Tacis

Traceca: Central Asian Railways
Restructuring Project
Module E Telecommunications

Progress Report

May 1998.

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 (Module E).
This project is financed by Tacis/Traceca in collaboration with the European Bank for Reconstruction and Development (EBRD).

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, Tadjikistan, 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 months

2. Executive Summary

2.1 Telecommunications Inventory

2.1.1 Caucasian countries

There was a time when telecommunications facilities at the 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 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 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.
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 technology.

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.

2.1.2 Central Asia

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2.2 Information Technology Inventory

2.2.1 Caucasian countries

On the whole, the railways in Caucasian countries - Armenia, Azerbaijan and Georgia - are poorly equipped for 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 IT centre in Moscow. The Moscow centre is the heart of the railway computer system of the former USSR 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. No IT management system for international passengers has 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 railways of Central Asia - Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

These facilities rely on three IT 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 IT 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 railways in Kyrgyzstan and Tajikistan 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.

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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, and on interconnection and links to western European systems.

Three main points were covered:

- European standards for telecommunications and IT

- 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 safeguards
  - 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 Telecommunications Preliminary Recommendations

2.4.1 Caucasian countries

Appendix 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 shown.

- 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,
- regulatory,
- informatory.

The specifications deal with:

- telecommunications for signalling and railway operations,
- transmission cables (type, laying, connection, capacity),
- the actual telecommunications network (digital transmission equipment, safety, 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.

3. Summary of the project to-date

3.1 Visits to Traceca countries

From September 1997 to November 1997, experts from UIC undertook three trips involving technical visits to the Traceca countries in order to investigate existing facilities at the railways and their most pressing needs.

The visits passed off reasonably well and the UIC experts were able to gather part of the information required. Only the Kazakhstan visit was unsuccessful, with the team leaving empty-handed as the information sought was deemed to be confidential and could not be released without ministerial authorisation.

3.2 Analysis of existing facilities

Following the technical visits, the UIC experts analysed both the field data gathered and that obtained from other past and ongoing Traceca studies in order to prepare an inventory of telecommunications and IT facilities on railways in Traceca countries.
A further advantage of this inventory exercise is that it provided the UIC experts with a good overview of the problems and needs of the Traceca country railways.

3.3 European systems presentation seminar

In order to familiarise telecommunications and IT managers from the Traceca railways with the facilities used in western Europe, a presentation seminar was organised in Poland.

In recent years, Poland has worked hard to modernise its IT and telecommunications system. A vast number of optical fibre cables and digital switches have been installed for use in conjunction with similar, but very old crossbar and "step by step" systems. Thus, the example was particularly instructive.

The programme, list of participants and reports are contained in Appendix 3.

4. Summary of project planning for the remainder of the project

4.1 Action and investment plan

In order to improve

- railway telecommunications
- telecommunications and IT links between the railways
- communication with administrative bodies (e.g. police and customs) and
- communication with railway customers

in Traceca countries, an action and investment plan will be put forward by UIC.

The action plan will also suggest links with Europe.

In addition to the action and investment plan, the final report will also propose further studies directly arising from the conclusions of the UIC project.

4.2 Action and investment plan conferences

The action and investment plan will be presented at the end of June 1998 at two regional conferences, one to be held in a Caucasian country and the other in Central Asia.
Representatives from the headquarters of the railways and telecommunications and IT experts will be invited.

As requested by the IT and telecommunications specialists who attended the Warsaw seminar (cf.3.3), an official proposal will be made at these conferences that a steering committee be set up to monitor implementation of the action and investment plan.

5. Project progress in the reporting period

5.1 Analysis of existing facilities

5.1.1 Telecommunications

Unfortunately, much of the information gathered during the technical visits to the Traceca countries was imprecise or incomplete. Furthermore, the maps and diagrams obtained were quite difficult to use as a result of station closures, successive name changes and variations in the spelling used in transcription in the different languages. Some technical diagrams were also contradictory.

During talks in Tashkent, Mr Ziller from the EBRD explained to the consultants that he expected them to produce a comprehensive telecommunications inventory as opposed to one just covering the corridor. This prompted them to collect information on the entire network of each of the railways visited during the last technical trip, which of course significantly increased the size of the report.

The UIC experts wanted to make their findings as accessible as possible, notably by providing diagrams with much greater detail than those available to date.

5.1.2 Information Technology

The inventory provided quite a clear and precise overview of IT systems in the railways and data exchanges.

The only really serious gap is the lack of detailed specifications explaining the messages used by the freight and passenger systems (Assoup and Express-2). Without them, only general, semi-specific recommendations can be made. Detailed specifications will be required for drawing up the contractual conditions.
The same type of work must already have been carried out or will have to be for the integration of national systems used as an aid in decision-making and management as recommended in the other studies.

5.2 European systems presentation seminar

The seminar was divided into four parts:
- Presentation by European railways of achievements and projects in their countries.
- Presentation by companies of the systems available on the market.
- Visit to Intertelecom 98 in Lotz.
- Technical visits to PKP installations.

PKP's help in organising the seminar and its hospitality were excellent.

Co-operation between the experts from UIC and those from the Traceca railways was productive and, among other things, helped to clear up certain technical problems.

5.3 Caucasian telecommunications preliminary recommendations

To comply with a request from Marc Graille, the Traceca co-ordinator for the Caucasian countries, that publication of the invitation to tender be speeded up for the first phase of reconstruction of the Caucasian railway telecommunications systems, preliminary recommendations have been included in this report. These recommendations will be part of the future action and investment plan, which will be distributed at a later date.

6. Project planning for the next reporting period

6.1 Action and investment plan

The UIC experts will take particular care to propose recommendations leading to an interoperable solution which corresponds to the needs of the railways and currently available funds.

There is a certain lack of information on operating needs, which are generally required as a basis for drawing up technical proposals. Findings in various past and ongoing studies on this subject are often contradictory.
In the absence of more precise information on restructuring of the railways, the UIC experts will have to base their proposals on the current state of the networks and on quantity options (e.g. facilities at 75% and 50% of stations). Notwithstanding, they will take the greatest care to provide a maximum of detail so that those features shared with similar organisations can be easily pinpointed.

At this point, a meeting or some form of contact is needed with the governing body of each railway and the EBRD.

6.2 Kazakhstan

To date, the UIC experts have received no official information from Kazakhstan railways, a situation which needs to be resolved before the end of the project and the sooner the better so that the proposals in the action plan can cover all eight countries of the Traceca corridor as set out in the terms of reference.

We would welcome an official invitation from Kazakhstan railways for two or three UIC experts to spend a week in Almaty.

6.3.Action and investment plan conferences

In the interests of project follow-up, it is particularly important that those technical experts from Traceca country railways who have already been involved in the project, for example through the Warsaw seminar (cf. Appendix 3), also attend the action and investment plan conferences.
The presence of railway senior management or representatives of the transport ministries will testify to the commitment of the interested parties.

Organising two regional conferences, one for the Caucasian region and one for Central Asia, will make it easier for local experts to attend. It will also enable participants to concentrate on the specific problems and features of each of the regions concerned.

7. Documents

7.1 List of local operators

Armenia
Railway of Armenia (ARM) 50, Tigran Meci st. 375000, Erevan Phone: (3742) 52 04 28 Fax: (3742) 57 36 30 Vladimir V. Asriianc Directeur Général
Azerbaijan
Azerbaijan State Railway (AZ) 230, D. Aliyev str. Baku 370010 Phone: (99412) 98 44 67 Fax: (99412) 98 42 80 Ziya A. Mamedov Directeur Général
Georgia
Ministry of Transport of Georgia Departement of Railway (GR) 12, Kazbegi str. Tibilisi, 380060 Phone: (7-8832) 99 40 12 Fax: (7-8832) 95 36 65 Akakii V. Chkhiadze Directeur Général
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 Dr. Yerkin KALIYEV General dierctor

Kyrgyzstan
Chemins de fer du Kirghizistan (KRG) 83, Lva Tolstovo st. 720009 Bichkek Phone: (7-3312) 25 30 54 Fax: (7-3312) 24 56 11 Sadykbek A. Ablesov Directeur Général
Tajikistan
Chemins de fer du Tadjikistan (TZR) 35, Akademika Nazarchoeva st. 734012 Duchanbe Phone: (7- 3772) 29 44 03 Fax: (7-3772) 27 63 47 Mahamad H. Habibov Directeur Général
Turkmenistan
Chemins de fer du Turkmenistan (TRK) " Turkmendemirellary " 7, Saparmyrat Turkmenbachi chaely st. 744007, Achkabad Phone : (7-3632) 25 55 45 Fax: (7-3632) 47 39 58 Mered B. Kutliev Directeur Général
Uzbekistan
Republic of Uzbekistan State Joint Stock Railway Company " Uzbek Railways " (UTI) 7, T. Shevchenko st. Tashkent, 700060 Phone: (7-3712) 36 44 00 Fax: (7-3712) 33 69 24 Normat E. Ermetov Président des Chemins de fer

7.2 Project Progress Report

Project Title: Traceca - Central Asian Railways Restructuring Module E: Telecommunications		Project Number : TNREG 9602						Countries: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan Tajikistan, Turkmenistan, Uzbekistan								
Pla	Planning period: Jan 98 to May 98				Prepared in : May 1997			EC Consultant : UIC, 16 rue Jean Rey, 75015 Paris, France								
Project objectives																
N°	Main Activities	Timeframe					Inputs									
		1998					Personnel				Other					
		Jan	Feb	Mar	Apr	May	EC		Counterpart		Equipment		Flights		Per Diem	
0	Project Management	xxxx	xxxx	xxxx	xxxx	xxxx	Planned	Used	Planned	Used	Planned	Used	Planned	Used	Planned	Used
1c	Analysis of survey data	xxxx	xxxx	xxxx	xxxx											
1d	Analysis of other Traceca Reports	xx	xxxx	xxxx												
2a	European systems presentation seminar preparation		xx	x												
2b	European systems presentation seminar			x												
				Total												

7.3 Resource Utilisation Report

Project Title: Traceca - Central Asian Railways Restructuring Module E: Telecommunications		Project Number : TNREG 9602	Countries: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan Tajikistan, Turkmenistan, Uzbekistan		
Planning period: Jan 98 to May 98		Prepared in : May 1998	EC Consultant : UIC, 16 rue Jean Rey, 75015 Paris, France		
Project objectives					
Resources / Inputs	Total Planned	Period Planned	Period Realized	Total Realized	Available for remainder
Personnel					
Sub-total					
Equipment & Material					
Sub-total					
Other Inputs					
Sub-total					
Total					

7.4 Output Performance Report

Project Title: Traceca - Central Asian Railways Restructuring Module E: Telecommunications	Project Number : TNREG 9602	Countries: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan Tajikistan, Turkmenistan, Uzbekistan	
Prepared in : May 1998		EC Consultant : UIC, 16 rue Jean Rey, 75015 Paris, France	
Output Results	Deviation original plan + or - %	Reason for deviation	Comment on constraints & assumptions

7.5 Work Programme (plan of operations for the next period)

Project Title: Traceca - Central Asian Railways Restructuring Module E: Telecommunications	Project Number : TNREG 9602	Countries: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan Tajikistan, Turkmenistan, Uzbekistan
Planning period: June 98 to July 98	Prepared on : May 1998	EC Consultant : UIC, 16 rue Jean Rey, 75015 Paris, France
Project objectives		

N°	Main Activities	Timeframe 1998					Inputs: Personnel		Inputs: Equipment and Materials	Inputs: Other	
		June	July	Aug	Sept	Oct	EC Consultant	Counterpart		Flights	Per Diem
0	Project Management	xxxx	xxxx								
1a	Questionnaire writing										
1b	Visit the Traceca countries for the survey										
1c	Analysis of survey data										
1d	Analysis of other Traceca Reports										
1e	Visit the Traceca countries to collect additional data										
2a	European systems presentation seminar preparation										
2b	European systems presentation seminar										
3a	Analysis of interconnection possibilities with Europe	xx									
3b	Action plan preparation	xxxx	xxxx								
3c	Action plan presentation in TRACECA countries										
4	Training										
						Total					

8. List of appendices

1 Caucasian countries: Inventory

2 Central Asia: Inventory

3 European systems presentation seminar (Warsaw)

4 Caucasian area: Preliminary recommendations - Telecommunications

Module E
Progress Report

Appendix 1

Caucasian countries

Inventory

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		
Staff :		
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	

outline map of railway network:

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 dual-track line	791 km	
Length of single-track line	487 km	
Staff :	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 $x10^6$	2778 $x10^6$
Length of Traceca corridor:	503 km	
Length of corridor electrified	503 km	
Type of electric current	3.3 kV D.C.	
Number of stations in 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

outline map of railway network:

1.3 Georgia

Railway abbreviation	**GR**		
Total country surface area:	69,700 km^2		
Population:	5,400 000		
Total line length :	1,575 km		
Staff :	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

outline map of railway network:

2. Telecommunications

2.1 Inventory

2.1.1 Armenia

2.1.1.1 Introduction

Armenian Railways only use analog systems 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 off the public electricity supply network. 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 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.

2.1.1.3 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	*Mileage 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. Section 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.
- Ticket reservation distribution.

The ticket reservation distribution centre is connected to some mainline 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
- Open track alarm (2 wire line).

Additional services:

- Traffic controller - depot line.
- Traffic controller - passenger train formation yard.

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. Transmission links are generally HF (frequency modulation) electronic transmission installations. Baseband transmission is also used.

The cables are type 7x4x1.2+5x2x0.7+1x0.7 (7 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 falling short of 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 capacity regulation. This interference is not easily eliminated from cables that have already been laid. All these problems arise when cable sections are stolen.

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
Objet 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 (mainline, 6 HF wires) or 5 mm (mainline, 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 /MP : 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 overleaf.

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 Tbilissi (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 the station or railway 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 up: 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 only use analog systems 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 Azerbaijani 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 off the public electricity supply network. 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 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	*MP*	*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.
- Ticket reservation distribution.

The ticket reservation distribution centre is connected to some mainline 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
- Open track alarm (2 wire line).

Additional services:

- 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. Transmission links are generally HF (frequency modulation) electronic transmission installations. Baseband transmission is also used.

The cables are type 7x4x1.2+5x2x0.7+1x0.7 (7 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 falling short of 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 capacity regulation. This interference is not easily eliminated from laid cables. All these problems apply when cables sections are stolen.

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.

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 Tbilissi (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 Tbilissi.

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. These diesel generators are located at Tbilissi, Khashuri, Samtredia and Supsa.

2.1.3.3 Switching

Switching nodes are located at the following stations: Gardabani, Rustavi-Gruzovaya, Tbilissi-Uzlovaya, Tbilissi-Passagirskaya, Tbilissi- 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 Tbilissi - Passagirskaya and those positioned at the following stations: Tbilissi - Elektricheskoe depo, Tbilissi - 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. The 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	*MP*	*No. of subscribers*	*Model*	*Note*
Gardabani	33			
Rustavi (Gruz.)	25	50	ATS	
Tbilissi (Uzlov.)	0/2510	600	ATS	
Tbilissi (Pass.)	2503/2304	4500+300	Kor+ATS	1990
Tbilissi (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 are 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 Tbilissi - 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 Tbilissi 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 Tbilissi 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
Tbilissi	Zestafoni - Khashuri	63 km
Tbilissi	Khashuri - Tbilissi	120 km
Tbilissi	Tbilissi - Beyuk-Kyasik	45 km (Gardabani) + 12 = 67 km
Tbilissi	Tbilissi - 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.
- Ticket reservation distribution.

The ticket reservation distribution centre is connected to some mainline 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
- Open track alarm (2 wire line).

Additional services:

- 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, Tbilissi-Pass and Tbilissi-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. Transmission lines are generally 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 Tbilissi Technical University. Use is also made of baseband transmission.

Cables are type 14 or 7x4x1.05+5x2x0.7+1x0.7 (14 or 7 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 - Tbilissi 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 / MP	*Station / MP*	*Length*	*Number of cables*	*Type*
Rustavi / 25	Tbilissi / 2510	25,5 km	2	MKPAP 7x4+5x2
Sadakhlo / 2563	Tbilissi / 2510	53 km	2	MKBAB 7x4+5x2
Tbilissi / 2510	Garajani / 116	116 km	1	MKBAB 7x4+5x2
Tbilissi / 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 falling short of 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 capacity regulation. This interference is not easily eliminated from cables that have already been laid. All these problems apply when cables sections are stolen.

The aerial lines have a diameter of 4 mm (mainline, 6 HF wires) or 5 mm (mainline; 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, Tbilissi-Uzlovaya, Sagaredjo, Katchreti, Mskheta, Gori, Khashuri, Zestafona and Rioni. In addition, channels are amplified at the emitting station and the endpoints indicated in the table 2.1.3.E

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

Station	*Station*	*Number of channels*	*Type of installation*
Tbilissi	Khashuri	60 channels	K-60-P
Tbilissi	Samtrediya	120 channels	2 x K-60-P
Tbilissi	Garajani	24 channels	K-12+12
Tbilissi	Rustavi	12 channels	V-12-3
Tbilissi	Gardabani	12 channels	P-305
Tbilissi	Marnauli	12 channels	P-305
Tbilissi	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 Tbilissi and Sanain (Armenia).

Figure2.1.3.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, Tbilissi, 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 :
Optical fibre cable : USD 6,000/km is more in line with the prices quoted by European suppliers
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 1.3.1). 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).

2.2.6 Study on a Communications Network for the Caucasian Railways (Tractebel)

(to be carried out)

3. Information Technology

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 authorities, 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 offices 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 V32a 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 authorities (customs, police, etc.)

3.1.1.4.1 Current situation

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 Current situation

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 Current situation

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 Description of 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 loading
- Goods carried
- Consignee
- Station of origin
- Station of destination
- 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 authorities (customs, police, etc.)

3.1.2.4.1 Current situation

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 Current situation

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 Current situation

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 Description of 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 loading
- Goods carried
- Consignee
- Station of origin
- Station of destination
- 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 micro-wave 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 authorities (customs, police, etc.)

3.1.3.4.1 Current situation

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 Current situation

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 Current situation

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 Description of 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 loading
- Goods carried
- Consignee
- Station of origin
- Station of destination
- 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 help market and sell the Trans-Caucasian Logistic Express service.

The system would consist of PC-type computers, with no 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.

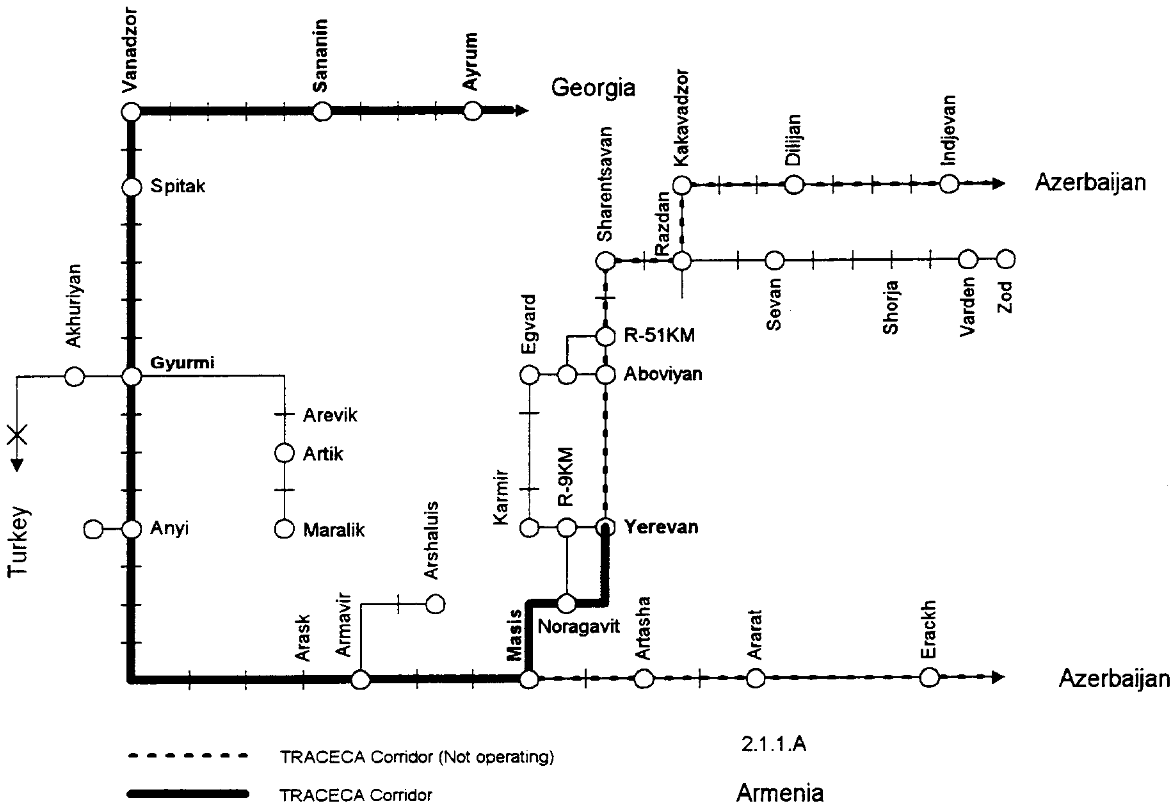
3.2.2 Joint Venture(s) for the Caucasian Railways - Draft Final Report - October 1997. (Tewet / DE-Consult / Gtz)

The railways of the Caucasus region are relatively un-computerised.

The aim is to give freight customers more satisfaction.

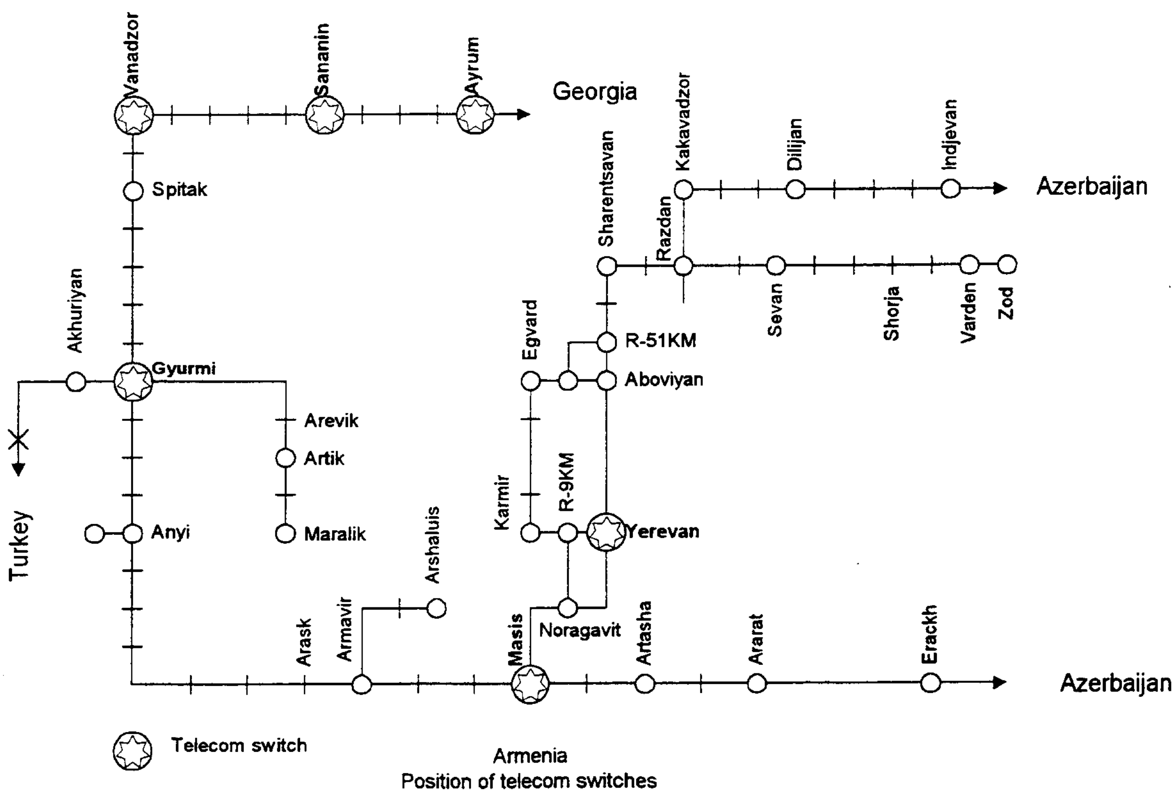
It is proposed that three systems be set up :

- Freight transport operation system
- Processing and freight cost calculation system
- Decision support system

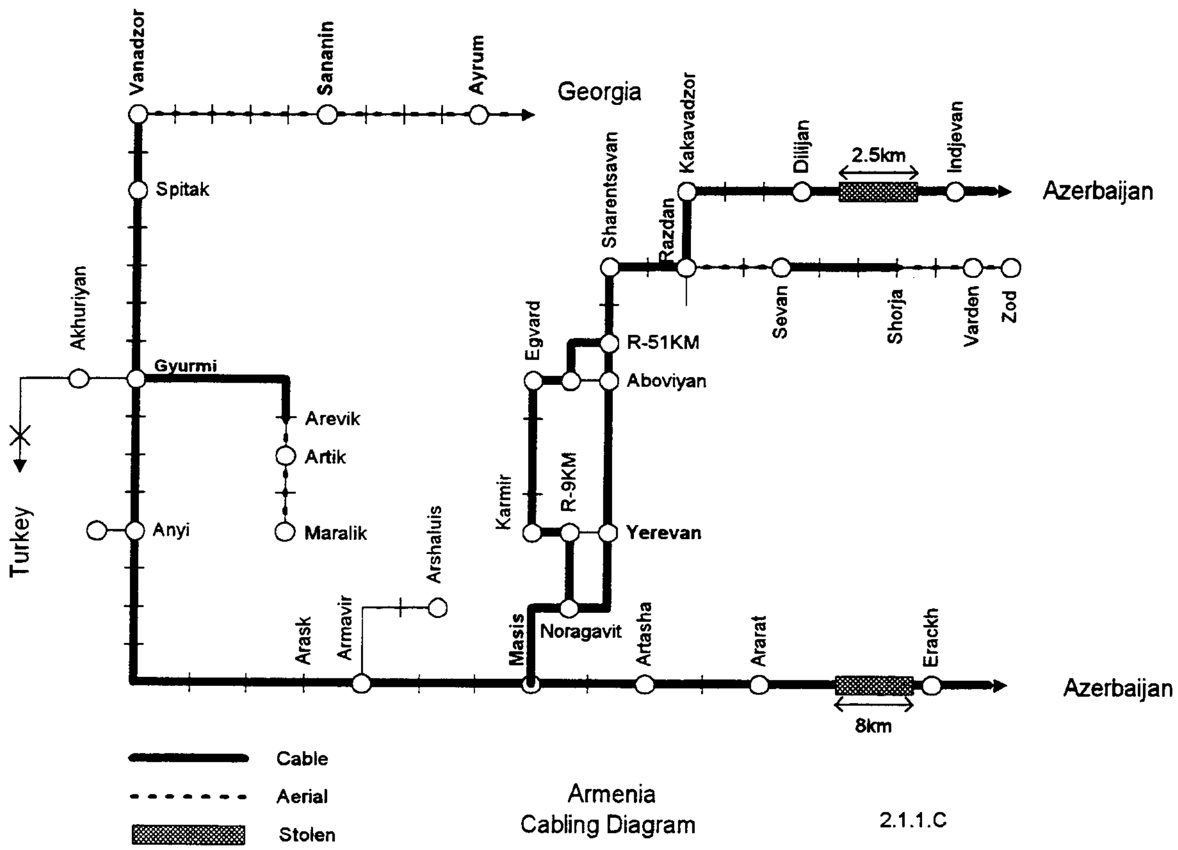


2.1.1.A

Armenia
Railways Diagram

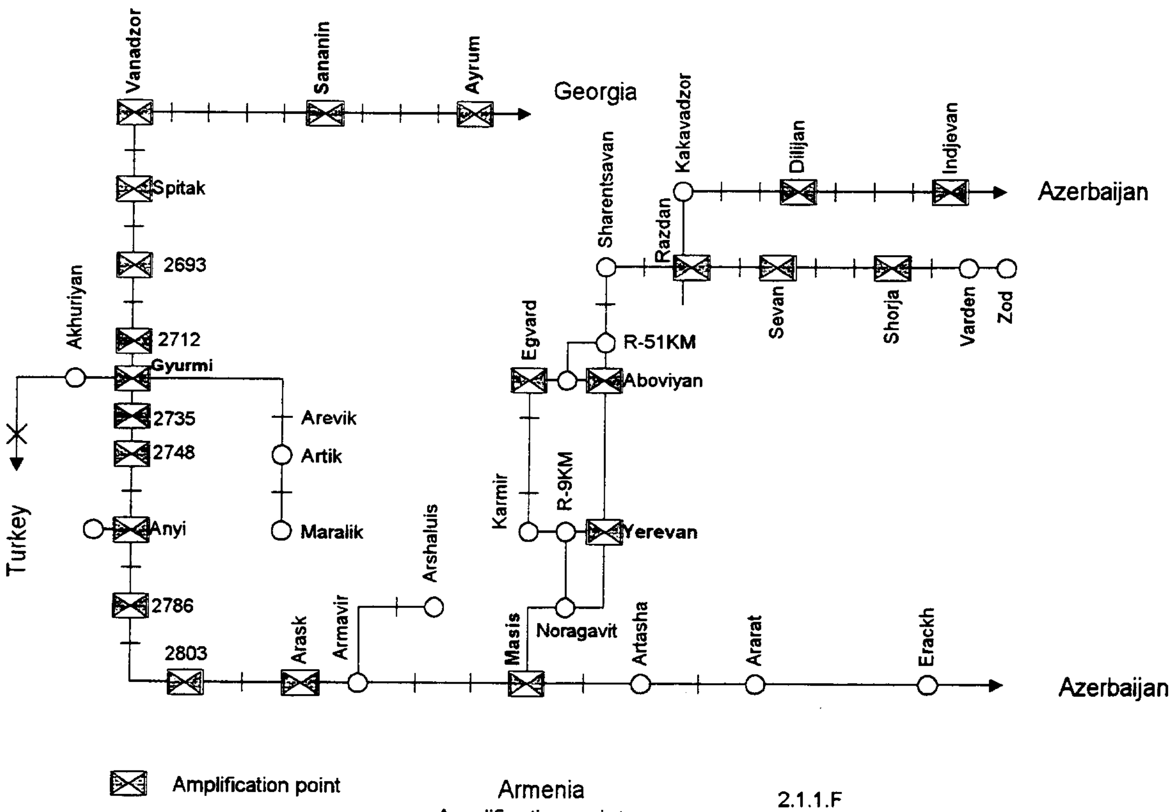


Armenia
Position of telecom switches
2.1.1.B



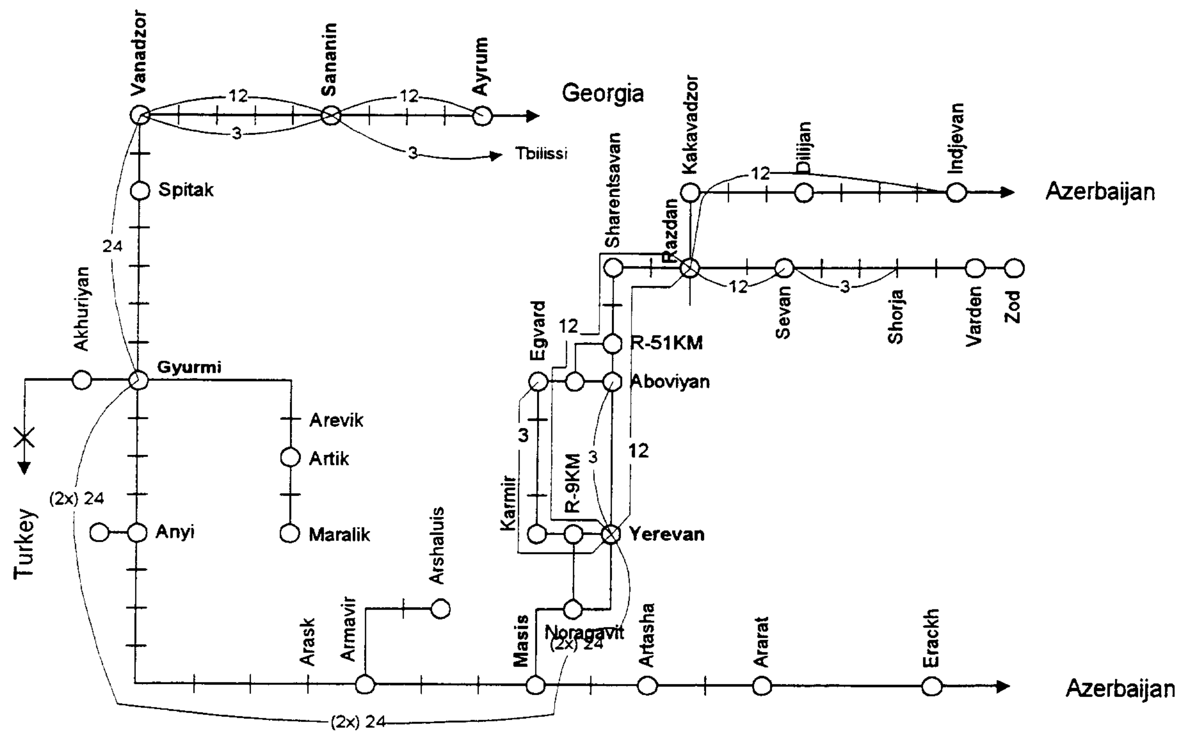
Armenia
Cabling Diagram

2.1.1.C



Armenia
Amplification points

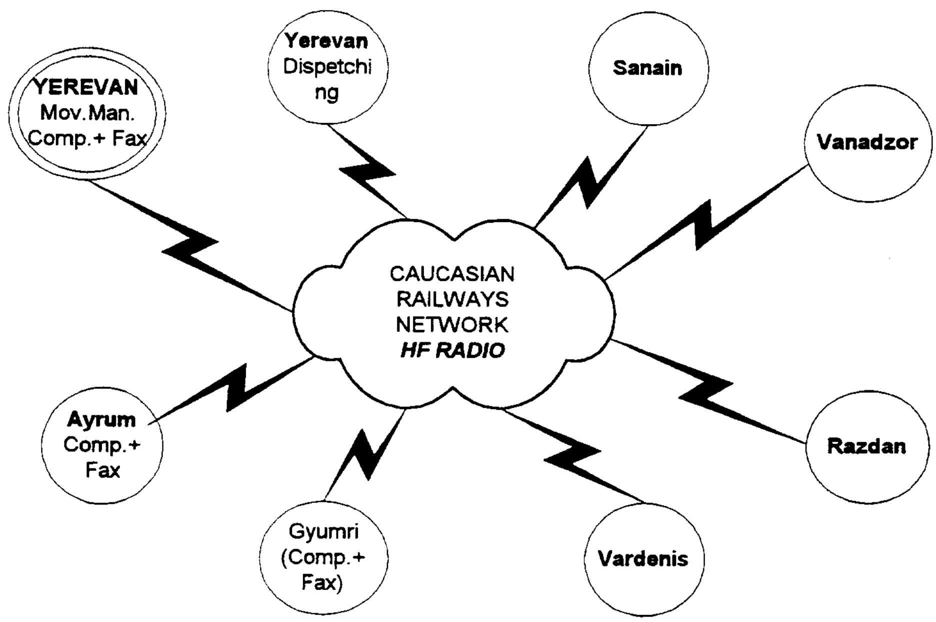
2.1.1.F



Number of channels

Armenia
Transmission capacity

2.1.1.D



Armenie 2.1.1.E

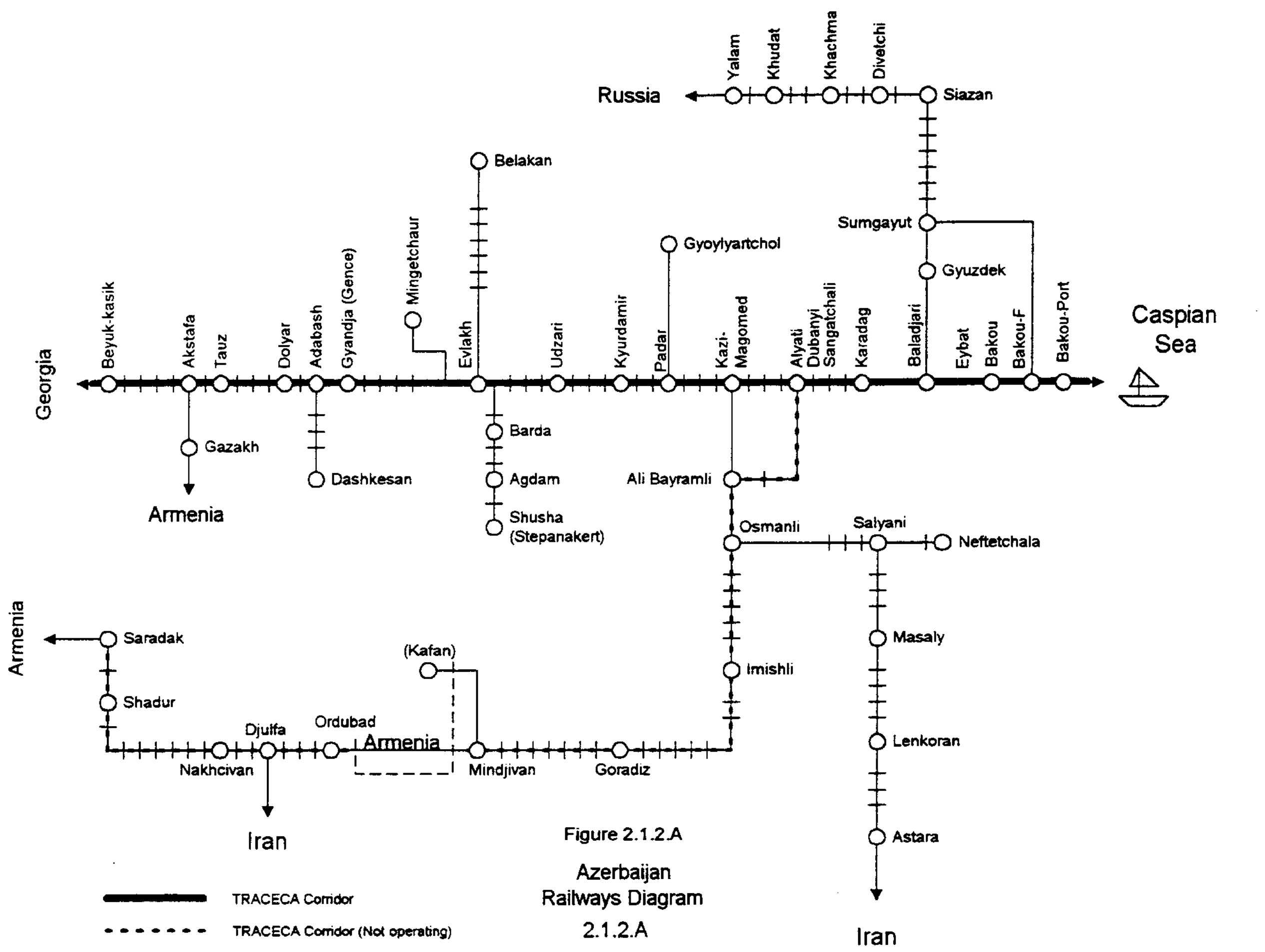
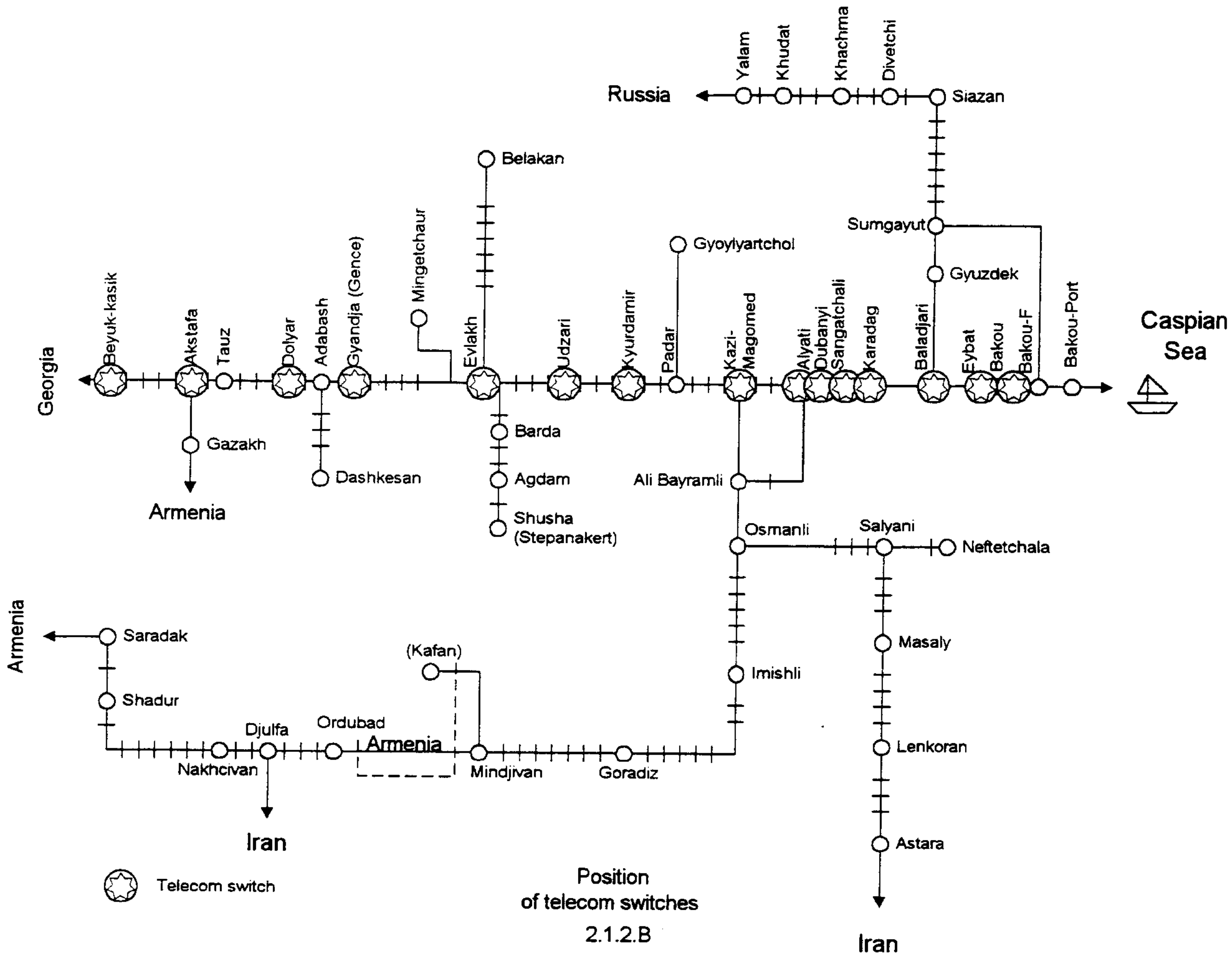


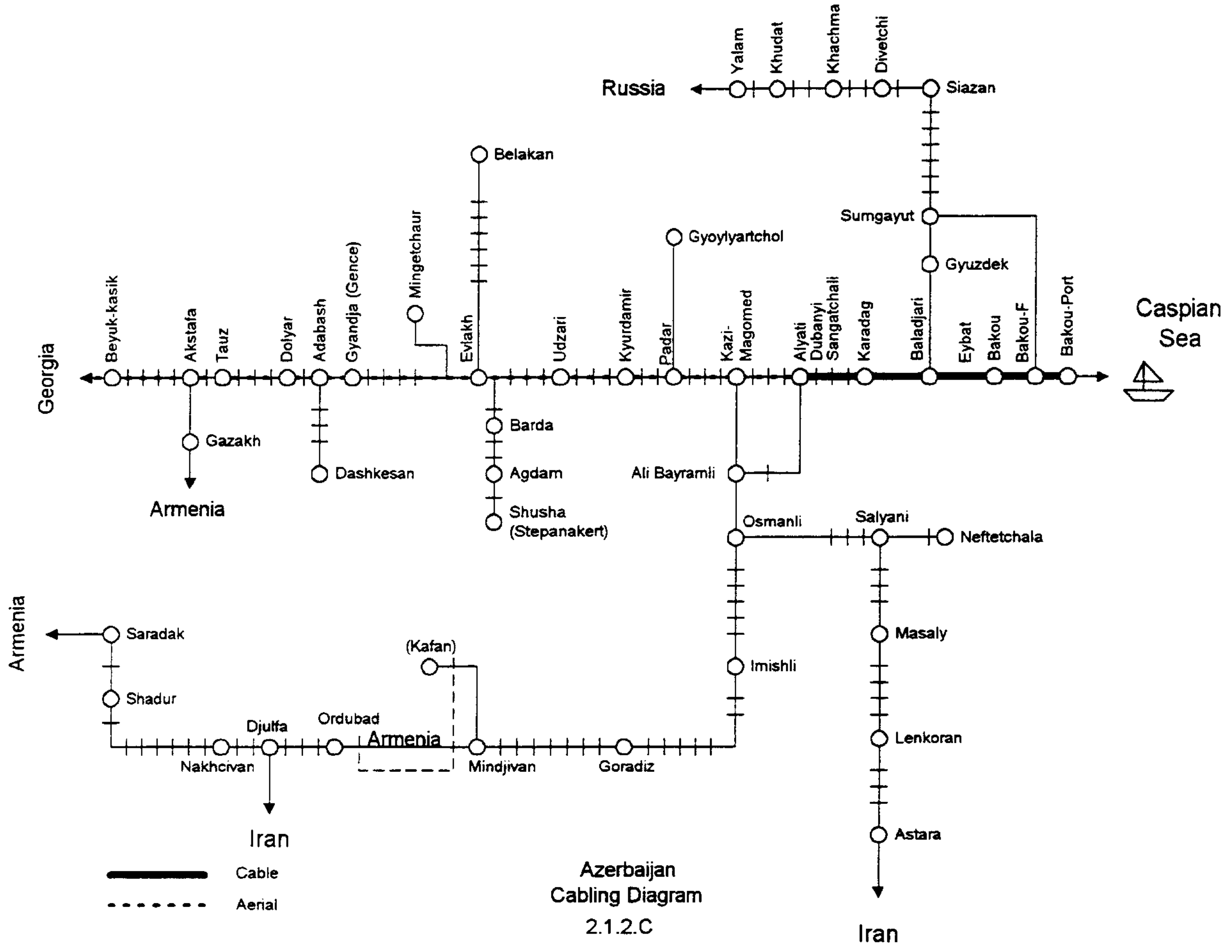
Figure 2.1.2.A

Azerbaijan Railways Diagram

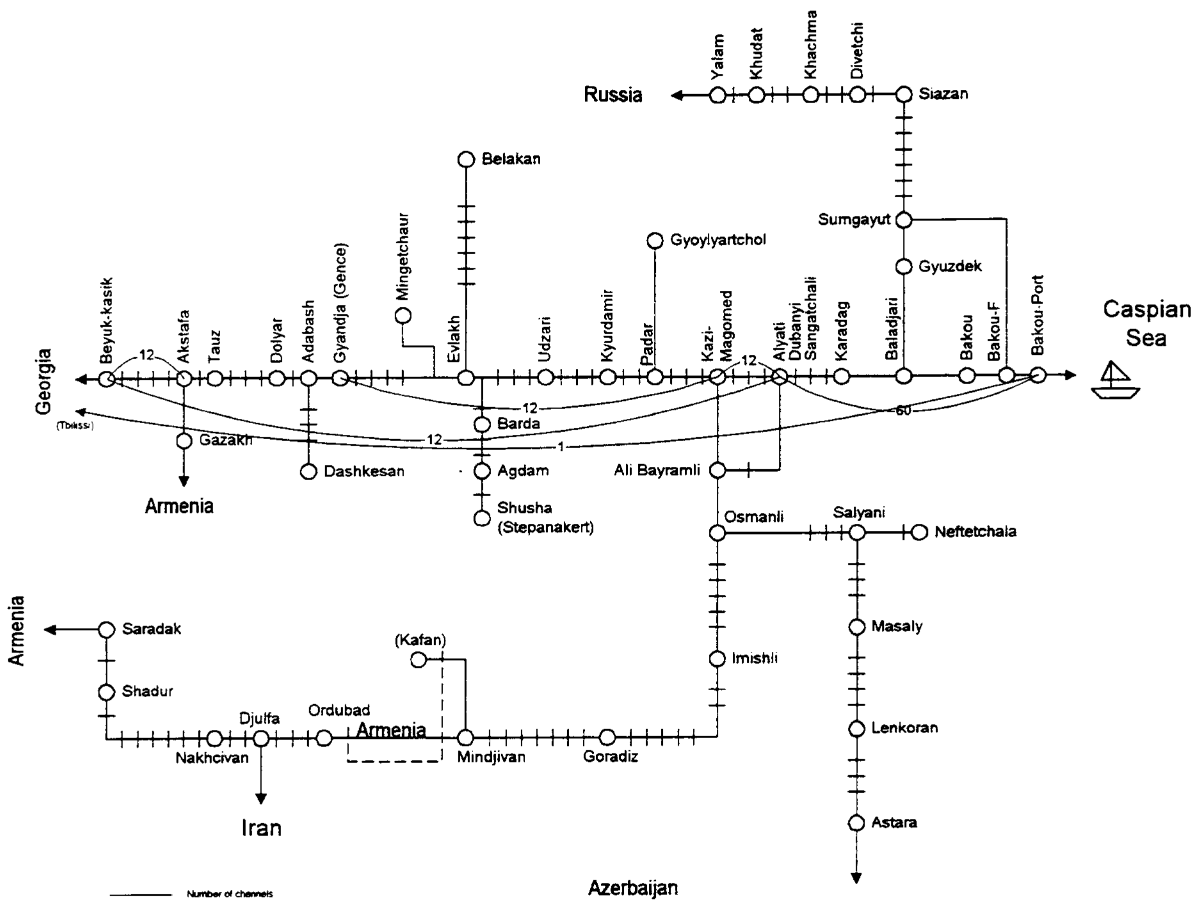
2.1.2.A



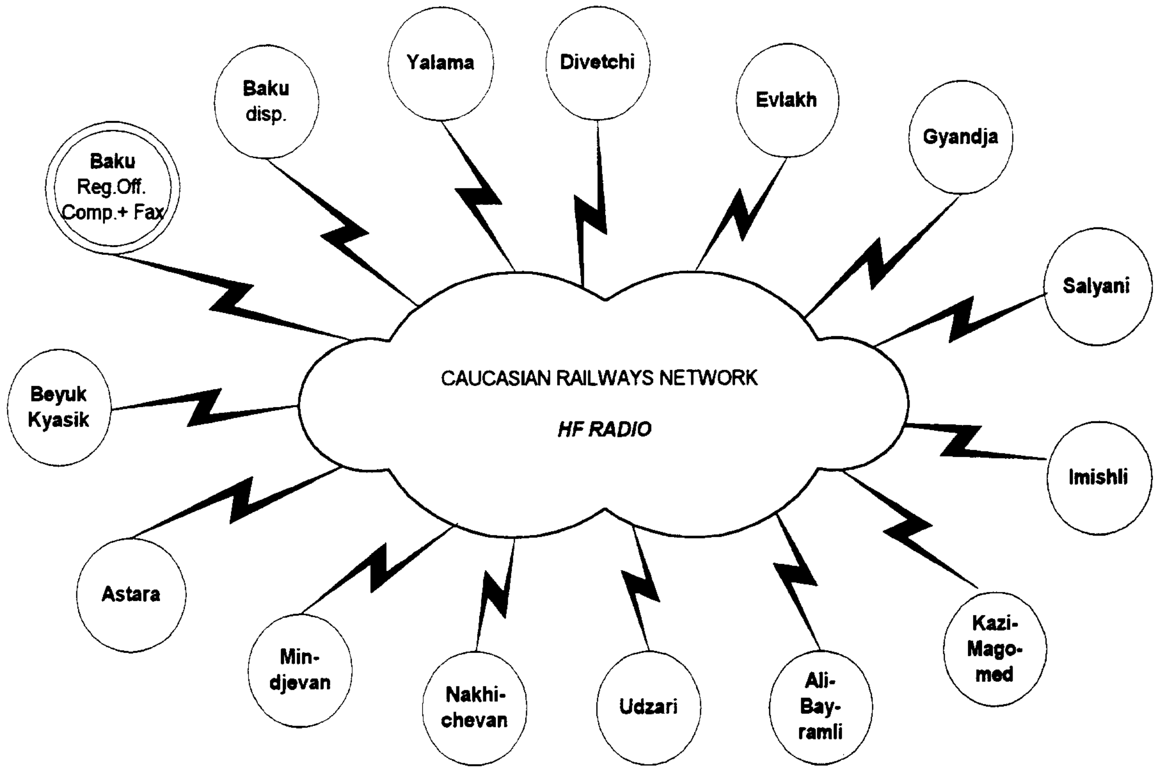
Position
of telecom switches
2.1.2.B



Azerbaijan
Cabling Diagram
2.1.2.C



Azerbaijan
Transmission capacity
2.1.2.D



N°2.1.2.E

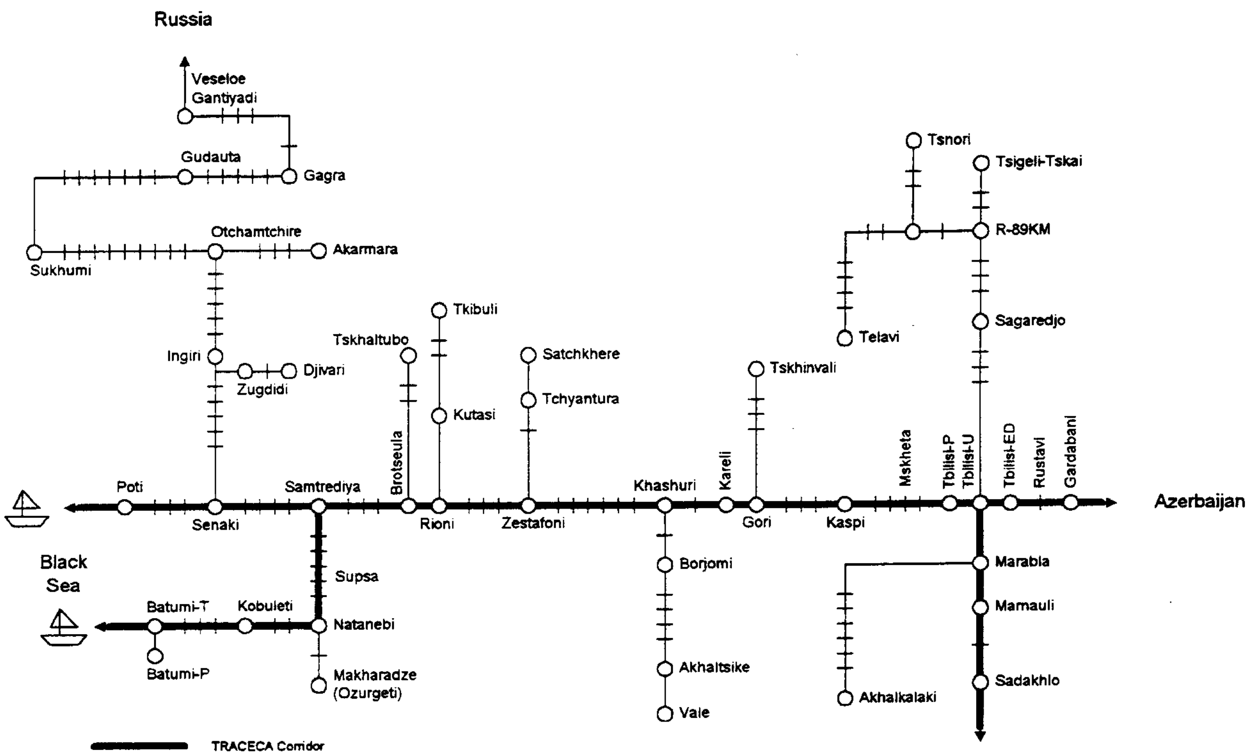
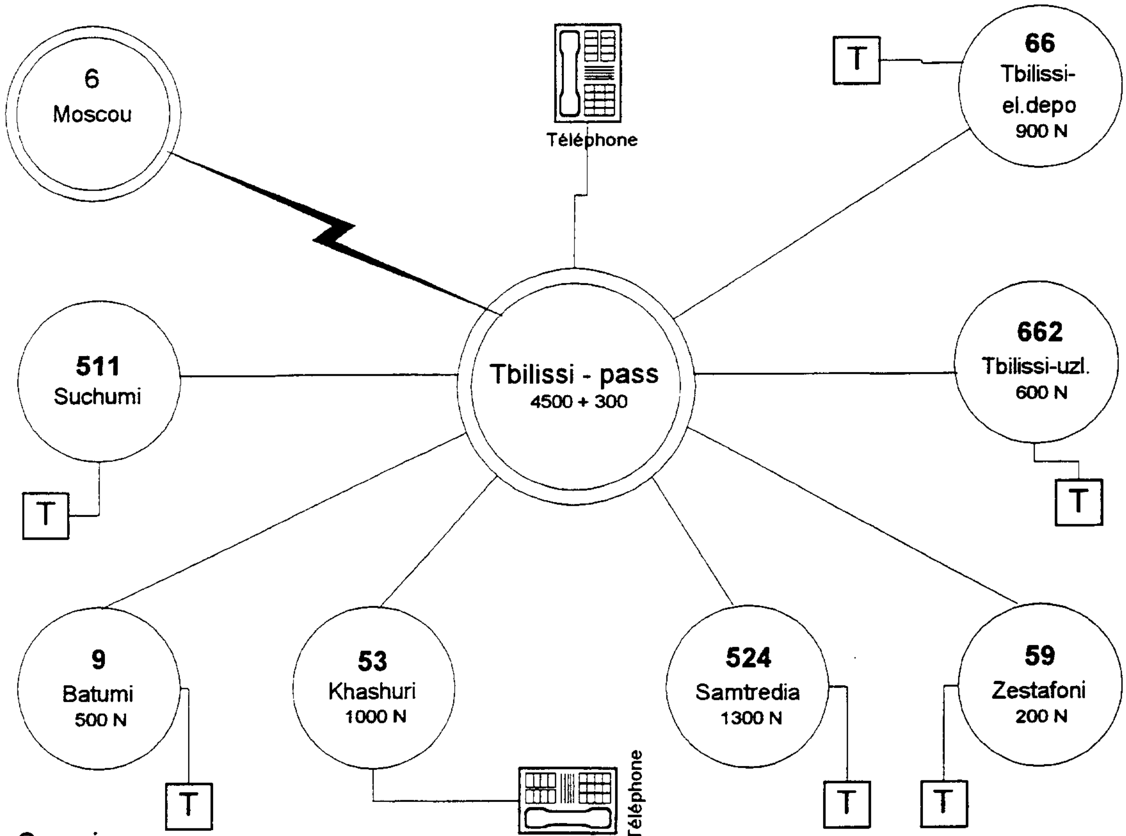
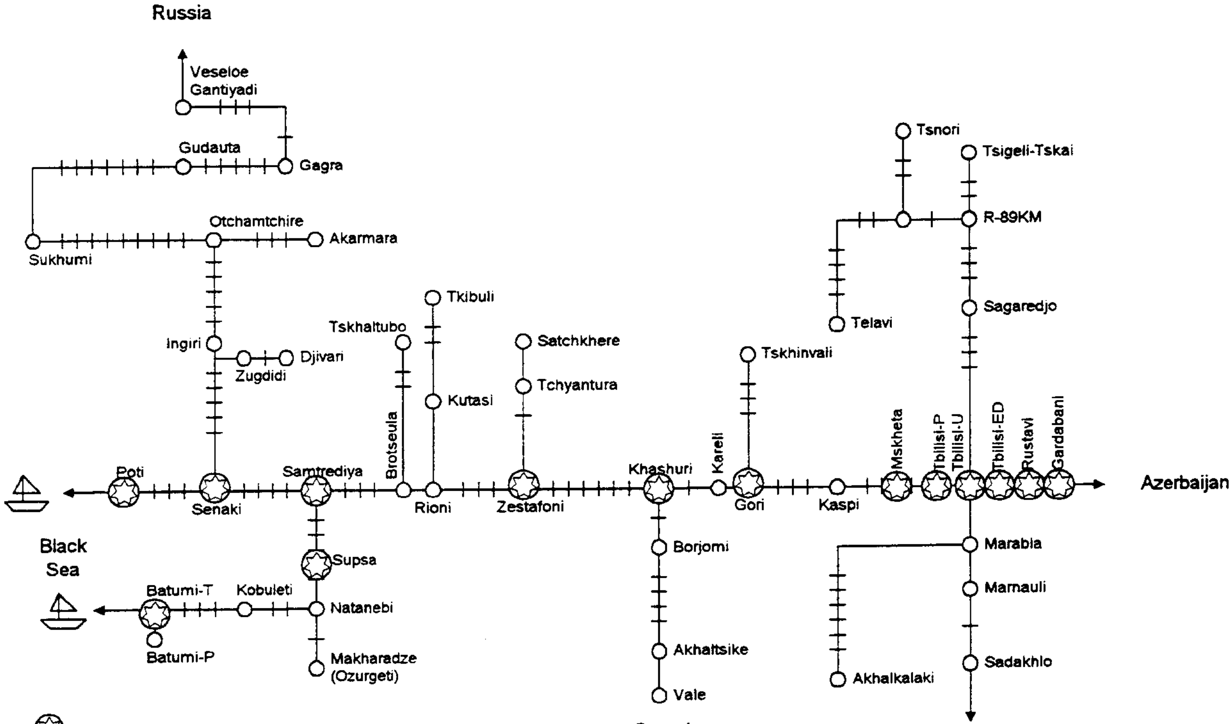


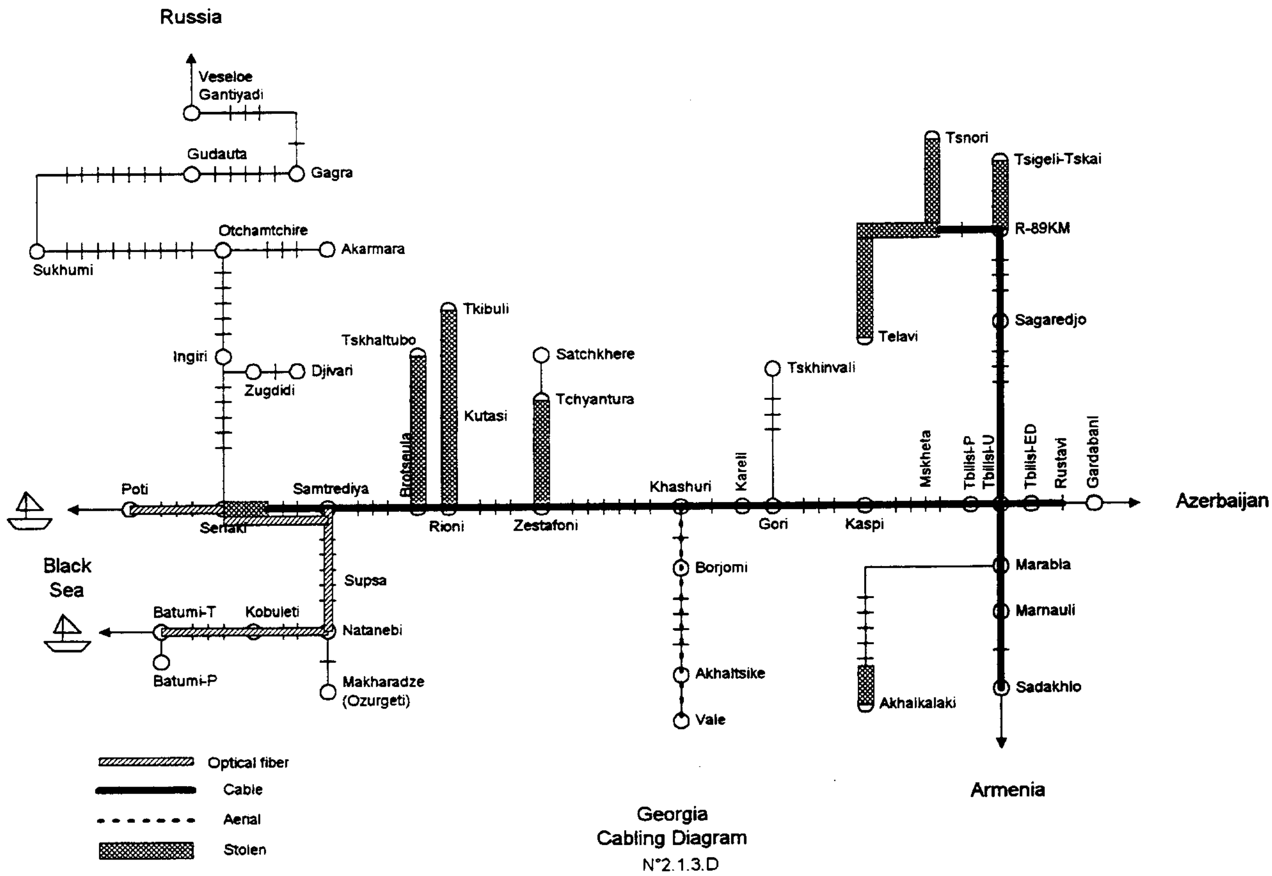
Figure 2.1.3.A
Georgia Railways Diagram



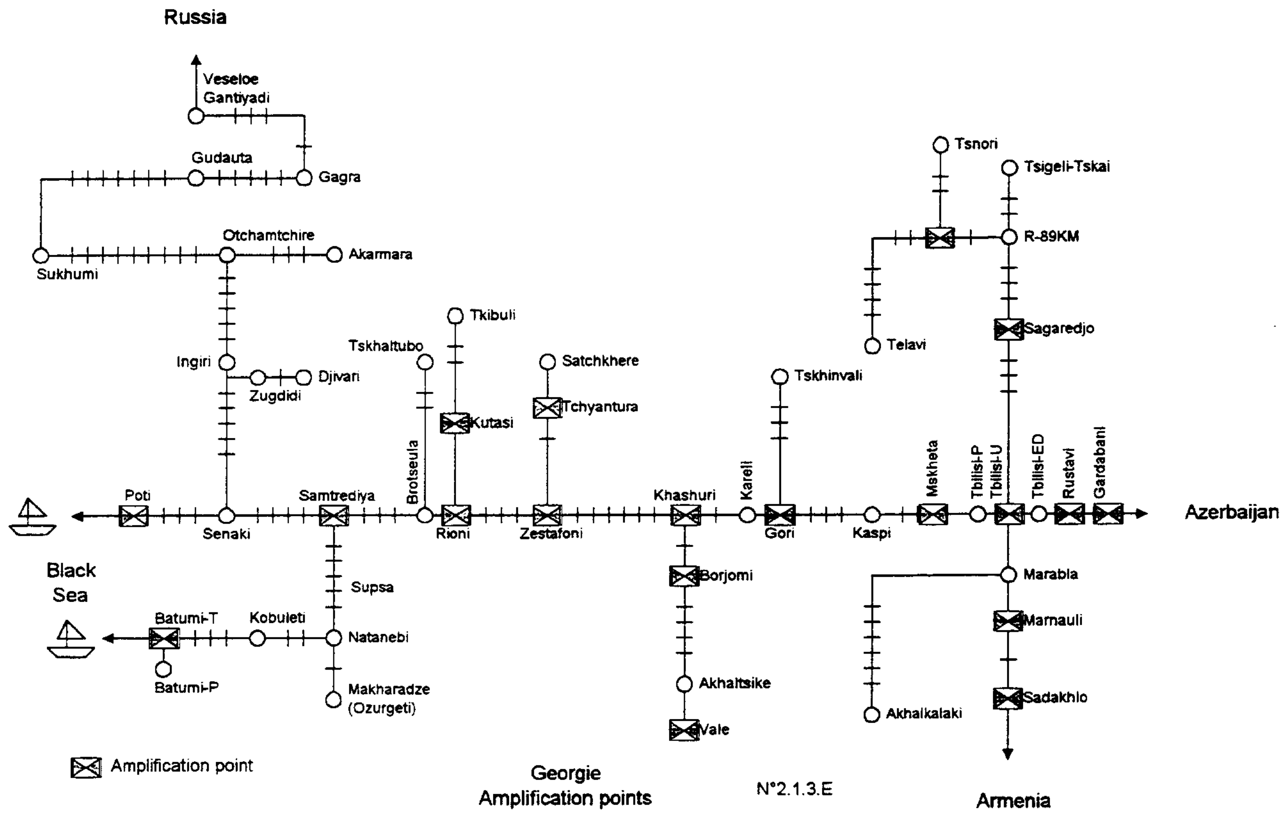
Georgia
N°2.1.3.B

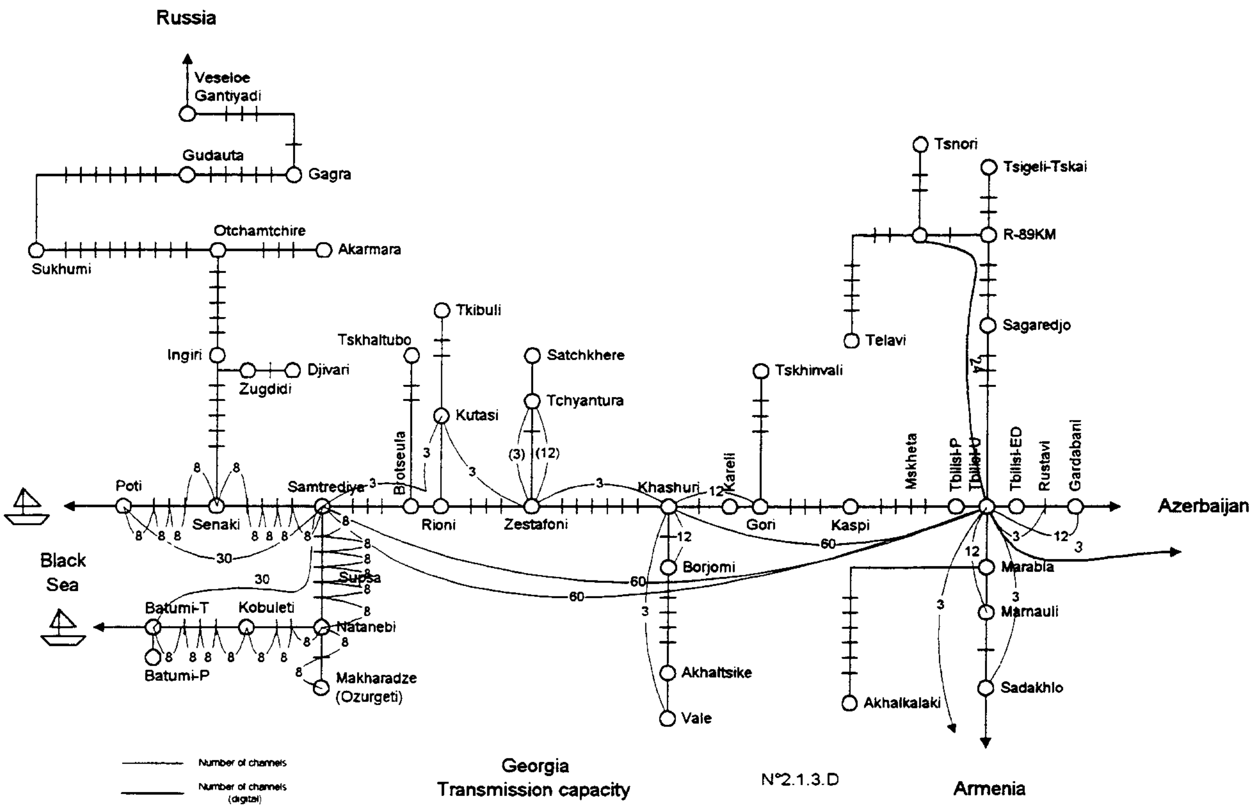


Georgia
Position of telecom switches
N°2.1.3.C



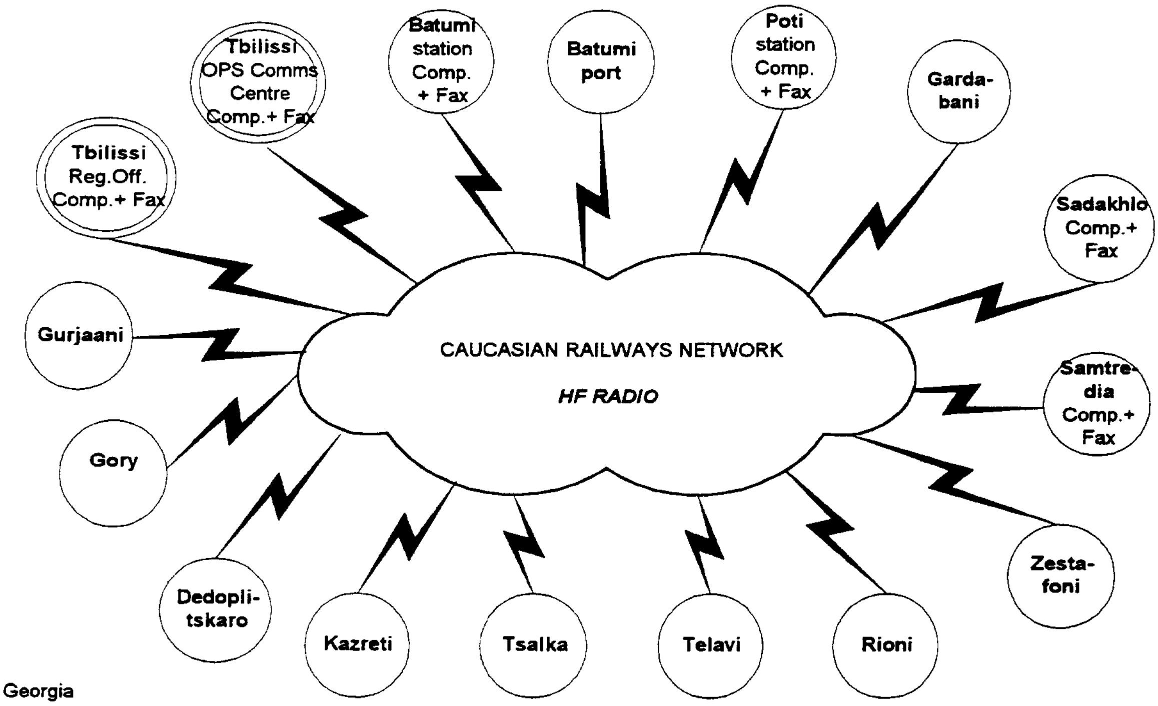
Georgia
Cabling Diagram
N°2.1.3.D


Russia
Veseloe
Gantiyadi
Gudauta
Gagra
Otchamtchire
Akarmara
Sukhumi
Tsnori
Tsigeli-Tskai
R-89KM
Telavi
Sagaredjo
Tkibuli
Tskhaltubo
Ingiri
Djvari
Zugdidi
Satchkhere
Tchyantura
Tskhinvali
Kutasi
Brotseula
Kareli
Mskheta
Tbilisi-P
Tbilisi-U
Tbilisi-ED
Rustavi
Gardabani
Poti
Samtrediya
Khashuri
Azerbaijan
Senaki
Rioni
Zestafoni
Gori
Kaspi
Black Sea
Supsa
Borjomi
Marabla
Batumi-T
Kobuleti
Natanebi
Marnauli
Batumi-P
Makharadze
(Ozurgeti)
Akhaltsike
Akhalkalaki
Sadakhlo
Vale
Amplification point
Georgie
Amplification points
N°2.1.3.E
Armenia



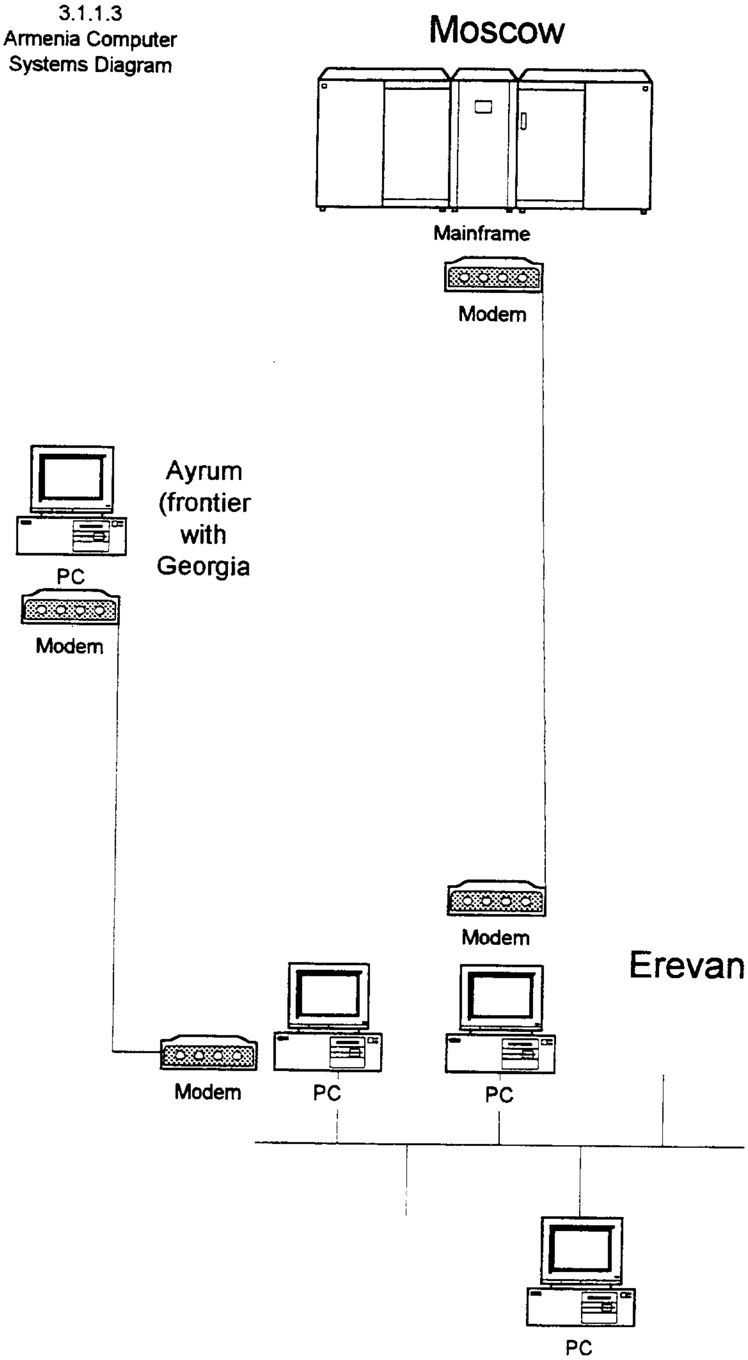
Georgia
Transmission capacity

N°2.1.3.D

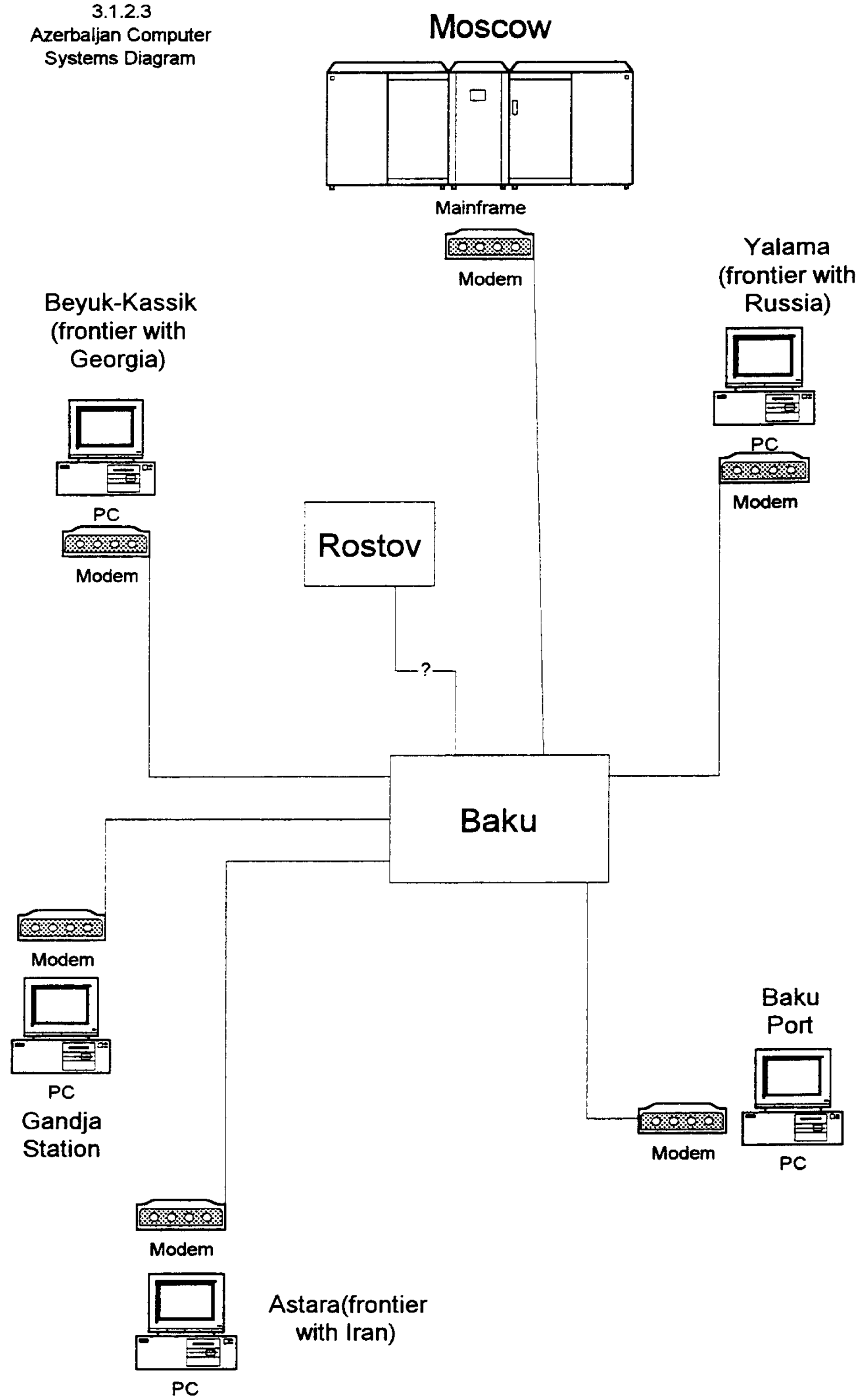


Georgia
N°2.1.3.F

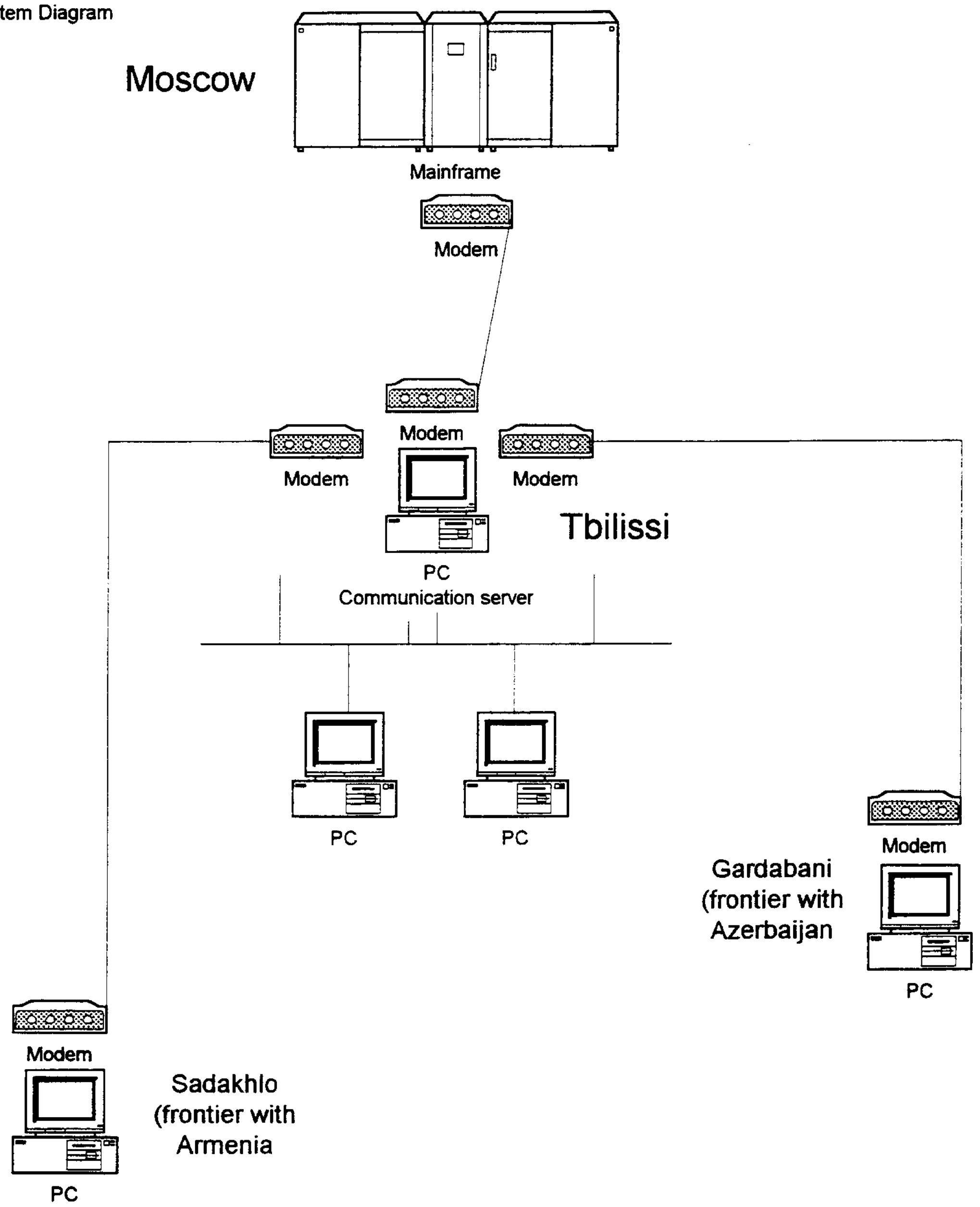
3.1.1.3
Armenia Computer
Systems Diagram



3.1.2.3
Azerbaijan Computer
Systems Diagram



3.1.3.3
Gorgia Computer
System Diagram



Module E
Progress Report

Appendix 2

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		

- an outline map:

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		

- an outline map:

1.3 Uzbekistan

Railway abbreviation:	**UTI**	
Total country surface area:	447,200 km^2	
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		

- an outline map:

1.4 Tajikistan

Railway abbreviation:	**TZD**	
Total country surface area:	143,100 km^2	
Population:	5,700,000	
Total line length:	483 km	
Length of lines electrified	0 km	
Staff:	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		

- an outline map:

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		

- an outline map:

2. Telecommunications

2.1 Inventory

2.1.1 Kazakhstan

It has so far proved impossible for UIC specialists to obtain the information required from Kazakhstan railways, neither during their trip to Kazakhstan, nor following repeated requests made at high level. This problem has been highlighted on several occasions.

2.1.1.1 Introduction

Kazakhstan railways use analog systems and ?.
Telecom switches are electromechanical and ?.
Transmission lines are served by HF (frequency modulation) electronic transmission equipment and ?
Physical media consist of copper cables and aerial lines and ?..

2.1.1.2 General characteristics

Telecommunications installations are standardised (GOST) and comply with OSJD leaflets for railway applications. The parts originate from the former Soviet Union and ?
These products are no longer compatible with present day technology ?
Other installations ?

2.1.1.3 Switching

Switching nodes are located in the following stations: .... ?
To make a local call, the subscriber dials the number he is calling and is put through automatically.?.
To make an outside call ?
the architecture, the map, the dialling scheme, the number of subscribers, the age, ...?

2.1.1.4 Services

To complement the phone service provided through the switched telephone network (cf Ch. 2.1.1.3), a certain number of voice services are provided through dedicated links. These dedicated links consist of a primary railway telephony transmitter/receiver and terminal installations (subscribers) hooked up in parallel to the transmission line. The operator (controller) is permanently connected.
The subscriber is selected ..?
The implementation date ..?
The following services are concerned: ?

- *traffic control (2 wire link).*

The traffic control centre is located ...?

- *Energy control (2 wire link). ?*
- *Dedicated station to station telephone line?*
- *Ticket reservation distribution ?*
- *Teleconferencing ?*
- *Railway police ?*
- *open track alarm (2 wire link). ?*

Other services: ?

- *telegraphy ?*

2.1.1.5 Transmission media

Transmission media consist of copper cables and aerial lines and ?. Transmission lines - transmission equipment ?
The cables are ?
Date introduced ?
Transmission quality ?
Cable tubes connect up with aerial lines ?.
The cable and aerial line layout ? Map ?
Transmission equipment? (frequency zone ?)
Capacity of lineside transmission channels ? (Sufficient ? Saturated?)
International transmission links ?
Spare parts ?

2.1.1.6 Radiocommunications

- *ground-train radio ? (system, frequency, handling, number of lineside wires, sections equipped, number of locomotives / number of locomotives equipped, transmission quality..)*
- *shunting radio ? (system, frequency, handling, stations equipped, number of locomotives / number of locomotives equipped, transmission quality..)*

2.1.2 Kyrgystan

2.1.2.1 Introduction

Kyrgystan 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 Kyrgystan 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 fed by 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. The 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 the following 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 connexion 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 70's to the 90's. 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 Bishkek railway division. 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.

- Ticket reservation distribution.

This link runs between the ticket reservation 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).
- Track alarm (2 wire link).

Other services:

- Maintenance of signalling and telecommunications.
- 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 1960's 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. Transmission lines are usually served by HF (frequency modulation) electronic transmission equipment and partly through digital transmission equipment. Use is also made of baseband transmission.

The cables used are 7x4x1.2+5x2x0.9+1x0.9 (7 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 overleaf 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.

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 +3.5 km	T3AVB 7x4x1.2 +TZBL 14x4x1.2	1967 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 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 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 origin and end stations indicated in the table overleaf.

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, Kyrgystan 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-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 station operations manager 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, Kyrgystan 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 fed by 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. The 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.

Origin 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 70's through to 90's. 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.
- Ticket reservation distribution.

This link connects the ticket reservation centre with some mainline 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).

Other services:
- Maintenance of signalling and telecommunications.
- Track maintenance.
- Open track 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 1960's 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. Transmission lines are usually served by HF (frequency modulation) electronic transmission equipment. Use is also made of baseband transmission.

Cables are 7x4x1.2+5x2x0.9+1x0.9 (7 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.

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. The amplification points are located in stations with an average distance of 35 km apart. Furthermore, channels are amplified in the origin and end stations indicated in the table overleaf 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-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 station operations manager 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. Switches are electromechanical. 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 fed by 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. The 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 numbering scheme is set out in the following 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 70's to the 90's. 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.

- Ticket reservation distribution.

This link runs between the ticket reservation centre and some mainline 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).

Other services:

- Signalling and telecommunications maintenance.
- Track maintenance.
- Open track 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 1960's 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. Transmission lines are are usually served by HF (frequency modulation) electronic transmission equipment. Use is also made of baseband transmission.

Cables are 7x4x1.2+5x2x0.7+1x0.7 (7 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 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.

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. The amplification points are located in stations with an average distance of 35 km apart. Furthermore, channels are amplified in the origin and end stations indicated in the table overleaf 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 Kyrgystan 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-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-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 station operations manager 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 connections 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 following table 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 table overleaf.

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 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 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.
- Ticket reservation distribution.

The ticket reservation distribution centre is connected to some mainline 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).

Other services:

- Signalling and telecommunications maintenance
- Track maintenance
- Open track 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. Transmission links are generally fed by HF (frequency modulation) electronic transmission installations. Baseband transmission is also used.

The cables are type 7x4x1.2+5x2x0.7+1x0.7 (7 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 falling short of 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 capacity regulation. This interference is not easily eliminated from cables that have already been laid. All these problems apply when cables sections are stolen.

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 (mainline, 6 HF wires) or 5 mm (mainline, 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. Station amplifiers are positioned at intervals of approximately 35 mm (for aerial lines, this distance is doubled). Furthermore, channels are amplified at emitting stations and at the endpoints 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).

To be done

3. Information Technology

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 IT 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 IT control centre in Almaty (Kazakhstan) and those in Tajikistan off 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 IT control 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 clients.

Neither is there any electronic exchange of data with port authorities or maritime companies.

For the pupose 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 "IT control 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 Outline of the IT system

For more detail 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...)

3.1.1.4.1 Current status

3.1.1.4.2 Projects

3.1.1.5 Electronic data interchange with customers

3.1.1.5.1 Current status

3.1.1.5.2 Projects

3.1.1.6 Electronic data interchange with port authorities and maritime companies

3.1.1.6.1 Current status

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 Outline 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 diagram

3.1.2.3.1 Diagram of principal computer sites

(See diagram 3.1.2.3.1)

3.1.2.3.2 Detailed diagram of computer sites

(See diagram 3.1.2.3.2)

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

3.1.2.4.1 Current status

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 Current status

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 maritime companies

3.1.2.6.1 Current status

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 IT control 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
- Commodities transported
- Consignee
- Originating station
- Receiving station
- Train consist
- Train routes and timetables
- 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 dispense 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 IT control 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 Outline of the IT system

The IT control 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 diagram

3.1.3.3.1 Diagram of principal computer sites.

(See diagram 3.1.3.3.1)

3.1.3.3.2 Detailed diagram of computer sites

(See diagram 3.1.3.3.2)

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

3.1.3.4.1 Current status

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 Current status

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 maritime companies

3.1.3.6.1 Current status

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 IT control 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
- Commodities transported
- Consignee
- Originating station
- Receiving station
- Train consist
- Train routes and timetables
- 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 IT control 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 Outline 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

(See diagram 3.1.4.3)

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

3.1.4.4.1 Current status

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 Current status

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 maritime companies

3.1.4.6.1 Current status

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 IT control 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
- Commodities transported
- Consignee
- Originating station
- Receiving station
- Train consist
- Train routes and timetables
- 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 IT control 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 IT control 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 Outline 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 IT control 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 diagram

3.1.5.3.1 Diagram of principal computer sites

(See diagram 3.1.5.3.1)

3.1.5.3.2 Detailed diagram of computer sites

(See diagram 3.1.5.3.2)

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

3.1.5.4.1 Current status

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 Current status

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 maritime companies

3.1.5.6.1 Current status

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 system

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
- Commodities carried
- Consignee
- Originating station

- Receiving station
- Train consist
- Train routes and timetables
- 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 IT control 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 IT control 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 Overview of existing studies

3.2.1 Central asian railways restructuring - Module A - Kazakhstan - Draft Final Report - Janurary 98

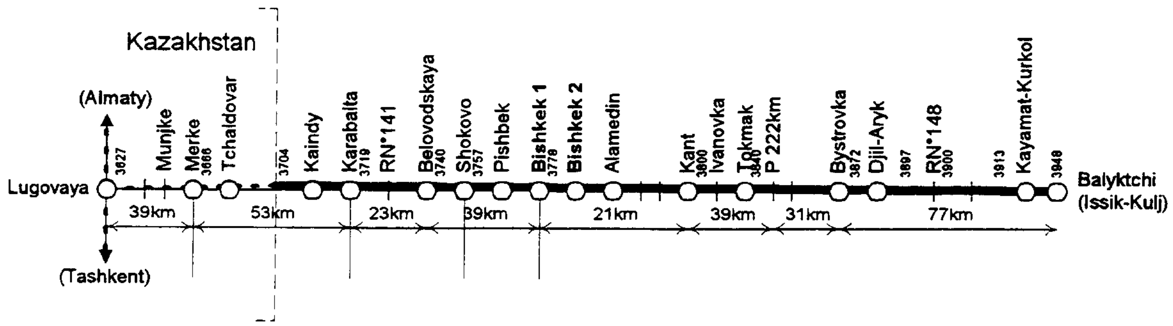
To be done

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

To be done

3.2.3 Central Asian railways restructuring - Module C - Turkmenistan - Draft Final Report - January 98

To be done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Lugovaya
(Tashkent)
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Munjke
Merke
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Tchaldovar
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Karabalta
3719
RN°141
Belovodskaya
3740
Shokovo
3757
Pishbek
Bishkek 1
3778
Bishkek 2
Alamedin
Kant
3800
Ivanovka
Tokmak
3840
P 222km
Bystrovka
3872
Djil-Aryk
3897
RN°148
3900
3913
Kayamat-Kurkol
Balyktchi
(Issik-Kulj)
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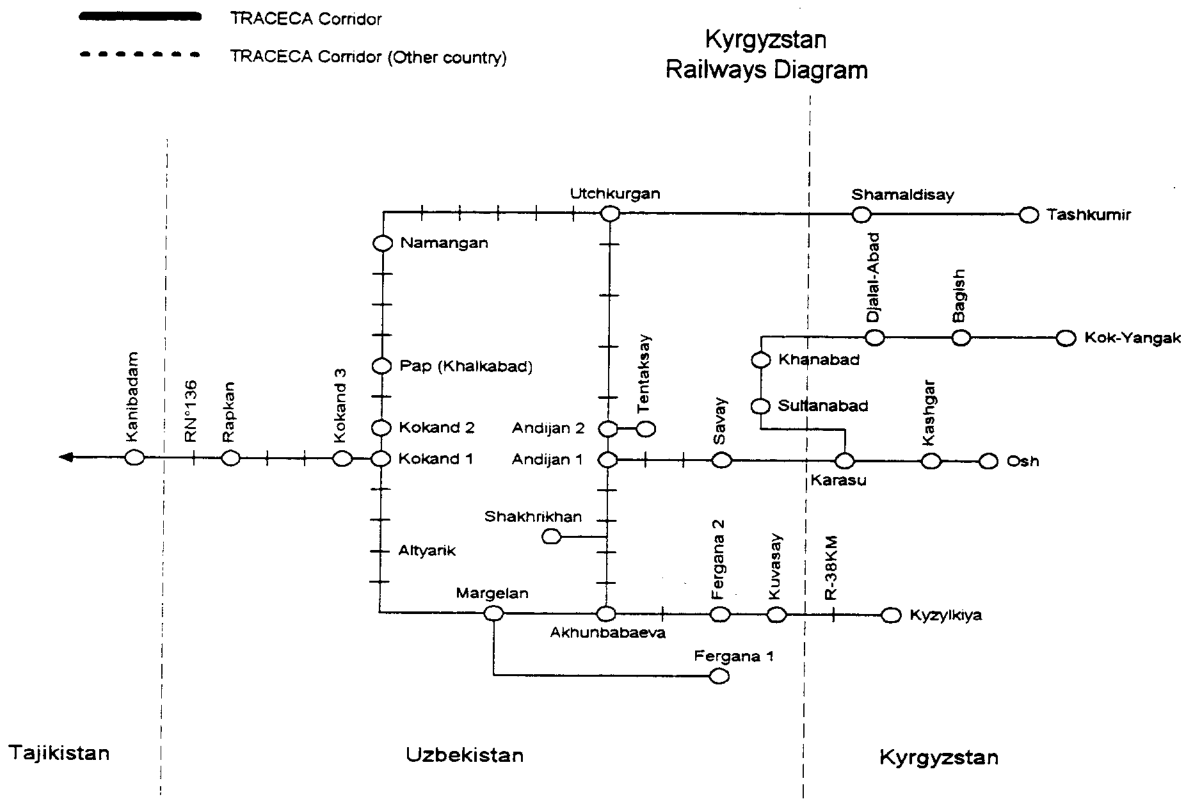
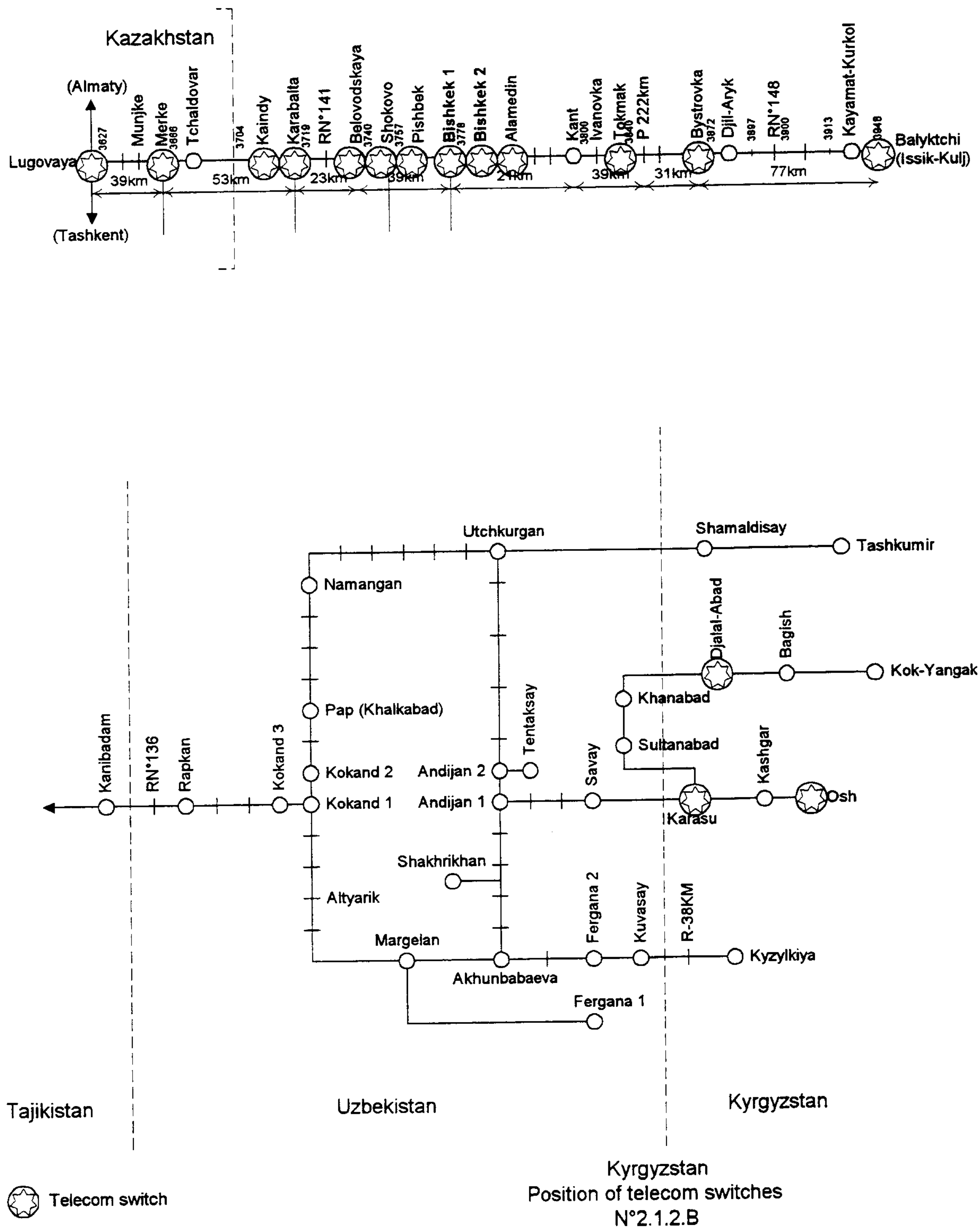
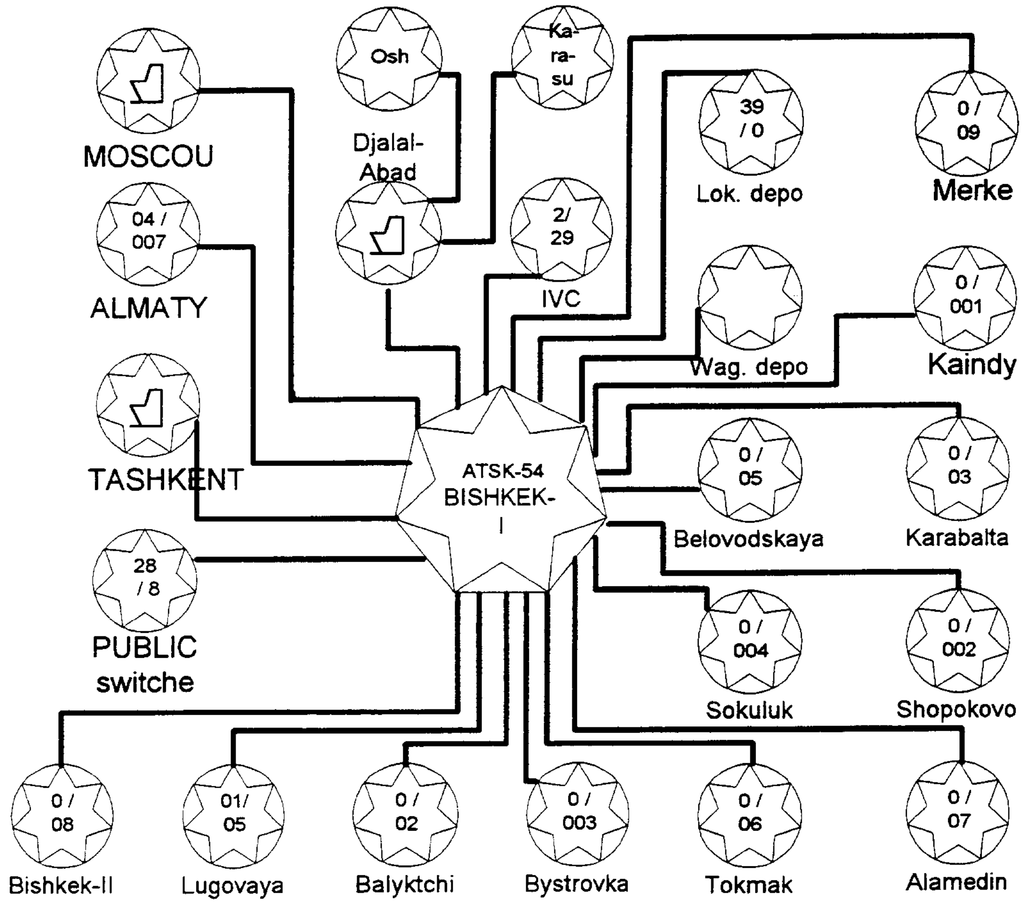
53km
23km
39km
21km
39km
31km
77km


TRACECA Corridor
TRACECA Corridor (Other country)
Kyrgyzstan
Railways Diagram
Utchkurgan
Shamaldisay
Tashkumir
Namangan
Djalal-Abad
Baglsh
Kok-Yangak
Pap (Khalkabad)
Khanabad
Sultanabad
Tentaksay
Kanibadam
RN°136
Rapkan
Kokand 3
Kokand 2
Kokand 1
Andijan 2
Andijan 1
Savay
Kashgar
Osh
Karasu
Shakhrikhan
Altyarik
Margelan
Akhunbabaeva
Fergana 2
Kuvasay
R-38KM
Kyzylkiya
Fergana 1
Tajikistan
Uzbekistan
Kyrgyzstan

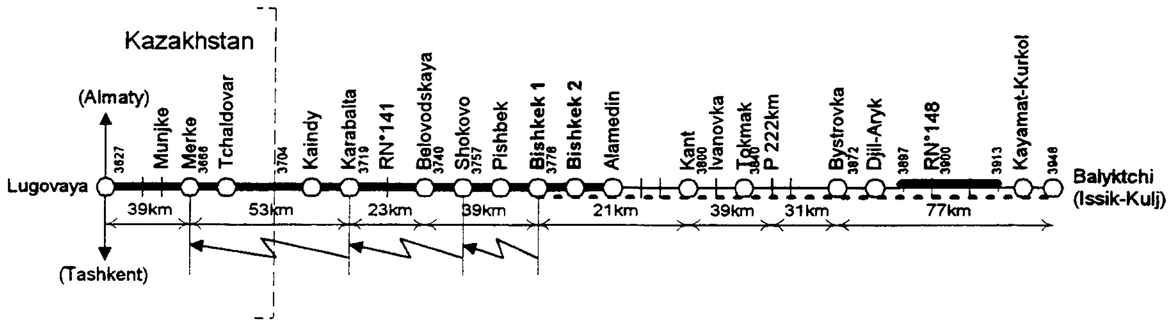
N°2.1.2.A



Kyrgyzstan
Position of telecom switches
N°2.1.2.B



Kyrgyzstan
N°2.1.2.C

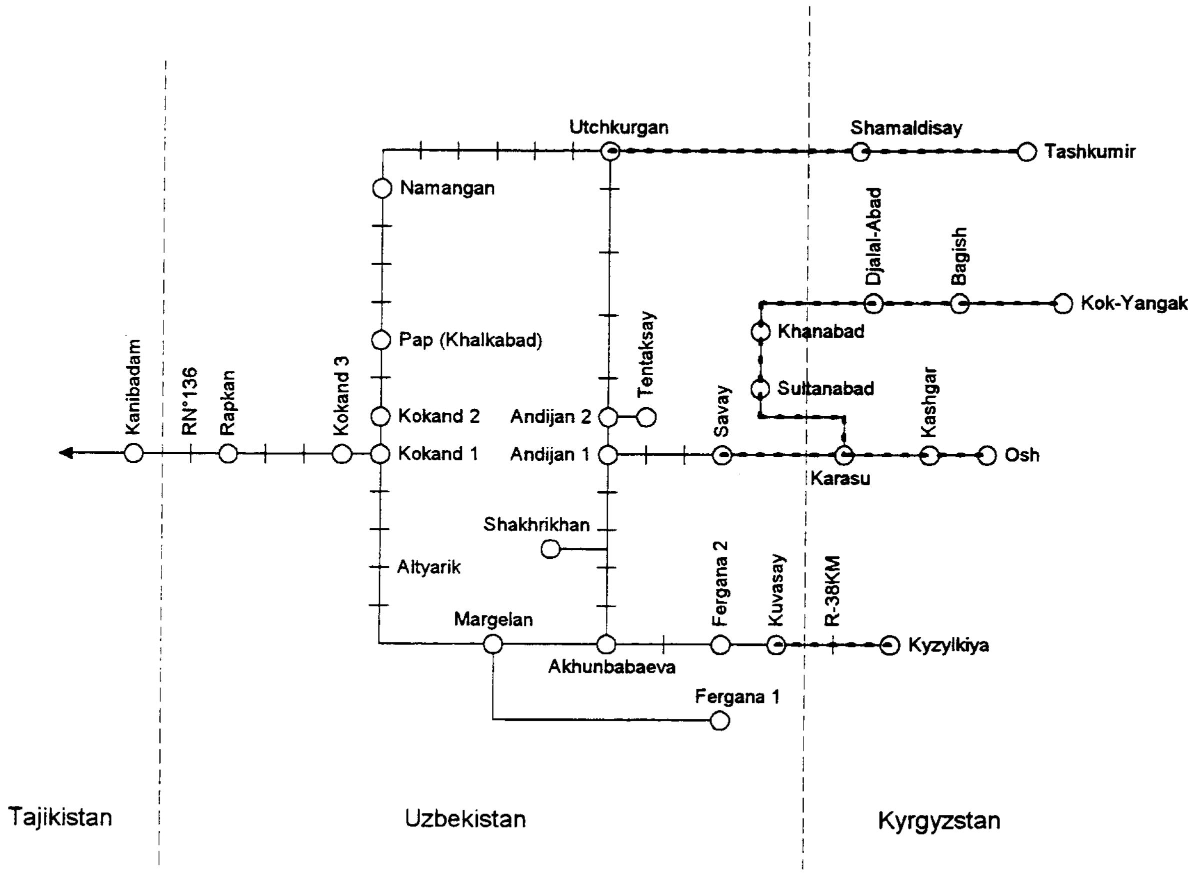


Cable

Aerial

Radio Link

Kyrgyzstan
Cabling Diagram

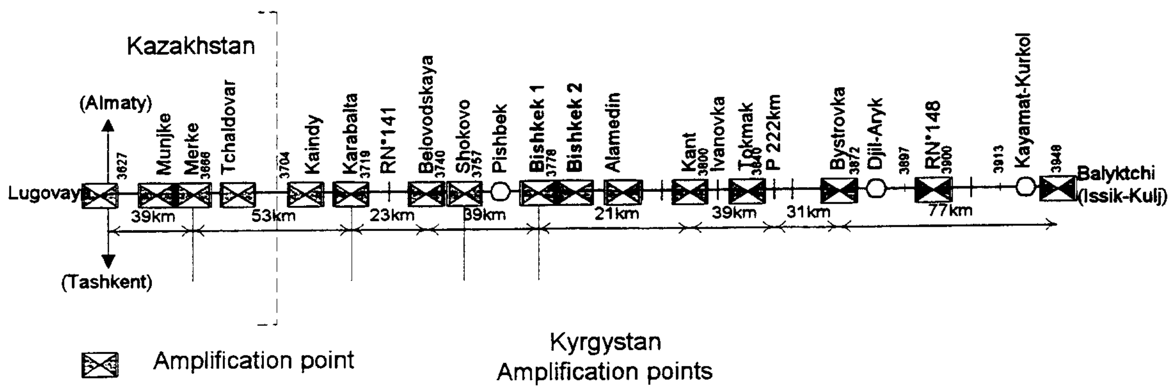


Cable

Aerial

Radio Link

Kyrgyzstan
Cabling Diagram
N°2.1.2.C


Kazakhstan
(Almaty)
(Tashkent)
Lugovaya
3627
Munjke
Merke
3666
Tchaldovar
3704
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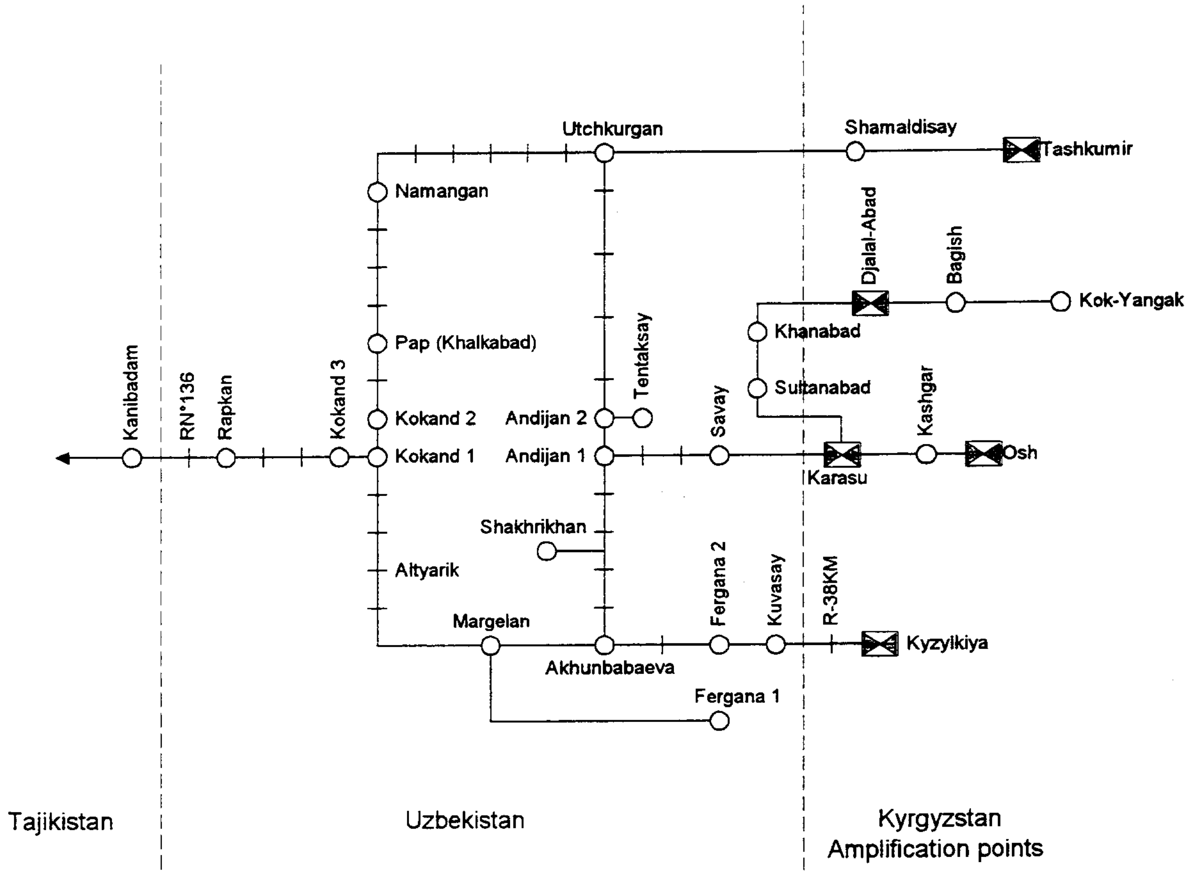
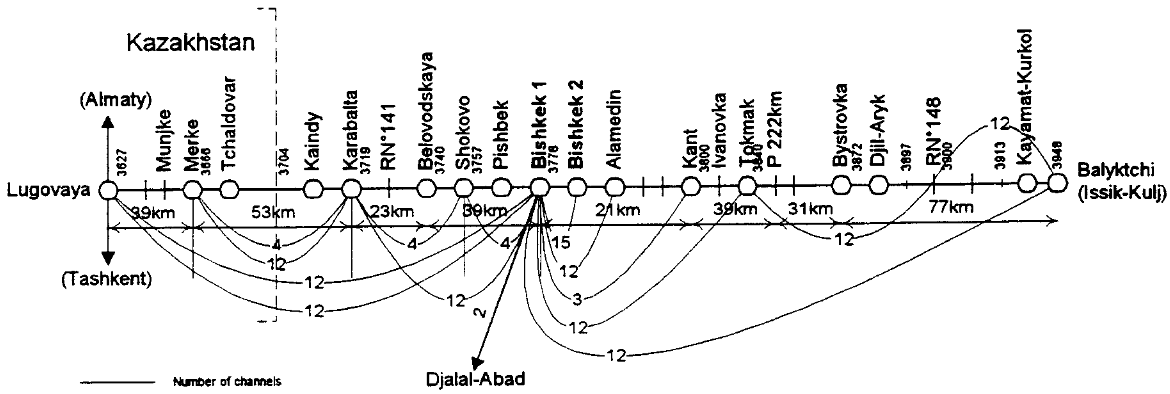
Karabalta
3719
RN°141
Belovodskaya
3740
Shokovo
3757
Pishbek
Bishkek 1
3778
Bishkek 2
Alamedin
Kant
3800
Ivanovka
Tokmak
3840
P 222km
Bystrovka
3872
Djil-Aryk
3897
RN°148
3900
3913
Kayamat-Kurkol
3948
Balyktchi
(Issik-Kulj)
39km
53km
23km
39km
21km
39km
31km
77km
Amplification point
Kyrgystan
Amplification points

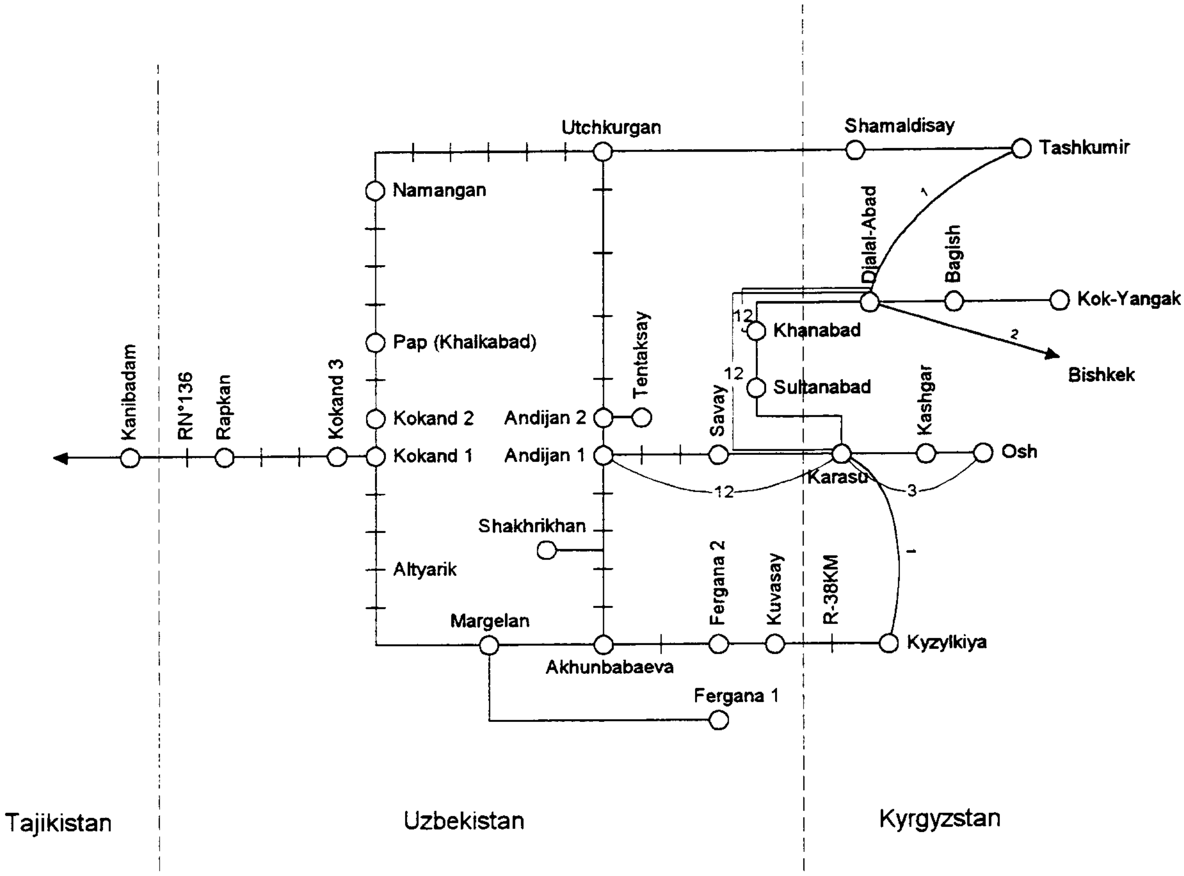

Utchkurgan
Shamaldisay
Tashkumir
Namangan
Djalal-Abad
Bagish
Kok-Yangak
Khanabad
Tentaksay
Pap (Khalkabad)
Sultanabad
Savay
Kashgar
Kanibadam
RN°136
Rapkan
Kokand 3
Kokand 2
Andijan 2
Kokand 1
Andijan 1
Karasu
Osh
Shakhrikhan
Altyarik
Fergana 2
Kuvasay
R-38KM
Margelan
Kyzylkiya
Akhunbabaeva
Fergana 1
Tajikistan
Uzbekistan
Kyrgyzstan
Amplification points



Number of channels

Number of channels (Public Telecom leased)

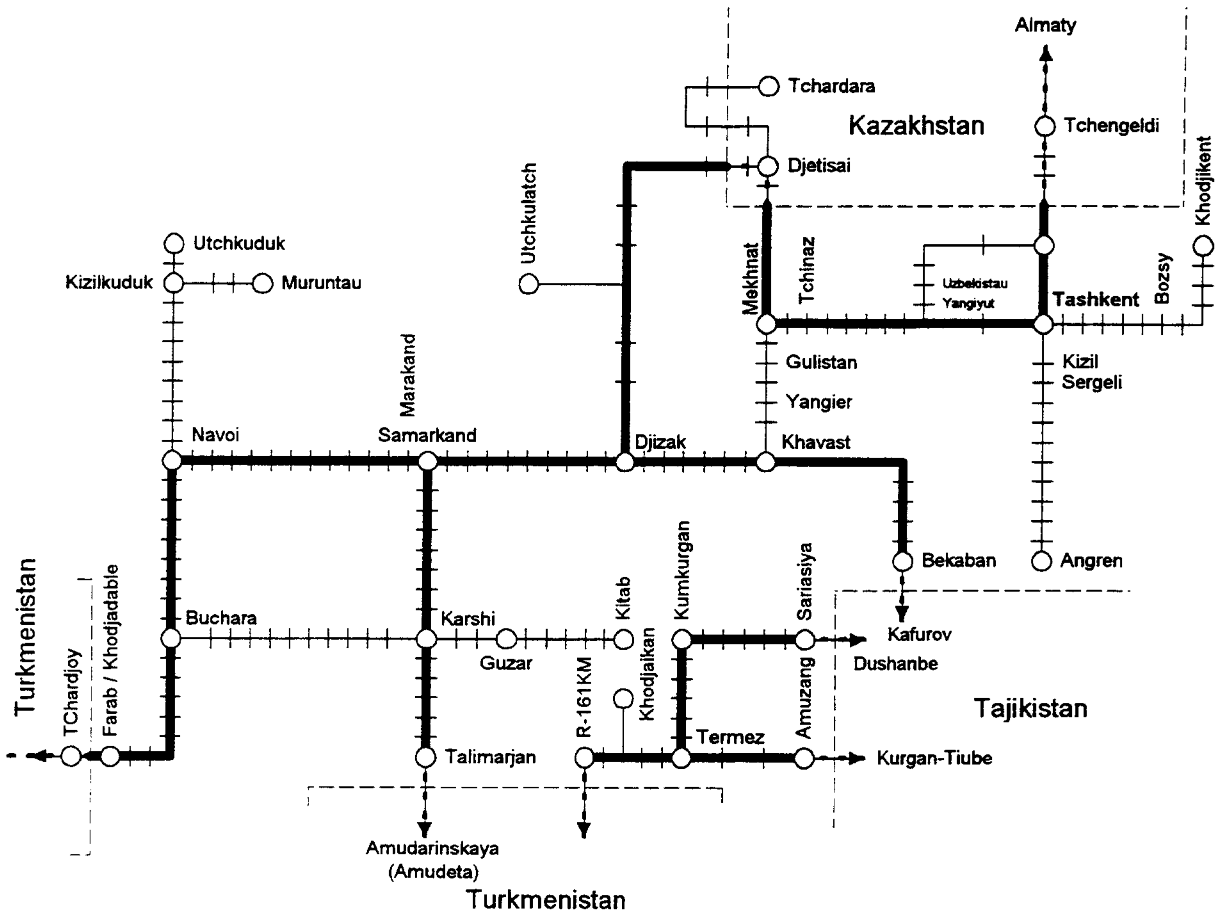
Kyrgyzstan
Transmission capacity



Number of channels

Number of channels (Public Telecom leased)

Kyrgyzstan
Transmission capacity
N°2.1.2.E

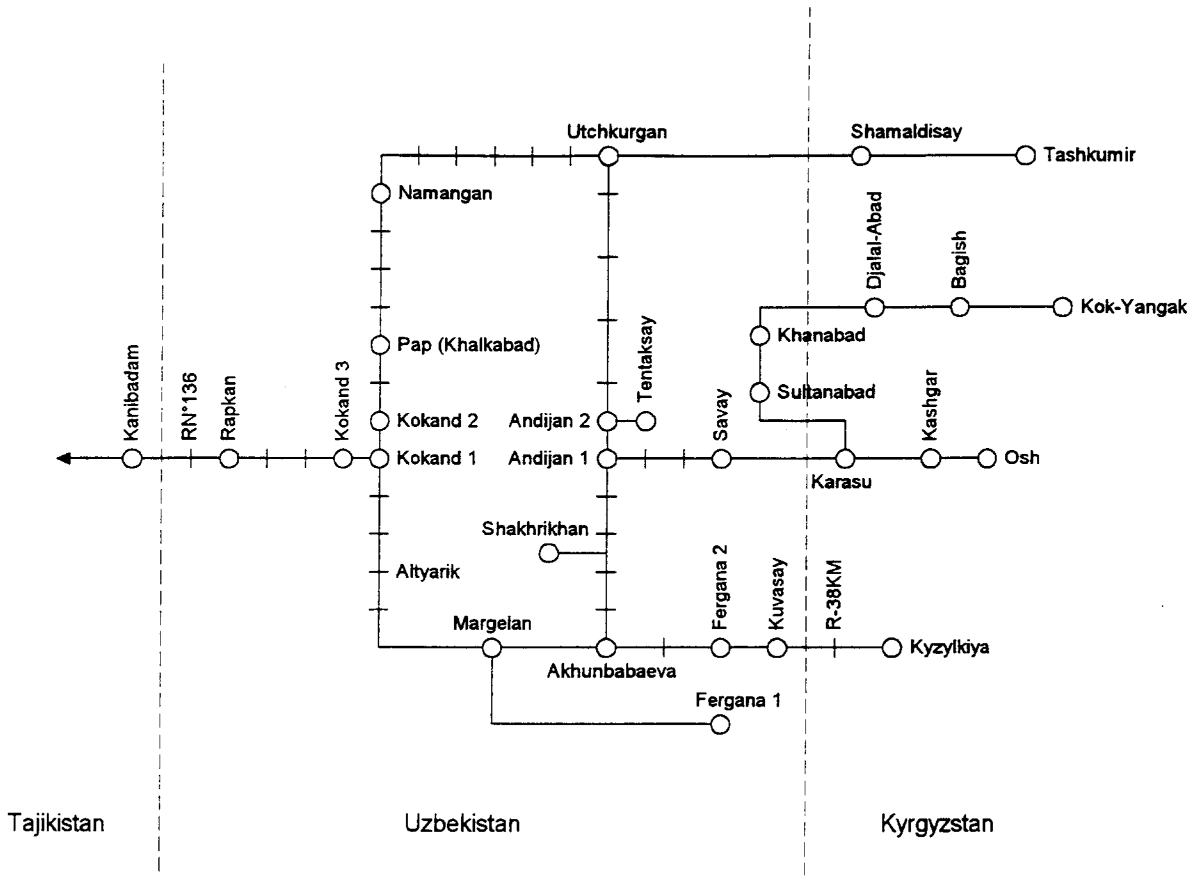


TRACECA Corridor

TRACECA Corridor (Other country)

Uzbekistan
Railways Diagram

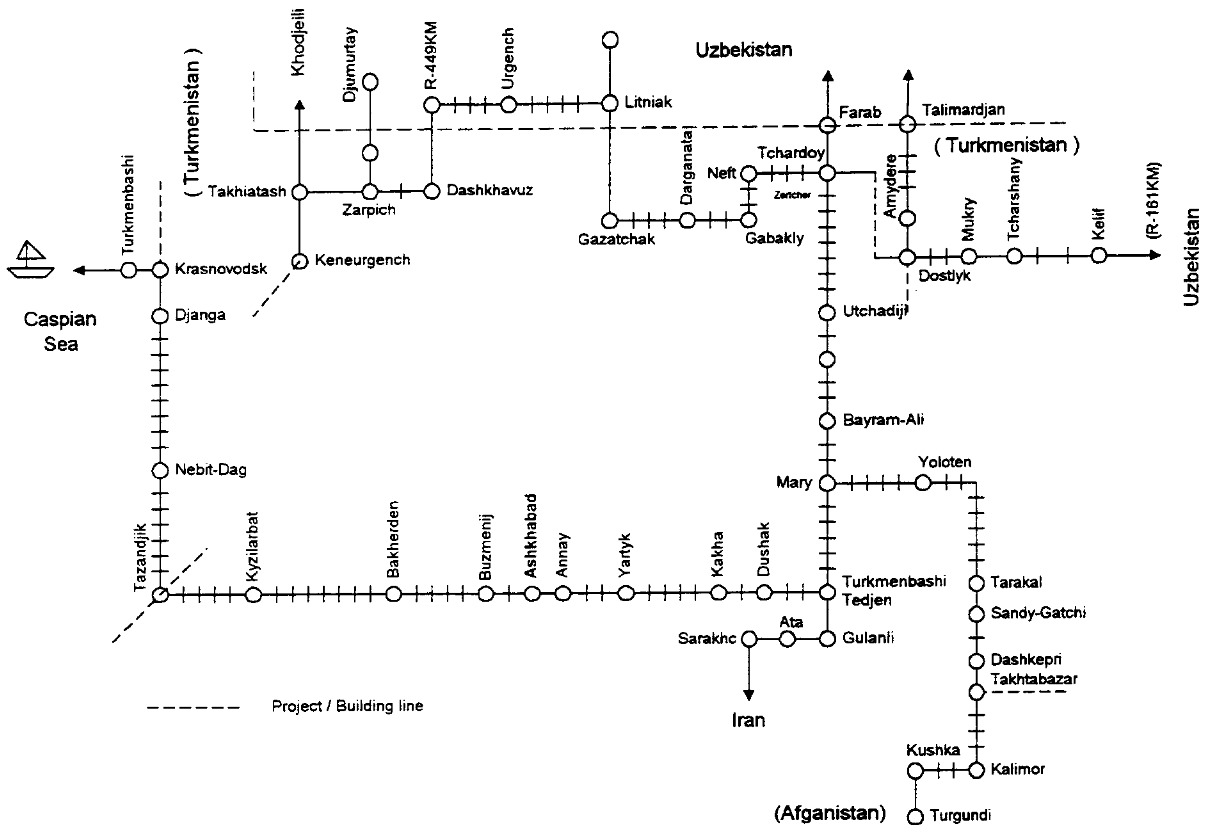
N°2.1.3.A - 1/3



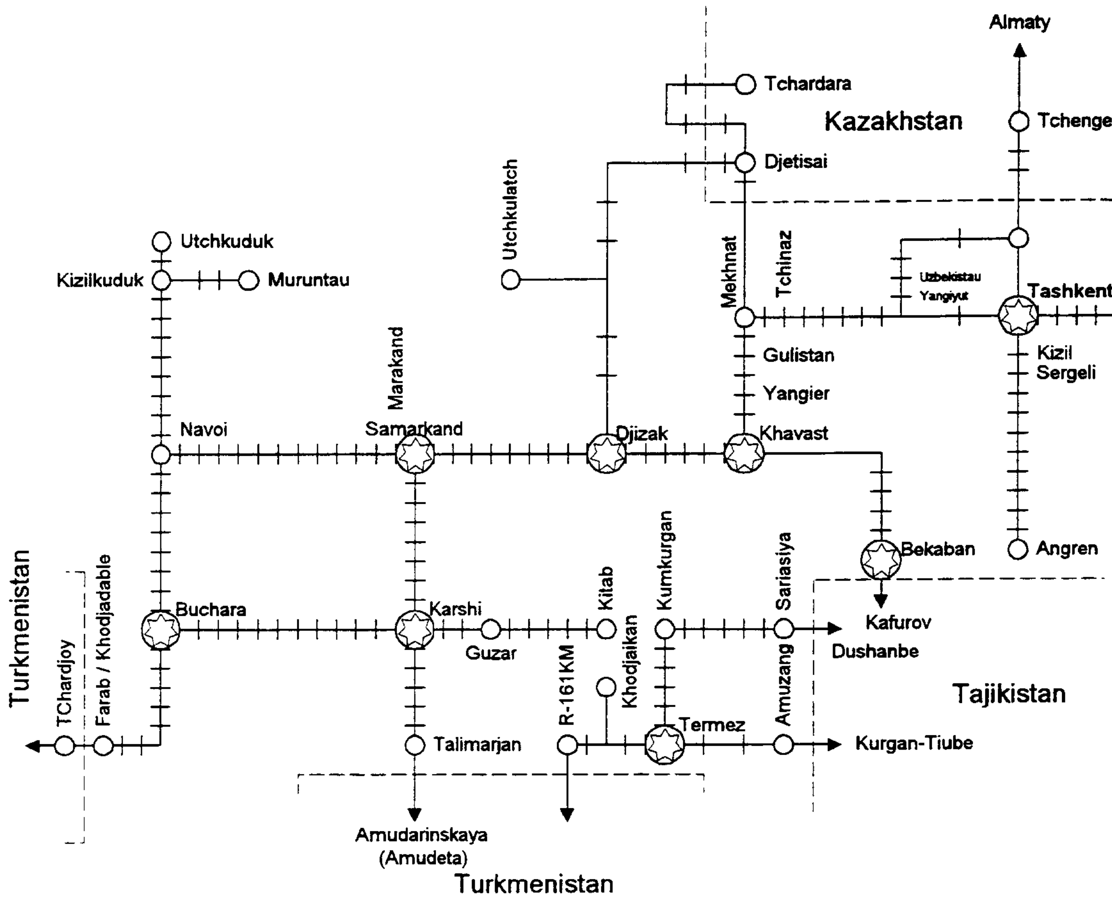
TRACECA Corridor

TRACECA Corridor (Other country)

Uzbekistan
Railways Diagram
N°2.1.3.A - 2/3


Uzbekistan
(Turkmenistan)
Khodjeili
Djumurtay
R-449KM
Urgench
Litniak
Farab
Talimardjan
(Turkmenistan)
Turkmenbashi
Takhiatash
Zarpich
Dashkhavuz
Darganata
Tchardoy
Neft
Zerchar
Amydere
Mukry
Tcharshany
Kelif
(R-161KM)
Uzbekistan
Gazatchak
Gabakly
Dostlyk
Krasnovodsk
Keneurgench
Caspian Sea
Djanga
Utchadiji
Bayram-Ali
Nebit-Dag
Yoloten
Mary
Tazandjik
Kyzilarbat
Bakherden
Buzmenij
Ashkhabad
Annay
Yartyk
Kakha
Dushak
Turkmenbashi
Tedjen
Tarakal
Sandy-Gatchi
Sarakhc
Ata
Gulanli
Dashkepri
Takhtabazar
Project / Building line
Iran
Kushka
Kalimor
(Afganistan)
Turgundi

N°2.1.3.A - 3/3


Almaty
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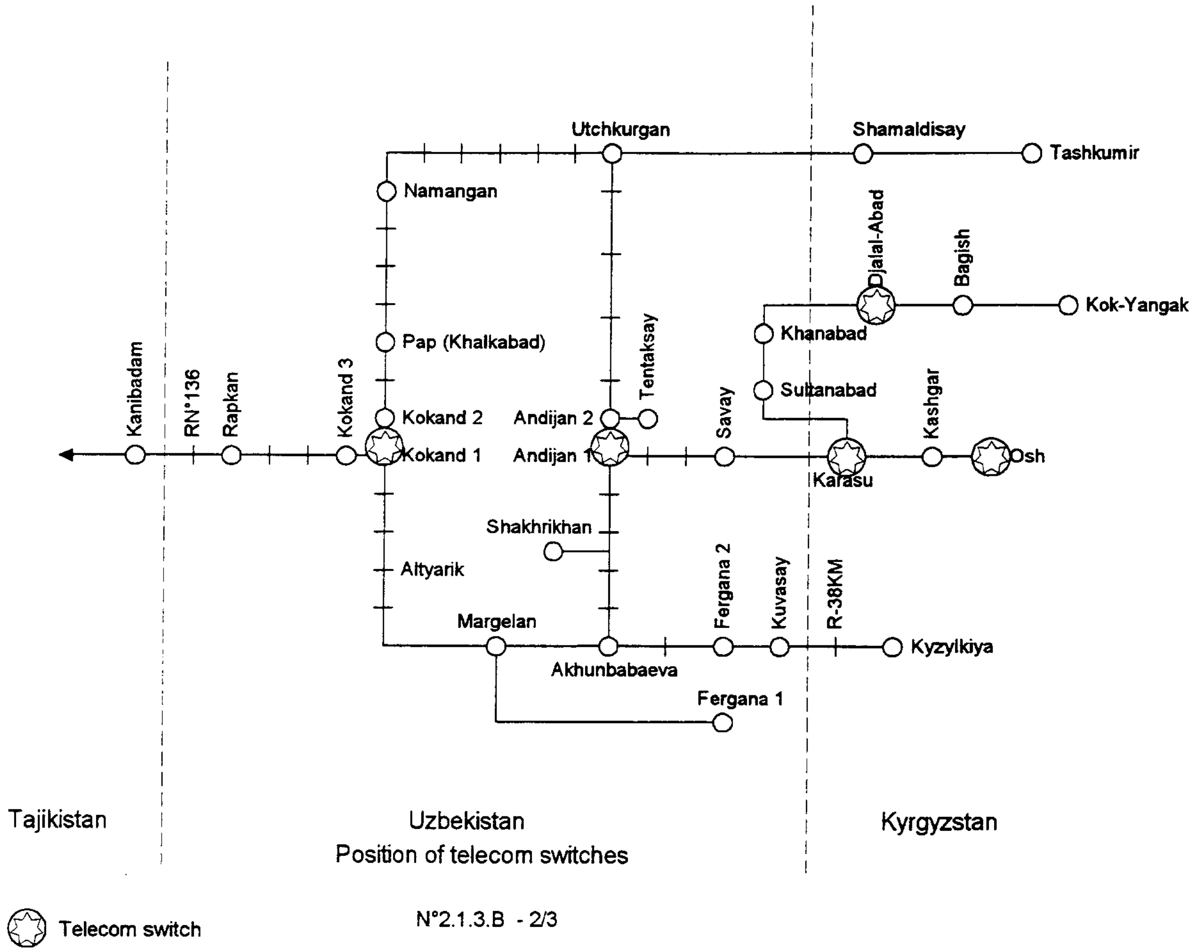
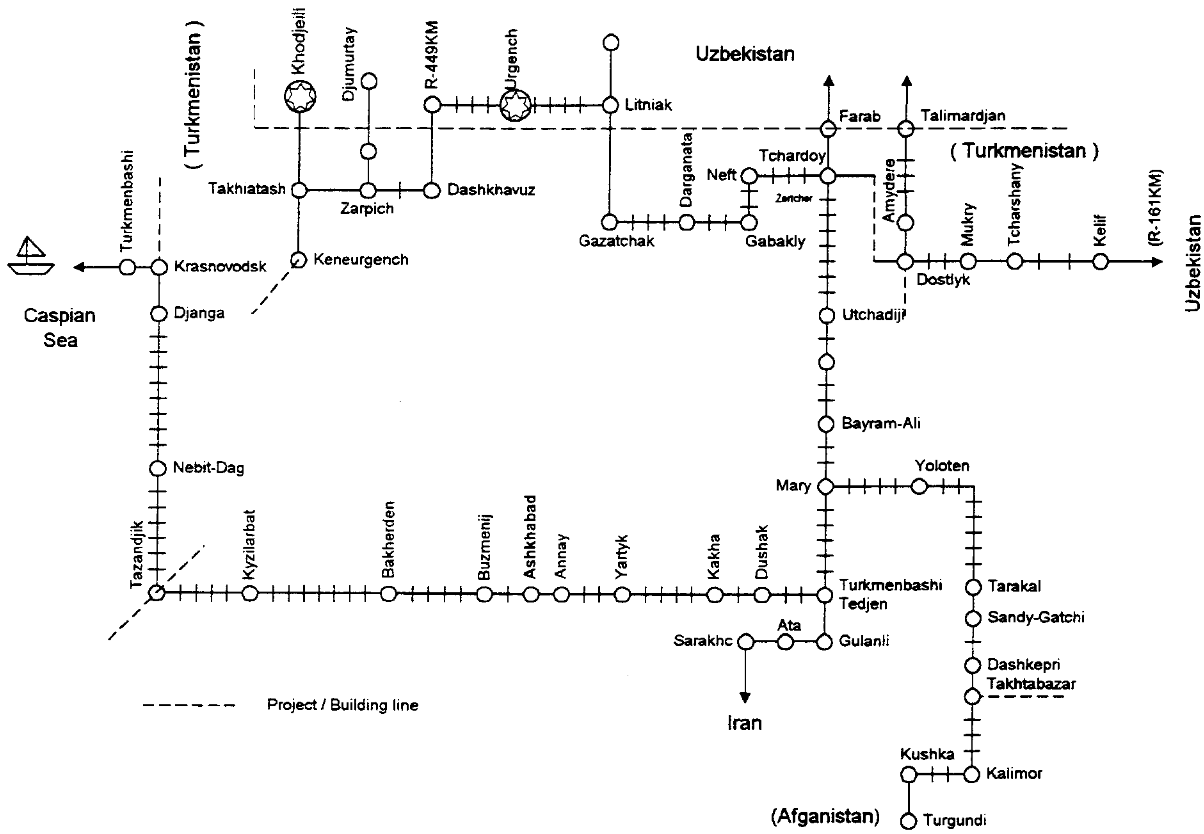
Kazakhstan
Tchengeldi
Khodjikent
Djetisai
Utchkulatch
Utchkuduk
Kizilkuduk
Muruntau
Mekhnat
Tchinaz
Uzbekistau
Yangiyut
Tashkent
Bozsy
Marakand
Gulistan
Kizil
Sergeli
Yangier
Navoi
Samarkand
Djizak
Khavast
Kumkurgan
Sariasiya
Bekaban
Angren
Turkmenistan
TChardjoy
Farab / Khodjadable
Buchara
Karshi
Kilab
Guzar
R-161KM
Khodjaikan
Amuzang
Kafurov
Dushanbe
Tajikistan
Termez
Talimarjan
Kurgan-Tiube
Amudarinskaya
(Amudeta)
Turkmenistan

N°2.1.3.B - 1/3

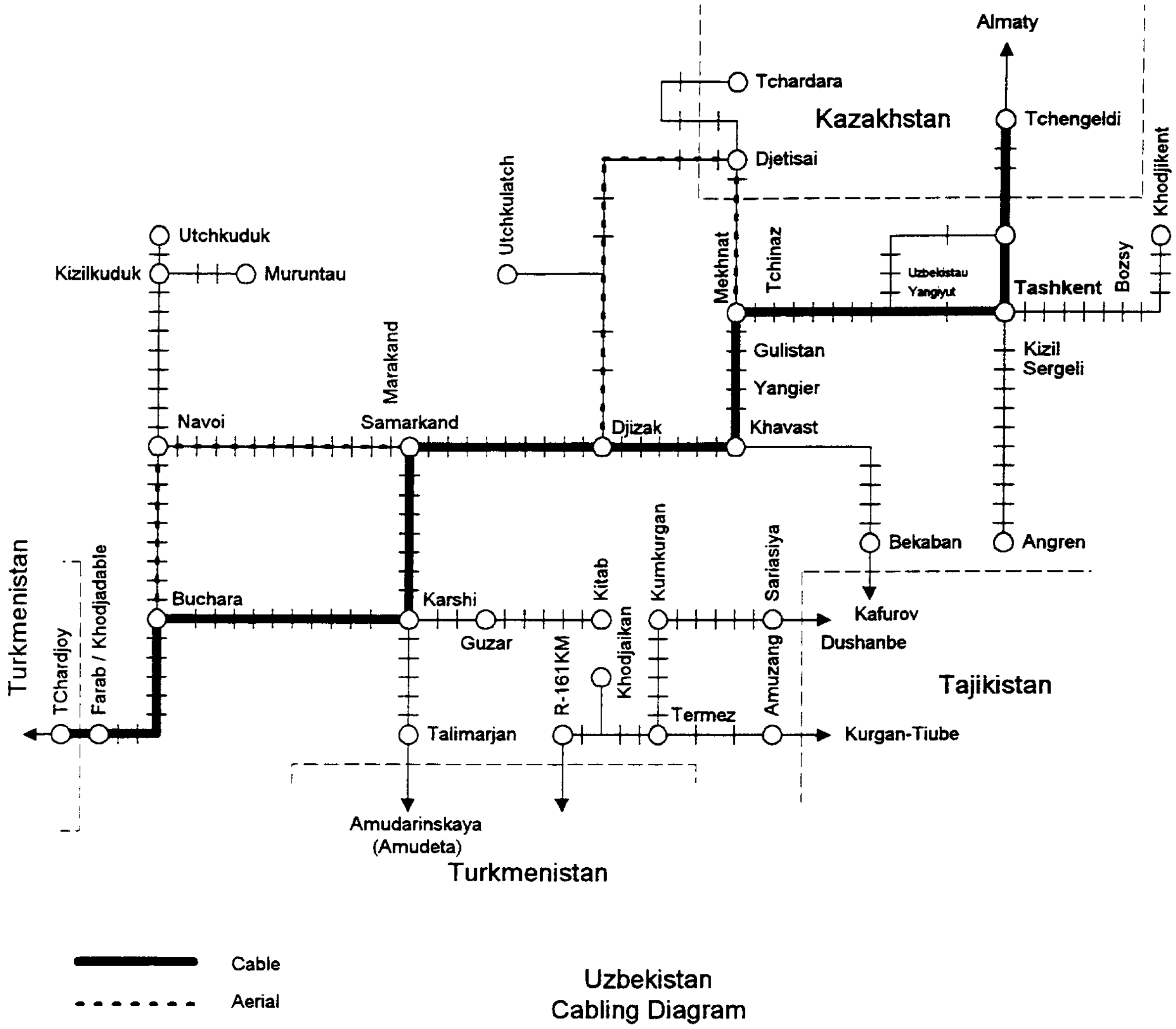


Position of telecom switches

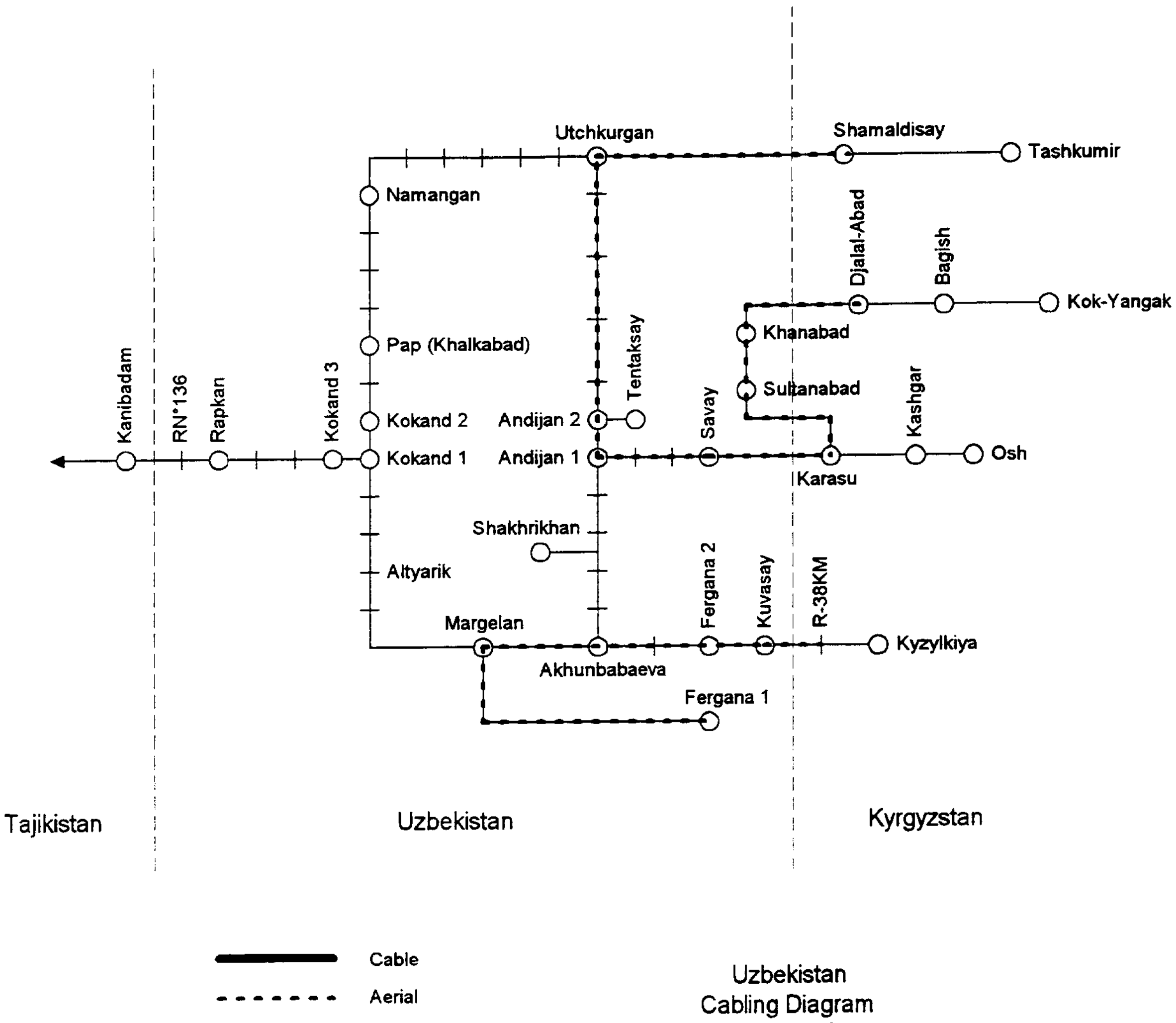
N°2.1.3.B - 2/3


Uzbekistan
(Turkmenistan)
Khodjeili
Djumurtay
R-449KM
Urgench
Litniak
Farab
Talimardjan
(Turkmenistan)
Turkmenbashi
Takhiatash
Zarpich
Dashkhavuz
Darganata
Tchardoy
Neft
Gazatchak
Gabakly
Amydere
Mukry
Tcharshany
Kelif
(R-161KM)
Uzbekistan
Krasnovodsk
Keneurgench
Dostlyk
Caspian Sea
Djanga
Utchadiji
Bayram-Ali
Nebit-Dag
Yoloten
Mary
Tazandjik
Kyzilarbat
Bakherden
Buzmenij
Ashkhabad
Annay
Yartyk
Kakha
Dushak
Turkmenbashi
Tedjen
Tarakal
Sandy-Gatchi
Ata
Sarakhc
Gulanli
Dashkepri
Takhtabazar
Project / Building line
Iran
Kushka
Kalimor
(Afganistan)
Turgundi

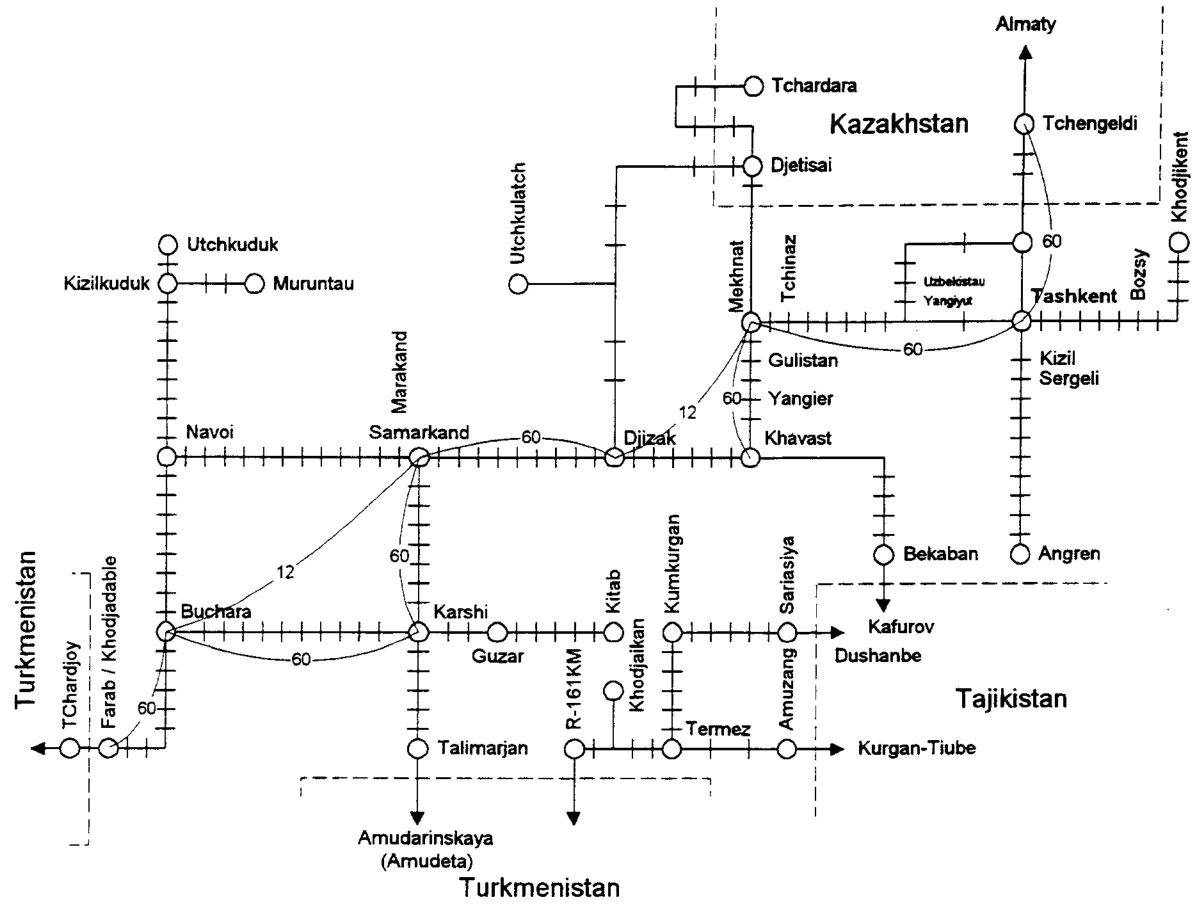
N°2.1.3.B - 3/3



Uzbekistan
Cabling Diagram



Uzbekistan
Cabling Diagram
N°2.1.3.C

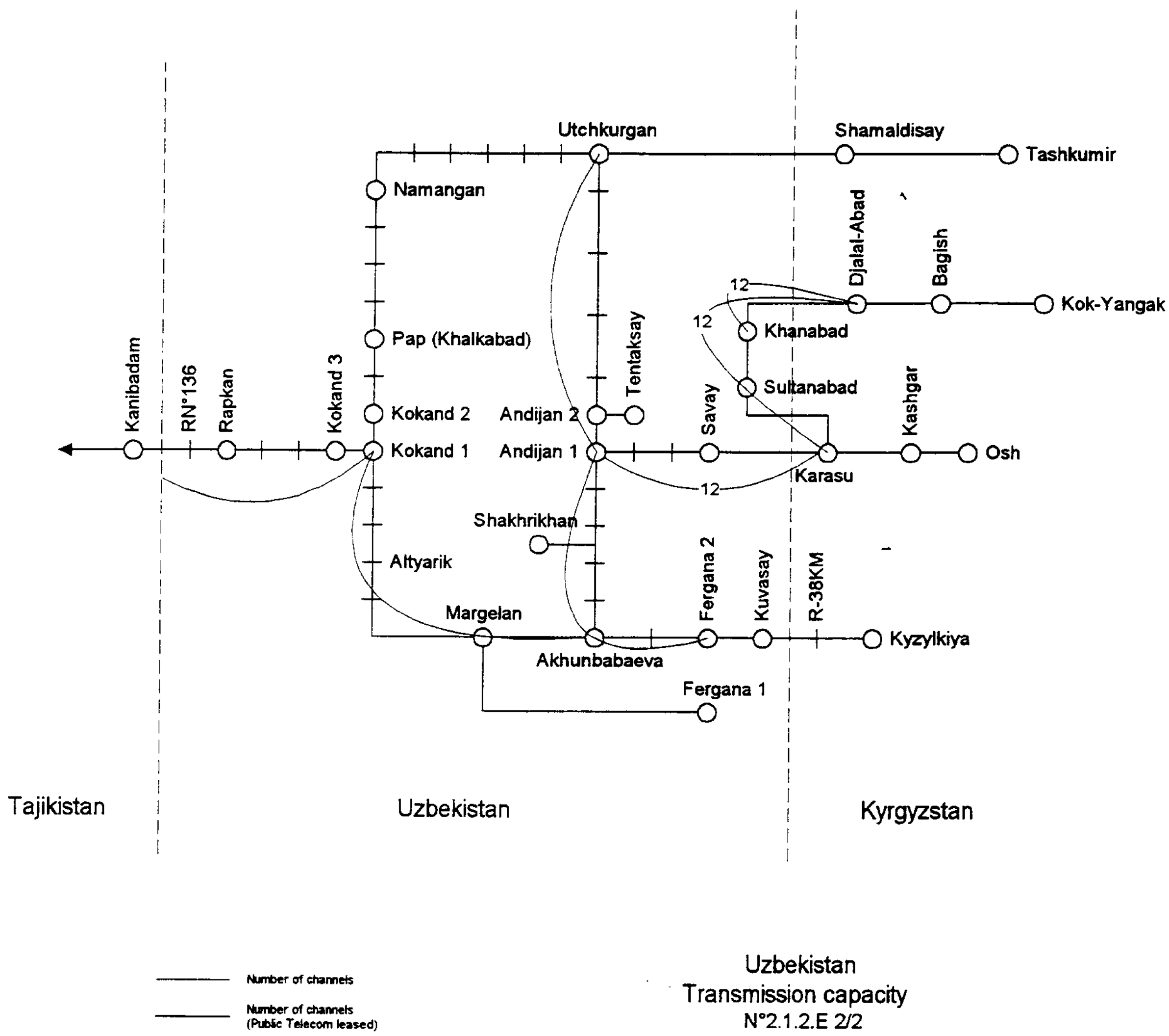


Number of channels

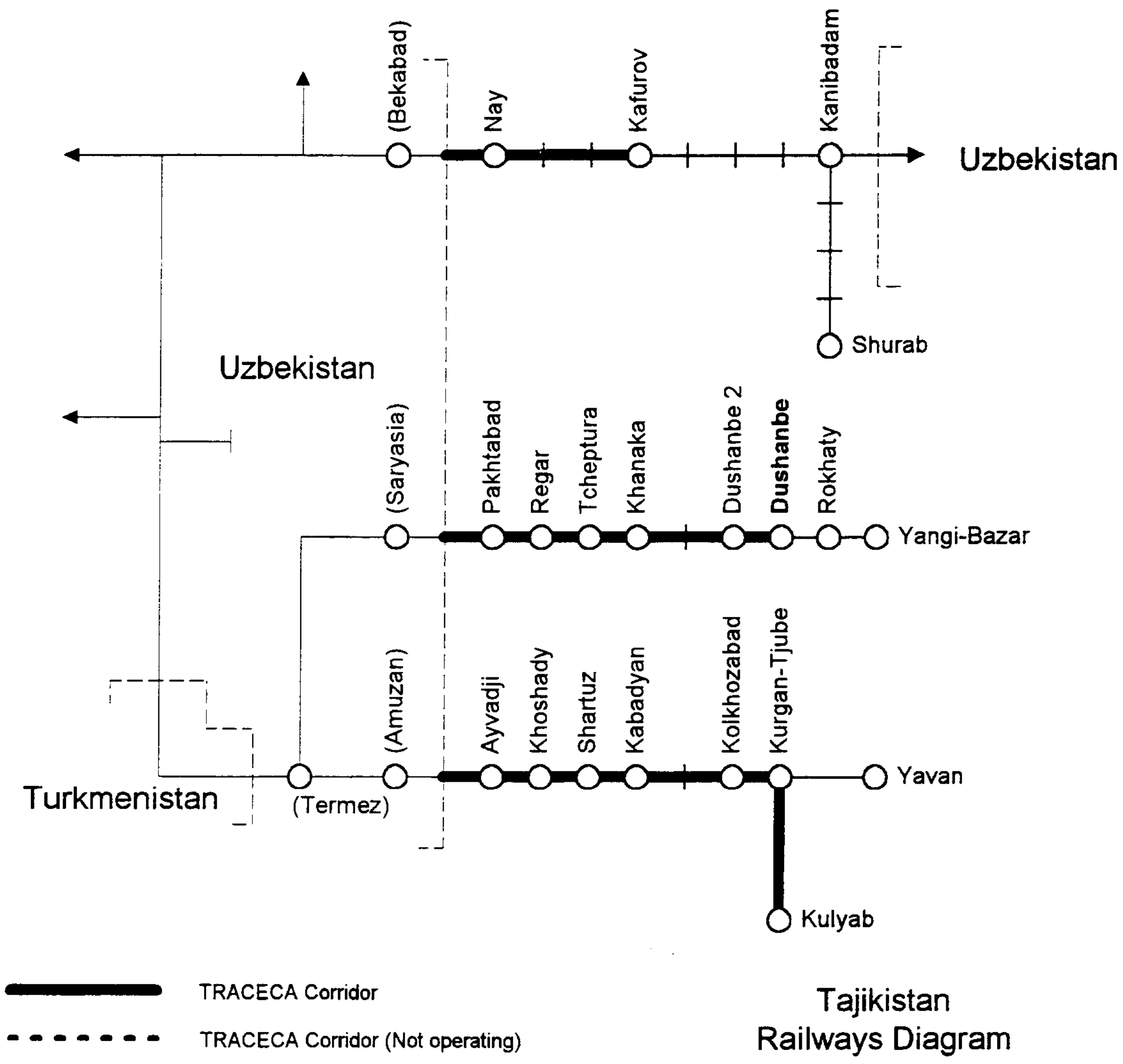
Number of channels
(Public Telecom leased)

Uzbekistan
Transmission capacity

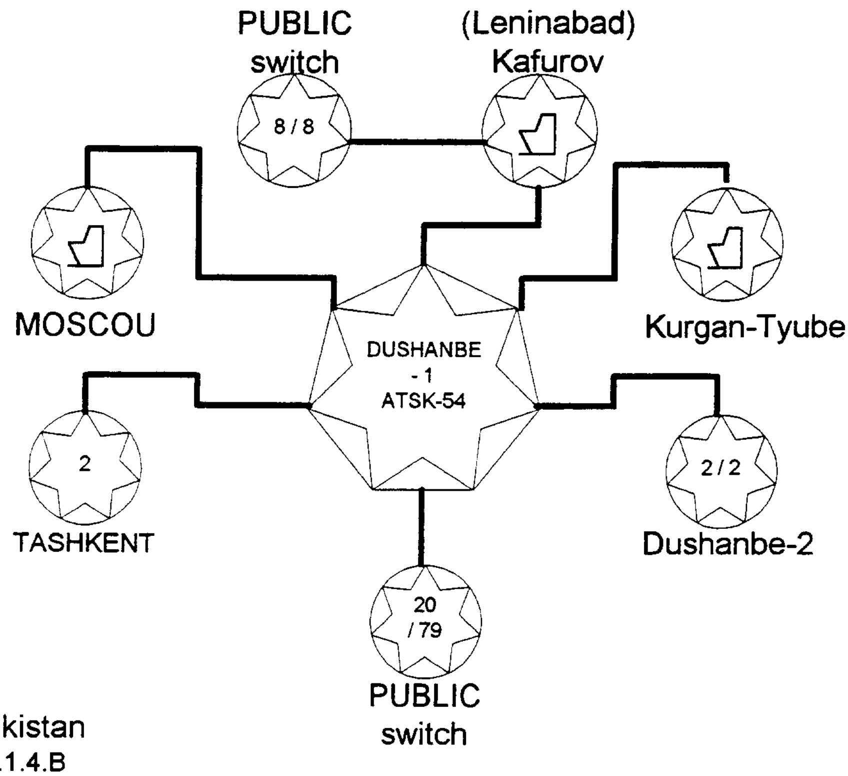
N°2.1.3.E - 1/2



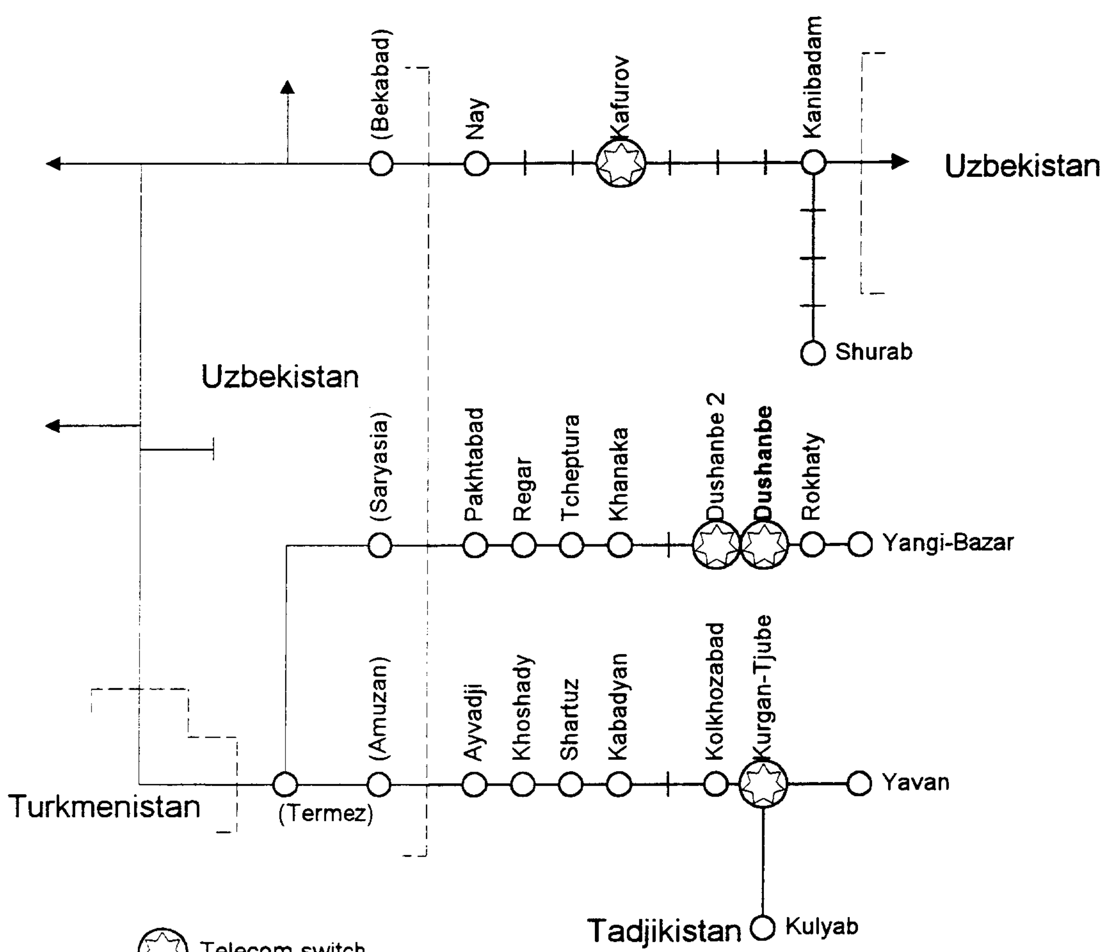
Uzbekistan
Transmission capacity
N°2.1.2.E 2/2



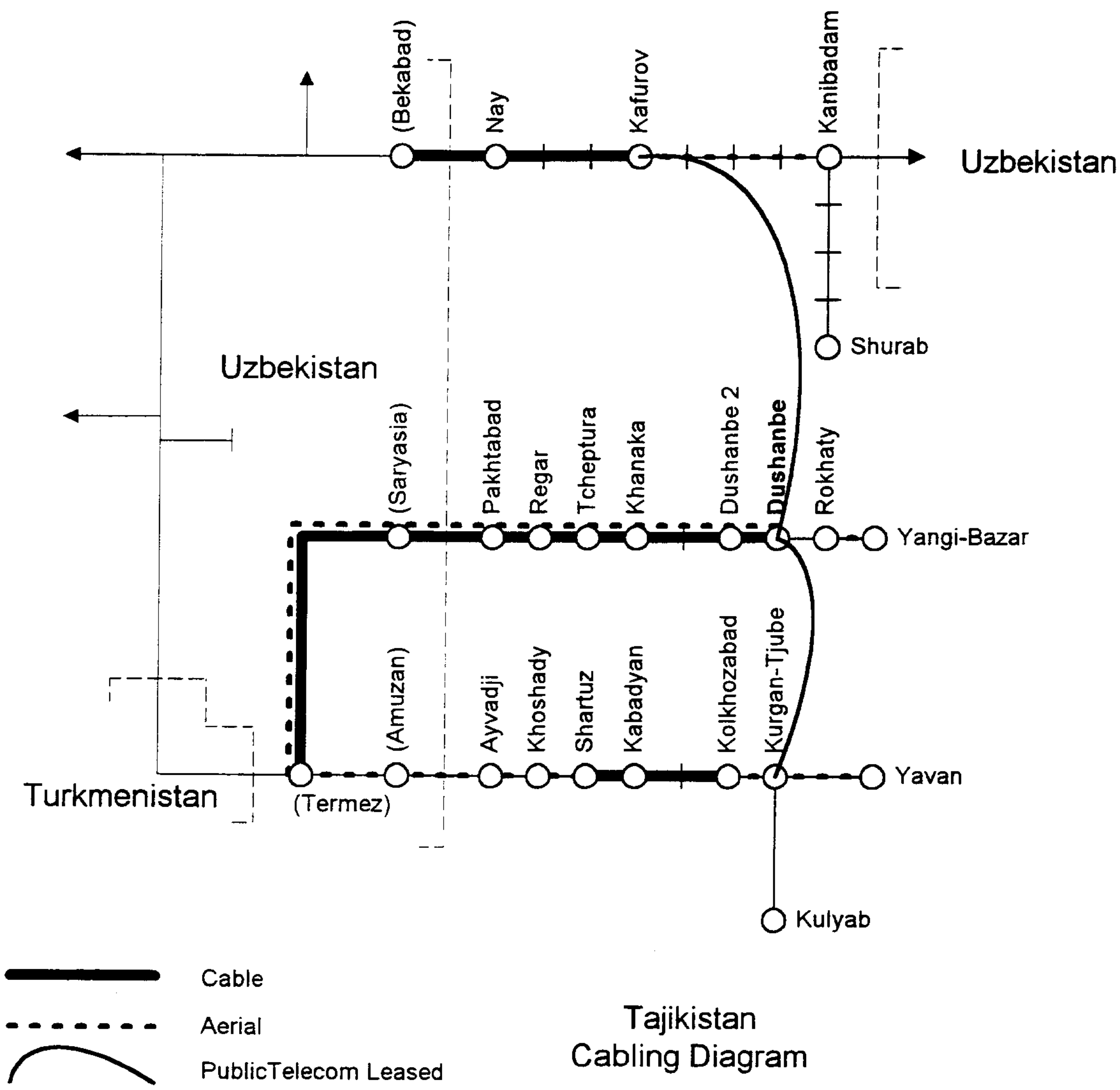
Tajikistan
Railways Diagram
N°2.1.4.A



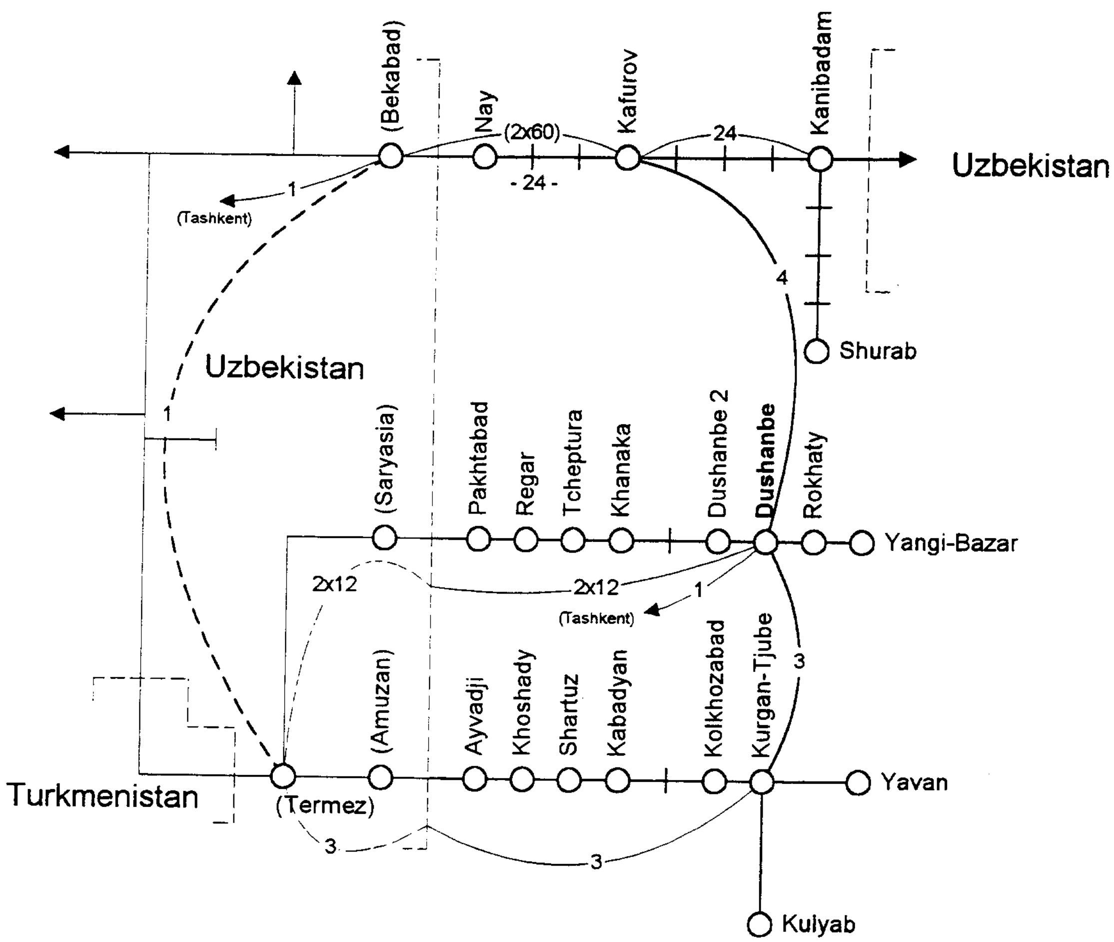
Tadjikistan
N°4.1.4.B



Position of switches
N°2.1.4.C



Tajikistan
Cabling Diagram
N°2.1.4.D

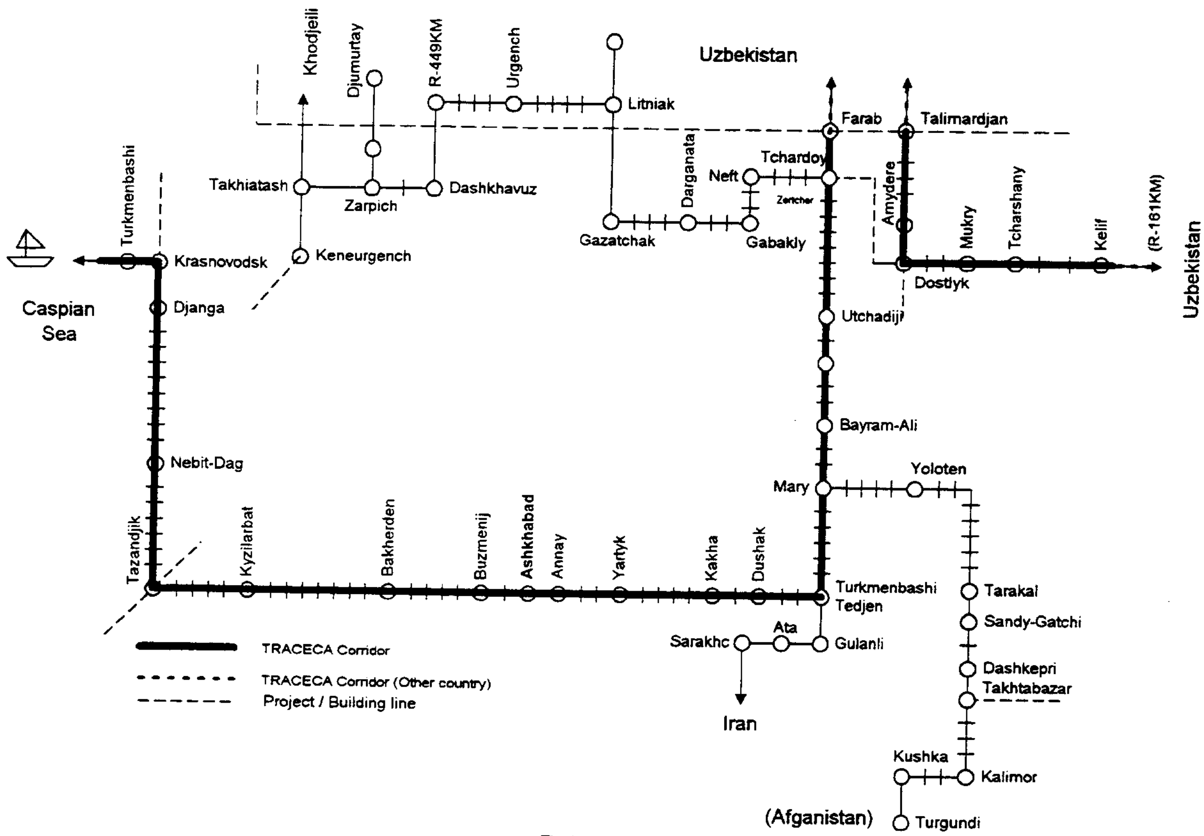


Number of channels

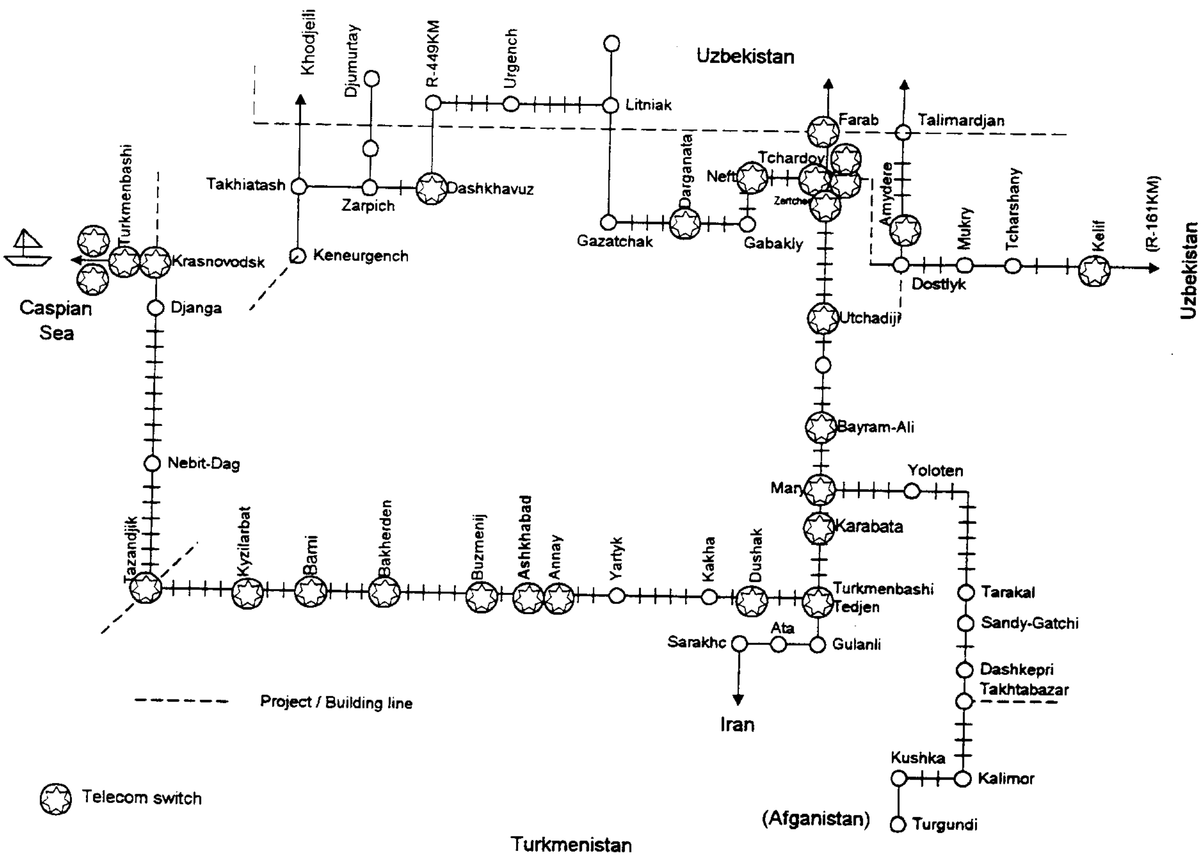
Number of channels
(Public Telecom leased)

Number of channels
(Belonging to another country)

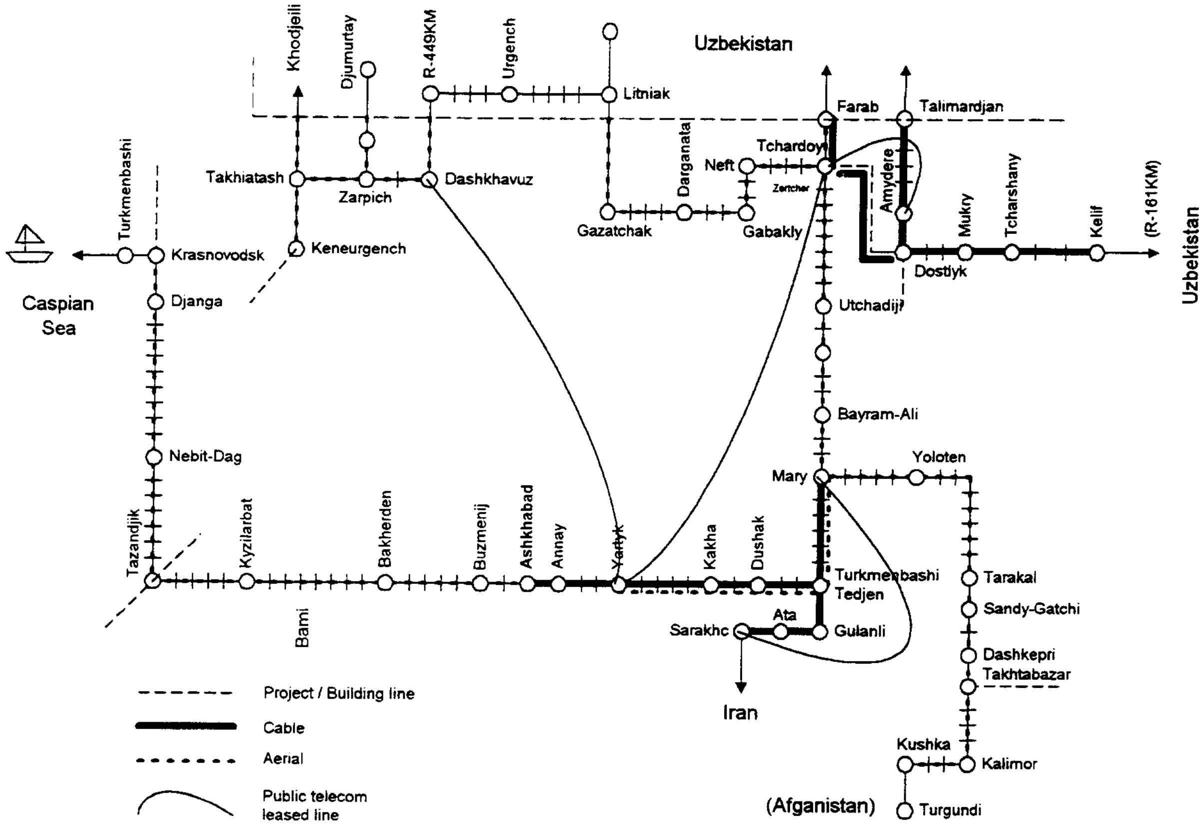
Tajikistan
Transmission capacity
N°2.1.4.E



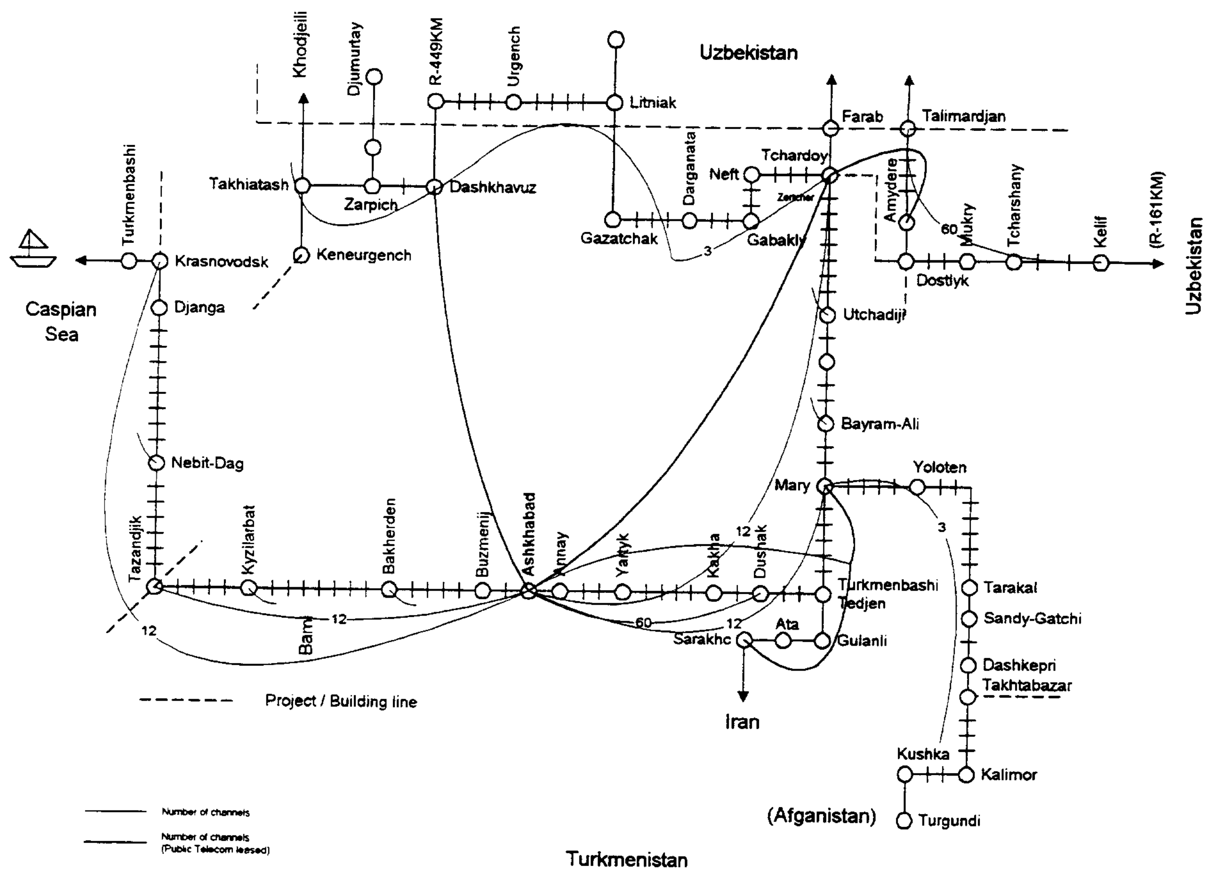
Turkmenistan
Railways diagram
N°2.1.5.A



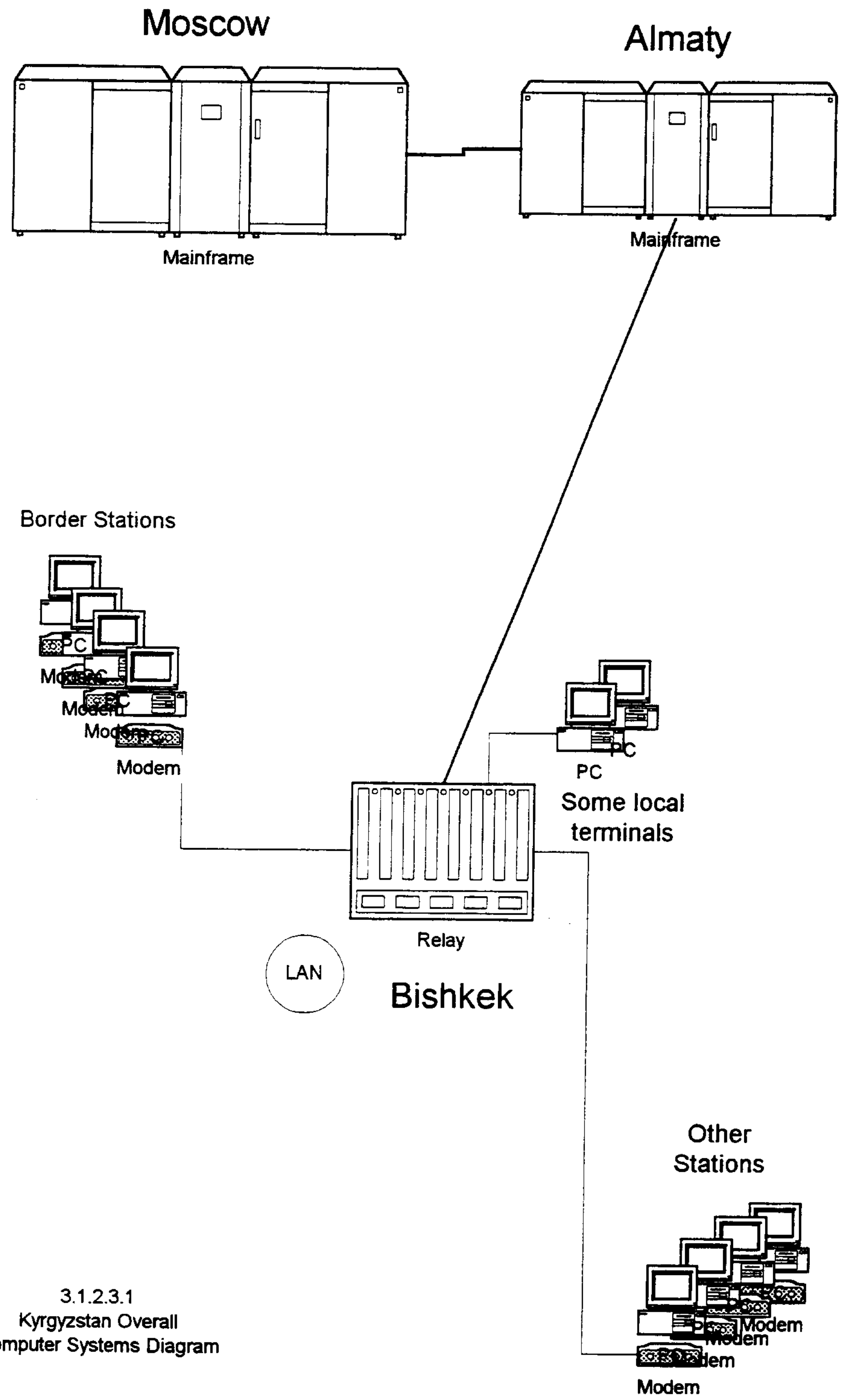
Turkmenistan
Position of telecom switches
N°2.1.5.B



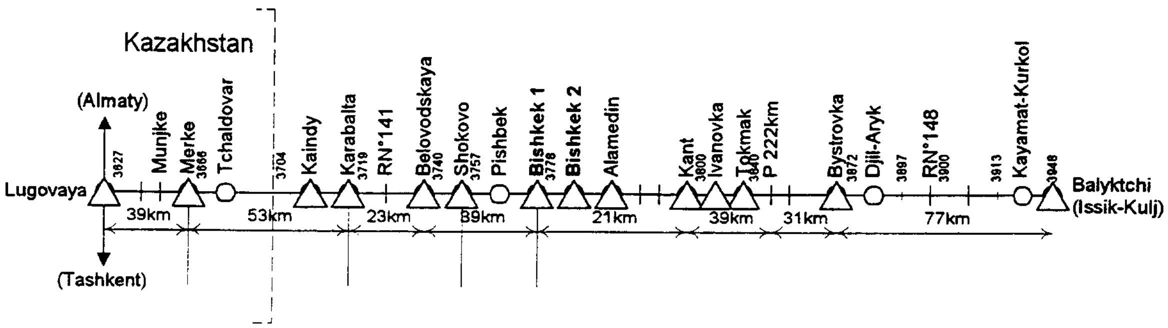
Turkmenistan
Cabling diagram
N°2.1.5.D



Turkmenistan
Transmission capacity
N°2.1.5..E

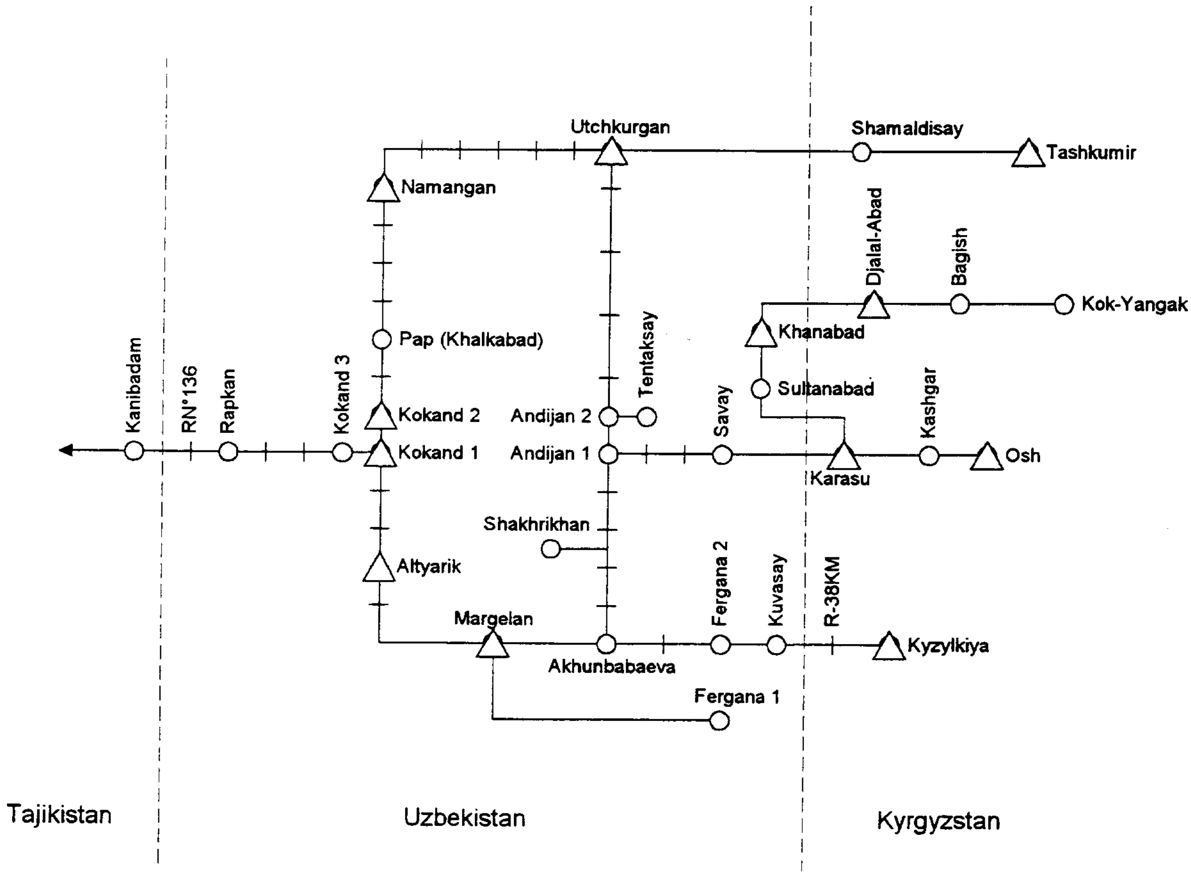


3.1.2.3.1
Kyrgyzstan Overall
Computer Systems Diagram



△ On-line connected stations

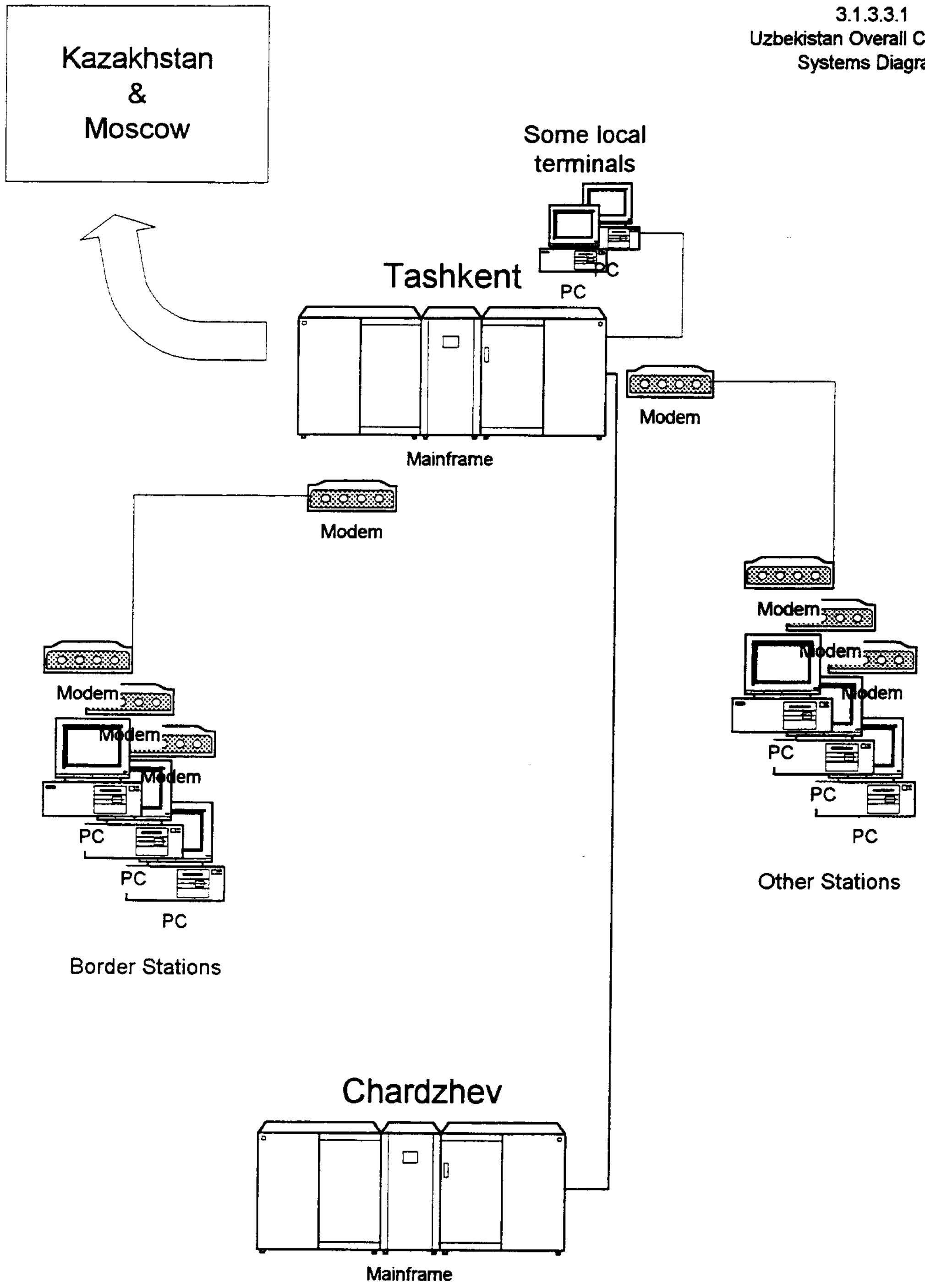
3.1.2.3.2 Kyrgyzstan Computer system Diagram

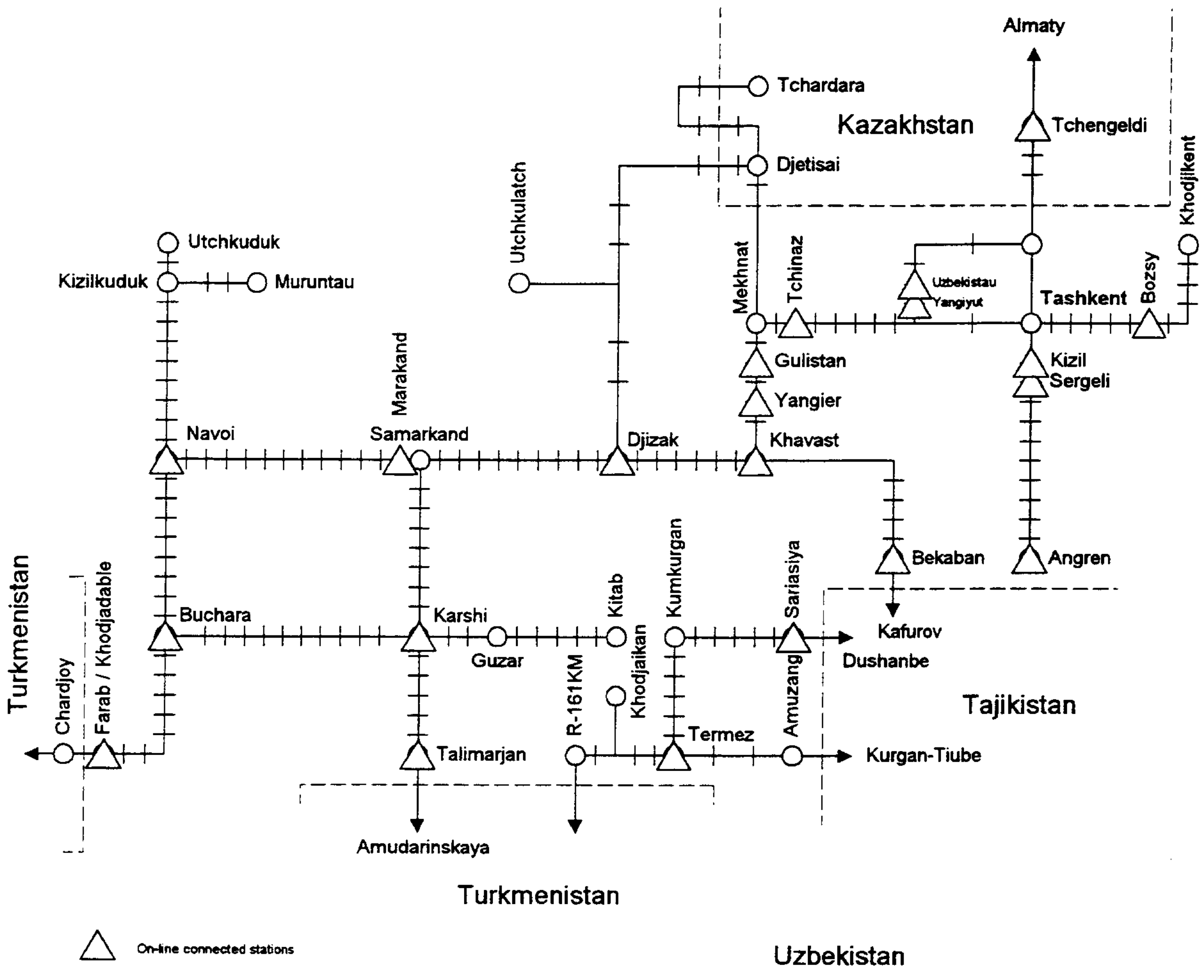


△ On-line connected stations

3.1.2.3.2 Kyrgyzstan & Uzbekistan Computer system Diagram

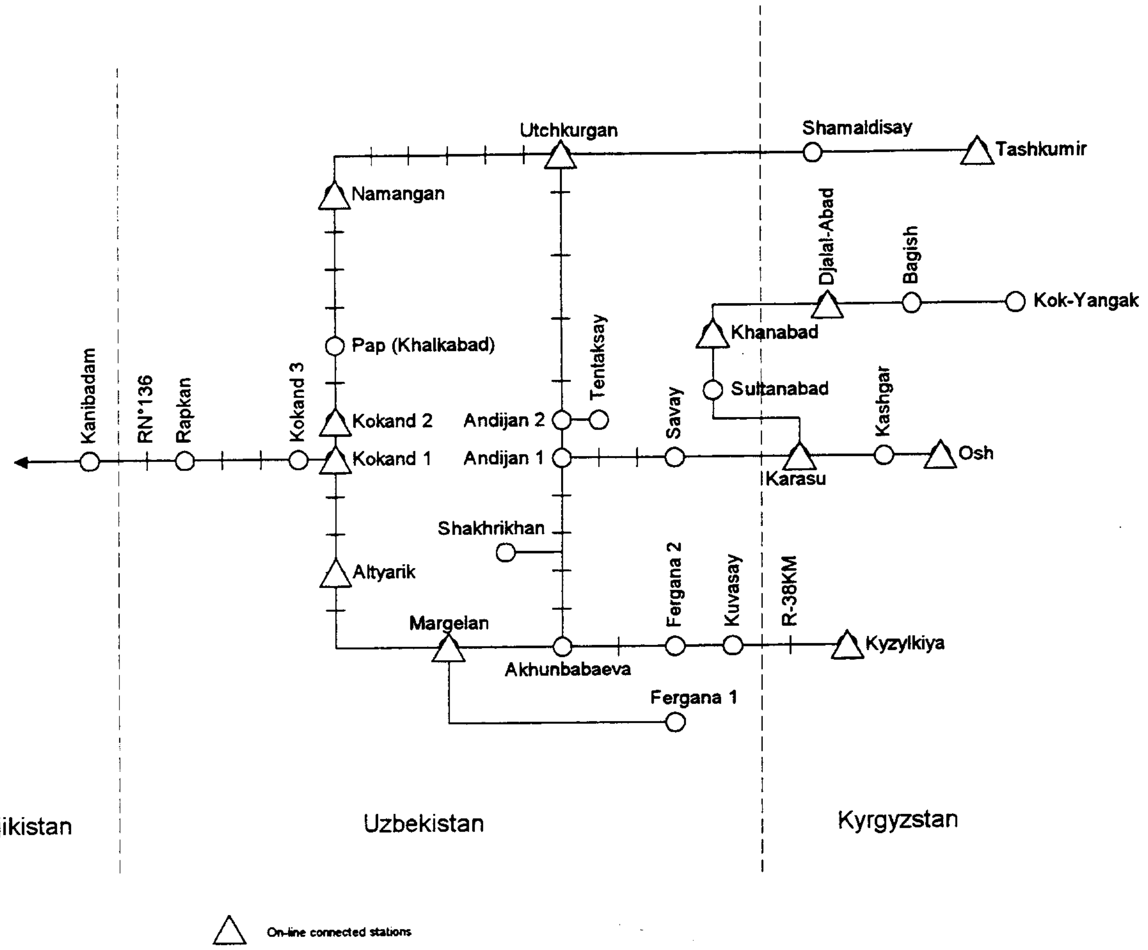
3.1.3.3.1
Uzbekistan Overall Computer Systems Diagram





3.1.3.3.2

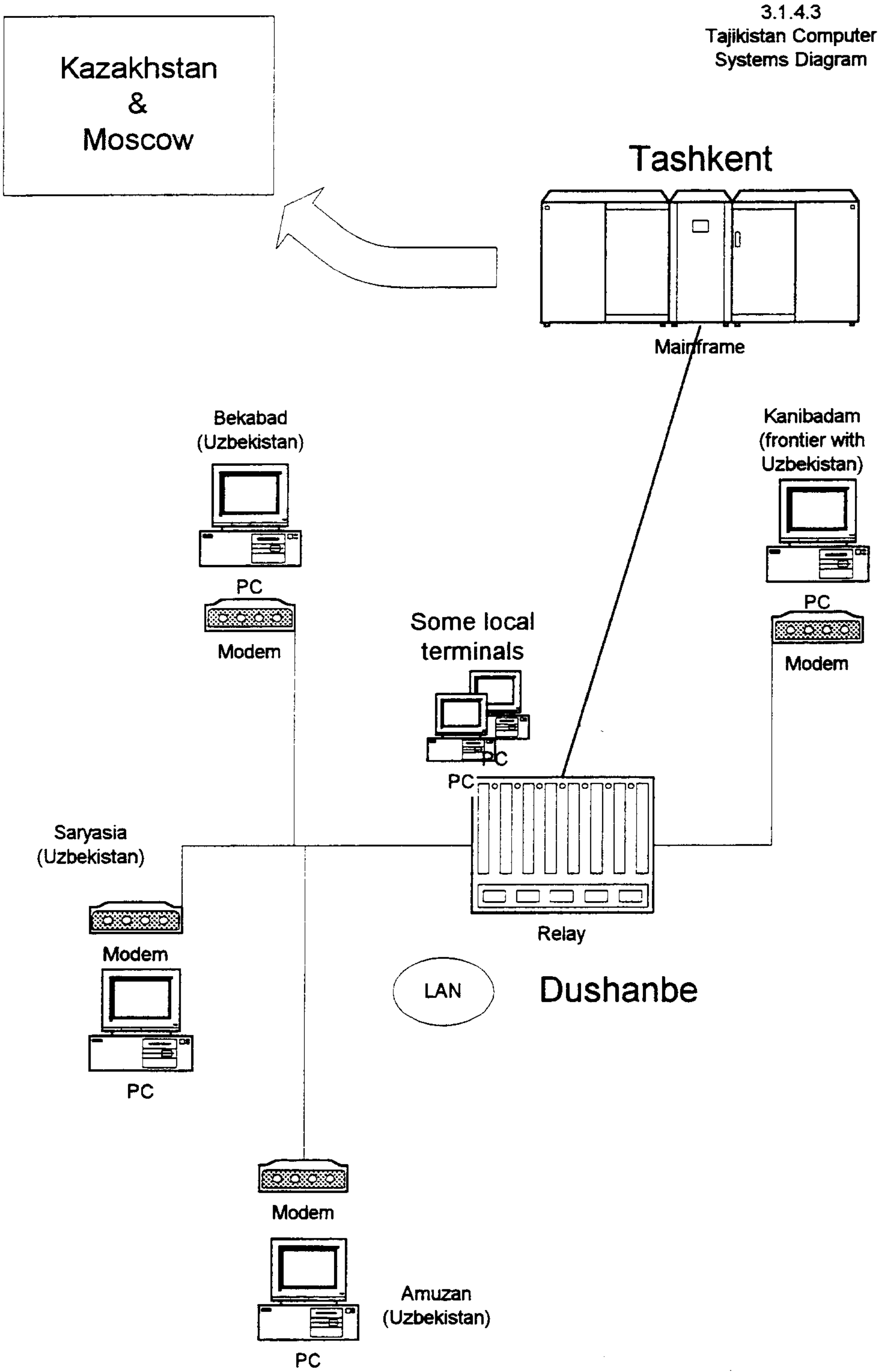
Uzbekistan
Computer system
Diagram



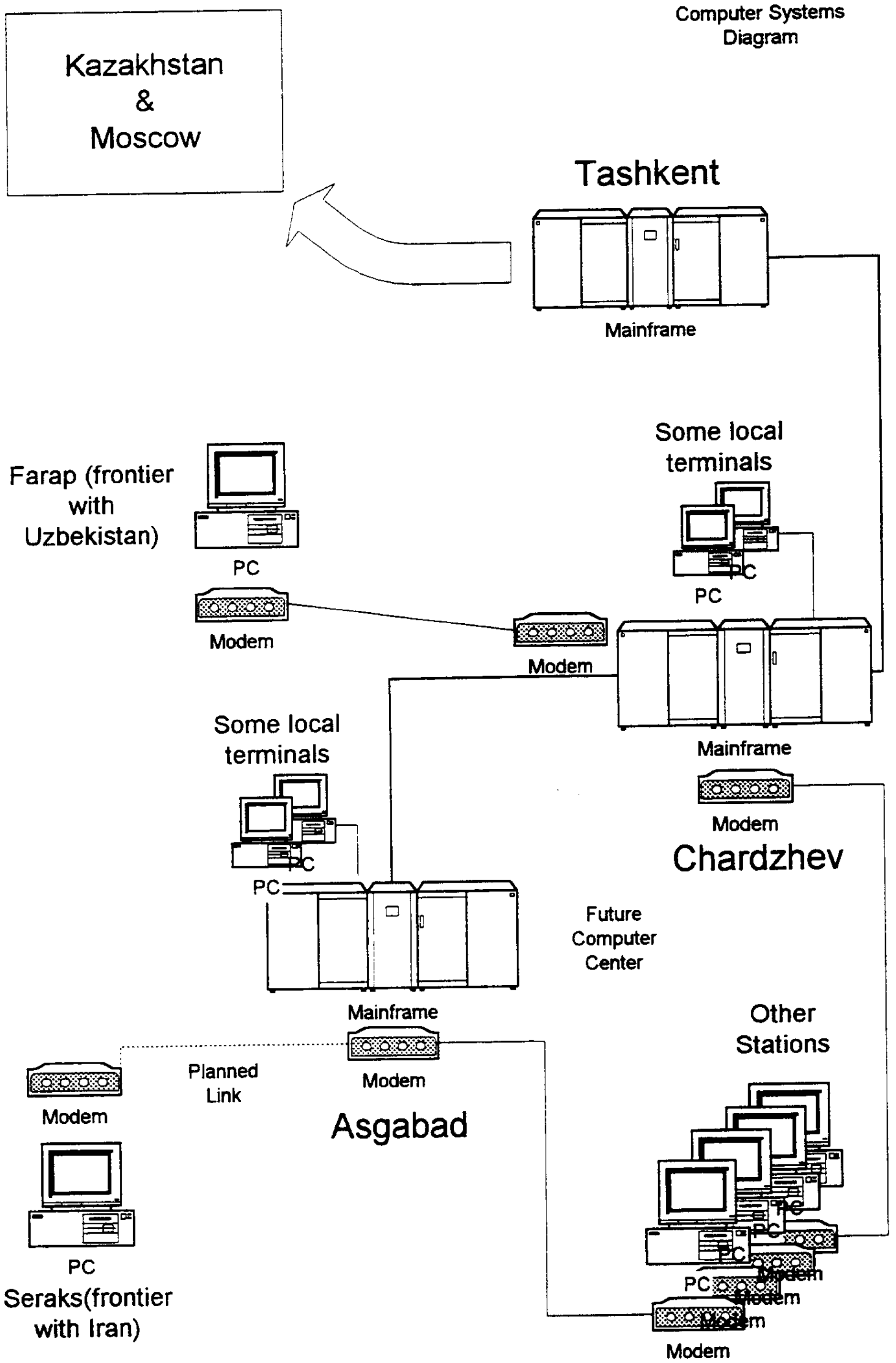
3.1.3.3.2

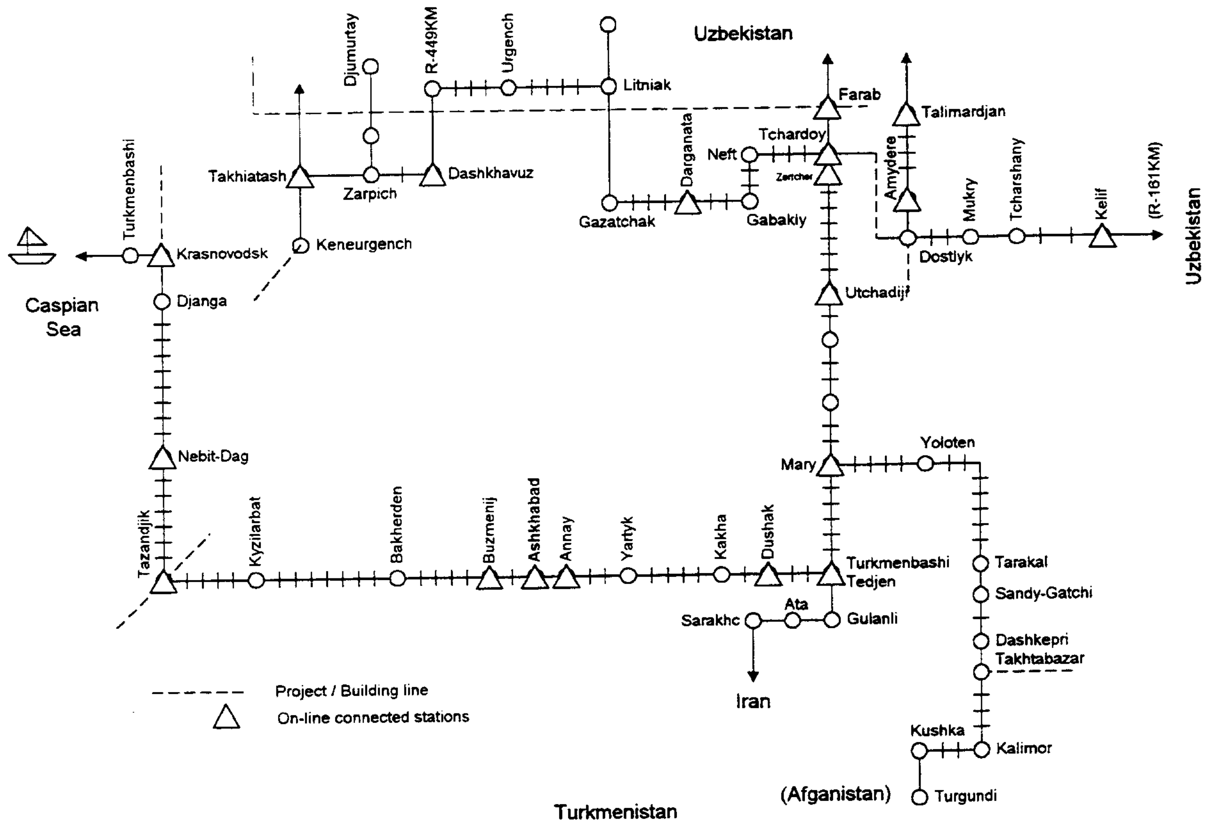
Kyrgyzstan & Uzbekistan Computer system Diagram

3.1.4.3
Tajikistan Computer
Systems Diagram



3.1.5.3.1
Turkmenistan Overall
Computer Systems
Diagram





3.1.5.3.2 Turkmenistan Computer system Diagram

Module E
Progress Report

Appendix 3

Warsaw Seminar

(9-13 March 1998)

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
	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
31.	Ericson	Magnus Svenningson	Area Manager	468/764 00 40	4670/586 85 79
32.		Stefan, Nilsson-Giftik	Product Information	46650/363 67	46650/362 00

	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		

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		

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		

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 telecommunica-tions centre - lunch - visit to the "Intertelecom" exhibition		
	16:35	Departure for Warsaw		
	18:32	Arrival in Warsaw		
	19:30	Dinner hosted by Kapsch		

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		

Module E
Progress Report

Appendix 4

Caucasian countries

Preliminary recommendations

1. Telecommunications

The purpose of this appendix 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.

Appendix 4 contains a range of preliminary 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 owner and project manager:

- The owner has a particularly important role. He:
  - voices the needs of the end user,
  - manages the financial resources,
  - fixes the schedule of work.
- The project manager implements the project within the framework set by the owner.
- The choice of project manager 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 appendix.

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 more or less clear.

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. This is particularly the case for telecommunications.

Thus, the relationship between railways and telecommunications operators can take one of the following, very diverse forms:

- concession of rights of passage 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 sections of an entire 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 precise statement of needs and technical specifications which are both:

- detailed 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 rise.

- Bibliographical reference [1] advocates a "turnkey" contract, with the contracting party being supervised by an experienced consulting firm.

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 responsability.

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 (spacing and protection of train running -(signalling telecommunications)),
- railway operation (traffic control, energy, stations, depots, etc. - (railway operating telecommunications)),
- applications (traffic supervision, passengers, freight, invoicing, maintenance, etc. - (applications telecommunications)).

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 2200 m for frequency track circuits and roughly 2800 m for pulse coded track circuits.

- Rail traffic may also be detected using an axle counter, which counts and records 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 underlying ideas have a broader application.

- 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 turnout 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, sent electrically following a manual action from the downline signal box, is generally subordinated to the passage of the train, in cunjunction with a treadle or some other equivalent device').

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 length is 2800 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 safety information must be securely transmitted

- 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 track 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).

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 vital to remember 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 from track and OHL maintenance,
- ground-to-train radio,
- shunting radio,
- maintenance, incidents and track site radio,
- local radio,
- 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, load-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.

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.

For example, 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 transmission railway data 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 the throughputs and transmission quality required.

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 re-used, 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.

- By contrast, where signalling telecommunications are concerned, their use needs to be subjected to closer examination

This subject 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, Azerbaïjan 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 Appendix 1);

In summary on the Baku - Tbilisi - Poti and Tbilisi - Yerevan routes (i.e. 1225 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 a 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 detailed architecture will be the responsibility of the firm selected on the basis of the invitation to tender.

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. Figure 2 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 security.

- Network security 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 security is largely dictated by quality of service considerations.

It is important to remember that quality of service standards is an indicator sine qua non for contracted telecommunications services.

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 90ties the Swedish railway administration (BV) required an availability rate of virtually 100 % 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 obtainable for nothing 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 (even to 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 the simple additional of other basic modules and parameter adjustments.

1.3.3. Technical specifications.

These consist of:

- Mandatory specifications marked with (M) (Mandatory),
- Recommendatory specifications (R),
- Informatory specifications (I).

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 without wayside colour-light signals and short block sections 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 track 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 wayside signalling facilities, located every 12 km at the minimum).
  - railway operation telecommunications circuits,
  - telecommunications circuits used for applications,
  - other 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.

3. The Danish Rail Administration (Banestyrelsen) use 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.: in some countries detecting broken rails is not necessary. 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 should 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)**

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 impose major constraints which require a solution based on the choice of copper transmission cables.

Discussions with operators is therefore essential to reach an "operating requirements - technical solution -cost compromise. **(I)**

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 1.3.3.2 , the obvious and imperative choice is optical fibre transmission cables. **(M)**

1.3.3.3.2.3. Optical fibres should be of the single-mode variety and be capable of being set for transmission frequencies of 1300 nm and 1550 nm these being the frequencies most commonly used by industry. **(M)**

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 resist high crush loads in accordance with the IEC-794-E3 standard,
- ability to resist 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 with a 3,000 d.c. power supply),
- 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 current between the fibre contacts, including losses at the connector, should not exceed:

- for a wave length of 1550 nm:
  - 0.25 dB/km over long distances,
  - 0.30 dB/km over short distances,
- for a wave length of 1300 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 should 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 should 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 Aerial cable under d.c. electrified line (for example 3000 V =) (type A).

The cable should 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 power supply line. **(I)**

This type of cable is vulnerable to wind and ice. **(I)**

Fears are sometimes expressed regarding the greater sensitivity of aerial optical fibre cables in terms of quality of service. These are unfounded since the quality of service is more a binary quantity. At the sensitivity limit, an additional attenuation of 1 dB may for example alter the sensitivity from 10^{-12} to 10^{-6}. **(I)**

1.3.3.3.3.2.2. Aerial cable under a.c. electrified line (25000 V, 50 Hz) (type B).

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)**

To lay the cable, power to the overhead line should 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)**

Fears are sometimes expressed regarding the greater sensitivity of aerial optical fibre cables in terms of quality of service. These are unfounded since the quality of service is more a binary quantity. At the sensitivity limit, an additional attenuation of 1 dB may for example alter the sensitivity from 10^{-12} to 10^{-6}. **(I)**

1.3.3.3.3.2.3. Cable laid in duct (type C).

1.3.3.3.3.2.4. Buried cable (type D).

For a longer life span (some 50 years), cable should 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. In this case, the problem of rodents should be borne in mind. (M)
In addition the new cable should be laid at least 30 cm away from existing cables (M)
A better solution is to lay the cable in the soil in a tube (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 2400 m. or as much as 9600 m in future. (R)

1.3.3.3.3.3. Choice of laying technique.
- 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 should 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 dry and cold 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 should 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 should 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 PCM's in each establishments, 2 for the intermediate 8 Mhz PDH and 2 for the 140 Mbit/s PDH). If the LN3 transmission network were to be designed from scratch today, there would 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. cables, 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 a backbone of SDH) plus 6 fibres in reserve:
        - 2 for the 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 Telecoms Development 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 = 25000 V - 50 Hz type). The « Telecommunications capacity» of this cable is 72 o.f., all for use by the subsidiary, Telecoms Development.

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 should be made to adopt digital technology. **(M)**

1.3.3.4.1.2. The new telecom network should 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)**

1.3.3.4.1.3. The architecture proposed in Figure 2 is recommended.
It consists of an SDH 155 Mhz (STM1) backbone network supporting a PDH 2 Mhz network. **(R)**
If necessary, manufacturers may install PDH networks with a capacity of more than 2 Mhz **(R)**

1.3.3.4.1.4. In general, the standards and recommendations of the ITU-T, CCITT and ETSI (European Telecommunications Standards Institute) should be applied. **(M)**

1.3.3.4.1.5. Some railway lines may be equipped with 2 Mhz PDH without immediately being connected up to the SDH equipment.
It should 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 the range is smaller given the imperative need to be able accurately to detect the position of a broken fibre by means of a reflectometer (N.B.: reflectometer accuracy diminishes with distance). **(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 should 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 should be quantified on the basis of the ITU-T recommendation with the reference G.826:
« Parameters and performance objectives in respect of errors in international digital links with a constant bit rate equal to or greater than the primary rate ».(**M**)

1.3.3.4.3. Network security.

1.3.3.4.3.1. Telecom network security 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 standard of security back-up required, 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. It is universally acknowledged today that telecom networks must be monitored. 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 should be provided. (**M**)

1.3.3.4.4.3. Network maintenance should be organised in accordance with the recommendations of serie M of the ITU-T. **(M)**

1.3.3.4.4.4. 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).

It is also possible that there may be two different managers: one for the backbone network (STMi), the other for the local networks.

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 should supply a detailed description of the operating interface used. **(M)**

N.B.: The advantage of an open interface is that it makes competitive invitations to tender possible.

It should be remembered that an interface depends entirely on:

- its mechanical connections,
- the electric signals exchanged,
- the telegrams interchanged,
- the protocols used. **(I)**

1.3.3.4.4.5. 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)**

1.3.3.4.4.6. 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 should 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 should 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 appendix 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 structure, and have no ring-shaped or point-to-point links, no concentration/distribution function, no broadcast mode or 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 work station to incorporate all the requisite services shown in section 1.2.2. 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 to 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 owner should indicate the primary source of energy provided for the project manager. **(M)**

1.3.3.6.3. The project manager must provide the secondary power supply to be used directly for the telecommunications network. **(M)**

1.3.3.6.4. The owner should specify requirements as regards the separate capacity of the secondary supply. **(M)**

1.3.3.6.5. The project manager must take all necessary steps to protect against power supply cuts and overvoltages in the primary power supply. **(M)**

1.3.3.6.6. Il is accepted that the telecommunications network may jam 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. The network should restart automatically when the primary supply returns to its nominal level. **(M)**

1.3.3.6.8. Should the owner fail to specify the primary power supply, the project manager 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)**

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 Azerbaïjan and Turkmenistan via the Caspian, 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 (freight traffic applications, wagon fleet management, customer information etc.),
- security of the transmission networks,

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 status reports in this interim 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)**

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),

- broad 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 radio.

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 status 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)**

1.4 Cost factors.

1.4.1 General.

1.4.1.1. The cost factors mentioned below are given merely as an indication.

1.4.1.2. As regards prices, caution must be the watchword. Generally prices tend to fluctuate for reasons not easy to pinpoint:

- assessment of user requirements,
- technological development,
- product/system study and manufacturing costs,
- product and system installation costs,
- transport costs,
- manpower costs,
- risk evaluation,
- corporate strategy.

Ultimately it is only via the invitation to tender (and associated negotiations) that it will be possible to come to grips with the price factor.
Nevertheless, for any given project, it is necessary to have an accurate appreciation of the orders of magnitude of the prices involved, despite the difficulties inherent in such an exercise.
Whence the importance of this section of the report.

1.4.2. Optical fibre cables.

1.4.2.1. The cost of a cable is not just the purchase price but includes all items, starting from supplies and extending to the provision of the cable ready to be laid and used, i.e.:
- supply,
- staking out and connecting,
- civil engineering and laying (including labour).

1.4.2.2. Experience has shown that investment costs can be expected to fluctuate widely.

1.4.2.3. The following table may nonetheless be drawn up to show the relative potential variations in investment costs for the different types of solution described in section «1.3.3.3.3 Cable laying », namely:
Solution A: aerial cable under d.c. OHL(e.g. 3000 V d.c;),
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	0.25 PA	0.25 PB	0.15 PC	0.20 PD
Supplies	0.30 PA	0.3-0.4 PB	0.15 PC	0.20 PD
Civil engineering and laying (including labour)	0.25-0.45 PA	0.25-0.45 PB	0.70 PC	0.60 PD
Total investment	1.0-1.7 PA	1.0-1.9 PA	1.9-2.5 PA	1.3-1.9 PA

N.B.: Solution D is based on a combination of 50% of buried cables and 50% laid in ducts. In reality, no cable is ever completely buried and has to be placed in a duct to pass through stations, etc. and over bridges and other structures, etc.

A mean value for Europe for PA is 12900 $ / km.

Solutions A, B, C and D have the following characteristic ranges:

- Solution A : 12900 - 21700 $ / km
- Solution B : 12900 - 24100 $ / km
- Solution C : 24100 - 32200 $ / km
- Solution D : 16100 - 24100 $ / km

The first thing to note is that the solutions overlap and that the variations noted are due to geology, access to railway lines, the impact of works on rail traffic (cost of line closures), etc.

1.4.2.4. At the TRACECA Seminar in Warsaw, K. Frak [9] quoted a figure of 20000 $ / km for buried 12 to 18 fibre cables. This tallies with Section 1.4.2.3.

1.4.2.5. It is interesting to compare the lower figure for Solution A (**12900 $ / km**) with the figure given in bibliographical reference [4], i.e.:

- 3500 $ / km for the supply of a cable with 12 optical fibres,
- 1000 $ / for laying and installation,

i.e. a total of **4500 $ / km**.

This enormous difference should be submitted to closer examination.

It is possible, however, that the second figure does not cover items such as civil engineering and connection or makes no allowance for man power costs.

1.4.2.6. One interesting parameter is the incremental cost of the cable the greater the number of fibres.

The cost is some 50 % more for each extra set of 12 fibres, which is about 10 to 15 % on the price of the complete cable laying operation.

1.4.3. Digital transmission equipment.

1.4.3.1. The mean price of digital terminal equipment (DTE) of the PCM 30 channel type is in the region of **12000 $.**

1.4.3.2. The mean price of SDH STM1 end multiplexers, standard version, is about **32000 $.** Prices (without back-up) vary between a minimum of 24000 and a maximum of 45000 $.

1.4.3.3 The mean price of SDH STM1 drop-insert multiplexers, standard version, is in the region of **24000 $.**

1.4.4. Network management.

A network management system in line with Section 1.3.3.4.4. costs an average of **110000 $.** The simplified version mentioned costs some 8000 $.

Bibliographical reference [4], quotes a price of **200000 $.**

1.4.5. Switching equipment.

1.4.5.1. This consists of the switches for the conventional switched telephone network (STN) and those for the railway voice communications equipment (cf. Section 1.3.3.5. « Dedicated or integrated telecommunications networks? »).

1.4.5.2. For the automatic telephone switches, a rule of thumb evaluation would give **160 $** for a conventional subscriber link (point to point only), from a minimum of 100 subscriber links.

Below this, the fixed part of the cost increases. For 50 subscriber links, for example, the cost of the switch would be some **12800 $**.

1.4.5.3. Railway voice communications equipment for railway operation telecommunications generally has less capacity but provides the various services set out in Section 1.2.2 « Railway operating telecommunications ».

The number of operators in the station (signalman, traffic manager, etc.) or at the control centre (traffic controllers, etc.) connected to the installation affects the cost to some degree.

The following orders of magnitude may serve as a guide:

- low capacity equipment (for example; dedicated to new lines) (1 operator, up to 8 lines) : **8000 $** i.e. **1000 $ / line**
- low capacity equipment (1 to 2 operators, up to 30 lines) : **40200 $** i.e. **1340 $ / line**
- medium capacity equipment (1 to 4 operators, up to 60 lines) : **61200 $** i.e. **1020 $ / line**
- high capacity equipment (4 to 12 operators, over 100 lines) : **136800 $** i.e. **1370 $ / line**

It is interesting to note that bibliographical reference [4], for its part quotes a price of **50000 $** per station (without explaining what is meant by "station").

Here again it is necessary to be wary of comparisons (for example whether or not the digital transmission equipment - SDH or PDH -is included in the figure quoted).

1.4.5. Power supply sources.

1.4.5.1. The cost of power supply sources varies enormously depending on the amount of power required.

1.4.5.2. Prices tend to fall in the **3200 $** to **48300 $** range.

1.4.6. Satellites.

1.4.6.1. Various figures were quoted at the TRACECA Seminar in Warsaw (bibliographical reference [14]), i.e.:

- cost of a fixed station: **50000 $ to 100000 $,**
- cost of a mobile: **4000 $** to **5000 $,**
- cost of one minute of transmission time for voice, fax and data: **1 $**
- cost of permanently leasing a 64 kbit/s duplex channel: **2000 $ / month**.

1.4.6.2. At the same TRACECA Seminar in Warsaw, one of the speakers stated that the cost of one minute of voice communications with INMARSAT was from **4 to 6 $.**
This shows that costs vary and that their variation is worthy of closer study. The phenomenon is doubtless in part due to differences in types of subscription and in the rates charged in this sector.

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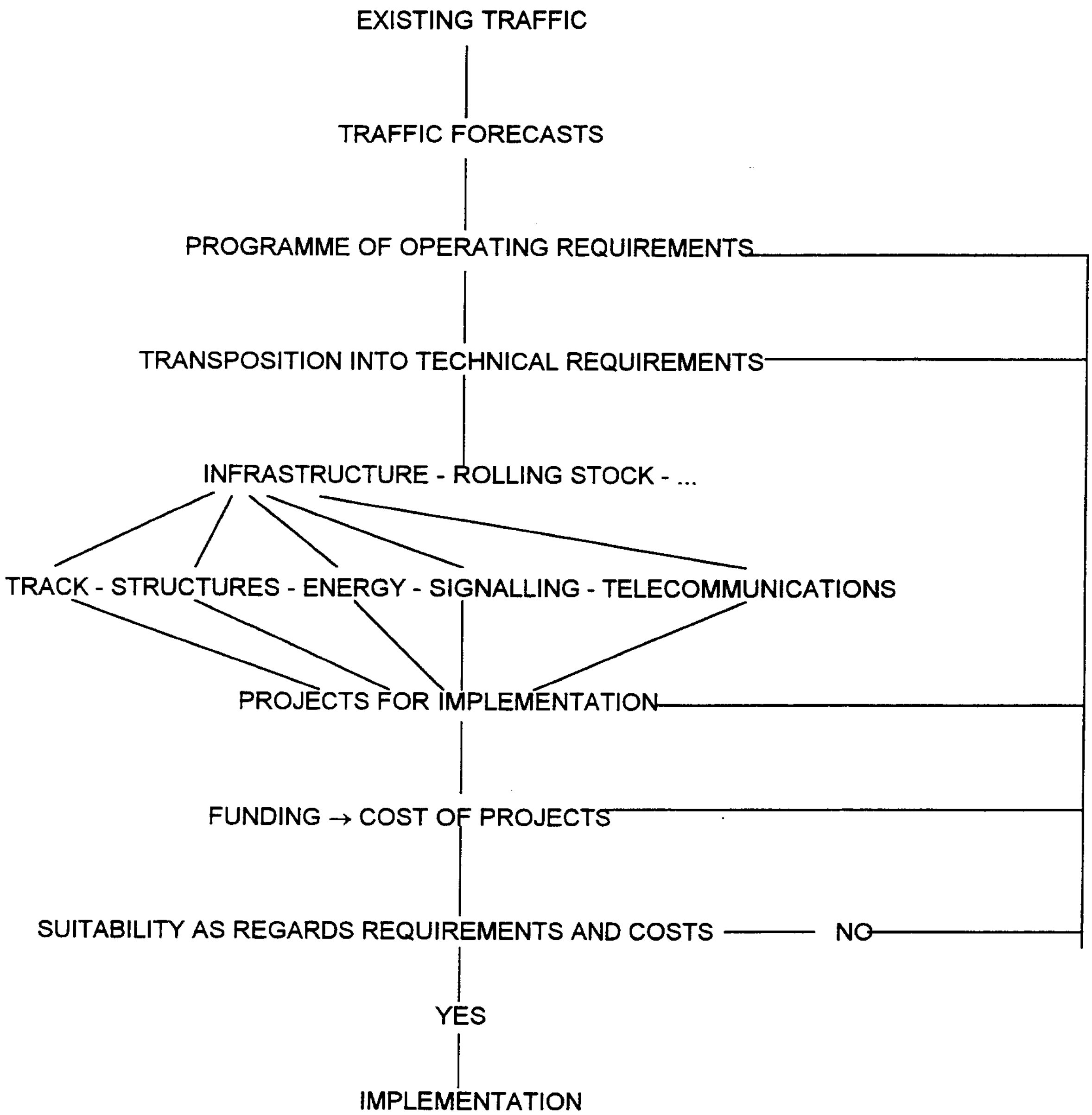
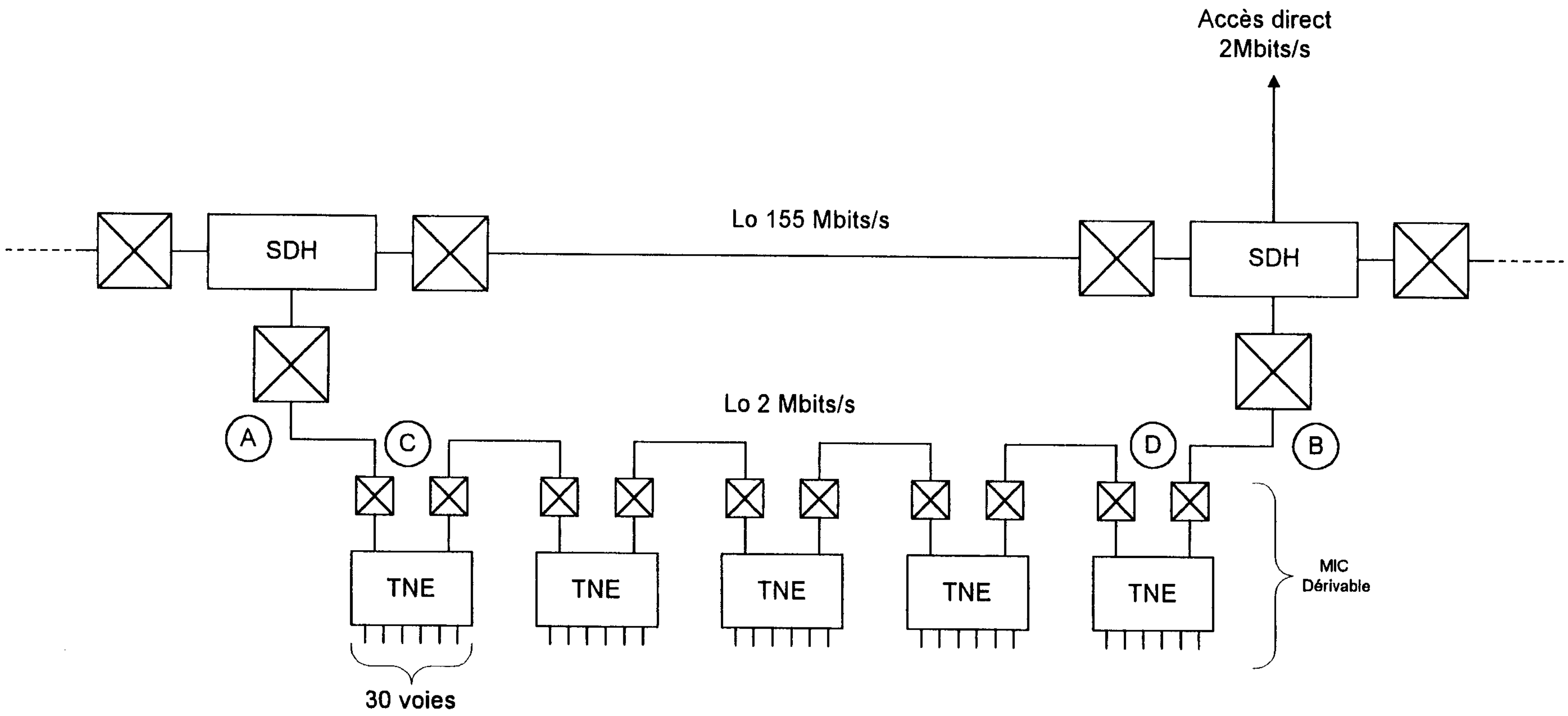
INVESTMENT CONCEPT MODEL

Figure 1



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

Figure 3A

Connection of optical fibre cable
Recommended solution

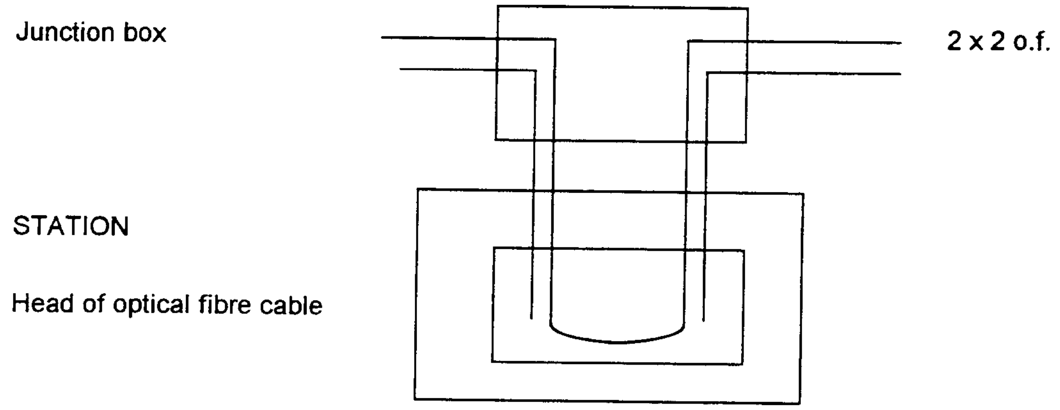


Figure 3B

Connection of optical fibre cable
Solution not recommended

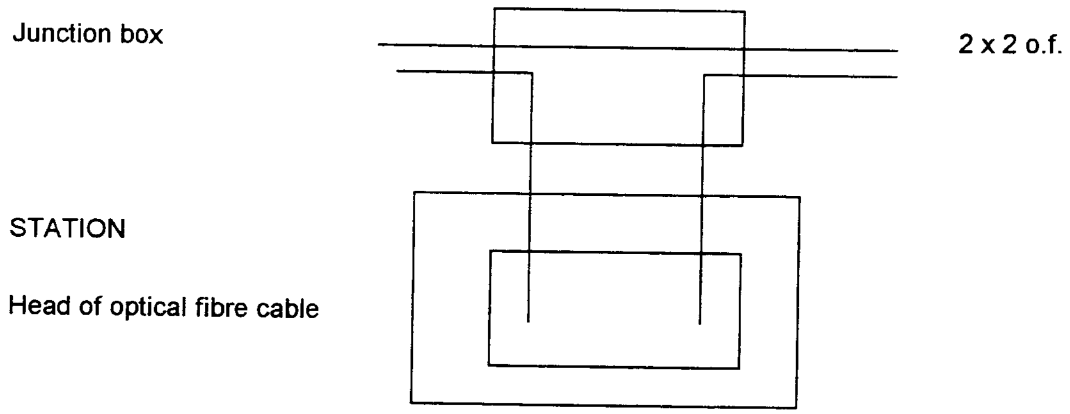


Figure 3C

Connection of optical fibre cable
Holding solution (optical connector)

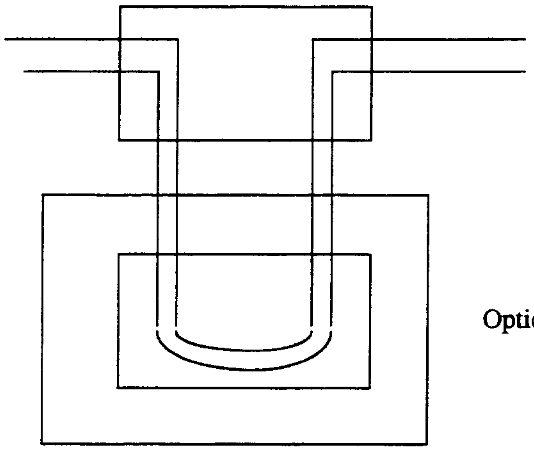
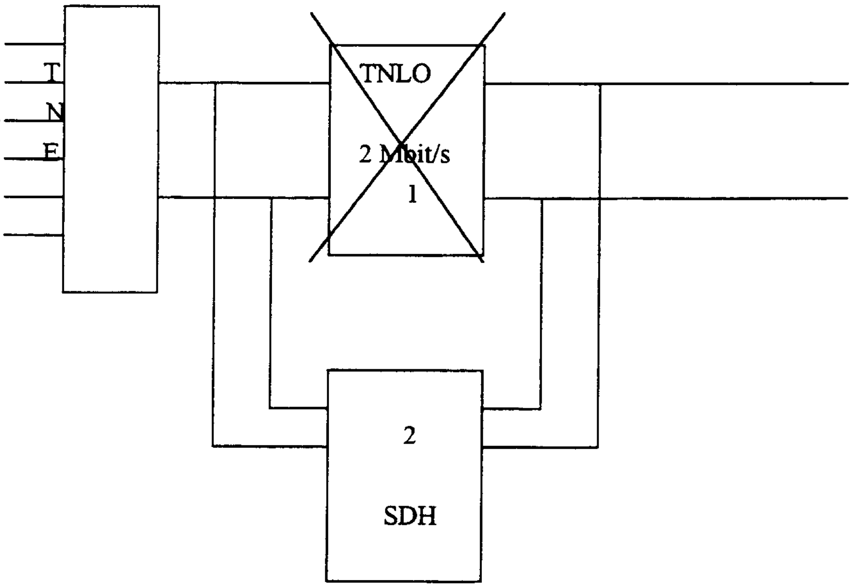


Figure 4

Migration from PDH to SDH



SDH : Synchronous Digital Hierarchy
TNE : End Digital Terminal
TNLO : Optical Line Digital Terminal