3.6.2 Excluding investment in locomotives

The internal rates of return calculated on the basis of revenue from dark fibre and PCM channel leasing alone are as follows:

	Kazakhstan	Kyrgyzstan	Uzbekistan	Turkmenistan
IRR	18%	10%	16%	15%
IRR (inv + 10%)	17%	9%	15%	14%
IRR (inv -10%)	19%	11%	18%	16%

The income generated by leasing excess telecommunications network capacity suffices to justify the project. However, it is vital that:

- the governments in question undertake to amend telecommunications legislation to enable the railways to compete against the existing national operator;
- agreements be signed apace with telecommunications operators.

1.3.7 Conclusion

The results depend to a considerable extent on revenue generated by the lease of excess network capacity. Indeed, while the advantages to be derived from the proposed investment are many, leasing revenue alone can be quantified, although the other internal spin-offs would suffice to justify implementing the project as part of the railway restructuring process.

Despite the rather pessimistic hypothesis taken, the internal rates of return on the projects proposed are considerable (in the region of 20%). However, if they are to be achieved, amendments will be required in telecommunications legislation over the coming five years.

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2 Electronic data interchange

2.1 Project context

2.1.1 Project objectives

This section of Module E aims to enhance electronic data interchange between the railways and their partners.
The partners include:
- other railways,
- customs authorities,
- police and immigration officials,
- major customers,
- freight forwarders,
- shipping companies.

The goals are to:
- boost productivity at the railways by cutting down on formalities and the number of forms to be filled in and monitoring goods throughout the journey,
- shorten freight transit times by simplifying formalities, particularly customs procedures at borders,
- allow customers direct access to information regarding the status of their goods,
- improve communication with shipping companies, thus ensuring continuous tracking of goods,
- enhance passenger traffic,
- and generally increase railway satisfaction ratings amongst customers.

2.1.2 General context

The level of computerisation at Central Asian railways is relatively high, with most of the stations kitted out with computers. There are three regional computer centres (RCC): Almaty (Kazakhstan), Tashent (Uzbekistan), Tchardjou (Turkmenistan). All three belong to the same network, the core of which is the Moscow Computer Centre (MCC) owned by Russian Railways. The RCCs constitute a certain degree of decentralisation, although much of the processing work is still carried out at the MCC.

Kazakhstan customs authorities are already equipped with a rather basic system installed in conjunction with Russia. An upgrade is planned, again in liaison with Russia.
Customs authorities in Kyrgyzstan and Turkmenistan use a national system, which is set to be either upgraded or replaced by Sofix (French system).
Uzbekistan customs authorities are equipped with a national system due to be updated using Oracle and Unix.
Tajikistan customs authorities use a national system, with no update planned for the time being.
Mongolian customs authorites (which are not included in this study but have recently joined the Traceca programme) use UNCTAD's Asycuda system.

With the exception of Kazakhstan, freight forwarders have relatively few IT facilities.

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The Turkmenbashi-based Turkmen Shipping Company (Turkmenistan) does not seem to be computerised.

At present, there is no electronic data interchange between the above-mentioned partners, although they are willing to redress the situation. Direct Trader Input (DTI) seems to be up and running in Kazakhstan.

(Details regarding customs, customers, freight forwarders and ports have been taken from "Traceca - Trade Facilitation - Computer Systems Report").

2.1.3 Legal context

CIS states do not seem to have any legislation governing electronic data interchange.
It is advocated that OSJD lend these electronic messages the same official and irrefutable status accorded to the hard-copy forms currently used.

It is particularly advised that bilateral, or preferably multilateral, interchange agreements be signed, possibly taking the following texts as reference:

- "Commission recommendation of 19 October 1994 relating to the legal aspects of electronic data interchange" and the "European Model EDI Agreement" (Official Journal of the European Communities, 28 December 1994, No.L338, page 98),)
- "Trade data interchange by teletransmission - UNCID" (International Chamber of Commerce, 22 September 1987)
- "UNCITRAL model law on electronic commerce" 29th session: 28 May - 14 June 1996).

UNCID: Uniform Rules of conduct for interchange of trade data by teletransmission
UNCITRAL: United Nations Commission for International Trade Law

2.2 Services to be provided

2.2.1 Data interchange with other Traceca railways

It is imperative that freight and passenger data be exchanged electronically between the railways. This task is indirectly performed by the existing system, which is centralised in Moscow. Whatever changes take place in railway IT facilities in the Central Asian countries, it is vital that this electronic exchange of data continues.

2.2.2 Data interchange with administrative bodies

Since the railways have information on goods passing through customs quite some time before the actual border-crossing, they should be able to forward this data electronically to the central customs office and/or the border station. This should considerably reduce train stoppage times at borders.

2.2.3 Data interchange with customers

The target should be to enable customers to access the railways electronically to:

- book wagons,
- input information on their goods,
- obtain tariff details,
- find out the status and location of their goods,
- be notified when the goods arrive,

- secure statistics,
- receive reference timetables.

2.2.4 Interconnecting Traceca railways with Europe

Since there is already electronic data interchange between the Traceca railways, it is recommended that the information exchanged be passed on to railways in the European countries bordering the corridor :

- Bulgaria,
- Romania,
- Ukraine,

and via Ukraine :

- Hungary,
- Moldavia,
- Poland,
- and Slovakia.

This data shall then be transferred via existing European IT systems, e.g. the Hermes network systems (European railway IT network).

Slovakia is currently hooked up to the Hermes network and links with Hungary, Romania and Poland are in the pipeline.
Bulgaria and Romania intend to install UNCTAD's railway IT network Acis, and there are also plans afoot to incorporate a Hermes interface module into Acis.

2.2.5 Data interchange with the shipping companies

In order to ensure continuity in the data chain, the ultimate goal being to provide uninterrupted coverage while the goods are in transit, electronic communication should be set up with the shipping companies.

Such a move would:

- speed up data transfer between railways and shipping companies,
- eliminate the need for paper forms,
- minimise the time required before loading the goods,
- extend the scope of freight tracking and tracing systems.

2.3 Recommendations

As a rule, it should be noted that setting up electronic data interchange facilities often triggers changes in working methods. It would be advisable to combine such a move with restructuring.

2.3.1 Telecommunications

Before considering electronic data interchange, it must be stressed that reliable and powerful telecommunications links are a prerequisite. Efficient communications facilities are particularly important for IT centres, major passenger and freight stations, marshalling yards, border points, port stations and control centres.

The availability of quality transmission lines between the countries will pave the way for a top-class regional information system.

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2.3.2 In-house IT facilities

Given that IT systems at the Central Asian railways are relatively well-developed and, most importantly, uniform, it is strongly advocated that this uniformity be preserved.
The CIE-Consult/Systra restructuring studies recommend that the existing freight and passenger applications (ASSOUP and Express-2) be retained for at least another five years but that regional data processing be decentralised rather than carried out in the Moscow Computer Centre, which is currently the case. The studies also advocate installation of financial and administrative management information systems (MIS).

2.3.3 Data interchange between the railways

2.3.3.1 Central Asian railways

The uniform nature of existing systems should be maintained. The drawbacks of these systems are that:

- they use old equipment
- they are centralised in Moscow
- Kyrgyzstan Railways depend on their Kazakhstan counterpart.
- Tajikistan Railways depend on their Uzbekistan counterpart.

It is feasible to decentralise information specific to Central Asia from the Moscow Computer Centre to the regional computer centres.
Kyrgyzstan and Tajikistan railways have stated that they would like their own RCC, which in itself is a justifiable wish. However, the specifications supplied by Kyrgyzstan Railways are out of proportion with the needs identified. A second-hand IBM 4381 (the model currently used in the other Central Asian RCCs) would be more suitable.

2.3.3.1.1 Passenger IT systems

Express-2 has been installed in all countries except Turkmenistan, where it is still at the planning stage.
It is recommended that the number of sales terminals be increased in each country and that Express-2 be installed in Turkmenistan.
Upgrading to version three of Express-2 is not a priority.

2.3.3.1.2 Freight IT systems

ASSOUP, the existing software, seems to be satisfactory, hence there is no need for action in this area.

2.3.3.2 Caucasian railways

Limited communication takes place via Moscow.
Once the Caucasian railways are better equipped on the IT front, it will be feasible to set up direct links provided transmission facilities are available.

2.3.4 Data interchange with administrative bodies

2.3.4.1 With customs authorities

The only country in which electronic data interchange is currently possible with customs authorities seems to be Kazakhstan.
Customs authorities in each of the five countries have adopted rather different approaches to modernisation:

- Russian system

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- special national system
- Sofix
- Oracle
- no modernisation.

Given that customs organisations are in the middle of a major overhaul, it is too early to set an electronic data interchange. However, a pilot project would be feasible in Kazakhstan.

2.3.4.2 With the police

Data interchange with the police would be in relation to international passenger traffic and does not seem to be a priority for the time being.

2.3.5 Data interchange with customers and freight forwarders

At present, ASSOUP has no module allowing access to customers and freight forwarders, although this may be redressed in an upgraded version. If not, a special programme will be required.

2.3.6 Data interchange with shipping companies

2.3.6.1 Caspian Sea /Turkmenistan

There are no IT facilities at the Turkmenbashi-based shipping companies.
Pending installation of an IT system, they should have at least one terminal hooked up to the Turkmenistan Railways' IT system.

2.3.7 Interconnecting the Traceca railways with Europe

2.3.7.1 Passengers

The Express 2 system already has a link with western Europe, between Moscow and Frankfort with the gateway between Express 2 and Kurs 90 (the DB system) located in Moscow. Connections between Moscow and Helsinki and Moscow and Warsaw are in the pipeline.

2.3.7.2 Freight

As was the case for Express 2, it is feasible to develop a gateway between the Hermes freight applications (see list in Appendix 2) and ASSOUP. At present, the centralisation of functions at the Moscow IT system would entail the gateway being installed there.
However, if functions are actually decentralised in line with Traceca railways' requests and as approved by OSJD decisions, the gateway could be installed in the Caucasus region and/or in Central Asia.

2.4 Action plan

2.4.1 Timeframe

Phase 1 : Information
Organise information and training seminars on the advantages and limitations of electronic data interchange, inviting IT and administration managers at the railways and shipping companies. Although freight forwarders and customs officers have already attended this type of seminar as part

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of the project "Traceca - Trade and custom facilitation/ Scott Wilson Kirkpatrick", they should also be invited so as to facilitate the creation of working parties at a later stage.

Phase 2 : Pilot project
- Interconnect with freight forwarders
- Interconnect with major customers
- Interconnect with customs authorities (in Kazakhstan)

Phase 3 : Extension
- Interconnect with customs authorities (except in Kazakhstan).
- Interconnect with shipping companies

2.4.2 Organisation

To ensure that the project runs smoothly, a steering committee should be set up in each country, comprising:
- a team of two European consultants (EDI and management) selected following an invitation to tender; the same team would work on a part-time basis in all five countries,
- in each country, a group of high-level managers drawn from each of the bodies concerned (railways, customs, etc.).

2.5 Investment

The investment requirement to implement the recommendations of this report is as follows:

Given the imprecise nature of available data, phase 2 and 3 budgets are merely estimates.
It is assumed that special programmes such as gateway software to interface with customs systems will be developed locally.
The timeframe for implementation is taken to be two years.

2.5.1 Supervision (for all five countries)

80 weeks /person for the European consultants	500 000 ECU

2.5.2 Kazakhstan

Phase 1 - Information

Organise a two-day seminar	10 000 ECU

Phase 2 - Pilot phase

Interconnect with freight forwarders	100 000 ECU
Interconnect with major customers	100 000 ECU
Interconnect with customs authorities	100 000 ECU

Total	310 000 ECU

2.5.3 Kyrgyzstan

Phase 1 - Information

Organise a two-day seminar	10 000 ECU

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Phase 2 - Pilot project

Interconnect with freight forwarders	50 000 ECU
Interconnect with major customers	50 000 ECU

Phase 3 - Extension

Interconnect with customs authorities	100 000 ECU

Total	210 000 ECU

2.5.4 Uzbekistan

Phase 1 - Information

Organise a two-day seminar	10 000 ECU

Phase 2 - Pilot project

Interconnect with freight forwarders	100 000 ECU
Interconnect with major customers	100 000 ECU

Phase 3 - Extension

Interconnect with customs authorities	100 000 ECU

Total	310 000 ECU

2.5.5 Tajikistan

Phase 1 - Information

Organise a two-day seminar	10 000 ECU

Phase 2 - Pilot project

Interconnect with freight forwarders	50 000 ECU
Interconnect with major customers	50 000 ECU

Phase 3 - Extension

Interconnect with customs authorities	100 000 ECU

Total	210 000 ECU

2.5.6 Turkmenistan

Phase 1 - Information

Organise a two-day seminar	10 000 ECU

Phase 2 - Pilot project

Interconnect with freight forwarders	100 000 ECU
Interconnect with major customers	100 000 ECU

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Phase 3 - Extension

Interconnect with customs authorities	100 000 ECU
Interconnect with shipping companies	50 000 ECU

Total	360 000 ECU

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Appendices

1) List of Hermes nodes

Company	Node	Country
Association of Train Operating Companies	Nottingham	Great Britain
Ceske Drahy (CD)	Prague	Czech Republic
Danish State Railways (DSB)	Copenhagen	Denmark
Deutsche Bahn (DB)	Frankfurt	Germany
Italian State Railways (FS)	Rome	Italy
Netherlands Railways (NS)	Amsterdam	Netherlands
Austrian Federal Railways (OeBB)	Vienna	Austria
Spanish National Railway Network (RENFE)	Madrid	Spain
Swiss Federal Railways (SBB/CFF/FFS)	Bern	Switzerland
Swedish Railways (SJ)	Stockholm	Sweden
Belgian National Railways Company (SNCB)	Brussels	Belgium
French National Railways Company (SNCF)	Paris	France
Slovenian Railways (SZ)	Ljubljana	Slovenia
Railways of the Slovak Republic (ZSR)	Bratislava	Slovak Republic

2) List of Hermes freight applications

- Advance notification of train consists
- ENEE : Railway locations database (FGE)
- EUROP
- GOETHE : Wagons worked abroad
- DAMOCLES : Dangerous goods database
- TEI : International block trains
- RIV exchange
- Wagon search
- Frontier crossing
- Incidents in transit
- Advice of dispatch
- Advice of arrival

Chapter 6

Central Asia - Recommendations and economic study Appendix 1 - Backbone network diagrams

Appendix 1 - Backbone network diagrams

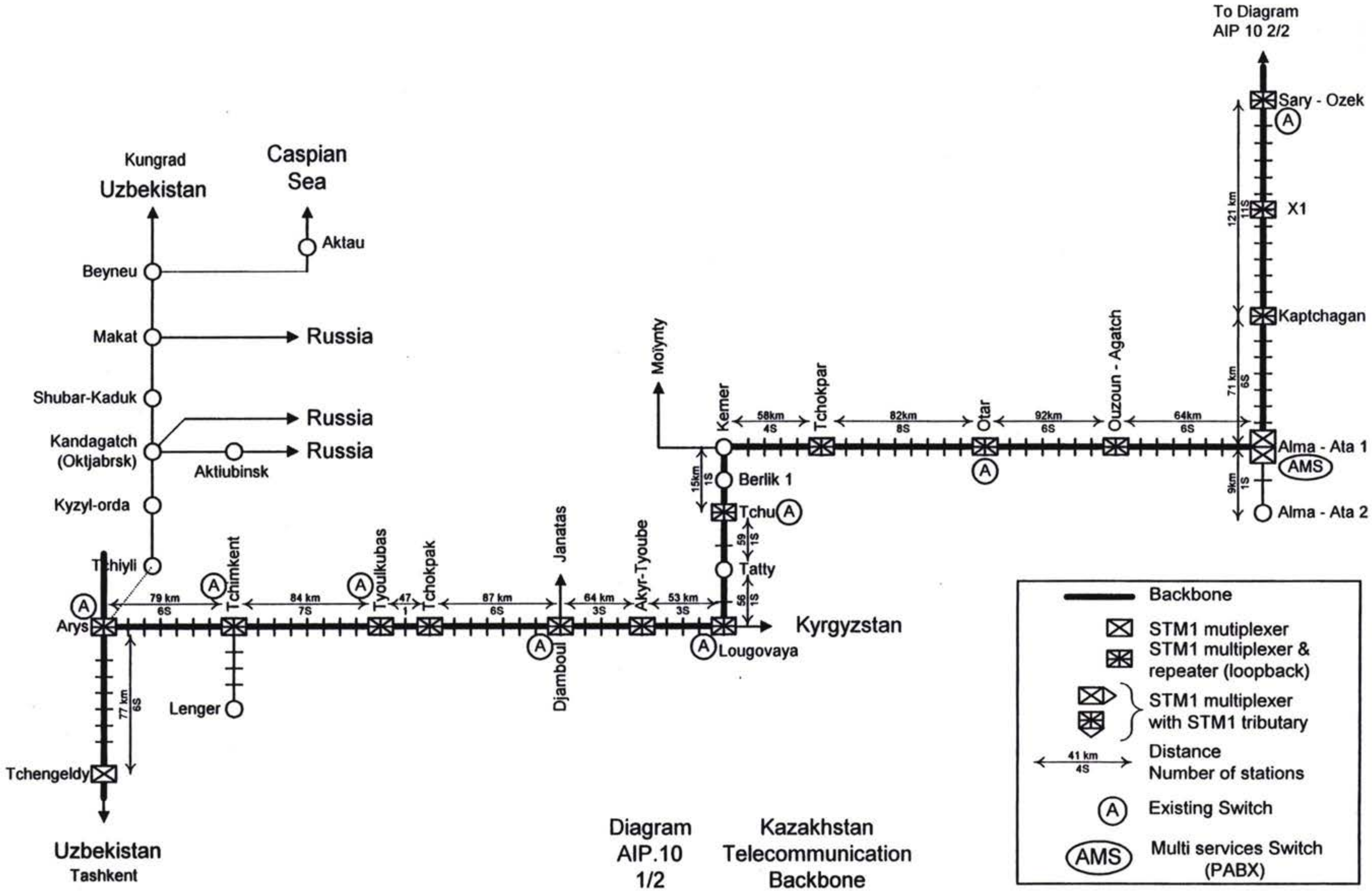


Diagram AIP.10 1/2

Kazakhstan Telecommunication Backbone

Appendix 1 - Backbone network diagrams

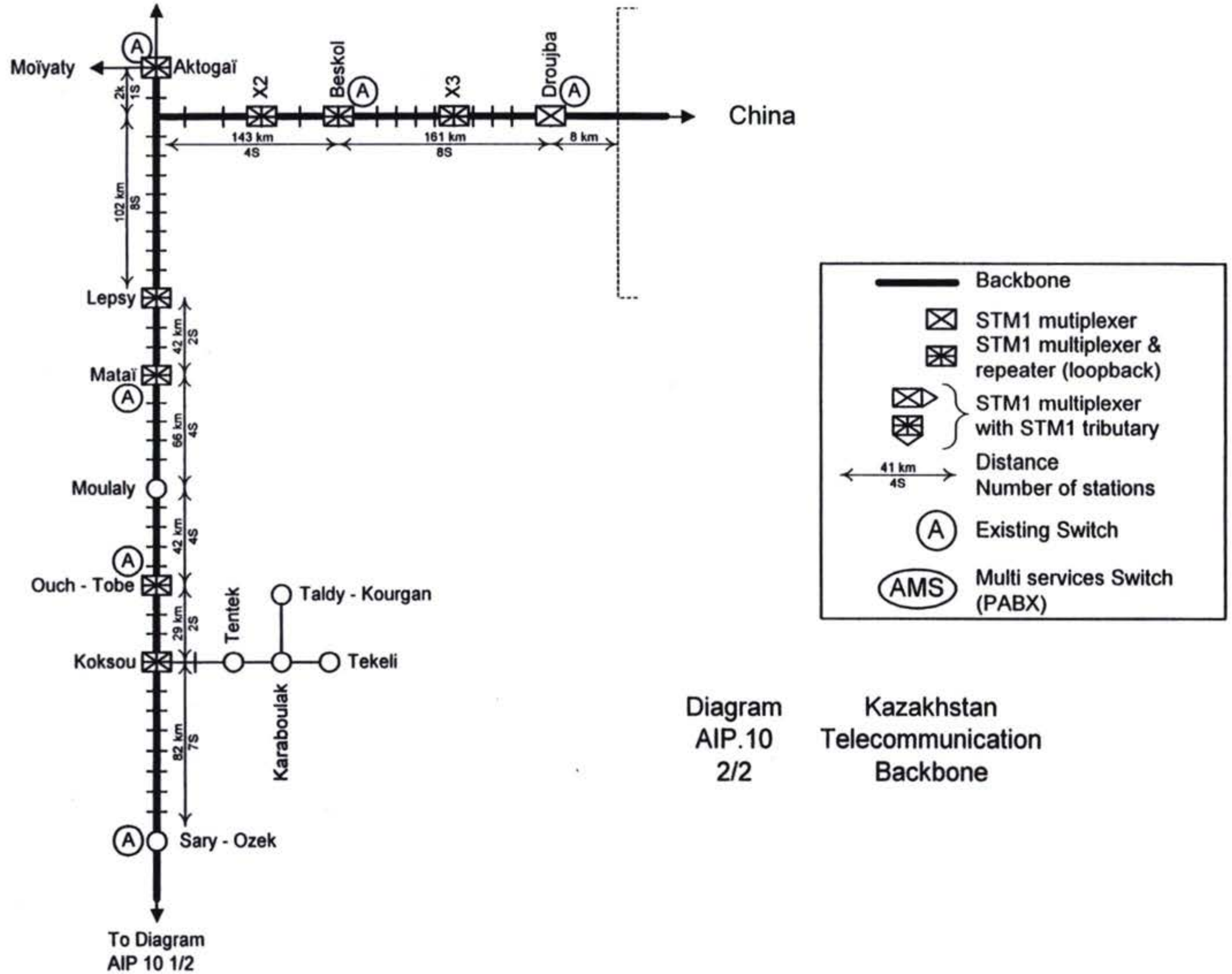


Diagram AIP.10 2/2 — Kazakhstan Telecommunication Backbone

Appendix 1 - Backbone network diagrams

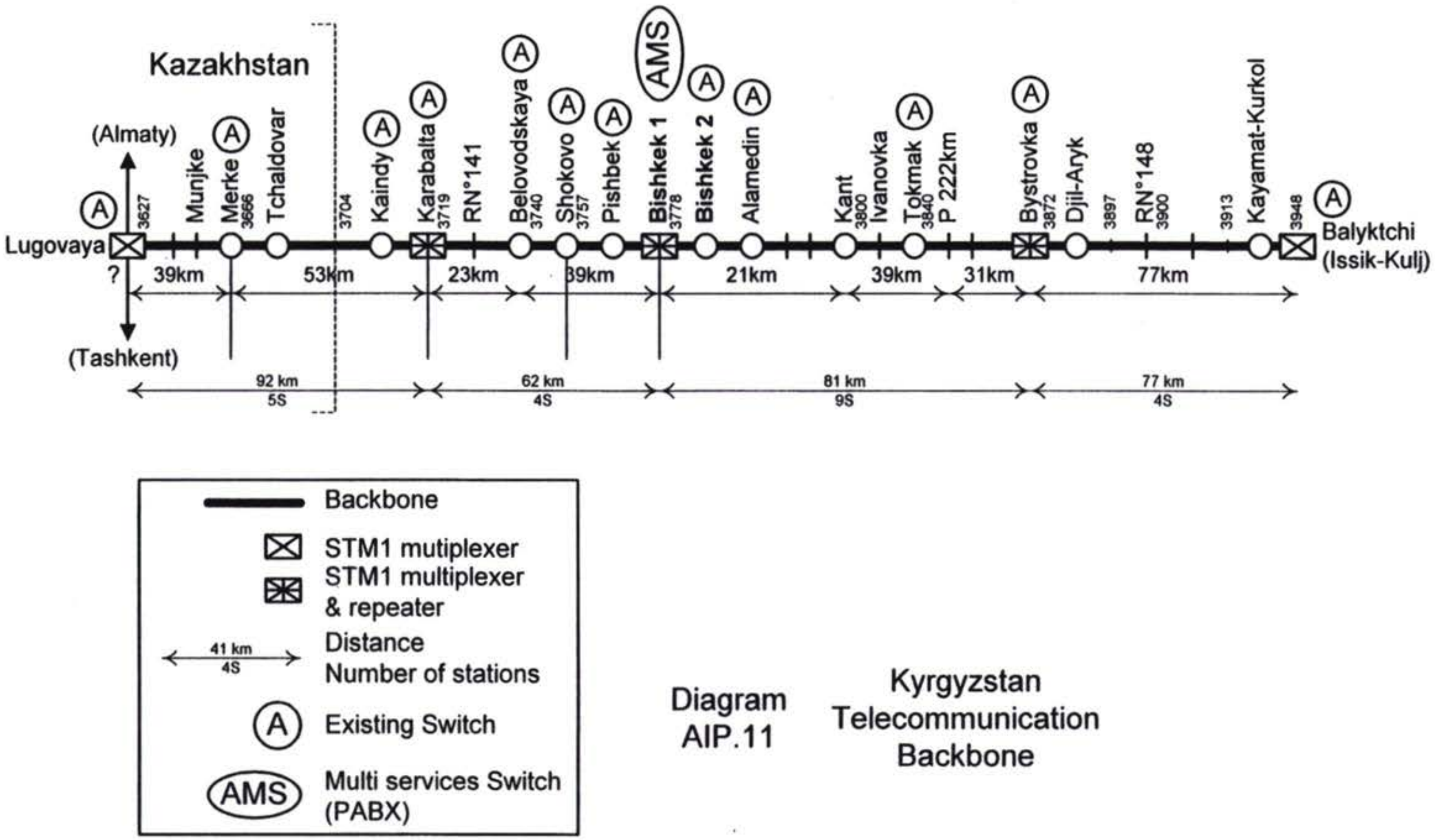


Diagram AIP.11

Kyrgyzstan Telecommunication Backbone

Appendix 1 - Backbone network diagrams

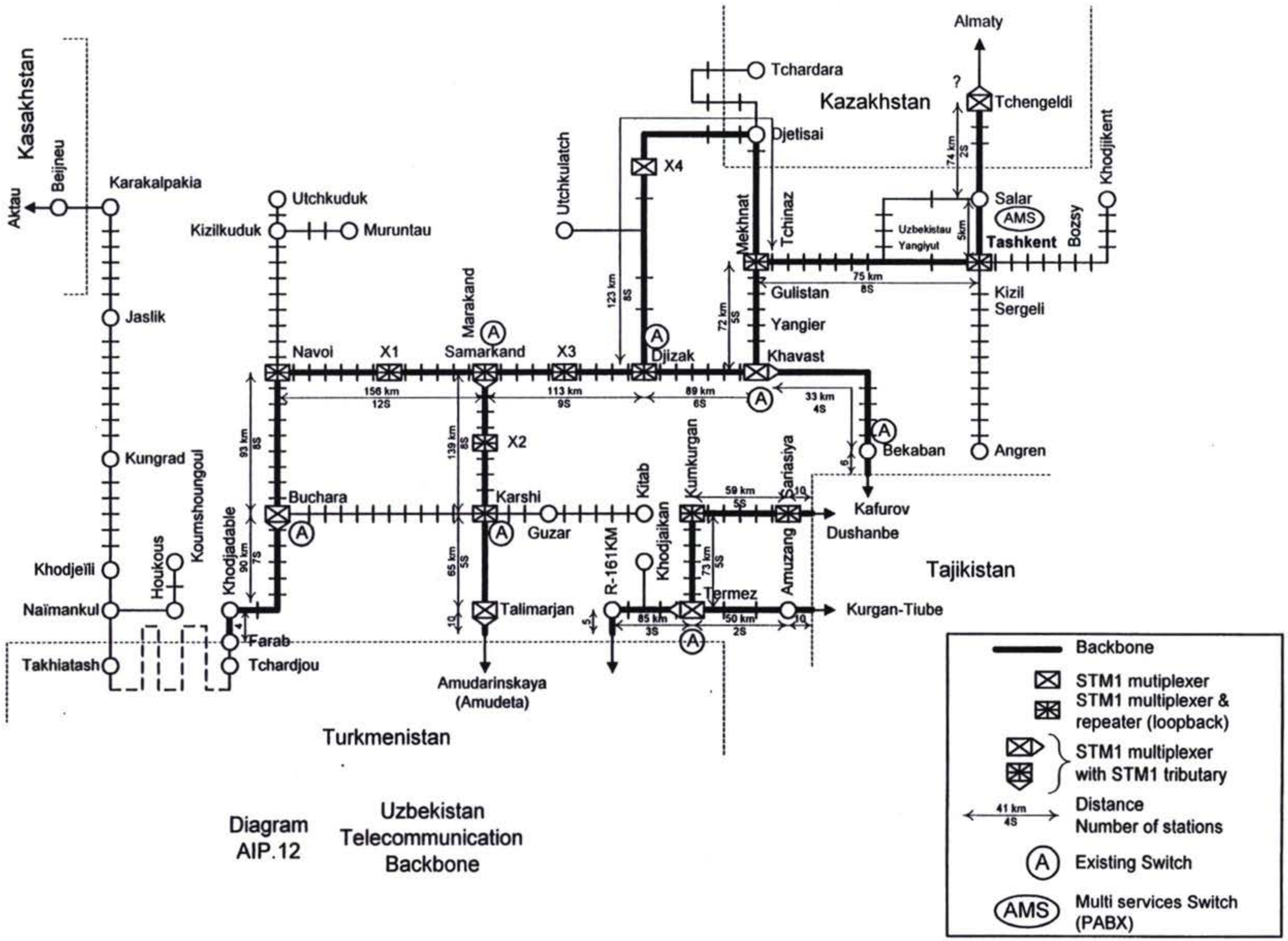


Diagram AIP.12

Uzbekistan Telecommunication Backbone

Appendix 1 - Backbone network diagrams

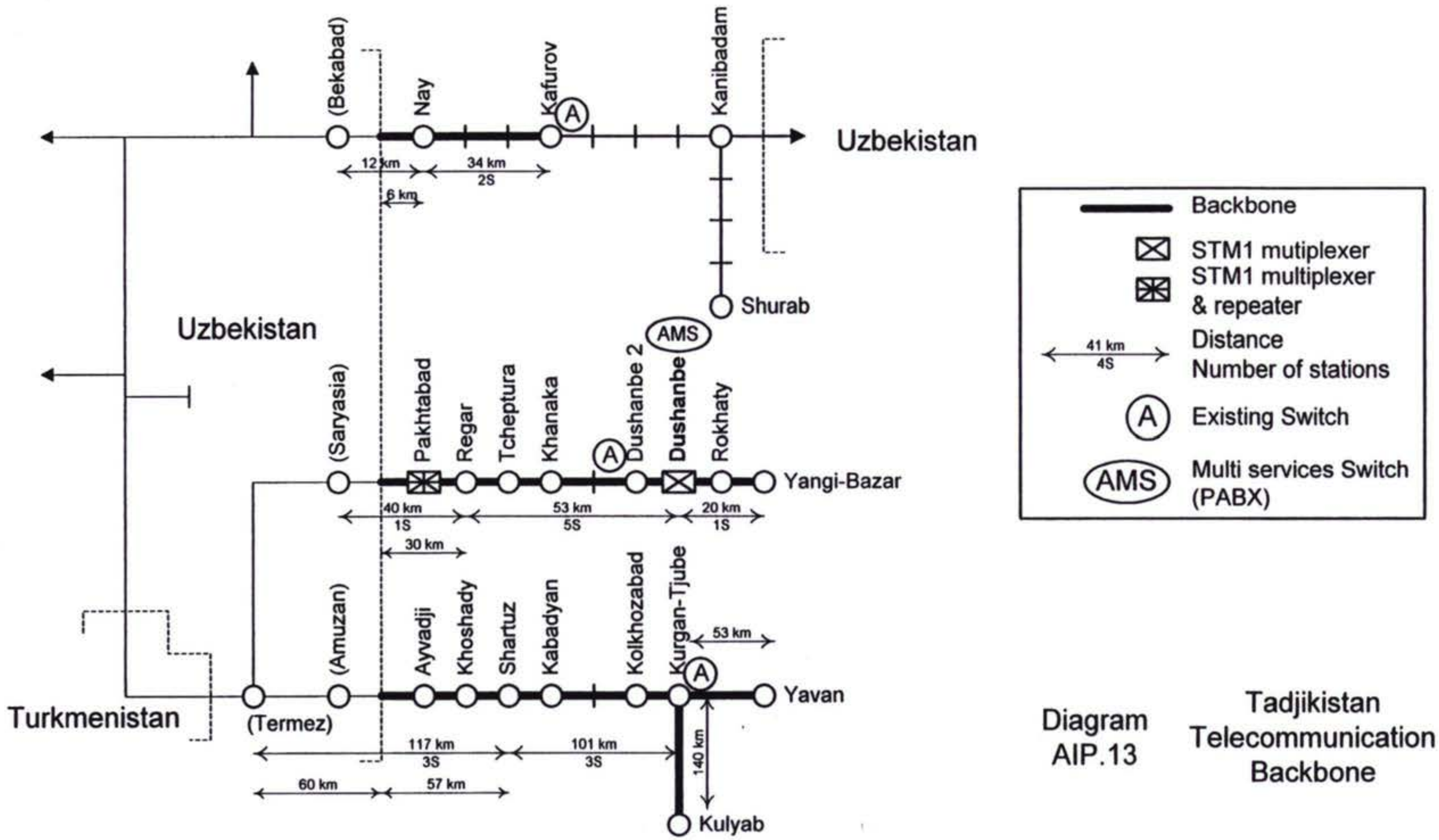


Diagram AIP.13

Tadjikistan Telecommunication Backbone

Appendix 1 - Backbone network diagrams

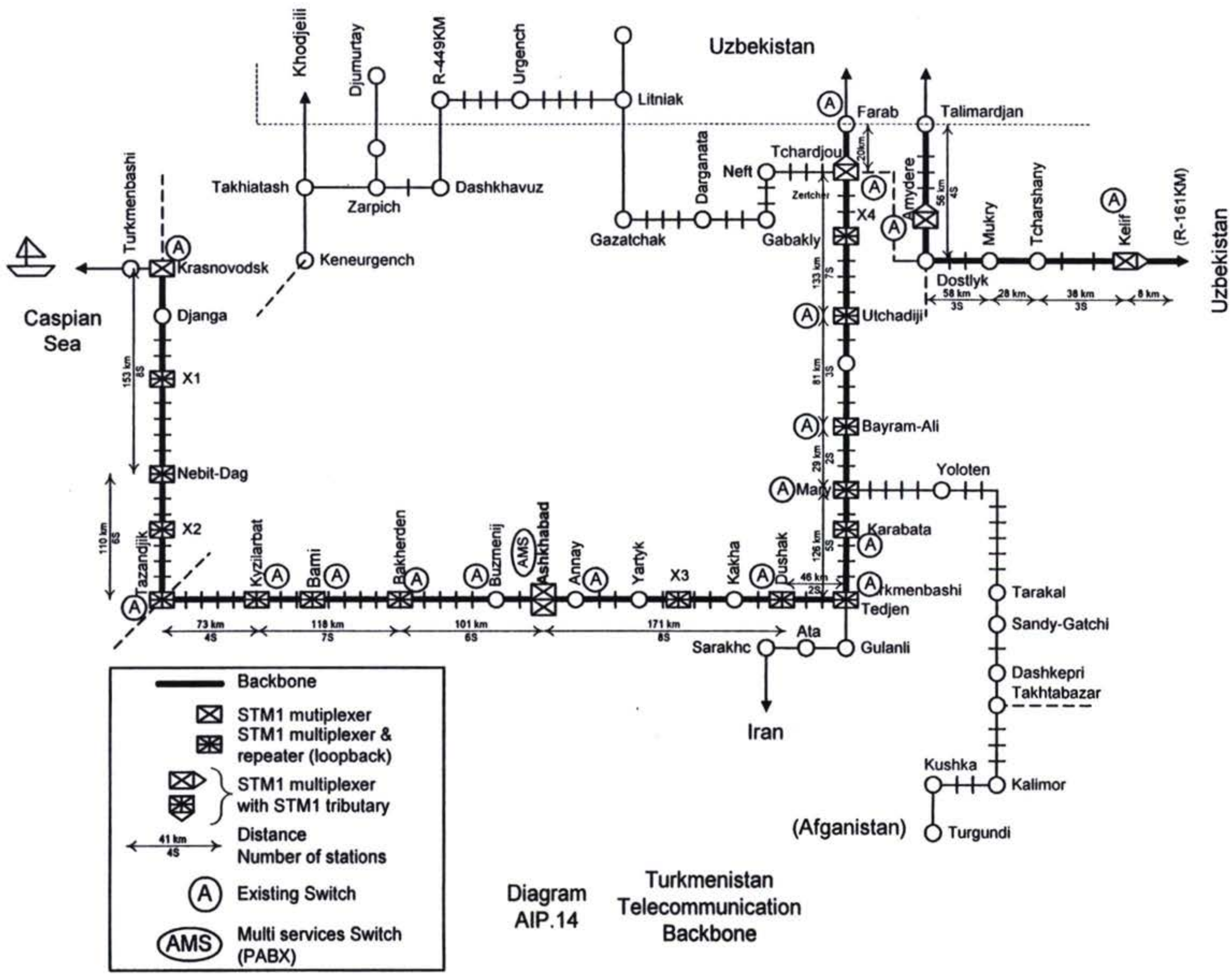


Diagram AIP.14

Turkmenistan Telecommunication Backbone

Chapter 6

Central Asia - Recommendations and economic study
Appendix 2
Investment tables for the backbone networks

Investment in backbone networks (Ce l Asia) - without back-up of the links between cc ɔl centre and stations - Summary - 26/02/99

	EU Investissement (Millions of ECU)	Railway investment (Millions of ECU)	Total
Kazakhstan	15,33	2,60	17,93
Kyrgyzstan	3,38	0,47	3,85
Ouzbekistan	12,13	2,09	14,22
Tajikistan	3,74	0,73	4,47
Turkmenistan	11,00	1,96	12,97
Total	**45,58**	**7,86**	**53,44**

Investme[illegible] backbone network, Kazakhstan (without back-up of the links between co[illegible] entre and stations)
(V0.8 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Total railway investment (adjusted to reflect local labour (millions of ECU)
	cabling	supplies	1808		20,5	37,06	5,62	
	cabling	supervision of staking-out work	1808		2	3,62	0,55	
	cabling	installing links	1808		4	7,23	1,10	
	cabling	staking out, civil engineering and laying (including labour)	1808		95	171,76		2,60
1	total expenditure on cabling				121,5	219,67	7,26	2,60
	large and medium-sized stations			27				
	smaller stations			114				
	total stations			141				
	number of links	(distribution network)		36				
	number of SDH nodes			26				
	Number of SDH repeaters			22				
	Number of STM1 tributaries			0				
2.1	STM1 equipment			26	190	4,94	0,75	
2.2	hooking up STM1 equipment			26	20	0,52	0,08	
2,3	STM1 Repeaters			22	110	2,42	0,37	
2,4	hooking up STM1 equipment			22	10	0,22	0,03	
2,5	STM1 tributaries			0	55	0,00	0,00	
2,6	hooking up STM1 equipment			0	5	0,00	0,00	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	Primary clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			177	64	11,33	1,72	
5.2	hooking up ADM equipment			177	8	1,42	0,21	
6	ADM management			3	100	0,30	0,05	
7.1	PABX	(equipment and management)		1	2000	2,00	0,30	
7.2	PABX	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		114	15	1,71	0,26	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		27	72	1,94	0,29	
10.1	large station and control centre equipement	(4-regulator control centre)		3	740	2,22	0,34	
10.2	hooking up	(4-regulator control centre)		3	80	0,24	0,04	
11.1	medium station equipment	(30 lines)		27	220	5,94	0,90	
11.2	hooking up	(30 lines)		27	21	0,57	0,09	
12.1	small station equipment	(6 lines)		114	44	5,02	0,76	
12.2	hooking up	(6 lines)		114	4	0,46	0,07	
13	spares	(10% of items (2-12))				4,23	0,64	
14	training			1	1456	1,46	0,22	
		Total of items (1-14)				268,09	14,60	2,60
15	provision for contingencies	5% of aggregate investment (items 1-14)				13,40	0,73	
		AGGREGATE TOTAL of items 1-15				**281,50**	**15,33**	**2,60**

Investmer ackbone network, Kyrgyzstan (without back-up of the links between cont· ntre and stations)
(V0.8 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Total railway investment (adjusted to reflect local labour (millions of ECU)
	cabling	supplies	327		20,5	6,70	1,02	
	cabling	supervision of staking-out work	327		2	0,65	0,10	
	cabling	installing links	327		4	1,31	0,20	
	cabling	staking out, civil engineering and laying (including labour)	327		95	31,07		0,47
1	total expenditure on cabling				121,5	39,73	1,31	0,47
	large and medium-sized stations			6				
	smaller stations			21				
	total stations			27				
	number of links	(distribution network)		6				
	number of SDH nodes			5				
	Number of SDH repeaters			3				
	Number of STM1 tributaries			0				
2.1	STM1 equipment			5	190	0,95	0,14	
2.2	hooking up STM1 equipment			5	20	0,10	0,02	
2,3	STM1 Repeaters			3	110	0,33	0,05	
2,4	hooking up STM1 equipment			3	10	0,03	0,00	
2,5	STM1 tributaries			0	55	0,00	0,00	
2,6	hooking up STM1 equipment			0	5	0,00	0,00	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	Primary clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			33	64	2,11	0,32	
5.2	hooking up ADM equipment			33	8	0,26	0,04	
6	ADM management			1	100	0,10	0,02	
7.1	PABX	(equipment and management)		1	1400	1,40	0,21	
7.2	PABX	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		21	15	0,32	0,05	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		6	72	0,43	0,07	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		6	220	1,32	0,20	
11.2	hooking up	(30 lines)		6	21	0,13	0,02	
12.1	small station equipment	(6 lines)		21	44	0,92	0,14	
12.2	hooking up	(6 lines)		21	4	0,08	0,01	
13	spares	(10% of items (2-12))				1,07	0,16	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				52,34	3,22	0,47
15	provision for contingencies	5% of aggregate investment (items 1-14)				2,62	0,16	
		AGGREGATE TOTAL of items 1-15				**54,95**	**3,38**	**0,47**

Investmer' backbone network, Uzbekistan (without back-up of the links between cont' entre and stations)
(V0 8 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Total railway investment (adjusted to reflect local labour (millions of ECU)
	cabling	supplies	1454		20,5	29,81	4,52	
	cabling	supervision of staking-out work	1454		2	2,91	0,44	
	cabling	installing links	1454		4	5,82	0,88	
	cabling	staking out, civil engineering and laying (including labour)	1454		95	138,13		2,09
1	**total expenditure on cabling**				121,5	176,66	5,84	2,09
	large and medium-sized stations			18				
	smaller stations			97				
	total stations			115				
	number of links	(distribution network)		26				
	number of SDH nodes			17				
	Number of SDH repeaters			11				
	Number of STM1 tributaries			5				
2.1	**STM1 equipment**			17	190	3,23	0,49	
2.2	**hooking up STM1 equipment**			17	20	0,34	0,05	
2,3	**STM1 Repeaters**			11	110	1,21	0,18	
2,4	**hooking up STM1 equipment**			11	10	0,11	0,02	
2,5	**STM1 tributaries**			5	55	0,28	0,04	
2,6	**hooking up STM1 equipment**			5	5	0,03	0,00	
3	**SDH management**			1	700	0,70	0,11	
4.1	**synchronisation**	Primary clock		1	100	0,10	0,02	
4.2	**synchronisation**	SSU		2	75	0,15	0,02	
4.3	**synchronisation**	GPS		2	25	0,05	0,01	
5,1	**ADM equipment**			141	64	9,02	1,37	
5.2	**hooking up ADM equipment**			141	8	1,13	0,17	
6	**ADM management**			3	100	0,30	0,05	
7.1	**PABX**	(equipment and management)		1	3000	3,00	0,45	
7.2	**PABX**	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	**low-capacity power supply**	(ADM, low-capacity station centre)		97	15	1,46	0,22	
9	**medium-capacity energy supply**	(STM1, medium-capacity station centre)		18	72	1,30	0,20	
10.1	**large station and control centre equipement**	(15-regulator control centre)		1	910	0,91	0,14	
10.2	**hooking up**	(15-regulator control centre)		1	90	0,09	0,01	
11.1	**medium station equipment**	(30 lines)		18	220	3,96	0,60	
11.2	**hooking up**	(30 lines)		18	21	0,38	0,06	
12.1	**small station equipment**	(6 lines)		97	44	4,27	0,65	
12.2	**hooking up**	(6 lines)		97	4	0,39	0,06	
13	**spares**	(10% of items (2-12))				3,26	0,49	
14	**training**			1	1456	1,46	0,22	
		Total of items (1-14)				214,36	11,55	2,09
15	**provision for contingencies**	5% of aggregate investment (items 1-14)				10,72	0,58	
		AGGREGATE TOTAL of items 1-15				**225,08**	**12,13**	**2,09**

Investm… backbone network, Tajikistan (without back-up of the links between cont… ntre and stations)
(V0.8 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Total railway investment (adjusted to reflect local labour (millions of ECU)
	cabling	supplies	509		20,5	10,43	1,58	
	cabling	supervision of staking-out work	509		2	1,02	0,15	
	cabling	installing links	509		4	2,04	0,31	
	cabling	staking out, civil engineering and laying (including labour)	509		95	48,36		0,73
1	total expenditure on cabling				121,5	61,84	2,04	0,73
	large and medium-sized stations			3				
	smaller stations			19				
	total stations			22				
	number of links	(distribution network)		5				
	number of SDH nodes			2				
	Number of SDH repeaters			1				
	Number of STM1 tributaries			0				
2.1	STM1 equipment			2	190	0,38	0,06	
2.2	hooking up STM1 equipment			2	20	0,04	0,01	
2,3	STM1 Repeaters			1	110	0,11	0,02	
2,4	hooking up STM1 equipment			1	10	0,01	0,00	
2,5	STM1 tributaries			0	55	0,00	0,00	
2,6	hooking up STM1 equipment			0	5	0,00	0,00	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	Primary clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			27	64	1,73	0,26	
5.2	hooking up ADM equipment			27	8	0,22	0,03	
6	ADM management			1	100	0,10	0,02	
7.1	PABX	(equipment and management)		1	1400	1,40	0,21	
7.2	PABX	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		19	15	0,29	0,04	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		3	72	0,22	0,03	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		3	220	0,66	0,10	
11.2	hooking up	(30 lines)		3	21	0,06	0,01	
12.1	small station equipment	(6 lines)		19	44	0,84	0,13	
12.2	hooking up	(6 lines)		19	4	0,08	0,01	
13	spares	(10% of items (2-12))				0,84	0,13	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				71,85	3,56	0,73
15	provision for contingencies	5% of aggregate investment (items 1-14)				3,59	0,18	
		AGGREGATE TOTAL of items 1-15				75,44	3,74	0,73

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Total railway investment (adjusted to reflect local labour (millions of ECU)
	cabling	supplies	1364		20,5	27,96	4,24	
	cabling	supervision of staking-out work	1364		2	2,73	0,41	
	cabling	installing links	1364		4	5,46	0,83	
	cabling	staking out, civil engineering and laying (including labour)	1364		95	129,58		1,96
1	total expenditure on cabling				121,5	165,73	5,48	1,96
	large and medium-sized stations			18				
	smaller stations			66				
	total stations			84				
	number of links	(distribution network)		22				
	number of SDH nodes			21				
	Number of SDH repeaters			15				
	Number of STM1 tributaries			3				
2 1	STM1 equipment			21	190	3,99	0,60	
2 2	hooking up STM1 equipment			21	20	0,42	0,06	
2,3	STM1 Repeaters			15	110	1,65	0,25	
2,4	hooking up STM1 equipment			15	10	0,15	0,02	
2,5	STM1 tributaries			3	55	0,17	0,03	
2,6	hooking up STM1 equipment			3	5	0,02	0,00	
3	SDH management			1	700	0,70	0,11	
4 1	synchronisation	Primary clock		1	100	0,10	0,02	
4 2	synchronisation	SSU		2	75	0,15	0,02	
4 3	synchronisation	GPS		2	25	0,05	0,01	
5,1	ADM equipment			106	64	6,78	1,03	
5 2	hooking up ADM equipment			106	8	0,85	0,13	
6	ADM management			3	100	0,30	0,05	
7 1	PABX	(equipment and management)		1	2000	2,00	0,30	
7 2	PABX	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		66	15	0,99	0,15	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		18	72	1,30	0,20	
10 1	large station and control centre equipement	(15-regulator control centre)		1	910	0,91	0,14	
10 2	hooking up	(15-regulator control centre)		1	90	0,09	0,01	
11 1	medium station equipment	(30 lines)		18	220	3,96	0,60	
11 2	hooking up	(30 lines)		18	21	0,38	0,06	
12 1	small station equipment	(6 lines)		66	44	2,90	0,44	
12 2	hooking up	(6 lines)		66	4	0,26	0,04	
13	spares	(10% of items (2-12))				2,85	0,43	
14	training			1	1456	1,46	0,22	
		Total of items (1-14)				198,74	10,48	1,96
15	provision for contingencies	5% of aggregate investment (items 1-14)				9,94	0,52	
		AGGREGATE TOTAL of items 1-15				**208,68**	**11,00**	**1,96**

Investment in backbone networks (C al Asia) - with back-up of the links between con centre and stations - Summary - 26/02/99

	Investissement UE (MECU)	Investissement Railways (MECU)	Total
Kazakhstan	15,78	2,60	18,38
Kyrgyzstan	3,46	0,47	3,93
Ouzbekistan	12,46	2,09	14,55
Tajikistan	3,80	0,73	4,53
Turkmenistan	11,28	1,96	13,24
Total	**46,78**	**7,86**	**54,64**

Investm backbone network, Kazakhstan (with back-up of the links between contr tre and stations)
(V0.8 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Total railway investment (adjusted to reflect local labour (millions of ECU)
	cabling	supplies	1808		20,5	37,06	5,62	
	cabling	supervision of staking-out work	1808		2	3,62	0,55	
	cabling	installing links	1808		4	7,23	1,10	
	cabling	staking out, civil engineering and laying (including labour)	1808		95	171,76		2,60
1	total expenditure on cabling				121,5	219,67	7,26	2,60
	large and medium-sized stations			27				
	smaller stations			114				
	total stations			141				
	number of links	(distribution network)		36				
	number of SDH nodes			26				
	Number of SDH repeaters			22				
	Number of STM1 tributaries			0				
2.1	STM1 equipment			26	190	4,94	0,75	
2.2	hooking up STM1 equipment			26	20	0,52	0,08	
2,3	STM1 Repeaters			22	110	2,42	0,37	
2,4	hooking up STM1 equipment			22	10	0,22	0,03	
2,5	STM1 tributaries			0	55	0,00	0,00	
2,6	hooking up STM1 equipment			0	5	0,00	0,00	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	Primary clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			213	64	13,63	2,07	
5.2	hooking up ADM equipment			213	8	1,70	0,26	
6	ADM management			3	100	0,30	0,05	
7.1	PABX	(equipment and management)		1	2000	2,00	0,30	
7.2	PABX	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		114	15	1,71	0,26	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		27	72	1,94	0,29	
10.1	large station and control centre equipement	(4-regulator control centre)		3	740	2,22	0,34	
10.2	hooking up	(4-regulator control centre)		3	80	0,24	0,04	
11.1	medium station equipment	(30 lines)		27	220	5,94	0,90	
11.2	hooking up	(30 lines)		27	21	0,57	0,09	
12.1	small station equipment	(6 lines)		114	44	5,02	0,76	
12.2	hooking up	(6 lines)		114	4	0,46	0,07	
13	spares	(10% of items (2-12)				4,49	0,68	
14	training			1	1456	1,46	0,22	
		Total of items (1-14)				270,94	15,03	2,60
15	provision for contingencies	5% of aggregate investment (items 1-14)				13,55	0,75	
		AGGREGATE TOTAL of items 1-15				284,49	15,78	2,60

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Total railway investment (adjusted to reflect local labour (millions of ECU)
	cabling	supplies	327		20,5	6,70	1,02	
	cabling	supervision of staking-out work	327		2	0,65	0,10	
	cabling	installing links	327		4	1,31	0,20	
	cabling	staking out, civil engineering and laying (including labour)	327		95	31,07		0,47
1	total expenditure on cabling				121,5	39,73	1,31	0,47
	large and medium-sized stations			6				
	smaller stations			21				
	total stations			27				
	number of links	(distribution network)		6				
	number of SDH nodes			5				
	Number of SDH repeaters			3				
	Number of STM1 tributaries			0				
2.1	STM1 equipment			5	190	0,95	0,14	
2.2	hooking up STM1 equipment			5	20	0,10	0,02	
2,3	STM1 Repeaters			3	110	0,33	0,05	
2,4	hooking up STM1 equipment			3	10	0,03	0,00	
2,5	STM1 tributaries			0	55	0,00	0,00	
2,6	hooking up STM1 equipment			0	5	0,00	0,00	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	Primary clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			39	64	2,50	0,38	
5.2	hooking up ADM equipment			39	8	0,31	0,05	
6	ADM management			1	100	0,10	0,02	
7.1	PABX	(equipment and management)		1	1400	1,40	0,21	
7.2	PABX	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		21	15	0,32	0,05	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		6	72	0,43	0,07	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		6	220	1,32	0,20	
11.2	hooking up	(30 lines)		6	21	0,13	0,02	
12.1	small station equipment	(6 lines)		21	44	0,92	0,14	
12.2	hooking up	(6 lines)		21	4	0,08	0,01	
13	spares	(10% of items (2-12)				1,12	0,17	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				52,81	3,30	0,47
15	provision for contingencies	5% of aggregate investment (items 1-14)				2,64	0,16	
		AGGREGATE TOTAL of items 1-15				**55,45**	**3,46**	**0,47**

Investm[illegible] backbone network, Uzbekistan (with back-up of the links between contro[illegible] [illegible]re and stations)
(V0.8 26/02/99)

Item No.	Item description	Comments	Length	Number	Unit price	Total	EU total	Total railway investment (adjusted to reflect local labour
			in km	of units	(in thousands of FRF)	(millions of FRF)	(millions of ECU)	(millions of ECU)
	cabling	supplies	1454		20,5	29,81	4,52	
	cabling	supervision of staking-out work	1454		2	2,91	0,44	
	cabling	installing links	1454		4	5,82	0,88	
	cabling	staking out, civil engineering and laying (including labour)	1454		95	138,13		2,09
1	total expenditure on cabling				121,5	176,66	5,84	2,09
	large and medium-sized stations			18				
	smaller stations			97				
	total stations			115				
	number of links	(distribution network)		26				
	number of SDH nodes			17				
	Number of SDH repeaters			11				
	Number of STM1 tributaries			5				
2.1	STM1 equipment			17	190	3,23	0,49	
2.2	hooking up STM1 equipment			17	20	0,34	0,05	
2,3	STM1 Repeaters			11	110	1,21	0,18	
2,4	hooking up STM1 equipment			11	10	0,11	0,02	
2,5	STM1 tributaries			5	55	0,28	0,04	
2,6	hooking up STM1 equipment			5	5	0,03	0,00	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	Primary clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		2	75	0,15	0,02	
4.3	synchronisation	GPS		2	25	0,05	0,01	
5,1	ADM equipment			167	64	10,69	1,62	
5.2	hooking up ADM equipment			167	8	1,34	0,20	
6	ADM management			3	100	0,30	0,05	
7.1	PABX	(equipment and management)		1	3000	3,00	0,45	
7.2	PABX	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		97	15	1,46	0,22	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		18	72	1,30	0,20	
10.1	large station and control centre equipement	(15-regulator control centre)		1	910	0,91	0,14	
10.2	hooking up	(15-regulator control centre)		1	90	0,09	0,01	
11.1	medium station equipment	(30 lines)		18	220	3,96	0,60	
11.2	hooking up	(30 lines)		18	21	0,38	0,06	
12.1	small station equipment	(6 lines)		97	44	4,27	0,65	
12.2	hooking up	(6 lines)		97	4	0,39	0,06	
13	spares	(10% of items (2-12)				3,45	0,52	
14	training			1	1456	1,46	0,22	
		Total of items (1-14)				216,42	11,86	2,09
15	provision for contingencies	5% of aggregate investment (items 1-14)				10,82	0,59	
		AGGREGATE TOTAL of items 1-15				**227,24**	**12,46**	**2,09**

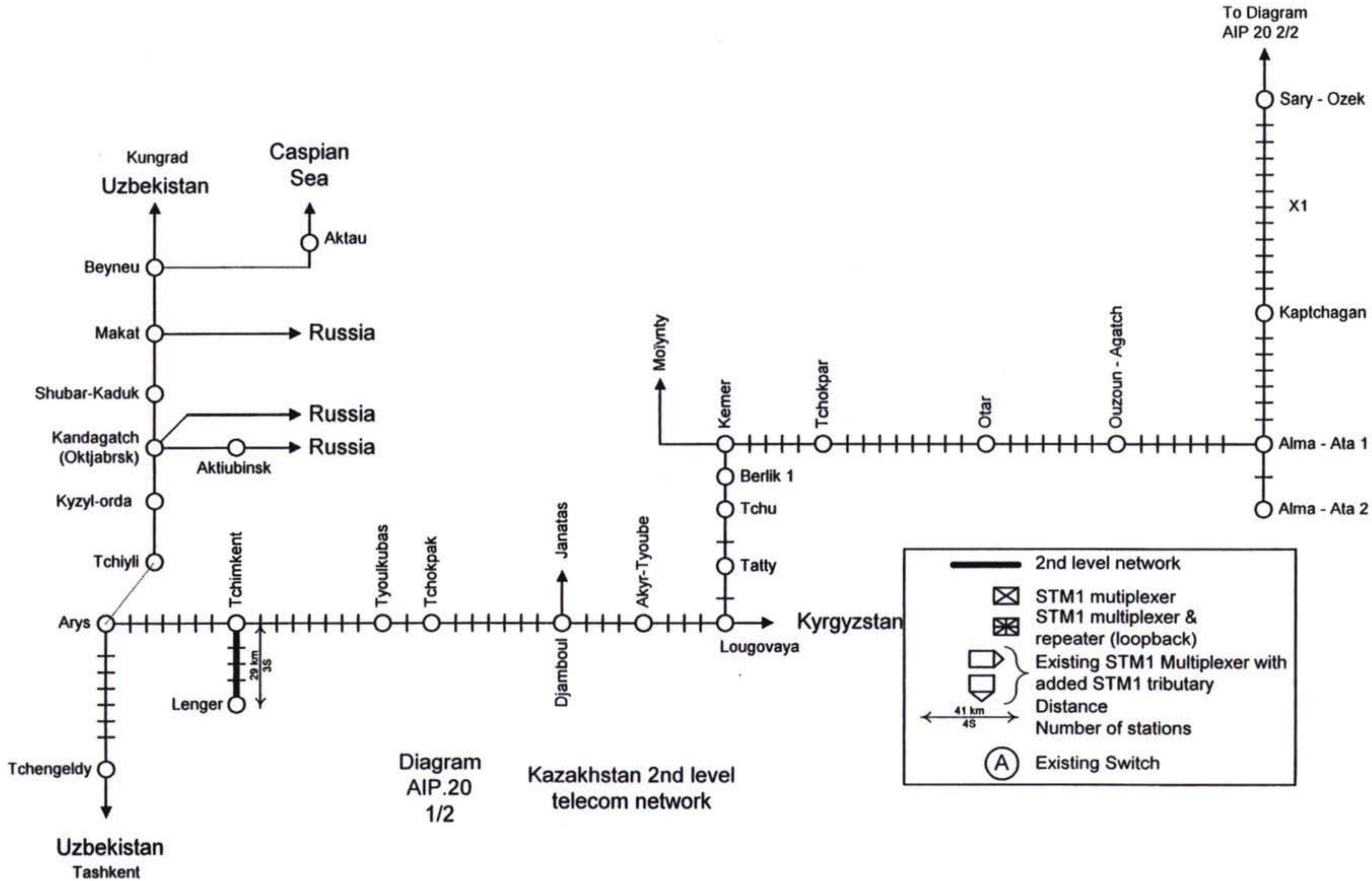
Item No.	Item description	Comments	Length	Number	Unit price	Total	EU total	Total railway investment (adjusted to reflect local labour
			in km	of units	(in thousands of FRF)	(millions of FRF)	(millions of ECU)	(millions of ECU)
	cabling	supplies	509		20,5	10,43	1,58	
	cabling	supervision of staking-out work	509		2	1,02	0,15	
	cabling	installing links	509		4	2,04	0,31	
	cabling	staking out, civil engineering and laying (including labour)	509		95	48,36		0,73
1	total expenditure on cabling				121,5	61,84	2,04	0,73
	large and medium-sized stations			3				
	smaller stations			19				
	total stations			22				
	number of links	(distribution network)		5				
	number of SDH nodes			2				
	Number of SDH repeaters			1				
	Number of STM1 tributaries			0				
2.1	STM1 equipment			2	190	0,38	0,06	
2.2	hooking up STM1 equipment			2	20	0,04	0,01	
2,3	STM1 Repeaters			1	110	0,11	0,02	
2,4	hooking up STM1 equipment			1	10	0,01	0,00	
2,5	STM1 tributaries			0	55	0,00	0,00	
2,6	hooking up STM1 equipment			0	5	0,00	0,00	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	Primary clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			32	64	2,05	0,31	
5.2	hooking up ADM equipment			32	8	0,26	0,04	
6	ADM management			1	100	0,10	0,02	
7.1	PABX	(equipment and management)		1	1400	1,40	0,21	
7.2	PABX	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		19	15	0,29	0,04	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		3	72	0,22	0,03	
10.1	large station and control centre equipement	(4-regulator control centre)		1	740	0,74	0,11	
10.2	hooking up	(4-regulator control centre)		1	80	0,08	0,01	
11.1	medium station equipment	(30 lines)		3	220	0,66	0,10	
11.2	hooking up	(30 lines)		3	21	0,06	0,01	
12.1	small station equipment	(6 lines)		19	44	0,84	0,13	
12.2	hooking up	(6 lines)		19	4	0,08	0,01	
13	spares	(10% of items (2-12)				0,87	0,13	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				72,24	3,62	0,73
15	provision for contingencies	5% of aggregate investment (items 1-14)				3,61	0,18	
		AGGREGATE TOTAL of items 1-15				75,86	3,80	0,73

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Total railway investment (adjusted to reflect local labour (millions of ECU)
	cabling	supplies	1364		20,5	27,96	4,24	
	cabling	supervision of staking-out work	1364		2	2,73	0,41	
	cabling	installing links	1364		4	5,46	0,83	
	cabling	staking out, civil engineering and laying (including labour)	1364		95	129,58		1,96
1	total expenditure on cabling				121,5	165,73	5,48	1,96
	large and medium-sized stations			18				
	smaller stations			66				
	total stations			84				
	number of links	(distribution network)		22				
	number of SDH nodes			21				
	Number of SDH repeaters			15				
	Number of STM1 tributaries			3				
2.1	STM1 equipment			21	190	3,99	0,60	
2.2	hooking up STM1 equipment			21	20	0,42	0,06	
2,3	STM1 Repeaters			15	110	1,65	0,25	
2,4	hooking up STM1 equipment			15	10	0,15	0,02	
2,5	STM1 tributaries			3	55	0,17	0,03	
2,6	hooking up STM1 equipment			3	5	0,02	0,00	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	Primary clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		2	75	0,15	0,02	
4.3	synchronisation	GPS		2	25	0,05	0,01	
5,1	ADM equipment			128	64	8,19	1,24	
5.2	hooking up ADM equipment			128	8	1,02	0,16	
6	ADM management			3	100	0,30	0,05	
7.1	PABX	(equipment and management)		1	2000	2,00	0,30	
7.2	PABX	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		66	15	0,99	0,15	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		18	72	1,30	0,20	
10.1	large station and control centre equipement	(15-regulator control centre)		1	910	0,91	0,14	
10.2	hooking up	(15-regulator control centre)		1	90	0,09	0,01	
11.1	medium station equipment	(30 lines)		18	220	3,96	0,60	
11.2	hooking up	(30 lines)		18	21	0,38	0,06	
12.1	small station equipment	(6 lines)		66	44	2,90	0,44	
12.2	hooking up	(6 lines)		66	4	0,26	0,04	
13	spares	(10% of items (2-12)				3,00	0,46	
14	training			1	1456	1,46	0,22	
		Total of items (1-14)				200,48	10,74	1,96
15	provision for contingencies	5% of aggregate investment (items 1-14)				10,02	0,54	
		AGGREGATE TOTAL of items 1-15				210,51	11,28	1,96

Chapter 6

Central Asia - Recommendations and economic study Appendix 3 - Network of secondary railway lines

Appendix 3 - Network of secondary railway lines



Appendix 3 - Network of secondary railway lines

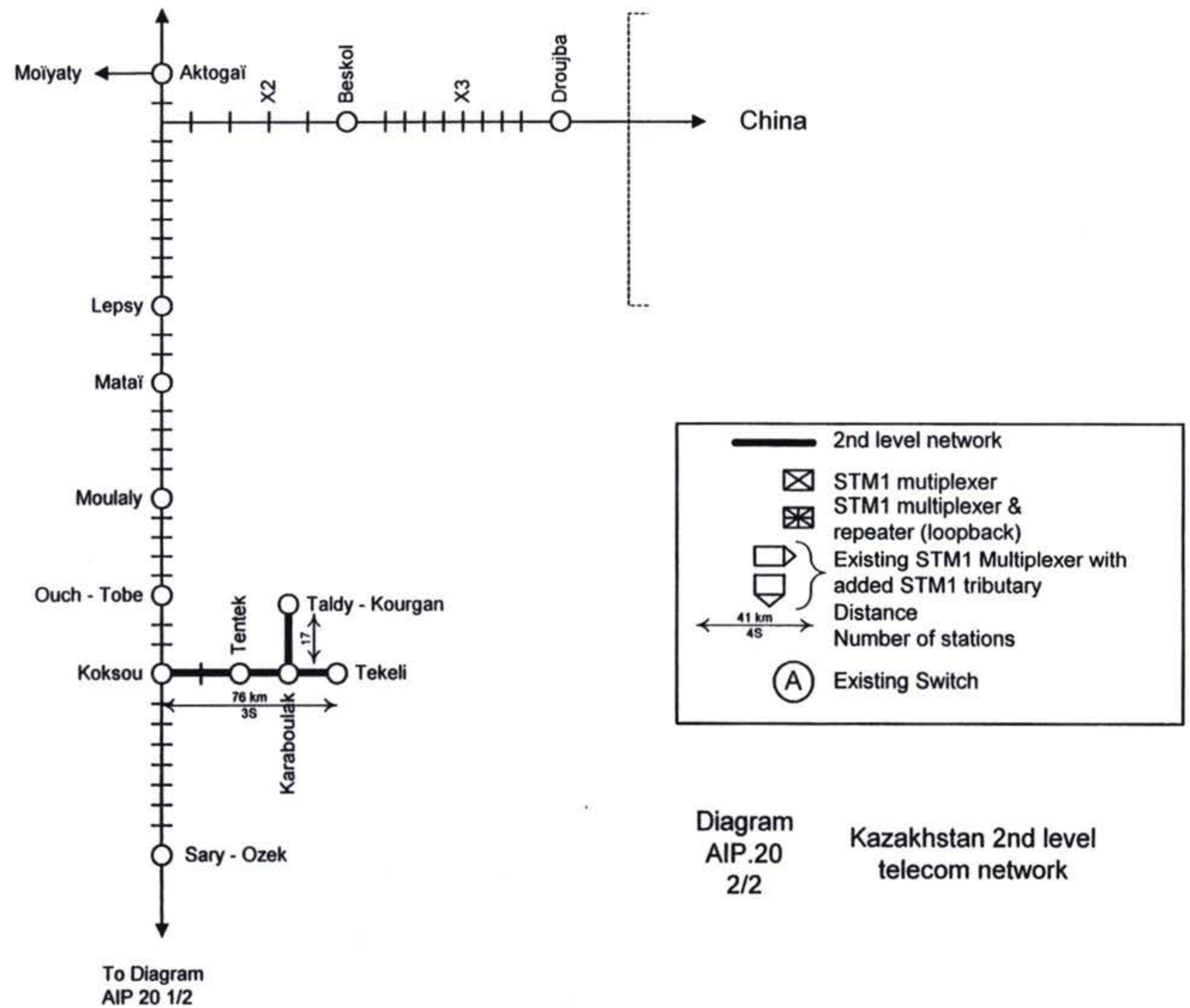


Diagram AIP.20 2/2

Kazakhstan 2nd level telecom network

Appendix 3 - Network of secondary railway lines

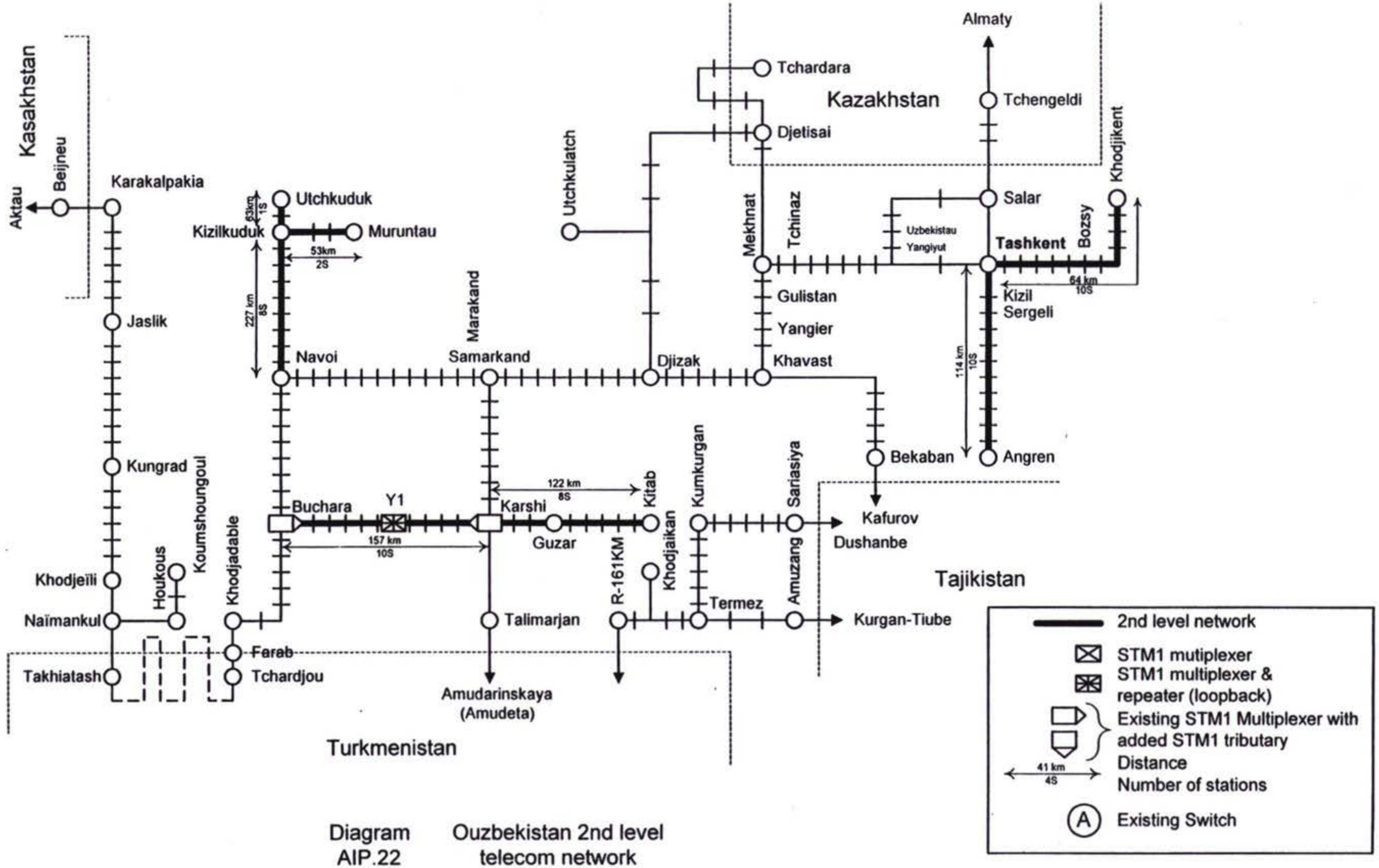


Diagram AIP.22 Ouzbekistan 2nd level telecom network

Appendix 3 - Network of secondary railway lines

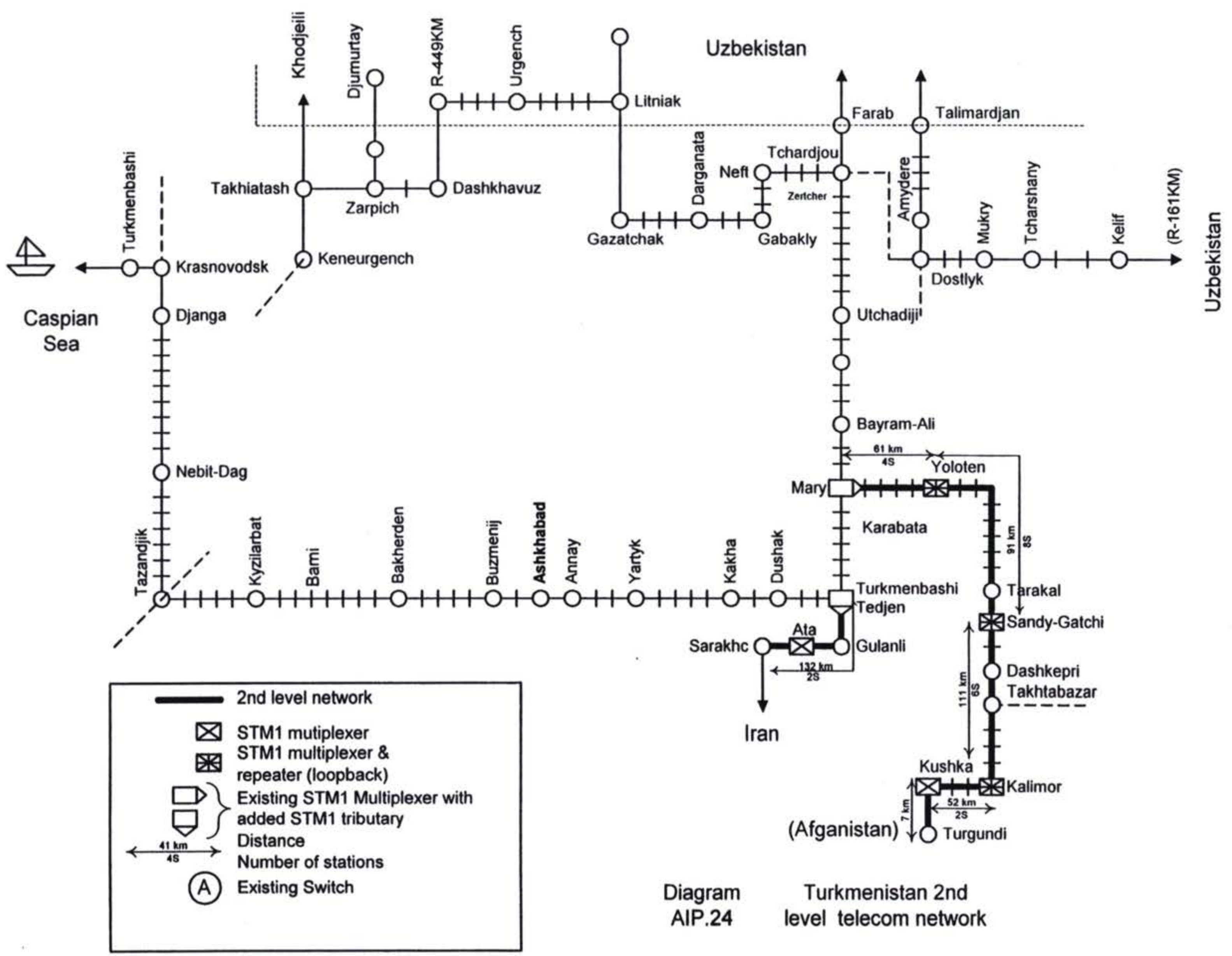
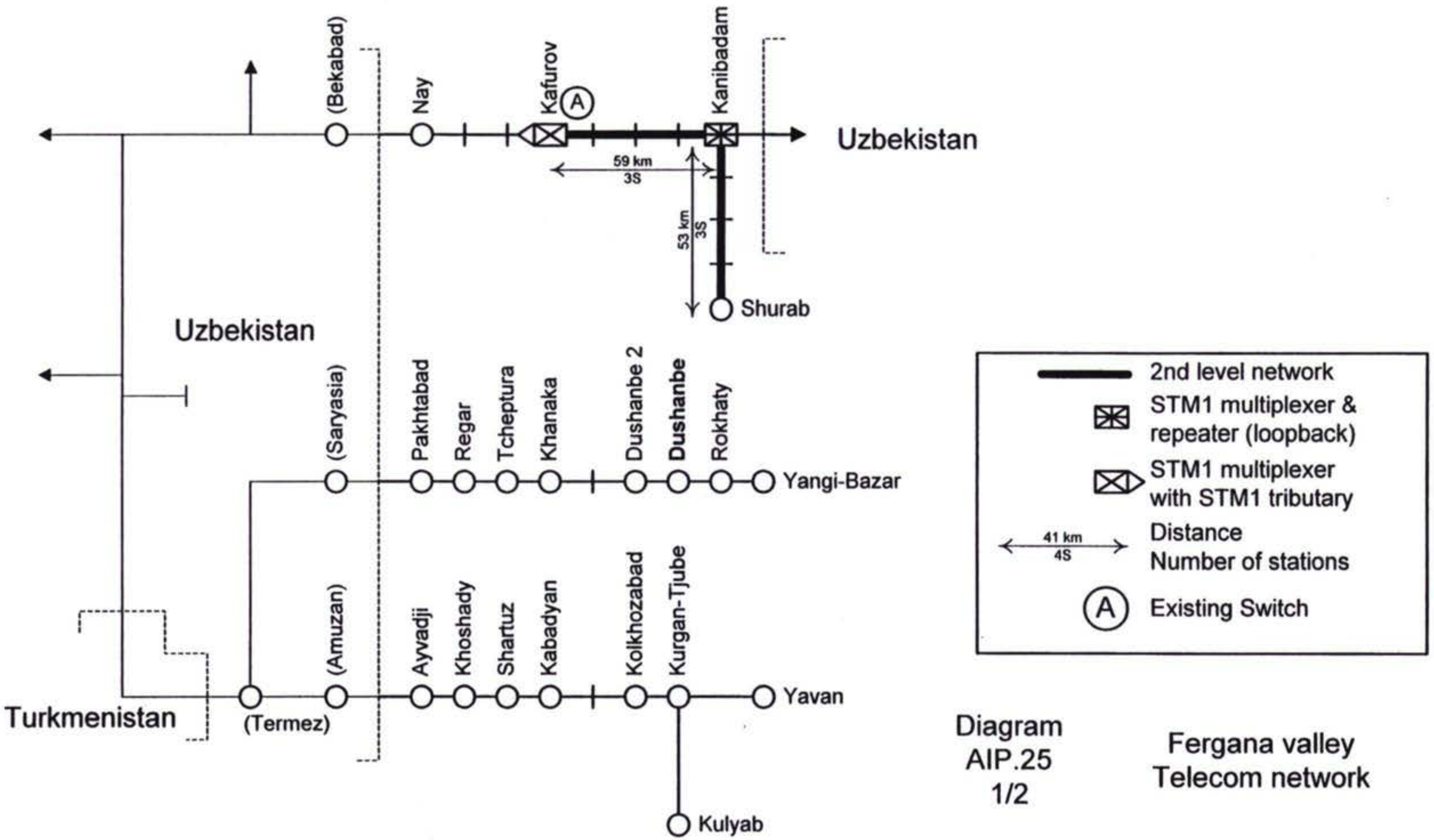


Diagram AIP.24 Turkmenistan 2nd level telecom network

Appendix 3 - Network of secondary railway lines



Appendix 3 - Network of secondary railway lines

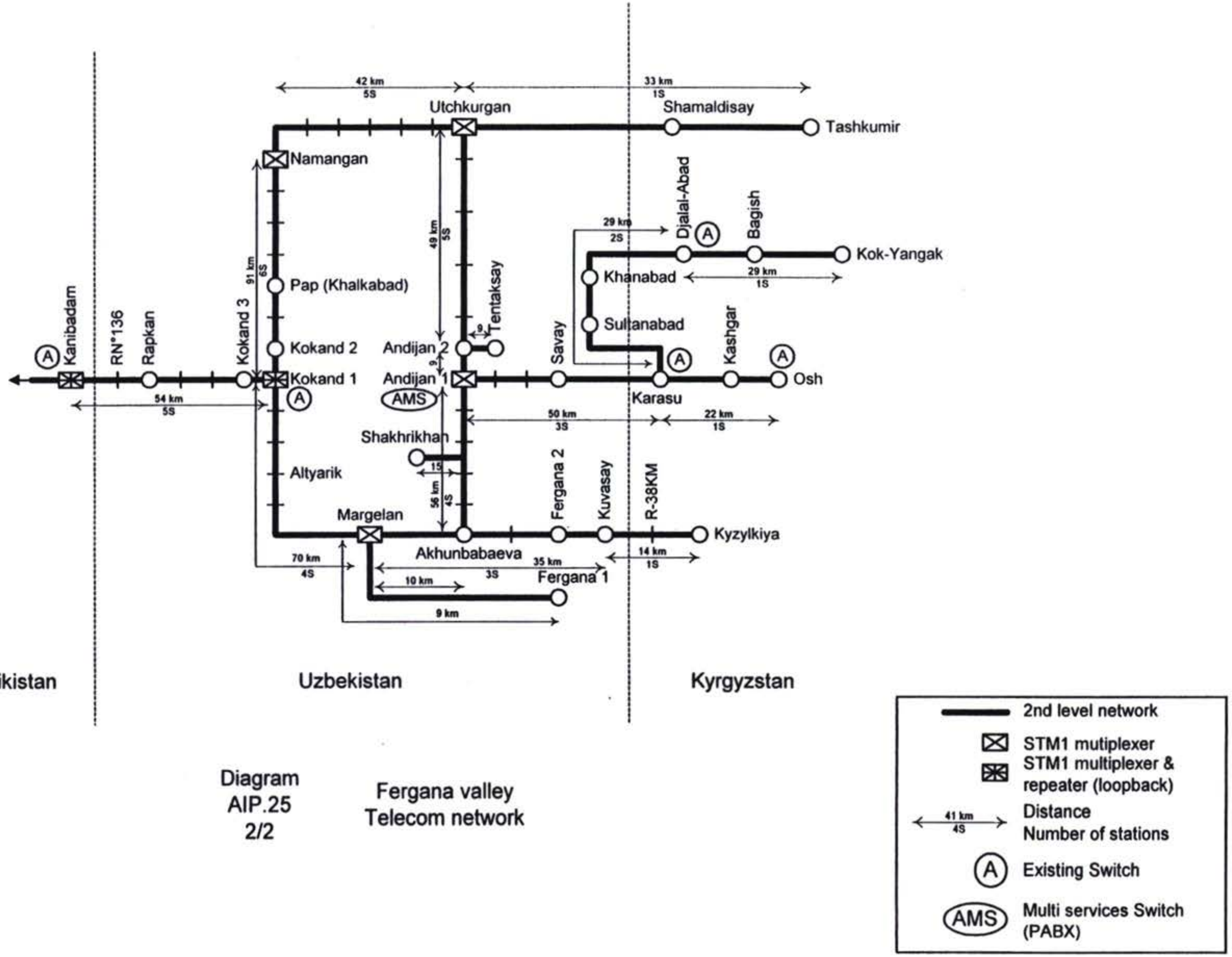


Diagram
AIP.25
2/2

Fergana valley
Telecom network

Appendix 3 - Network of secondary railway lines

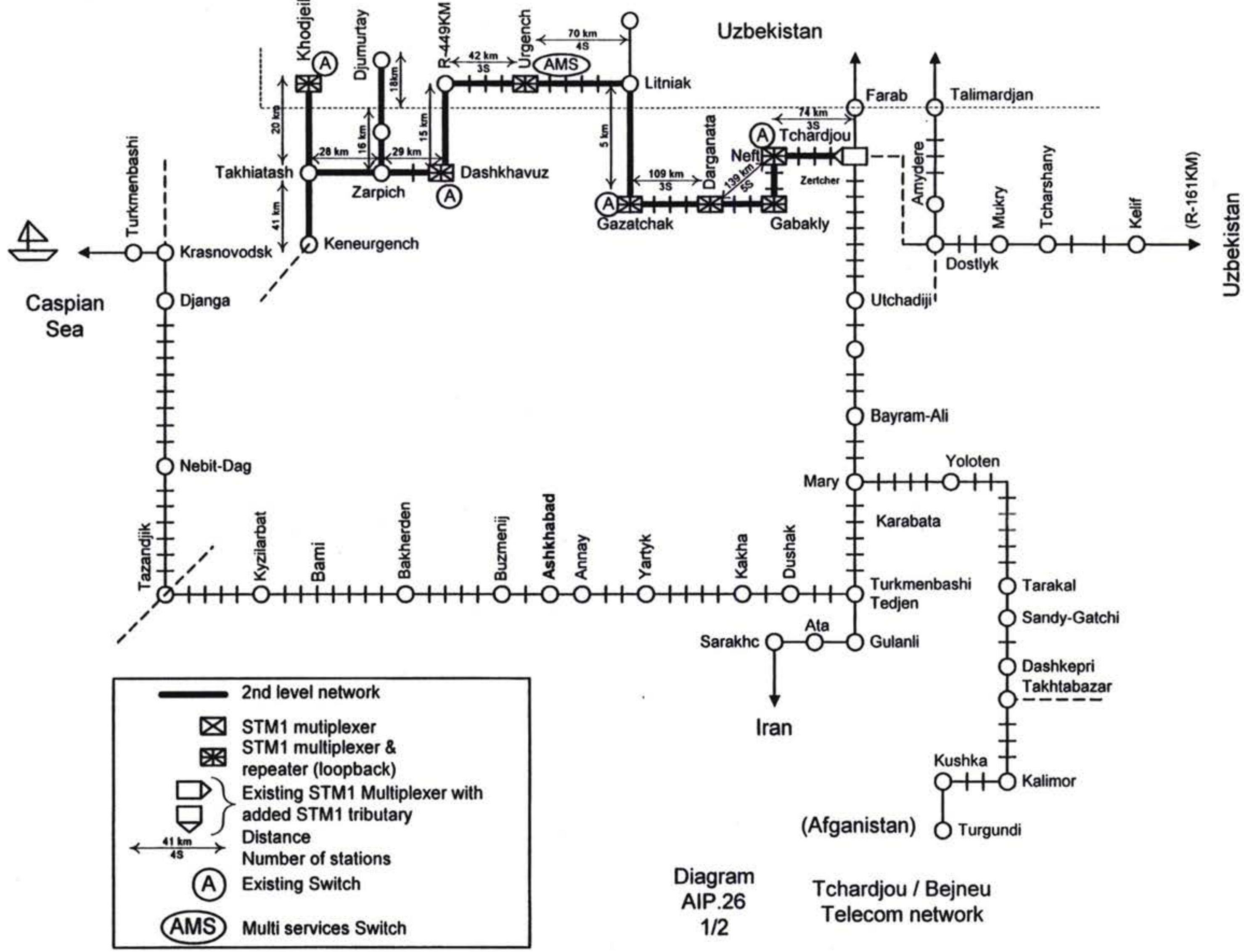


Diagram AIP.26 1/2

Tchardjou / Bejneu Telecom network

Appendix 3 - Network of secondary railway lines

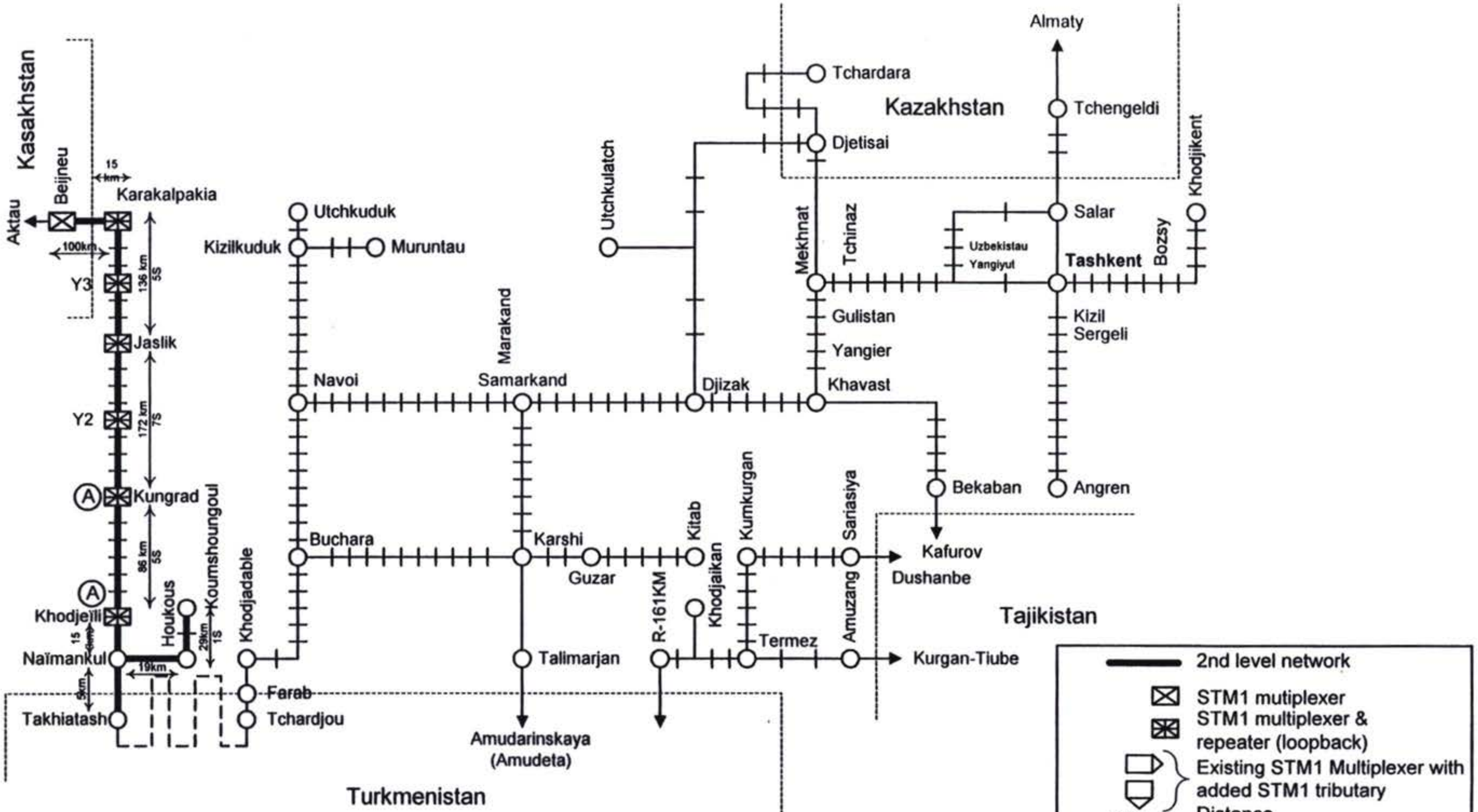


Diagram
AIP.26
2/2

Tchardjou / Bejneu
Telecom network

Chapter 6

Central Asia - Recommendations and economic study Appendix 4 - Investment tables for the network of secondary railway lines

Investment in the secondary network, Central Asia - 03/03/99

	EU Investissement (Millions of ECU)	Railway investment (Millions of ECU)	Total
Kazakhstan	0,84	0,18	1,02
Ouzbekistan	4,24	0,98	5,22
Turkmenistan	3,36	0,65	4,02
Fergana Valley	6,11	1,05	7,16
Tchardjou/Beijneu	8,07	1,65	9,73
Total	**22,64**	**4,51**	**27,14**

Investment in the secondary network, Kazakhstan
(V0.7 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	investment (adjusted to reflect local labour costs) (millions of ECU)
	cabling	supplies (24 fibres)	0		20,5	0,00	0,00	
	cabling	supplies (6 fibres)	122		17	2,07	0,31	
	cabling	supervision of staking-out work	122		2	0,24	0,04	
	cabling	installing links	122		4	0,49	0,07	
	cabling	staking out, civil engineering and laying (including labour)	122		95	11,59		0,18
1	**total expenditure on cabling**					14,40	0,43	0,18
	large and medium-sized stations			1				
	smaller stations			8				
	total stations			9				
	number of links	(distribution network)		2				
	number of SDH nodes			0				
	Number of SDH repeaters			0				
	Number of STM1 tributaries			0				
2.1	**STM1 equipment**			0	190	0,00	0,00	
2.2	**hooking up STM1 equipment**			0	20	0,00	0,00	
2,3	**STM1 Repeaters**			0	110	0,00	0,00	
2,4	**hooking up STM1 equipment**			0	10	0,00	0,00	
2,5	**STM1 tributaries**			0	55	0,00	0,00	
2,6	**hooking up STM1 equipment**			0	5	0,00	0,00	
3	**SDH management**			0	700	0,00	0,00	
4.1	**synchronisation**	Primary clock		0	100	0,00	0,00	
4.2	**synchronisation**	SSU		0	75	0,00	0,00	
4.3	**synchronisation**	GPS		0	25	0,00	0,00	
5,1	**ADM equipment**			11	64	0,70	0,11	
5.2	**hooking up ADM equipment**			11	8	0,09	0,01	
6	**ADM management**			0	100	0,00	0,00	
7.1	**PABX**	(equipment and management)		0	2000	0,00	0,00	
7.2	**PABX**	(technical facilities, power supply, etc.)		0	600	0,00	0,00	
8	**low-capacity power supply**	(ADM, low-capacity station centre)		8	15	0,12	0,02	
9	**medium-capacity energy supply**	(STM1, medium-capacity station centre)		1	72	0,07	0,01	
11.1	**medium station equipment**	(30 lines)		1	220	0,22	0,03	
11.2	**hooking up**	(30 lines)		1	21	0,02	0,00	
12.1	**small station equipment**	(6 lines)		8	44	0,35	0,05	
12.2	**hooking up**	(6 lines)		8	4	0,03	0,00	
13	**spares**	(10% of items (2-12))				0,16	0,02	
14	**training**			1	728	0,73	0,11	
		Total of items (1-14)				16,89	0,80	0,18
15	**provision for contingencies**	5% of aggregate investment (items 1-14)				0,84	0,04	
		AGGREGATE TOTAL of items 1-15				**17,74**	**0,84**	**0,18**

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Investment (adjusted to reflect local labour costs) (millions of ECU)
	cabling	supplies (24 fibres)	157		20,5	3,22	0,49	
	cabling	supplies (6 fibres)	521		17	8,86	1,34	
	cabling	supervision of staking-out work	678		2	1,36	0,21	
	cabling	installing links	678		4	2,71	0,41	
	cabling	staking out, civil engineering and laying (including labour)	678		95	64,41		0,98
1	total expenditure on cabling					80,55	2,45	0,98
	large and medium-sized stations			7				
	smaller stations			39				
	total stations			46				
	number of links	(distribution network)		7				
	number of SDH nodes			1				
	Number of SDH repeaters			1				
	Number of STM1 tributaries			2				
2 1	STM1 equipment			1	190	0,19	0,03	
2 2	hooking up STM1 equipment			1	20	0,02	0,00	
2,3	STM1 Repeaters			1	110	0,11	0,02	
2,4	hooking up STM1 equipment			1	10	0,01	0,00	
2,5	STM1 tributaries			2	55	0,11	0,02	
2,6	hooking up STM1 equipment			2	5	0,01	0,00	
3	SDH management			0	700	0,00	0,00	
4 1	synchronisation	Primary clock		0	100	0,00	0,00	
4 2	synchronisation	SSU		0	75	0,00	0,00	
4 3	synchronisation	GPS		0	25	0,00	0,00	
5,1	ADM equipment			53	64	3,39	0,51	
5 2	hooking up ADM equipment			53	8	0,42	0,06	
6	ADM management			0	100	0,00	0,00	
7 1	PABX	(equipment and management)		0	2000	0,00	0,00	
7 2	PABX	(technical facilities, power supply, etc.)		0	600	0,00	0,00	
8	low-capacity power supply	(ADM, low-capacity station centre)		39	15	0,59	0,09	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		7	72	0,50	0,08	
11 1	medium station equipment	(30 lines)		7	220	1,54	0,23	
11 2	hooking up	(30 lines)		7	21	0,15	0,02	
12 1	small station equipment	(6 lines)		39	44	1,72	0,26	
12 2	hooking up	(6 lines)		39	4	0,16	0,02	
13	spares	(10% of items (2-12))				0,88	0,13	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				91,07	4,04	0,98
15	provision for contingencies	5% of aggregate investment (items 1-14)				4,55	0,20	
		AGGREGATE TOTAL of items 1-15				95,62	4,24	0,98

Investment in the secondary network, Turkmenistan
(V0.7 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	investment (adjusted to reflect local labour costs) (millions of ECU)
	cabling	supplies (24 fibres)	454		20,5	9,31	1,41	
	cabling	supplies (6 fibres)	0		17	0,00	0,00	
	cabling	supervision of staking-out work	454		2	0,91	0,14	
	cabling	installing links	454		4	1,82	0,28	
	cabling	staking out, civil engineering and laying (including labour)	454		95	43,13		0,65
1	total expenditure on cabling					55,16	1,82	0,65
	large and medium-sized stations			7				
	smaller stations			21				
	total stations			28				
	number of links	(distribution network)		8				
	number of SDH nodes			5				
	Number of SDH repeaters			3				
	Number of STM1 tributaries			2				
2.1	STM1 equipment			5	190	0,95	0,14	
2.2	hooking up STM1 equipment			5	20	0,10	0,02	
2,3	STM1 Repeaters			3	110	0,33	0,05	
2,4	hooking up STM1 equipment			3	10	0,03	0,00	
2,5	STM1 tributaries			2	55	0,11	0,02	
2,6	hooking up STM1 equipment			2	5	0,01	0,00	
3	SDH management			0	700	0,00	0,00	
4.1	synchronisation	Primary clock		0	100	0,00	0,00	
4.2	synchronisation	SSU		0	75	0,00	0,00	
4.3	synchronisation	GPS		0	25	0,00	0,00	
5,1	ADM equipment			36	64	2,30	0,35	
5.2	hooking up ADM equipment			36	8	0,29	0,04	
6	ADM management			0	100	0,00	0,00	
7.1	PABX	(equipment and management)		0	2000	0,00	0,00	
7.2	PABX	(technical facilities, power supply, etc.)		0	600	0,00	0,00	
8	low-capacity power supply	(ADM, low-capacity station centre)		21	15	0,32	0,05	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		7	72	0,50	0,08	
11.1	medium station equipment	(30 lines)		7	220	1,54	0,23	
11.2	hooking up	(30 lines)		7	21	0,15	0,02	
12.1	small station equipment	(6 lines)		21	44	0,92	0,14	
12.2	hooking up	(6 lines)		21	4	0,08	0,01	
13	spares	(10% of items (2-12))				0,76	0,11	
14	training			1	728	0,73	0,11	
		Total of items (1-14)				64,28	3,20	0,65
15	provision for contingencies	5% of aggregate investment (items 1-14)				3,21	0,16	
		AGGREGATE TOTAL of items 1-15				67,49	3,36	0,65

Investment in the secondary network, Fergana valley
(V0.7 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	investment (adjusted to reflect local labour costs) (millions of ECU)
	cabling	supplies (24 fibres)	440		20,5	9,02	1,37	
	cabling	supplies (6 fibres)	288		17	4,90	0,74	
	cabling	supervision of staking-out work	728		2	1,46	0,22	
	cabling	installing links	728		4	2,91	0,44	
	cabling	staking out, civil engineering and laying (including labour)	728		95	69,16		1,05
1	total expenditure on cabling					87,44	2,77	1,05
	large and medium-sized stations			9				
	smaller stations			55				
	total stations			64				
	number of links	(distribution network)		16				
	number of SDH nodes			7				
	Number of SDH repeaters			2				
	Number of STM1 tributaries			1				
2.1	STM1 equipment			7	190	1,33	0,20	
2.2	hooking up STM1 equipment			7	20	0,14	0,02	
2,3	STM1 Repeaters			2	110	0,22	0,03	
2,4	hooking up STM1 equipment			2	10	0,02	0,00	
2,5	STM1 tributaries			1	55	0,06	0,01	
2,6	hooking up STM1 equipment			1	5	0,01	0,00	
3	SDH management			1	700	0,70	0,11	
4.1	synchronisation	Primary clock		1	100	0,10	0,02	
4.2	synchronisation	SSU		1	75	0,08	0,01	
4.3	synchronisation	GPS		1	25	0,03	0,00	
5,1	ADM equipment			80	64	5,12	0,78	
5.2	hooking up ADM equipment			80	8	0,64	0,10	
6	ADM management			1	100	0,10	0,02	
7.1	PABX	(equipment and management)		1	1600	1,60	0,24	
7.2	PABX	(technical facilities, power supply, etc.)		1	600	0,60	0,09	
8	low-capacity power supply	(ADM, low-capacity station centre)		55	15	0,83	0,13	
9	medium-capacity energy supply	(STM1, medium-capacity station centre)		9	72	0,65	0,10	
11.1	medium station equipment	(30 lines)		9	220	1,98	0,30	
11.2	hooking up	(30 lines)		9	21	0,19	0,03	
12.1	small station equipment	(6 lines)		55	44	2,42	0,37	
12.2	hooking up	(6 lines)		55	4	0,22	0,03	
13	spares	(10% of items (2-12))				1,68	0,25	
14	training			1	1456	1,46	0,22	
		Total of items (1-14)				107,59	5,82	1,05
15	provision for contingencies	5% of aggregate investment (items 1-14)				5,38	0,29	
		AGGREGATE TOTAL of items 1-15				112,97	6,11	1,05

Investment in the secondary network, Tchardjou/Beijneu
(V0.7 26/02/99)

Item No.	Item description	Comments	Length in km	Number of units	Unit price (in thousands of FRF)	Total (millions of FRF)	EU total (millions of ECU)	Investment (adjusted to reflect local labour costs) (millions of ECU)
	cabling	supplies (24 fibres)	1025		20,5	21,01	3,18	
	cabling	supplies (6 fibres)	123		17	2,09	0,32	
	cabling	supervision of staking-out work	1148		2	2,30	0,35	
	cabling	installing links	1148		4	4,59	0,70	
	cabling	staking out, civil engineering and laying (including labour)	1148		95	109,06		1,65
1	**total expenditure on cabling**					139,05	4,54	1,65
	large and medium-sized stations			9				
	smaller stations			46				
	total stations			55				
	number of links	(distribution network)		12				
	number of SDH nodes			13				
	Number of SDH repeaters			12				
	Number of STM1 tributaries			1				
2 1	**STM1 equipment**			13	190	2,47	0,37	
2 2	**hooking up STM1 equipment**			13	20	0,26	0,04	
2,3	**STM1 Repeaters**			12	110	1,32	0,20	
2,4	**hooking up STM1 equipment**			12	10	0,12	0,02	
2,5	**STM1 tributaries**			1	55	0,06	0,01	
2,6	**hooking up STM1 equipment**			1	5	0,01	0,00	
3	**SDH management**			1	700	0,70	0,11	
4 1	**synchronisation**	Primary clock		1	100	0,10	0,02	
4 2	**synchronisation**	SSU		1	75	0,08	0,01	
4 3	**synchronisation**	GPS		1	25	0,03	0,00	
5,1	**ADM equipment**			67	64	4,29	0,65	
5 2	**hooking up ADM equipment**			67	8	0,54	0,08	
6	**ADM management**			1	100	0,10	0,02	
7 1	**PABX**	(equipment and management)		1	1200	1,20	0,18	
7 2	**PABX**	(technical facilities, power supply, etc)		1	600	0,60	0,09	
8	**low-capacity power supply**	(ADM, low-capacity station centre)		46	15	0,69	0,10	
9	**medium-capacity energy supply**	(STM1, medium-capacity station centre)		9	72	0,65	0,10	
11 1	**medium station equipment**	(30 lines)		9	220	1,98	0,30	
11 2	**hooking up**	(30 lines)		9	21	0,19	0,03	
12 1	**small station equipment**	(6 lines)		46	44	2,02	0,31	
12 2	**hooking up**	(6 lines)		46	4	0,18	0,03	
13	**spares**	(10% of items (2-12))				1,74	0,26	
14	**training**			1	1456	1,46	0,22	
		Total of items (1-14)				159,82	7,69	1,65
15	**provision for contingencies**	5% of aggregate investment (items 1-14)				7,99	0,38	
		AGGREGATE TOTAL of items 1-15				**167,81**	**8,07**	**1,65**

Chapter 6

Central Asia - Recommendations and economic study
Appendix 5 - Telecom switches

ıvestment in PABX systems, Central Asia - Sur ary

	EU Investissement (Millions of ECU)	Railway investment (Millions of ECU)	Total
Kazakhstan	0,17	0,02	0,19
Kirghistan	0,00	0,00	0,00
Ouzbekistan	0,55	0,05	0,61
Tadjikistan	0,00	0,00	0,00
Turkmenista	0,00	0,00	0,00
Total	**0,72**	**0,08**	**0,80**

	number of telephones	telephones to be fitted	unit price (FRF)	Total (FRF)	Total EU investment (ECU)	Total railway investment (ECU)
Sary-Ozek						
PABX	700	700	1 000	700 000	106 061	
service to subscribers	700	700	150	105 000		15 909
Beskol				0		
PABX	200	200	1 000	200 000	30 303	
service to subscribers	200	200	150	30 000		4 545
Training					25 000	
Contingencies					8 068	1 023
Total					**169 432**	**20 455**

	number of telephones	telephones to be fitted	unit price (FRF)	Total (FRF)	Total EU investment (ECU)	Total railway investment (ECU)
Samarkand						
PABX	1 000	1 000	1 000	1 000 000	151 515	
service to subscribers	1 000	1 000	150	150 000		22 727
technical facilities	1	1	500 000	500 000	75 758	
Karshi				0		
PABX	1 300	1 300	1 000	1 300 000	196 970	
service to subscribers	1 300	1 300	150	195 000		29 545
technical facilities	1	1	500 000	500 000	75 758	
Training					25 000	
Contingencies					26 250	2 614
Total					**551 250**	**54 886**

Chapter 6

Central Asia - Recommendations and economic study
Appendix 6 - Economic tables

Hypothesis

	KAZAKHSTAN	UZBEKISTAN	KYRGYZSTAN	TURKMENISTAN	France
Length of cable laid (in km)	1808	1454	327	1364	
Line length (in km)	13280	3655	427	2313	
PCM Cost US$	0,014	0,014	0,014	0,014	0,057
Black Fibre Cost US$	0,001	0,001	0,0005	0,001	0,0013 à 0,0033
km loco / year	144 000	110 000	63 000	80 000	
Delays growth rate	1,03	1,03	1,03	1,03	

TRI

	KAZAKHSTAN	UZBEKISTAN	KYRGYZSTAN	TURKMENISTAN
+0%	20%	19%	18%	20%
+10%	19%	18%	16%	18%
-10%	22%	21%	21%	22%

	Kazakhstan	Ouzbékistan	Kirghistan	Turkménistan
Line length (in km)	13 280	3 655	427	2 313
Length of cable laid (in km)	1 808	1 454	327	1 364
Telecomunications and Signalling staff	11 190	3 290	245	1 790
Telecomunications staff *	4 476	1 316	98	716
Expenditure in 1,000 US $				
salaries and social insurance	21 693	3 925	219	1 367
materials	2 627	396	48	309
repairs and repair fund	0	676	0	0
other costs	6 120	2 803	176	1 041
Total	**30 440**	**7 800**	**443**	**2 717**
Total cost	4 144	3 103	339	1 602
Maintenance and Operating costs in 1000 US$	**1 658**	**1 241**	**136**	**641**
$ / year / employee (salary+social security contributions)	1 939	1 193	893	764

Sources : Traceca - Central Asia Railways Restructuring (A-D) modules

* 40 % of total

Maintenance and operating costs	6
* equipment: 2 % of investment in equipment	0,02
* cable : 1 FRF/m	1,00

in Millions of US $	Kazakhstan	Ouzbekistan	Kirghistan	Turkmenistan
cable length (in km)	1808	1454	327	1364
Total Inv	19,93	16,31	4,24	14,27
Inv for equipments	7,27	5,96	1,80	4,79
Operations	0,15	0,12	0,04	0,10
Cable maintenance	0,30	0,24	0,05	0,23
M+O Total	**0,45**	**0,36**	**0,09**	**0,32**

inv +10%

Maintenance and operating costs	6
* equipment: 2 % of investment in equipment	0,02
* cable : 1 FRF/m	1,00

in Millions of US $	Kazakhstan	Ouzbekistan	Kirghistan	Turkmenistan
cable length (in km)	1808	1454	327	1364
Total Inv	21,93	17,94	4,66	15,69
Inv for equipments	8,00	6,56	1,98	5,26
Operations	0,16	0,13	0,04	0,11
Cable maintenance	0,30	0,24	0,05	0,23
M+O Total	**0,46**	**0,37**	**0,09**	**0,33**

inv -10%

Maintenance and operating costs	6
* equipment: 2 % of investment in equipment	0,02
* cable : 1 FRF/m	1,00

in Millions of US $	Kazakhstan	Ouzbekistan	Kirghistan	Turkmenistan
cable length (in km)	1808	1454	327	1364
Total Inv	17,94	14,68	3,81	12,84
Inv for equipments	6,54	5,37	1,62	4,31
Operations	0,13	0,11	0,03	0,09
Cable maintenance	0,30	0,24	0,05	0,23
M+O Total	**0,43**	**0,35**	**0,09**	**0,31**

Unit price (in thousands of FRF)	TOTAL (in millions of FRF)	TOTAL (in millions of ECU)	TOTAL (in millions of US$)	Residual value per remaining year
Backbone	118,34	17,93	**19,72**	0,217
PABX	1,25	0,19	**0,21**	
Total	**119,59**	**18,12**	**19,93**	over 30 years
divided into: equipments	43,63	6,61	7,27	6,51
: optical cable	65,08	9,86	10,85	
+ 10 %				
Backbone	130,17	19,72	21,70	0,239
PABX	1,38	0,21	0,23	
Total	**131,55**	**19,93**	**21,93**	over 30 years
divided into: equipments	47,99	7,27	8,00	7,16
: optical cable	71,58	10,85	11,93	
- 10 %				
Backbone	106,50	16,14	17,75	0,195
PABX	1,13	0,17	0,19	
Total	**107,63**	**16,31**	**17,94**	over 30 years
divided into: equipments	39,26	5,95	6,54	5,86
: optical cable	58,57	8,87	9,76	

Unit price (in thousands of FRF)	TOTAL (in millions of FRF)	TOTAL (in millions of ECU)	TOTAL (in millions of US$)	Residual value per remaining year
Backbone	25,41	3,85	4,24	0,039
PABX	0,00	0,00	0,00	
Total	**25,41**	**3,85**	**4,24**	over 30 years
divided into: equipments	10,82	1,64	1,80	1,17
: optical cable	11,75	1,78	1,96	
+ 10 %				
Backbone	27,95	4,24	4,66	0,043
PABX	0,00	0,00	0,00	
Total	**27,95**	**4,24**	**4,66**	over 30 years
divided into: equipments	11,91	1,80	1,98	1,29
: optical cable	12,92	1,96	2,15	
- 10 %				
Backbone	22,87	3,47	3,81	0,035
PABX	0,00	0,00	0,00	
Total	**22,87**	**3,47**	**3,81**	over 30 years
divided into: equipments	9,74	1,48	1,62	1,06
: optical cable	10,57	1,60	1,76	

Unit price (in thousands of FRF)	TOTAL (in millions of FRF)	TOTAL (in millions of ECU)	TOTAL (in millions of US$)	Residual value per remaining year
Backbone	93,85	14,22	15,64	0,174
PABX	4,03	0,61	0,67	
Total	**97,88**	**14,83**	**16,31**	over 30 years
divided into: equipments	35,77	5,42	5,96	5,23
: optical cable	52,34	7,93	8,72	
+ 10 %				
Backbone	103,24	15,64	17,21	0,192
PABX	4,43	0,67	0,74	
Total	**107,67**	**16,31**	**17,94**	over 30 years
divided into: equipments	39,35	5,96	6,56	5,76
: optical cable	57,57	8,72	9,60	
- 10 %				
Backbone	84,47	12,80	14,08	0,157
PABX	3,62	0,55	0,60	
Total	**88,09**	**13,35**	**14,68**	over 30 years
divided into: equipments	32,19	4,88	5,37	4,71
: optical cable	47,10	7,14	7,85	

Unit price (in thousands of FRF)	**TOTAL (in millions of FRF)**	**TOTAL (in millions of ECU)**	**TOTAL (in millions of US$)**	**Residual value per remaining year**
Backbone	85,60	12,97	14,27	0,164
PABX	0,00	0,00	0,00	
Total	**85,60**	**12,97**	**14,27**	over 30 years
divided into: equipments	28,71	4,35	4,79	4,91
: optical cable	49,10	7,44	8,18	
+ 10 %				
Backbone	94,16	14,27	15,69	0,180
PABX	0,00	0,00	0,00	
Total	**94,16**	**14,27**	**15,69**	over 30 years
divided into: equipments	31,58	4,79	5,26	5,40
: optical cable	54,01	8,18	9,00	
- 10 %				
Backbone	77,04	11,67	12,84	0,147
PABX	0,00	0,00	0,00	
Total	**77,04**	**11,67**	**12,84**	over 30 years
divided into: equipments	25,84	3,92	4,31	4,42
: optical cable	44,19	6,70	7,37	

3% growth/year for delays caused by old equipment

KAZAKHSTAN		Hypothesis like Uzbekistan
Line length (in km)	13280	Delays growth rate
Length of cable laid (in km)	1808	1,03

Years	**2 000**	**2 001**	**2 002**	**2 003**	**2 004**	**2 005**	**2 006**	**2 007**	**2 008**	**2 009**	**2 010**	**2 011**	**2 012**	**2 013**	**2 014**	**2 015**	**2 016**	**2 017**	**2 018**	**2 019**
Delays																				
hours / year	6 474	6 668	6 868	7 074	7 287	7 505	7 730	7 962	8 201	8 447	8 701	8 962	9 230	9 507	9 793	10 086	10 389	10 701	11 022	11 352
proportion attributed to cable section laid (in km)	3 202	3 299	3 397	3 499	3 604	3 713	3 824	3 939	4 057	4 178	4 304	4 433	4 566	4 703	4 844	4 989	5 139	5 293	5 452	5 616
number of locos	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Cost	2,2	0,0	0,0	0,0	2,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2	0,0	0,0
Residual Value	0,11	0	0	0	0,55	0	0	0	0	0	0	0	0	0	0	0	0	1,98	0	0
Total Residual Value	**2,64**																			

Locomotive

Cost of one locomotive	2,2 M US $	
Lifespan (in years)	20	**144 000 km/year**
		12 000 km/month
		40 km/hrs
		300 hrs/month
		3600 hrs/year

HYPOTHESIS (source : Study on Kyrgyzstan) : in 1997, 1655 hours of downtime
3% growth/year for delays caused by old equipment

	KYRGYZSTAN	Delays growth rate
Line length (in km)	**427**	
Length of cable laid (in km)	327	1,03

Years	**2 000**	**2 001**	**2 002**	**2 003**	**2 004**	**2 005**	**2 006**	**2 007**	**2 008**	**2 009**	**2 010**	**2 011**	**2 012**	**2 013**	**2 014**	**2 015**	**2 016**	**2 017**	**2 018**	**2 019**
Delays																				
hours / year	1 655	1 705	1 756	1 808	1 863	1 919	1 976	2 035	2 097	2 159	2 224	2 291	2 360	2 430	2 503	2 578	2 656	2 735	2 818	2 902
proportion attributed to cable section laid (in km)	1267	1305	1345	1385	1426	1469	1513	1559	1606	1654	1703	1754	1807	1861	1917	1975	2034	2095	2158	2222
number of locos	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Cost	2,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Residual Value	0,11	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,43	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total Residual Value	**1,54**																			

		Diesel locomotive
Cost of one locomotive	2,2 M US $	
Lifespan (in years)	20	**71 000 km/year**
		5 917 km/month
		40 km/hrs
		148 hrs/month
		1775 hrs/year

HYPOTHESIS (source : Study on Uzbekistan) : in 96, 2158 incidents lasting on average 3hrs
2% growth/year for delays caused by old equipment

UZBEKISTAN

Line length (in km)	3655	Delays growth rate	
Length of cable laid (in km)	1454	1,03	

Years	**2 000**	**2 001**	**2 002**	**2 003**	**2 004**	**2 005**	**2 006**	**2 007**	**2 008**	**2 009**	**2 010**	**2 011**	**2 012**	**2 013**	**2 014**	**2 015**	**2 016**	**2 017**	**2 018**	**2 019**
Delays																				
hours / year	6 474	6 668	6 868	7 074	7 287	7 505	7 730	7 962	8 201	8 447	8 701	8 962	9 230	9 507	9 793	10 086	10 389	10 701	11 022	11 352
proportion attributed to cable section laid (in km)	2575	2653	2732	2814	2899	2986	3075	3167	3262	3360	3461	3565	3672	3782	3896	4012	4133	4257	4384	4516
number of locos	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost	2,2	0	0	2,2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,11	0	0	0,44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Residual Value	**0,55**																			

Locomotive

Cost of one locomotive	2,2 M US $	
Lifespan (in years)	20	**110 000 km/year**
		9 167 km/month
		40 km/hrs
		229 hrs/month
		2750 hrs/year

HYPOTHESIS (source : Study on Turkmenistan) : en 1996, 6000 hours of downtime
3% growth/year for delays caused by old equipment

	TURKMENISTAN	Delays growth rate
Line length (in km)	**2313**	
Length of cable laid (in km)	1364	1,03

Years	**2 000**	**2 001**	**2 002**	**2 003**	**2 004**	**2 005**	**2 006**	**2 007**	**2 008**	**2 009**	**2 010**	**2 011**	**2 012**	**2 013**	**2 014**	**2 015**	**2 016**	**2 017**	**2 018**	**2 019**
Delays																				
hours / year	6 000	6 180	6 365	6 556	6 753	6 956	7 164	7 379	7 601	7 829	8 063	8 305	8 555	8 811	9 076	9 348	9 628	9 917	10 215	10 521
proportion attributed to cable section laid (in km)	3538	3644	3754	3866	3982	4102	4225	4352	4482	4617	4755	4898	5045	5196	5352	5512	5678	5848	6024	6204
number of locos	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Cost	4,4	0	0	0	0	2,2	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Residual Value	0,22	0,00	0,00	0,00	0,00	0,66	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,09	0,00
Total Residual Value	**2,97**																			

			Diesel locomotive
Cost of one locomotive	2,2	M US $	
Lifespan (in years)	20		**80 000 km/year**
			6 667 km/month
			40 km/hrs
			167 hrs/month
			2000 hrs/year

(In millions of US $) KAZAKHSTAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	1,658	1,691	1,725	1,759	1,794	1,830	1,867	1,904	1,942	1,981	2,021	2,061	2,102	2,144	2,187	2,231	2,276	2,321	2,368	2,415
Inv Loco	2,2	0,0	0,0	0,0	2,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,2	0,0	0,0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,6
Cash flow	**-3,858**	**-1,691**	**-1,725**	**-1,759**	**-3,994**	**-1,830**	**-1,867**	**-1,904**	**-1,942**	**-1,981**	**-2,021**	**-2,061**	**-2,102**	**-2,144**	**-2,187**	**-2,231**	**-2,276**	**-4,521**	**-2,368**	**0,225**
Project case : S1																				
Investments	19,93																			
Maintenance cost	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45
Residual Value	0																			6,508
PCM revenues	0,00	0,00	0,00	0,09	0,18	0,26	0,35	0,44	0,53	0,62	0,71	0,79	0,88	0,88	0,88	0,88	0,88	0,88	0,88	0,88
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,81	1,81	3,62	3,62	5,42	5,42	7,23	7,23	9,04	9,04	10,85	10,85	10,85
Cash flow	**-20,38**	**-0,45**	**-0,45**	**-0,36**	**-0,27**	**-0,18**	**-0,09**	**1,80**	**1,89**	**3,79**	**3,87**	**5,77**	**5,86**	**7,67**	**7,67**	**9,48**	**9,48**	**11,28**	**11,28**	**17,79**
S1-S0	**-16,52**	**1,24**	**1,28**	**1,40**	**3,72**	**1,65**	**1,77**	**3,71**	**3,83**	**5,77**	**5,90**	**7,83**	**7,96**	**9,81**	**9,85**	**11,71**	**11,75**	**15,80**	**13,65**	**17,57**

IRR **20%**

Locomotive cost	2,2	
Maintenance cost increase		1,02

VR
0 1
1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels	63
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,001
Number of km	1808

(In millions of US $) KAZAKHSTAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	1,658	1,691	1,725	1,759	1,794	1,830	1,867	1,904	1,942	1,981	2,021	2,061	2,102	2,144	2,187	2,231	2,276	2,321	2,368	2,415
Inv Loco	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,6
Cash flow	**-3,858**	**-1,691**	**-1,725**	**-1,759**	**-3,994**	**-1,830**	**-1,867**	**-1,904**	**-1,942**	**-1,981**	**-2,021**	**-2,061**	**-2,102**	**-2,144**	**-2,187**	**-2,231**	**-2,276**	**-4,521**	**-2,368**	**0,225**
Project case : S1																				
Investments	17,94																			
Maintenance cost	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43
Residual Value	0,00																			5,86
PCM revenues	0,00	0,00	0,00	0,09	0,18	0,26	0,35	0,44	0,53	0,62	0,71	0,79	0,88	0,88	0,88	0,88	0,88	0,88	0,88	0,88
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,81	1,81	3,62	3,62	5,42	5,42	7,23	7,23	9,04	9,04	10,85	10,85	10,85
Cash flow	**-18,37**	**-0,43**	**-0,43**	**-0,34**	**-0,26**	**-0,17**	**-0,08**	**1,82**	**1,90**	**3,80**	**3,89**	**5,79**	**5,87**	**7,68**	**7,68**	**9,49**	**9,49**	**11,30**	**11,30**	**17,15**
S1-S0	**-14,51**	**1,26**	**1,29**	**1,42**	**3,74**	**1,66**	**1,79**	**3,72**	**3,85**	**5,78**	**5,91**	**7,85**	**7,98**	**9,83**	**9,87**	**11,72**	**11,77**	**15,82**	**13,67**	**16,93**

IRR **22%**

VR

Locomotive cost	2,2		0	1
Maintenance cost increase		1,02		

1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels	63
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,001
Number of km	1808

(In millions of US $)   KAZAKHSTAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	1,658	1,691	1,725	1,759	1,794	1,830	1,867	1,904	1,942	1,981	2,021	2,061	2,102	2,144	2,187	2,231	2,276	2,321	2,368	2,415
Inv Loco	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,6
Cash flow	**-3,858**	**-1,691**	**-1,725**	**-1,759**	**-3,994**	**-1,830**	**-1,867**	**-1,904**	**-1,942**	**-1,981**	**-2,021**	**-2,061**	**-2,102**	**-2,144**	**-2,187**	**-2,231**	**-2,276**	**-4,521**	**-2,368**	**0,225**
Project case : S1																				
Investments	21,93																			
Maintenance cost	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461	0,461
Residual Value	0,00																			7,16
PCM revenues	0,00	0,00	0,00	0,09	0,18	0,26	0,35	0,44	0,53	0,62	0,71	0,79	0,88	0,88	0,88	0,88	0,88	0,88	0,88	0,88
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,81	1,81	3,62	3,62	5,42	5,42	7,23	7,23	9,04	9,04	10,85	10,85	10,85
Cash flow	**-22,39**	**-0,46**	**-0,46**	**-0,37**	**-0,28**	**-0,20**	**-0,11**	**1,79**	**1,88**	**3,77**	**3,86**	**5,76**	**5,84**	**7,65**	**7,65**	**9,46**	**9,46**	**11,27**	**11,27**	**18,43**
S1-S0	**-18,53**	**1,23**	**1,26**	**1,39**	**3,71**	**1,63**	**1,76**	**3,69**	**3,82**	**5,75**	**5,88**	**7,82**	**7,95**	**9,80**	**9,84**	**11,69**	**11,74**	**15,79**	**13,64**	**18,20**

IRR **19%**

Locomotive cost 2,2
Maintenance cost increase 1,02

VR
0 1

1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels 63
Average 2Mb/s PCM cost 0,014
Number of black fibres 12
Average black fibre cost 0,001
Number of km 1808

(In millions of US $) **KYRGYZSTAN**

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,136	0,138	0,141	0,144	0,147	0,150	0,153	0,156	0,159	0,162	0,165	0,169	0,172	0,175	0,179	0,183	0,186	0,190	0,194	0,198
Inv Loco	2,2	0	0	0	0	0	0	0	0	0	0	0	2,2	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,5
Cash flow	**-2,34**	**-0,14**	**-0,14**	**-0,14**	**-0,15**	**-0,15**	**-0,15**	**-0,16**	**-0,16**	**-0,16**	**-0,17**	**-0,17**	**-2,37**	**-0,18**	**-0,18**	**-0,18**	**-0,19**	**-0,19**	**-0,19**	**1,34**
Project case : S1																				
Investments	4,24																			
Maintenance and operation cost	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09
Residual Value	0,00																			1,17
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,05	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,50	0,50	0,50	0,50	0,50
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,16	0,16	0,33	0,33	0,49	0,49	0,65	0,65	0,82	0,82	0,98	0,98	0,98
Cash flow	**-4,33**	**-0,09**	**-0,09**	**-0,09**	**-0,09**	**-0,04**	**0,01**	**0,22**	**0,27**	**0,49**	**0,54**	**0,75**	**0,80**	**1,02**	**1,07**	**1,23**	**1,23**	**1,39**	**1,39**	**2,57**
S1-S0	**-1,99**	**0,05**	**0,05**	**0,05**	**0,06**	**0,11**	**0,16**	**0,38**	**0,43**	**0,65**	**0,70**	**0,92**	**3,18**	**1,19**	**1,25**	**1,41**	**1,42**	**1,58**	**1,59**	**1,23**

IRR **18%**

VR

Locomotive cost	2,2			0	1
Maintenance cost increase		1,02			
				1	PCM revenues
Number of free 2Mb/s PCM channels		36		1	Black fibres revenues
Average 2Mb/s PCM cost		0,014			
Number of black fibres		12			
Average black fibre cost		0,0005	/km		
number of km		327			

(In millions of US $) KYRGYZSTAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,136	0,138	0,141	0,144	0,147	0,150	0,153	0,156	0,159	0,162	0,165	0,169	0,172	0,175	0,179	0,183	0,186	0,190	0,194	0,198
Inv Loco	2,2	0	0	0	0	0	0	0	0	0	0	0	2,2	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,5
Cash flow	**-2,34**	**-0,14**	**-0,14**	**-0,14**	**-0,15**	**-0,15**	**-0,15**	**-0,16**	**-0,16**	**-0,16**	**-0,17**	**-0,17**	**-2,37**	**-0,18**	**-0,18**	**-0,18**	**-0,19**	**-0,19**	**-0,19**	**1,34**
Project case : S1																				
Investments	3,81																			
Maintenance and operation cost	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087	0,087
Residual Value	0,00																			1,06
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,05	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,50	0,50	0,50	0,50	0,50
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,16	0,16	0,33	0,33	0,49	0,49	0,65	0,65	0,82	0,82	0,98	0,98	0,98
Cash flow	**-3,90**	**-0,09**	**-0,09**	**-0,09**	**-0,09**	**-0,04**	**0,01**	**0,23**	**0,28**	**0,49**	**0,54**	**0,76**	**0,81**	**1,02**	**1,07**	**1,23**	**1,23**	**1,40**	**1,40**	**2,46**
S1-S0	**-1,56**	**0,05**	**0,05**	**0,06**	**0,06**	**0,11**	**0,17**	**0,38**	**0,44**	**0,65**	**0,71**	**0,93**	**3,18**	**1,20**	**1,25**	**1,42**	**1,42**	**1,59**	**1,59**	**1,11**

IRR **21%**

VR

0 1

Locomotive cost 2,2
Maintenance cost increase 1,02

1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels 36
Average 2Mb/s PCM cost 0,014
Number of black fibres 12
Average black fibre cost 0,0005 /km
number of km 327

(In millions of US $) KYRGYZSTAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,136	0,138	0,141	0,144	0,147	0,150	0,153	0,156	0,159	0,162	0,165	0,169	0,172	0,175	0,179	0,183	0,186	0,190	0,194	0,198
Inv Loco	2,2	0	0	0	0	0	0	0	0	0	0	0	2,2	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,5
Cash flow	**-2,34**	**-0,14**	**-0,14**	**-0,14**	**-0,15**	**-0,15**	**-0,15**	**-0,16**	**-0,16**	**-0,16**	**-0,17**	**-0,17**	**-2,37**	**-0,18**	**-0,18**	**-0,18**	**-0,19**	**-0,19**	**-0,19**	**1,34**
Project case : S1																				
Investments	4,66																			
Maintenance and operation cost	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,09
Residual Value	0,00																			1,29
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,05	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,50	0,50	0,50	0,50	0,50
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,16	0,16	0,33	0,33	0,49	0,49	0,65	0,65	0,82	0,82	0,98	0,98	0,98
Cash flow	**-4,75**	**-0,09**	**-0,09**	**-0,09**	**-0,09**	**-0,04**	**0,01**	**0,22**	**0,27**	**0,48**	**0,54**	**0,75**	**0,80**	**1,01**	**1,06**	**1,23**	**1,23**	**1,39**	**1,39**	**2,68**
S1-S0	**-2,42**	**0,04**	**0,05**	**0,05**	**0,05**	**0,11**	**0,16**	**0,38**	**0,43**	**0,65**	**0,70**	**0,92**	**3,17**	**1,19**	**1,24**	**1,41**	**1,41**	**1,58**	**1,58**	**1,34**

IRR **16%**

VR

0 1

Locomotive cost	2,2
Maintenance cost increase	1,02

1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels	36
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,0005 /km
number of km	327

(In millions of US $) **UZBEKISTAN**

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	1,24	1,27	1,29	1,32	1,34	1,37	1,40	1,43	1,45	1,48	1,51	1,54	1,57	1,61	1,64	1,67	1,70	1,74	1,77	1,81
Inv Loco	2,2	0	0	2,2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,6
Cash flow	**-3,44**	**-1,266**	**-1,291**	**-3,517**	**-1,344**	**-1,370**	**-1,398**	**-1,426**	**-1,454**	**-1,483**	**-1,513**	**-1,543**	**-1,574**	**-1,606**	**-1,638**	**-1,670**	**-1,704**	**-1,738**	**-1,773**	**-1,258**
Project case : S1																				
Investments	16,31																			
Maintenance cost	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36	0,36
Residual Value	0,00																			5,234
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,04	0,08	0,11	0,15	0,19	0,23	0,26	0,30	0,34	0,38	0,38	0,38	0,38	0,38	0,38
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,45	1,45	2,91	2,91	4,36	4,36	5,82	5,82	7,27	7,27	8,72	8,72	8,72
Cash flow	**-16,67**	**-0,36**	**-0,36**	**-0,36**	**-0,36**	**-0,32**	**-0,29**	**1,21**	**1,24**	**2,74**	**2,77**	**4,27**	**4,30**	**5,79**	**5,83**	**7,29**	**7,29**	**8,74**	**8,74**	**13,97**
S1-S0	**-13,23**	**0,90**	**0,93**	**3,16**	**0,98**	**1,05**	**1,11**	**2,63**	**2,70**	**4,22**	**4,29**	**5,81**	**5,88**	**7,40**	**7,47**	**8,96**	**8,99**	**10,48**	**10,51**	**15,23**

IRR **19%**

Locomotive cost	2,2	
Maintenance cost increase		1,02

VR

0 1

1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels	27
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,001
number of km	1454

(In millions of US $) UZBEKISTAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	1,24	1,27	1,29	1,32	1,34	1,37	1,40	1,43	1,45	1,48	1,51	1,54	1,57	1,61	1,64	1,67	1,70	1,74	1,77	1,81
Inv Loco	2,2	0	0	2,2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,6
Cash flow	-3,44	-1,266	-1,291	-3,517	-1,344	-1,370	-1,398	-1,426	-1,454	-1,483	-1,513	-1,543	-1,574	-1,606	-1,638	-1,670	-1,704	-1,738	-1,773	-1,258
Project case : S1																				
Investments	14,68																			
Maintenance cost	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350	0,350
Residual Value	0,00																			4,71
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,04	0,08	0,11	0,15	0,19	0,23	0,26	0,30	0,34	0,38	0,38	0,38	0,38	0,38	0,38
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,45	1,45	2,91	2,91	4,36	4,36	5,82	5,82	7,27	7,27	8,72	8,72	8,72
Cash flow	-15,03	-0,35	-0,35	-0,35	-0,35	-0,31	-0,27	1,22	1,26	2,75	2,79	4,28	4,31	5,81	5,84	7,30	7,30	8,75	8,75	13,46
S1-S0	-11,59	0,92	0,94	3,17	0,99	1,06	1,12	2,64	2,71	4,23	4,30	5,82	5,89	7,41	7,48	8,97	9,00	10,49	10,53	14,72

IRR **21%**

Locomotive cost	2,2		VR		
Maintenance cost increase		1,02		0	1

1 PCM revenues
1 Black fibres revenues

Number of free 2Mb/s PCM channels	27
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,001
number of km	1454

(In millions of US $) UZBEKISTAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	1,24	1,27	1,29	1,32	1,34	1,37	1,40	1,43	1,45	1,48	1,51	1,54	1,57	1,61	1,64	1,67	1,70	1,74	1,77	1,81
Inv Loco	2,2	0	0	2,2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,6
Cash flow	-3,44	-1,266	-1,291	-3,517	-1,344	-1,370	-1,398	-1,426	-1,454	-1,483	-1,513	-1,543	-1,574	-1,606	-1,638	-1,670	-1,704	-1,738	-1,773	-1,258
Project case : S1																				
Investments	17,94																			
Maintenance cost	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37
Residual Value	0,00																			5,76
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,04	0,08	0,11	0,15	0,19	0,23	0,26	0,30	0,34	0,38	0,38	0,38	0,38	0,38	0,38
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,45	1,45	2,91	2,91	4,36	4,36	5,82	5,82	7,27	7,27	8,72	8,72	8,72
Cash flow	-18,32	-0,37	-0,37	-0,37	-0,37	-0,34	-0,30	1,19	1,23	2,72	2,76	4,25	4,29	5,78	5,82	7,27	7,27	8,73	8,73	14,49
S1-S0	-14,88	0,89	0,92	3,14	0,97	1,03	1,10	2,62	2,69	4,21	4,27	5,80	5,87	7,39	7,46	8,94	8,98	10,47	10,50	15,74

IRR 18%

Locomotive cost 2,2

Maintenance cost increase 1,02

VR

0 1

1 PCM revenues

1 Black fibres revenues

Number of free 2Mb/s PCM channels	27
Average 2Mb/s PCM cost	0,014
Number of black fibres	12
Average black fibre cost	0,001
number of km	1454

(In millions of US $) TURKMENISTAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,641	0,654	0,667	0,680	0,694	0,708	0,722	0,736	0,751	0,766	0,781	0,797	0,813	0,829	0,846	0,863	0,880	0,897	0,915	0,934
Inv Loco	4,4	0	0	0	0	2,2	0	0	0	0	0	0	0	0	0	0	0	0	2,2	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,0
Cash flow	**-5,04**	**-0,65**	**-0,67**	**-0,68**	**-0,69**	**-2,91**	**-0,72**	**-0,74**	**-0,75**	**-0,77**	**-0,78**	**-0,80**	**-0,81**	**-0,83**	**-0,85**	**-0,86**	**-0,88**	**-0,90**	**-3,12**	**2,04**
Project case : S1																				
Investments	14,27																			
Maintenance and operation cost	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32
Residual Value	0,00																			4,91
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,11	0,22	0,32	0,43	0,54	0,65	0,75	0,86	0,97	1,08	1,08	1,08	1,08	1,08	1,08
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,36	1,36	2,73	2,73	4,09	4,09	5,46	5,46	6,82	6,82	8,18	8,18	8,18
Cash flow	**-14,59**	**-0,32**	**-0,32**	**-0,32**	**-0,32**	**-0,22**	**-0,11**	**1,36**	**1,47**	**2,94**	**3,05**	**4,52**	**4,63**	**6,10**	**6,21**	**7,57**	**7,57**	**8,94**	**8,94**	**13,85**
S1-S0	**-9,55**	**0,33**	**0,34**	**0,36**	**0,37**	**2,69**	**0,61**	**2,10**	**2,22**	**3,71**	**3,83**	**5,32**	**5,44**	**6,93**	**7,06**	**8,44**	**8,45**	**9,84**	**12,05**	**11,81**

IRR **20%**

VR

0 1

Locomotive cost 2,2

Maintenance cost increase 1,02

1 PCM revenues

1 Black fibres revenues

Number of free 2Mb/s PCM channels 77

Average 2Mb/s PCM cost 0,014

Number of black fibres 12

Average black fibre cost 0,001 /km

number of km 1364

(In millions of US $) TURKMENISTAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,641	0,654	0,667	0,680	0,694	0,708	0,722	0,736	0,751	0,766	0,781	0,797	0,813	0,829	0,846	0,863	0,880	0,897	0,915	0,934
Inv Loco	4,4	0	0	0	0	2,2	0	0	0	0	0	0	0	0	0	0	0	0	2,2	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,0
Cash flow	**-5,04**	**-0,65**	**-0,67**	**-0,68**	**-0,69**	**-2,91**	**-0,72**	**-0,74**	**-0,75**	**-0,77**	**-0,78**	**-0,80**	**-0,81**	**-0,83**	**-0,85**	**-0,86**	**-0,88**	**-0,90**	**-3,12**	**2,04**
Project case : S1																				
Investments	12,84																			
Maintenance and operation cost	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31
Residual Value	0,00																			4,42
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,11	0,22	0,32	0,43	0,54	0,65	0,75	0,86	0,97	1,08	1,08	1,08	1,08	1,08	1,08
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,36	1,36	2,73	2,73	4,09	4,09	5,46	5,46	6,82	6,82	8,18	8,18	8,18
Cash flow	**-13,15**	**-0,31**	**-0,31**	**-0,31**	**-0,31**	**-0,21**	**-0,10**	**1,37**	**1,48**	**2,95**	**3,06**	**4,53**	**4,64**	**6,11**	**6,22**	**7,58**	**7,58**	**8,95**	**8,95**	**13,37**
S1-S0	**-8,11**	**0,34**	**0,35**	**0,37**	**0,38**	**2,70**	**0,62**	**2,11**	**2,23**	**3,72**	**3,84**	**5,33**	**5,45**	**6,94**	**7,07**	**8,45**	**8,46**	**9,85**	**12,06**	**11,33**

IRR **22%**

			VR		
Locomotive cost	2,2			0	1
Maintenance cost increase		1,02			
				1	PCM revenues
Number of free 2Mb/s PCM channels		77		1	Black fibres revenues
Average 2Mb/s PCM cost		0,014			
Number of black fibres		12			
Average black fibre cost		0,001 /km			
number of km		1364			

(In millions of US $) TURKMENISTAN

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Base case : SO																				
Maintenance and operating cost	0,641	0,654	0,667	0,680	0,694	0,708	0,722	0,736	0,751	0,766	0,781	0,797	0,813	0,829	0,846	0,863	0,880	0,897	0,915	0,934
Inv Loco	4,4	0	0	0	0	2,2	0	0	0	0	0	0	0	0	0	0	0	0	2,2	0
Residual Value	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,0
Cash flow	**-5,04**	**-0,65**	**-0,67**	**-0,68**	**-0,69**	**-2,91**	**-0,72**	**-0,74**	**-0,75**	**-0,77**	**-0,78**	**-0,80**	**-0,81**	**-0,83**	**-0,85**	**-0,86**	**-0,88**	**-0,90**	**-3,12**	**2,04**
Project case : S1																				
Investments	15,69																			
Maintenance and operation cost	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33	0,33
Residual Value	0,00																			5,40
PCM revenues	0,00	0,00	0,00	0,00	0,00	0,11	0,22	0,32	0,43	0,54	0,65	0,75	0,86	0,97	1,08	1,08	1,08	1,08	1,08	1,08
Black fibres revenues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,36	1,36	2,73	2,73	4,09	4,09	5,46	5,46	6,82	6,82	8,18	8,18	8,18
Cash flow	**-16,03**	**-0,33**	**-0,33**	**-0,33**	**-0,33**	**-0,22**	**-0,12**	**1,35**	**1,46**	**2,93**	**3,04**	**4,51**	**4,62**	**6,09**	**6,20**	**7,57**	**7,57**	**8,93**	**8,93**	**14,33**
S1-S0	**-10,99**	**0,32**	**0,33**	**0,35**	**0,36**	**2,68**	**0,60**	**2,09**	**2,21**	**3,70**	**3,82**	**5,31**	**5,43**	**6,92**	**7,05**	**8,43**	**8,45**	**9,83**	**12,04**	**12,29**

IRR **18%**

VR

Locomotive cost	2,2		0	1
Maintenance cost increase		1,02		
			1	PCM revenues
Number of free 2Mb/s PCM channels		77	1	Black fibres revenues
Average 2Mb/s PCM cost		0,014		
Number of black fibres		12		
Average black fibre cost		0,001 /km		
number of km		1364		