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TRACECA :
Rolling Stock Maintenance - Railways TNREG9309

Completion Report

Part 2 - Draft 1 - May, 1997

Completion report - Part 2

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Chapter 1 Description of the Existing Situation

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1. Background

This report covers the project TRACECA - Railways; Rolling Stock Maintenance TNREG 9309.

It covers the Rolling Stock and its maintenance. It also includes the facilities for maintenance, the management structures related to maintenance and the spare parts procurement.

It covers the situation in the eight TRACECA countries:

Both aspects of the Rolling Stock have been analyzed : quality and quantity.

In terms of quality, the original technology has determined the maintenance structure and the manufacturing features . Both the management and the performance of the maintenance have been analyzed.

In terms of quantity, the existing fleets have been upraised, an estimate of the needs has been provided.

The current chapter reports on:

- the origins of the existing situation which is compulsory for a better understanding
- the rolling stock management.
- the analysis of the current needs for rolling stock, which are based on traffic demands and train operation organizations
- the rolling stock inventory in the area, both in terms of technology and quantity
- the maintenance organisation related to the existing technology of rolling stock
- an overview of manufacturing capabilities in the area and the spare part procurement policy
- an analysis of the current operating costs.

1.1 The former railway organisation, SZD

All of the railways in these eight countries were part of the railway organisation in the FSU; SZD.

This is indeed a grand heritage. Possessing 12% of the track length in the world in 1990, the number of passengers were 20% and the freight transport an amazing 53% or the world rail freight production.

SZD had 2 million employees, caring not only for the railway operation but for a wide range of social activities. For instance there were 13.000 teachers in 175 schools and a medical staff of 30.000 in 2.650 clinics and hospitals.

SZD was split in several semi-independent railway administrations according to area. These areas were not identical to the current borders.

Broadly speaking, the railways in KAZAKHSTAN were three separate administrations; Zapadno-Kazakhstanskaya (West KAZAKHSTAN); Almaatinskaya (Almaty) and Tselinnaya.

The Southern part of Central Asia was one administration Sredneaziatskaya (Middle Asian) with centre in Tashkent.

In Caucasus, there were two administrations; Azerbaidzhanskaya in AZERBAIJAN and Zakavkazskaya (Trans Caucasian) in Armenia and Georgia.

All railways are operating on the Russian Broad Gauge. This gauge was 1524 mm until 1972. In order to reduce lateral movement at high speed, a new standard gauge of 1520 mm was introduced in this year, and all lines were altered during the next 20 years. The Russian Broad Gauge further includes the big Russian clearance profile. Previously there were a number of narrow gauge lines in operation. No traces of these have been found in our investigation. If there are any left, they are probably operated as industrial sidings, and they cannot be of any significance for this report.

The Rolling Stock procurement of the SZD, relied on a very limited number of rolling stock manufacturers. There was a major specialisation with specific factories producing a very limited range of rolling stock. For instance, all EMU´s came from Riga locomotive works; RVR - all refrigerated trainsets came from Waggonbau Dessau in Eastern Germany - all heavy shunters came from CKD in Czechoslovakia etc.

The separate railway administrations were allocated rolling stock in series, but basically all came from the same sources. As further, quite a number of the current railways, were branched off from the same regional railway, the rolling stock here is some fraction of the original stock. The reasoning for the exact content of this fraction is not always easy.

The maintenance rules and procedures were the same all over SZD. There was a rulebook for the maintenance, specifying the maintenance intervals for rolling stock, specifying who was to undertake which maintenance levels, and specifying the content and activities connected to each type of maintenance. The intervals and content differed for different kinds of rolling stock, but there were no differences due to regional or operational differences.

To a large extend, the maintenance facilities are constructed by a limited number of people, centrally placed with the SZD. This means that workshops for the same level of maintenance is more or less identical, being only adapted to local conditions like shape of available area, possible track connections etc. They obviously have been developed due to local initiatives, but the basics are the same.

The depots were not only taking care of the operational maintenance of the rolling stock. Each depot is caring for the complete traffic on a certain stretch of track. They supply traction power with staff for the haul to the area of the next depot on the line. Here, the traction unit is uncoupled, and a replacement unit from the next depots takes over the train. The uncoupled unit then waits for a train in the reverse direction, and eventually returns to the home depot with this haul.

This means that included in the costs from a depot are not only maintenance costs, but also costs for train driver and assistants, for fuel or electric energy, for traction, etc.

The reasoning for the focus on spare parts supply within the railways are probably not only the importance of the railway in the FSU economy, but also the "policy" of a spare parts supply that is directly linked to the transport volume, also in the Plan. This because spare parts consumption was replacements due to a fixed programme, not dependent on the needs.

The transport production, and thus the kilometre production of the different types of rolling stock were planned in detail years ahead. The number of rolling stock going through the different maintenance levels could thus be calculated. Each maintenance interval had a well defined amount of spare parts to be used (regardless the needs) so the spare part consumption could be worked out in detail and put into the overall production planning of the USSR.

As it turned out, the production plan for the rolling stock suppliers ended up in a target for spare parts representing a certain value to be supplied, which caused some practical problems for the actual maintenance. (If you need to replace a broken front screen of a loco, you cannot utilise a traction motor) But this problem was largely overcome by trading spare parts in-between the depots.

Over the years all depots build up a large stock of useless spare parts. There were no incentives to reduce this stock.

Without any monitoring of spare part the real requirements of spare parts is unknown

- Current estimates come from local experience and existing deficiencies.
- However, the capabilities of workers to deal with local spare parts, to repair second hand spare parts and to cannibalise useless vehicles hides to a large extend the shortage of spare parts.

There are very limited funds allocated for the maintenance of the rolling stock, and practically no foreign currency available. Most of the fleets are therefore in a very poor condition and the entire operation is said to be on the verge of being brought to a complete standstill.

Many positions of management and engineering were held by Russian educated people. Some of these went back to Russia at the breakdown of the FSU. Due to the exodus of these engineers and managers, some lack of competence is suffered in the management, and in the railway workforce.

The railways, in particular the workshops, are still in charge of social activities; welfare, schools, accommodation etc. The railways are evidently not specialised in the management of such activities, this is not their core business, but it was traditionally a part of the operation of a major organisation. For the railways, these activities are most often centred around the larger depots and workshops, as this is where the majority of personnel is employed. Most of the beneficiary railways would like to withdraw from such activities, but in some cases they cannot forget their social obligations.

1.2 TRACECA networks

In many ways, the 8 railways can be separated into two regions, which in a number of ways differ from each other. Further, the two networks have no direct connection.

Some differences can be illustrated by the following schedule:

	Central Asia	**Caucasus**
Sqkm area per km railway line	199	41
Inhabitants per km railway line	2,661	3,698
Inhabitants per sqkm area	13	91

1.2.1 Caucasus region

It has its rail network concentrated around a corridor from the Black Sea to the Caspian Sea. It is a mountain area. Electrification is 3kV DC There are only connections to the North along the two coastlines. The longest run possible is less than 1.000 km. Considering the area of mountains, this is a quite densely populated area, providing good opportunities for a well functioning rail link.

The tracks in the Caucasus countries, are in such a condition that the maximum speed in some areas is reduced up to 10 km/h. Such conditions have a major impact on the train operation efficiency and in the maintenance requirements for the rolling stock, which suffers under these conditions.

In all the Caucasian countries, the railways are in a poor state. The track conditions are bad, limiting speed and capacity on the lines. The maintenance of the rolling stock is poor, with a large number of units not being available for operation. Many of them have been stripped beyond repair. Further, the electric power for the catenary is unstable and often cut off completely.

1.2.1.1 Armenia

The Armenian Railway (AR) network consists of 845 km of electrified lines, mostly single track. All lines are electrified. The area is mountainous, so several of the lines are heavily graded and have very narrow curves. Armenia has a rail connection to Turkey through a branch line from Gümri to the Turkish city of Ahurian.

There are two main lines:

- Georgian border to the Naghitchevan enclave of Azerbaijan:
  Airum-Vanadzor-Gioumri-Oktembri-Massis-Yerash-Veldagh
- Massis-Yerevan-Abovian-Razdan-Vardeniz-Zod (a gold mine district)

Three branch lines feed major industrial sites:

- Gumri-Maralik
- Oktembri-Arsaluis

- Massis-Karmirblur

In many parts of the country, the lines have to negotiate mountainous terrain requiring sharp bends with minimum radii down to 150 m and gradients a steep as 38 o/oo on a 18 km length.

Going down the slopes the electric locomotives are feeding electric power back to the carenary, to assist with the braking. As lines are single track, this fed-back energy cannot be utilised by other units.

1.2.1.2 Azerbaijan

The Azerbaijan railway (AZhD) has a network of 2125 km, of which 1280 is electrified (3 kV DC). There are rail connections to Russia and Iran. The maximum slope is 25 o/oo on a 13.9 km length

Due to the unrest in the Caucasian Region, the only line to neighbouring countries currently in operation is the lines to Georgia.

The present number of employees totals more than 48,000 people, but a major re-organisation including a comprehensive, forced redundancy programme is going to take place in the near future.

1.2.1.3 Georgia

The Georgian railway (GZD) has a network of 1600 km, all of which is electrified (3 KV DC). The railway is serving the two very important Black Sea ports, Poti and Batumi. There is a rail connection to Russia. some of the line are in very difficult terrain, so they are heavily graded with narrow curves.

Tbilisi (Azerbaijan border) - Samtredia - Poti and Batumi constitutes the Georgian part of the Caspian Sea-Black Sea back bone.

The network includes 255 km in the Abkhazetia region. From the border of this region to the main line at Senaki, the distance is about 39 km.

There are two important lines connecting Black Sea ports to the main line. From Poti to Senaki is a distance of 41 km, and from Batumi to Samtredia is 106 km. The only other line of importance is from Tbilisi Junction to the border with Armenia of 69 km.

On the Tbilisi - Black Sea Main line, there are presently some 40+ km in the Zestafoni to Khashuri section which are worked as single track due to river erosion of the track embankments. Work is in progress to restore this section to double track throughout.

Maximum speeds, which was formally limited to 60 km/hfor passenger and 40 km/hfor freight trains have been reduced to 20 and 15 km/h.

The section from Zestafoni to Khashuri is the most arduous on the network. The line rising nearly 2000 m in just over 60 km. Ruling grades are as steep as 28 o/oo and, whereas trains of 3,500 tonne can be operated from Batumi and Poti to Zestafoni by a single locomotive, they are limited to 2,500 tonne on the Zestafoni to Khashuri section with three locomotives. In addition to the grades there are torturous curves with many radii as tight as 150 m.

1.2.2 Central Asian region

It is dominated by vast distances with only limited population. Quite a lot is desert or tundra like areas. The rail network is dominated by some few main long distance connections. Electrification is 25 kV 50 Hz AC. The Baikal Amur Magisterial is part of this network, being one of the East/West trunk routes connecting the major population areas with the Moscow region.

Population concentrations are only found in two areas. The Tashkent/Samarkand/Dushanbe area in Uzbekistan/Tadjikistan and The Almaty/Bishkek area in Kazakhstan/Kyrghyzstan.

A considerable number of lines in the area are now cut by the new borders, creating a number of practical and economical problems, as reasonable mutual agreements for smooth cross-border operation have not been reached yet.

1.2.2.1 Kazakhstan

The Kazakhstan railways has a total network of 13.500 km. 3.300 km is electrified; 25 KV AC. It is the only of the Central Asian countries to have rail connections to Russia and to China. Until November 1996, the railway of Kazakhstan was divided into three separate administrations, The Almaty, the Tselinaya and the West Kazakhstan network.

The "Druzhba" Station in the Far East of Kazakhstan is the only door to China for the TRACECA countries.

Kazakhstan is by far the largest country of the TRACECA region but of a very low population density. This gives very long travelling distances in-between population and industrial centres. This involves a high cost for infrastructure maintenance and that rolling stock maintenance is divided on a major number of depots.

The network is mainly constituted by a North - South line, between Akmola and Chu, East - West lines are connected to this backbone line. To the North, the line is divided into two East - West branches linking Akmola to Moscow. To the South at Chu, the line receives the East and North East branch, coming from Almaty and turns West to Shimkent and serves Tashkent and the TRACECA corridor.

The main lines are double tracked and mostly electrified. The Chengeldy (Uzbekistan border)- Arys - Kangadach - Aktubinsk, constitutes the major East West backbone line of the country. The Kandagach junction ties to the Makat - Aktao branch connection to the Caspian Sea. The Chu - Almaty branch, 311 km, is partially fitted with double track

A single track links Almaty - Aktogay and to China border at Druzhba. This Chinese connection is of major importance to international traffic, but even though being upgraded, the capacity is limited as it is needed both to change bogies and couplers to the rolling stock.

It should be noted that the TRACECA line does not follow the Trans Asia corridor and the country may have difficulties to properly maintain both corridors.

It should also be pointed out that the main link to Moscow is not electrified. The electrified line follows the corridor of minerals resources (Karaganda, then the line Pavlodar, Ekibastuz, Akmola)

There is a very heavy concentration of freight traffic in the area of Akmola/Karaganda which is a mining and heavy industry area, with coal mines in Ekibastus and Karaganda, iron ore mines in Karagaill, and Atasuski Baikonur and steel plants in Karaganda.

The situation here is better than in Caucasus. The maintenance standard is far better, and the operation is in general functioning. In Central Asia, the track conditions are better on the main lines, but the Central Asian railways face difficulties due to lack of maintenance on the secondary lines.

1.2.2.2 Kyrghyzstan

The Kyrghyzstan railway has a network of 424 km, single track, consisting of two separate branch lines :

- the Northern branch links Ribachyc (Issyk-Kul lake) to Bishkek and Lubavoye (Kazakhstan);
- the Southern branch links Osh - Djalal-Abad - Kairma through the eastern part of the Uzbek territory.

On the mountainous Northern main line, the minimum curve radius is 300 m. Maximum slopes are 20 o/00 northbound and 37 o/oo southbound for about 10 km

1.2.2.3 Tadjikistan

The Tadjik railway (TR) has a network of 423 km, split in three separate lines without connection at the border.

The Northern Line, 110 km, connected to the Uzbekistan network at both ends, goes from Nau in the east via Hujang to Kanibadam, which constitutes on heavy transit links for Uzbek Freight Traffic.

The Central Line 93 km, runs from Patahabad at the Uzbek border via Dushambe to Yangibazar.

The Southern Line, 220 km, runs from Hashidy at the Uzbek border via Kurkan-Tube to Vash.

In order to go from the Central and Southern Lines to the Northern Line the trains have to pass through 700 km of the Uzbekistan and Turkmenistan railway networks.

Maximum. slope of the TR tracks is 18 o/oo and there is no electrification.

1.2.2.4 Turkmenistan

The Turkmenistan railways (TDDY) has a network of 2198 km, mainly consisting of the through main line from Uzbekistan to The Caspian Sea and part of the line along the Amur, that winds across the border to Uzbekistan. and a separate piece of the link between Uzbekistan and Tadjikistan, crossing Turkmenistan territory.

There is a rail link to Iran, (Tedzen-Mashkhad). The line was inaugurated on May 13, 1996, and is linked with the Iranian national railways network, albeit at a different gauge. Turkmenistan thus has a direct line to the Gulf port of Iran at Bafq.

1.2.2.5 Uzbekistan

The Uzbekistan railway has a network of 3656 km. 480 km is electrified line, 25 kV 50 Hz AC. Several major Uzbek connections are crossing borders. The connection to the North is crossing Tadjikistan, the connection to Tashkent is crossing Kazakhstan, the connection to the south-west area is through Turkmenistan and the line along the Amur is winding across the border of Turkmenistan. Especially the connection to the North is problematic, as this is an area with a high economic development potential.

1.2.3 Country summary

	State area	No. inhabitants	Length of network	No. of stations
ARMENIA	29,800 Km^2	3,500,000	845 Km	72
AZERBAIJAN	86,600 Km^2	7,700,000	2,125 Km	
GEORGIA	69,700 Km^2	5,700,000	1,600 Km	158
KAZAKHSTAN	2.725,000 Km^2	17,000,000	13,500 Km	
KYRZGHYSTAN	199,000 Km^2	4,500,000	424 Km	
TADJIKISTAN	143,000 Km^2	5,600,000	423 Km	29
TURKMENISTAN	488,000 Km^2	4,400,000	2,198 Km	
UZBEKISTAN	447,400 Km^2	22,100,000	3,600 Km	about 300

Some data about the TRACECA countries and their railway networks.

	Length of double track	Length of electrified	No. of loco workshops	No. of coach workshops	No of wagon workshops
ARMENIA	-	845 Km	2	1	2
AZERBAIJAN	800 Km	1,280 Km	6	1	4
GEORGIA	268 Km	1,600 Km	7	2	3
KAZAKHSTAN	3,540 Km	3,300 Km	42	6	20
KYRGHYZSTAN	-	-	2	2	5
TADJIKISTAN	-	-	3	2	2
TURKMENISTAN	-	-	3	2	4
UZBEKISTAN	680 Km	480 Km	11	2	8

Main data on the railways and the maintenance infrastructure

Among the 24.700 km of links, only 5.290 km are double tracks which represents 21% of the total.

However, trains crossing are possible thanks to many shunting loops. Every 15 km, shunting loops allow crossing of 850 m long trains.

Most of those shunting loops are fitted with several tracks which allow to accommodate several trains or to store wagons or to be used for line inspections.

1.3 Traffics and railway management

1.3.1 Traffics

1.3.1.1 Freight traffic

The current requirements for rolling stock have strongly decreased due to the overhaul decrease of freight transport demand.

The following table gives an overview of the data the Consultant could get on traffic evaluation.

	Freight turnover (10^6 t.km)	Total freight transported (10^3 t)	Transit (10^3 t)	Domestic (10^3 t)
Armenia	402	1,610		
Azerbaijan	2,250	8,985		
Georgia	1,250	4,700	1,775	1,370
Kazakhstan	190,000	174,400		
Kyrghyzstan	403	2,500		
Tadjikistan	600	2,000		
Turkmenistan	8,570	21,955		
Uzbekistan	27,475	48,209	6,500	12,940

During the project period, no traffic growth was reported in any of the TRACECA countries. However, actions undertaken should ,at least, allow them to maintain those traffics.

- concerning the transit traffic, only the number of wagons are usually recovered, volumes or load are not known ;

- 3 areas have been identified for bulk traffic:

  Azerbaijan for oil products

  West Kazakhstan for oil products

  Northern Kazakhstan for coal.

Most of the traffic origins in the Asian countries railroad deals with 90% of the freight traffic and for technical feasibility of road development, as well as for climatic conditions, it is unlikely that road transport takes over a major part of the traffic at a short term basis. In the Caucasus countries the railroad has a lower part of the modal split than in Asia countries, about 70%, where sea transport represents a significant share of traffic.

1.3.1.2 Passenger traffic

The real demand in passenger traffic is unknown. Trains are constituted according to the capabilities and the availability of passenger coaches.

The timetables are based on former timetables where slight modifications have been done. Due to the wide spread delocation inherent to the FSU population still need to move in order not only to meet family and relatives but also to find employment, to do trade as they were used to, and as the current custom regulations allow them to do. Therefore, passenger demand is still high but origins, destinations and flows are unknown . Former framework of time schedules has not been modified but it is likely that the demand has changed.

It is unlikely that passenger will stand for 3 days to go from Almaty to Moscow.

Passenger coaches, trains arrangements and timetables should be adapted to the current demand. An analysis of current and futur demands will be required to define future services and rolling stock accordingly.

The passenger trains are always crowded, but fraud is frequent , which could explain some deficiencies on our evaluation on requirements of passenger coaches. Therefore, the present study attempted to synthesise all information provided to the Consultants:

production annual ridership and annual passenger x km;

train operation performances: number of passenger trains, number of coaches per train, average speed.

Then a model has been built up to evaluate passenger coaches requirements for each country.

The following table gives an overview of the passenger traffic in the area for the year 1995 and the evolution of the last five years :

	Passenger turnover (10^6 pass.km)	Total ridership (10^3 pass)	Transit (10^3 pass)	Domestic (10^3 pass)
Armenia	166	976		
Azerbaijan	790	5,276		
Georgia	316	1,400		
Kazakhstan	20,500	41,200		
Kyrghyzstan	87	580		
Tadjikistan	124	825		
Turkmenistan	1,876	5,518		
Uzbekistan	3,610	14,440		

1.3.2 Railway organisation

1.3.2.1 Railway management

As mentioned above, the railway companies are young and independent.

This is not reflected, however, in the way the railway companies are organised.

In general the railway companies are heavy and production oriented. It has not been possible to substantiate the influence from actual commercial organisational units. It is the Traffic Departments which are determining and it is here that supply, systems, quality, frequency and other competition parameters are determined.

There is no care for the customer, no marketing of the railways services, no monitoring of the customers satisfaction, no traffic forecasts and no knowledge of the passenger demands.

At the visit in Uzbekistan it was confirmed that the Department of Traffic Services holds substantial power and influence. About 200 stations and 4.500 employees belong under Traffic Services. Here, the assessment of supply is made by evaluation of the current plans and forecasts for the coming period. In connection with the timetable, all other plans in connection with this are prepared for the decentralised part of the organisation. Finally, Traffic Services manages and controls the traffic and its implementation through the centrally located Operations Centre.

1.3.3 Railway council

Russia and the now independent states from the FSU have set up a Railway Council with headquarters and secretariat located in Moscow. Ministerial representatives participate in the 2 yearly general meetings held by turns in the different member countries. Every day, each individual railway company can draw on the expertise of the secretariat. In the Railway Council, rules and guidelines for the traffic are determined, timetables and fares are matched and the "wagon-pool" is being administered.

It seems that by setting up this Railway Council, all countries are maintained in the same systems etc. as applied before the breaking up of the USSR. This of course gives advantages in relation to the infrastructure, the traffic regulation rules, the safety rules, etc., where a large degree of inter-operability between the countries is secured.

However., the Railway Council seems to be a disadvantage. for the traffic systems, the train systems, the timetables etc

No formalised forum for direct contacts in-between the TRACECA country railways have been located.

The wagon pool

The so called « wagon pool », to some extend in operation, is not a pool in the Western understanding of this term. The Railway Council is keeping track of wagons crossing borders, to the extend they are informed, in order that a railway administration can keep track of the whereabouts of their wagons. At least to the extend that they know in which country they are currently running.

The main purpose of this is to administer the accounting in-between the countries as they are paying for "renting" each others wagons.

To some extend, the Railway Council can also issue directions for empty wagons to be moved to somewhere where cargo is waiting. To which extend this is actually functioning in practice is not easily determined. Statements to this issue differs widely.

1.3.4 Train operation

Efficiency and productivity is substantially lower than what is possible, regarding both rolling stock and staff resources.

A highly contributory cause is the system used in all the regions, according to which the locomotive and the team of engine driver/assistant is a fixed, collective entity, which always drives together. This means that the switching of locomotive must always be made on the basis of the rules on working hours of the engine drivers/assistants. Even though a locomotive is usually connected with several teams, the productivity for the motive power fleet must still be considered very low (250-350 km per 24 hours).

Locomotives driving passenger trains and freight trains are always worked by 2 employees (engine driver and assistant), whereas the shunting locomotives are one-man operated.

Locomotives with their teams are either driving passenger trains or freight trains and the individual locomotive drives the same trains every day.

As can be understood, the system is fixed and totally inflexible, and there is no doubt that this production element is absolutely decisive for how the timetable is planned and thus for the supply of products which is to attract customers.

The fact that the railway companies have chosen this form of production must be seen in the light of the locomotives being attended to and taken care of in a good and efficient way, when the locomotive is "owned" by a few engine drivers/assistants. This advantage can ultimately not justify the small effectively and low productivity of a large capital investment.

This form of production was well adapted to the former high level of traffic. The number of pairs of trains was large enough so that driver/locomotives did not wait for trains to be hauled, they were highly solicited.

However, within such an organisation the driver teams ensure the quality control of the maintenance. Therefore, this organisation could only be changed when an efficient and adapted quality control system will be set up.

Both for operation of passenger trains and freight trains, there is a substantial use of personnel. A passenger train with one restaurant car and 14 couched carriages and sleeping cars will for example be staffed with about 20 people. For freight trains, many staff resources are required both at the marshalling yards and when shunting.

Finally, the speed reductions as a consequence of the inadequate maintenance of the infrastructure means that generally there will be less effectively and lower productivity than otherwise possible.

1.3.4.1 Passengers

The passenger traffic is being operated in accordance with a time schedule dating from the former times. There does not seem to be any mechanism to adjust this time schedule to the actual needs for travel.

The train travel was a "large scale production" meaning that trains were very long, often more than 20 coaches in a passenger train. It is a very economic mode of passenger transport when the passengers are ready (or have no other alternatives) to wait for the few running trains.

Nowadays, in order to save operational costs, some trains are cancelled, often without prior warning, resulting in fewer long trains, passengers coming to catch trains that are cancelled, missed connections etc.

The passenger train speed is very low. Average speed is between 30 to 60 km/h.

That situation is partly due to infrastructure conditions :

- deficiencies in track maintenance , mainly in Caucasus countries;
- deficiencies in bridge maintenance in some places ;
- single track layout, which increases standstill for train crossing.

It also due to operation regulations :

- long stop in station for wheel and bearings inspections, exchange of locomotives ;
- timing with too much "built-in recovery " ;

and due to performance of rolling stock : most of locomotives have a maximum speed of 100 km/h.

1.3.4.2 Freight

The great majority of the freight comes from state enterprises. They have been using rail transport for decades, and also here changes in operation are an extremely slow process. Even though rail transport is still some 90% of the total transport, transfer of shipments to truck operation has happened, and still is happening.

In most of the TRACECA countries, the wagons had an acceptable turn around of 6 to 8 days, but the slowdown of traffic has increased. The turn around of wagons is not only related to the speed of the train but also to the organisation of loading/unloading terminals.

During a decline phase of production, the users of wagons get more wagons than they need and, since they have available space to store them, they are not very keen to set rid of them.

It is of the duty of railway management to monitor the availability of the wagons and to give their customers the incentive or fine them to release the wagons according to a tight schedule.

2. Rolling Stock

2.1 Overall

Today, the railways of the TRACECA area are based on the principles and technology from the FSU. All railway activity in the TRACECA region was previously part of the big SZD organisation.

This technology has a number of advantages compared to the comparable technology of the Western Europe.

Main advantage for the railway is the much larger clearance profile that comes with the Russian Broad Gauge. Being 650 mm higher and 250 mm wider than the Western, the Russian profile is 22% bigger in cross section. This provides immense possibilities when constructing traction power and vehicles.

The diesel engines are of a simple and sturdy design. They are not particularly sensitive to the quality and purity of the diesel fuel that they are running on. They do not require being adjusted and checked with advanced measuring equipment etc. They are understandable to the people operating them. Most often the driver is able to make a defect locomotive run home, where it can be maintained with relatively simple means.

But they are uneconomical locomotives in power/weight ratio and in fuel consumption.

A similar situation applies for the electric engines. Also the electrical engines are simple, sturdy and understandable.

They can be maintained with simple means, but are uneconomical in power/weight ratio and in power consumption.

2.2 Rolling stock characteristics

All Rolling Stock in the Region comes from the FSU railways, SZD, so some technical information have been drawn from sources dealing with SZD Rolling Stock.

2.2.1 Traction power

2.2.1.1 Overall

In 1984, it was decided to introduce a new system of traction power classes, providing an eight digit classification and numbering system that was "computer friendly", containing only digits. However, in the field and in the depots, there are no traces of this system being in operation, therefore, it was chosen to base this presentation on the old class designation system, that is the one in current practical use.

The following types of Traction Power have been located in the TRACECA Region .

Main Line Diesel Traction

Type	Axle arr.	Weight tons	Maximum. axle load	Power kW (continuos)	Maximum. Speed km/h	Tractive power kn. (start)
M 62	CoCo	116,5	19,4	1470	100	350
2M 62	2xCoCo	2x120,0	20,0	2x1470	100	2x350
TE 3	2xCoCo	2x120,6 2x127,0	20,1 21,2	2x1472	100	2x285
2TE 10 L	2xCoCo	2x130,0	21,7	2x2208	100	2x375
2TE 10 M	2xCoCo	2x138,0	23,0	2x2208	100	2x399
3TE 10 M	3xCoCo	3x138,0	23,0	3x2208	100	Maximum. 932
2TE 10 U	2xCoCo	2x138,0	23,0	2x2206	100	2x255 (cont.)
2TE 10 V	2xCoCo	2x138,0	23,0	2x2208	100	2x399
2TE 116	2xCoCo	2x138,0	23,0	2x2250	100	2x399
TEP 60	CoCo	129,0	21,5	2208	160	201
2TEP 60	2xCoCo	2x129	21,5	2x2208	160	2x201
TEP 70	CoCo	129,0 131,0	21,5 21,8	2944	160	288

Weight indicated is with 2/3 of capacity of fuel, oil and sand
For some main types, several sets of figures refer to different versions

Main Line Electric; 25 kV AC, 50 Hz

Type	Axle arr.	Weight (tons)	Maximum. axle load	Continuous power (kW)	Maximum. Speed (km/h)	Tractive power kN (start)
VL 60 K	CoCo	138,0	23,0	4050	100	487
2VL 60 K	2xCoCo	2x138,0	23,0	2x4050	100	2x487
VL 80 S	2xBoBo	2x92,0 2x96,0	23,0 24,0	2x3160	110	2x325
3VL 80 S	3xBoBo	3x96,0	24,0	3x3160	110	3x325
VL 80 T	2xBoBo	2x92,0	23,0	2x2960	110	2x325

Weight indicated is with 2/3 of capacity of Oil and sand
For some main types, several sets of figures refers to different versions

Main Line Electric; 3 kV DC

Type	Axle arr.	Weight tons	Maximum. axle load	Continuous power (kW)	Maximum. Speed (km/h)	Tractive power kN (start)
VL 8	2xBoBo	2x92,0	23,0	2x1880	80 100	2x298
VL 10	2xBoBo	2x92	23,0	2x2300	100	2x307
VL 10 U	2xBoBo	2x100	25,0	2x2300	100	2x333
VL 11	2xBoBo	2x92	23,0	2x2300	100	2x306
VL 22 M	CoCo	132	22,0	1860	80	378
VL 23	CoCo	138	23,0	2740	100	446

Weight indicated is with 2/3 of capacity of Oil and sand
For some main types, several sets of figures refer to different versions

Electric Multiple Units

Type	No. of cars	Weight M=motor T=trailer DT=cab t. DM=cab m.	Maximum. axle load	Power per motor car (kW)	Maximum. Speed (km/h)	Current
ER 2	10/12	M: 54,6 T: 38,3 DT: 40,9	19,9	800	130	3 kV DC
SR 3	3/4	M: 61,5 T: 38,5	n.a.	720	85	3 kV DC
ER 9 E	10/12	M: 59,5 T: 37,0 DT: 39,0	19,7	800	130	25 kV AC
ER 22	8	DM: 63,5 T: 41	22,4	880	130	3 kV DC

Weight indicated is with 2/3 of capacity of Oil, water and sand

Shunting Diesels

Type	Axle arr.	Weight (tons)	Maximum. axle load	Power kW	Maximum. Speed (km/h)	Tractive power kN (start)
TEM 1	CoCo	126 120	21,0 20,0	736	90	347
TEM 2	CoCo	120	20,0	883	100	347
TEM 3	CoCo	120	20,0	883	100	200 (cont.)
ChME 3	CoCo	123	20,5	993	95	356
TGM 3	BoBo	68	17	552	33/70	196/118

Weight indicated is with 2/3 of capacity of Diesel, oil and sand
Some types have two sets of gearing, one for shunting and one for main line running. Indicated with a slash.
For some main types, several sets of figures refer to different versions

Diesel Multiple Units and Shunting Electrics have not been located in the Region

2.2.1.2 Description of the individual types of traction power.

Main line diesels

In accordance with the command economy, a pattern of specialised production grew during the 50´ties and the 60´ties. Passenger locomotives were produced by Kolomna. Freight locomotives by Lugansk and Kolomna. Diesel engines by Kolomna and Kharkov. The development was most driven by requirements for higher power for the freight engines and higher power and speed for the passenger engines. An indicated weakness in the main line diesel fleet is the Kharkov 2-stroke engines 2D100 of 1472 kW and 10D100 of 2208 kW. These are well known as being unreliable and have a high fuel consumption. This is a problem in the TRACECA region, as the types TE 3 and 2TE 10 L/V/M/U with these engines are widespread. But there are "second opinions" in the workshops, stating that these are reliable engines, if treated properly.

M 62 - 2M 62

These freight locomotives were build for SZD by Lugansk. Series production in 1970 - 76 (M62) and 1976 - 87 (2M62). Total production is 735 M62 and 1261 2M62. They are powered by Kolomna type 14D40, V-12 2 stroke supercharged diesel engines.

The type is the first main line diesel, originally developed for export in the FSU. The 2M62 unit is basically two single units with a few modifications.

TE3

These freight locomotives were build for SZD by Kharkov, Lugansk and Kolomna. Series production 1955 - 73. Total production is 6809 sets. They are powered by Kharkov type 2D100, 10 cylinder 2-stroke diesel engines. Produced for more than 20 years, the TE3 became the main type of diesel freight locomotive from the mid sixties, and is probably the world's most produced twin-unit diesel.

2TE 10L

These freight locomotives were build for SZD by Lugansk. Series production 1966 - 77. Total production is 3533 sets. They are powered by Kharkov type 10D100, 10 cylinder 2-stroke supercharged diesel engines. It is the next step in the development after the TE3.

2TE 10V

These freight locomotives were build for SZD by Lugansk. Series production 1975 - 81. Total production is 1557 sets. They are powered by Kharkov type 10D100, 10 cylinder 2-stroke supercharged diesel engines. It is a development of the 2TE10L. The V stands for Voroshilovgradskii, the name of Lugansk in the period 1970 - 91.

2TE 10M - 3TE 10M

These freight locomotives were build for SZD by Lugansk. Series production 1979 - 90 (3TE10M) and 1981 - 90 (2TE10M). Total production aprx. 3000. They are powered by Kharkov type 10D100, 10 cylinder 2-stroke supercharged diesel engines. It is a development of the 2TE 10V. The M stands for Modernizirovannyi - Modernised. The 3TE 10M is basically 1 x 2TE 10M.

2TE 10U

These freight locomotives were build for SZD by Lugansk. Series production from 1989. Total production until 1992 aprx. 500. They are powered by Kharkov type 10D1002, 10 cylinder 2-stroke turbocharger diesel engines. It is a development of the 2TE 10M. The U stands for Universalnyi - Universal. The 3TE 10M is basically 1 x 2TE 10M.

2TE 116

These freight locomotives were build for SZD by Lugansk. Series production from 1972. Total production until 1992 aprx. 1625. They are powered by Kolomna type 1A-5D49, 16 cylinder 4-stroke diesel engines. It is the first diesel locomotive in the FSU to use AC/DC electric transmission, providing reduced weight and increased reliability. This type was delivered to Eastern Germany as classes 130 - 132.

TEP 60 - 2TEP 60

These passenger locomotives were build for SZD by Kolomna. Series production 1961 - 85 (TEP60) and 1966 - 87 (2TEP60). Total production 1241 TEP60 and 116 2TEP60. A number of TEP60 have been converted to 2TEP60. They are powered by Kolomna type 11D45, 16 cylinder 2-stroke diesel engines. It is the first purpose build passenger locomotive in the FSU. The 2TEP60 is intended for fast and heavy passenger services.

TEP 70

These passenger locomotives were build for SZD by Kolomna. Series production from 1987, with some preceding small batches. Total production in 1992 was some 300 units. They are powered by Kolomna type 2A-5D49, 16 cylinder 4-stroke diesel engines. It is the first 3MW single section passenger locomotive in the FSU. It is intended as a more powerful passenger locomotive than the TEP60, without the weight and maintenance increases of a twin-unit.

Main line Electrics

All electric is designated VL - Vladimir Lenin, in commemoration of the initiator of the first plan for the Russian railway electrification. The development in the electric was also driven by requirements for higher Tractive effort. After being rebuild after the war, Novocherkassk became the dedicated plant for electric locomotives, being supplemented by the Tbilisi plant in the late 50´ies. Passenger electric came from Skoda in Czecoslovakia, but none of these ended up in the TRACECA Region.

VL 60 K - 2VL 60 K

These 25 kV freight locomotives were build for SZD by Novocherkassk. Series production 1965 - 68, with older locomotives being upgraded 1965 - 73. Twin unit have been formed from existing locomotives in 1987 - 90. Total production of VL 60 K is 2612 units incl. rebuilds. The K stands for Kremnievyi - Silicone, as the locomotive uses silicone rectifiers for improved conversion of the AC overhead current to the DC traction motors.

VL 80S - 3VL 80S

These 25 kV freight locomotives were build for SZD by Novocherkassk. Series production from 1980. Total production of VL 60 K is 2612 units incl. rebuilds. The K stands for Kremnievyi - Silicone, as the locomotive uses silicone rectifiers for improved conversion of the AC overhead current to the DC traction motors. Note that the 3VL80S is not three times one VL80S. VL80S is a twin unit, 3VL80S is a triple unit and thus 1 times a VL80S.

VL 8

These 3 kV freight locomotives were build for SZD by Novocherkassk and Tbilisi. Series production 1955 - 67. Total production of VL 8 is 1723 sets. This is the first series build twin electric of the FSU, developed in order to cut the need for double heading.

VL 10

These 3 kV freight locomotives were build for SZD by Novocherkassk and Tbilisi. Series production 1967 - 77. Total production of VL 10 is 1902 sets. This is a development of the VL8 providing higher Tractive power.

VL 10U

These 3 kV freight locomotives were build for SZD by Novocherkassk and Tbilisi. Series production 1976 - 86. Total production of VL10U is 980 sets. The U stands for Usilennyi - Strengthened. This is a variant of the VL10, being ballasted with 8 tons of iron blocks per unit, in order to increase the adhesive power.

VL 11

These 3 kV freight locomotives were build for SZD by Tbilisi. Series production 1976 - 86. Total production of VL10U is 980 sets. The U stands for Usilennyi - Strengthened. This is a variant of the VL10, being ballasted with 8 tons of iron blocks per unit, in order to increase the adherence power.

VL 22 M

These 3 kV freight locomotives were build for SZD by Kolomna and Novocherkassk. Series production 1947 - 58. Total production of VL22M is 1523 units. The M stands for Modernizirovannyi - Modernised, but this is related to the pre-war VL22.

VL 23

These 3 kV freight locomotives were build for SZD by Novocherkassk. Series production 1958 - 61. Total production of VL23 is 489 units. This is essentially a strengthened VL22M with Tractive equipment similar to the VL8. It was intended as a single unit replacement for the VL22M.

EMU´s

From the late 40´ies the production of EMU´s were concentrated in Riga in Latvia.

ER2

These 3 kV EMU´s were build by RVZ in Riga, with the driving trailers coming from Kalinin. Series production 1962 - 84. Total production 850 sets. This is by far the most numerous type of EMU from the FSU.

SR3

These 3 kV EMU´s were build by RVZ in Riga. Series production 1952 - 58. Total production 638 sets.

ER 9 E

These 25 kV EMU´s were build by RVZ in Riga. Series production 1982 - 88. Total production 78 sets.

ER 22

These 3 kV EMU´s were build by RVZ in Riga. Series production 1966 - 68. Total production 66 sets.

Diesel shunters

The production of diesel shunters were the responsibility of Bryansk, Kaluga and Lyudinovo. This strongly supplemented with import from SZD in Czecoslovakia. Initially the main goal was to replace steam shunting, but in time, requirements for still heavier shunting came forward resulting in still stronger shunters. Some types with two sets of gearing can also run main line services.

TEM 1

These diesel-electric shunters were build by Bryansk. Series production 1958 - 68. Total production 1925 units. It is powered by a Penza type 2D50, a 6 cylinder 4-stroke diesel engine. This type was mass produced in an effort to eliminate steam shunting. It has a strong relation to the DA shunters delivered to the FSU by ALCO as part of the Lend/Lease deal during the war.

TEM 2

These diesel-electric shunters were build by Bryansk. Series production 1967 - 87. Total production, many thousands. It is powered by a Penza type PD1, 6 cylinder 4-stroke diesel engine. This was developed from the TEM1 as a more powerful version.

TEM 3

These diesel-electric shunters were build by Bryansk. Series production 1980 - 86. Total production only 26. It is powered by a Penza type PD1M, 6 cylinder 4-stroke diesel engine. This was developed from the TEM2 with minor adjustments.

ChEM 3

These diesel-electric shunters were build by CKD in Czechoslovakia. Series production 1965 - 87. Total production 6027. It is powered by a CKD type K6S310DR, 6 cylinder 4-stroke diesel engine. This very successful Czech design was the most common shunter in the FSU. The Ch stands for Czechoslovakia.

TGM 3

These diesel-hydraulic shunters were build by Lyudinovo. Series production 1959 - 67. Total production aprx. 3.775. It is powered by a Zvezda type M751, V-12 4-stroke supercharged diesel engine. The G in the class name stands for Gidravlicheskoi - Hydraulic.

2.2.1.3 Comparison between Western and TRACECA traction power

Main line diesels

Type of loco	Rated power in kW	Weight in tons	kW per tons
DB Class 218	1840	80	23,0
DSB Class ME	2410	116	20,8
CC 72000			
M62	1470	116,5	12,6
2 TE 10 U	2 x 2208	2 x 138	16,0
TEP 60	2208	129	17,1
TEP 70	2944	129	22,8

kW/weight ratio for some Danish, German and TRACECA diesel locomotives

It is definitely worth noting that the most recent type of FSU locomotive is actually a match for the Western diesels in performance/weight ratio. The DB class 218 is a 25 year old design, but the DSB class ME is only some 10 years old.

Main line Electrics

Type of loco	Type of current	Rated power in kW Continuos	Weight in tons	kW per tons
DB Class 103	15 kV 16,7 Hz	5950	110	54,1
DB Class 120	15 kV 16,7 Hz	4400	84	52,4
DSB Class EA	25 kV 50 Hz	4000	80	50,0
BB 26000				
VL 11	3 kV DC	2 x 2300	2 x 92	25,0
VL 23	3 kV DC	2740	138	19,9
VL 60 K	25 kV 50 Hz	4050	138	29,3
VL 80 T	25 kV 50 Hz	2 x 2960	2 x 92	32,2

kW/weight ratio for some Danish, German and TRACECA electric locomotives

This schedule shows the better performance/weight ratio reached with the DC traction, but also demonstrates the advantages that can be reached with modern Western electric traction.

These two schedules also show that the Western development has been moving quicker within Electric traction, than within diesels.

2.2.2 Passenger coaches

For a Western reader, the most important thing to note on Russian Railways Coaches, is that the majority of coaches are sleepers of some kind. This is evidently due to the distances normally travelled.

Only an estimated 10 - 12% are seating coaches.

Standard measures for the vast majority of Coaches:

Length: 24.540 mm
Width: 3.058 mm
Height: 4.355 mm
Bogies: ZMW or KWS5
Coupler: SA 3 or SA 7
Weight: 50 - 60 tons

Factories are Amendorf in DDR and Tver in Russia.

Summary of passenger coach characteristics

Type	Reference	Dimensions (m)	Weight (t)	Couches / Seats	Speed limit (km/h)
Suburban cars	MOBI	23.6 x 3.1 x 4.4	49	68 / -	160
Couchette cars	TSMO	23.6 x 3.1 x 4.4	52	54 / 81	160
Sleeping cars	TSMK	23.6 x 3.1 x 4.4	52	36, 38 / -	160
Comfort Sleeping cars	SV	23.6 x 3.1 x 4.4	64 58	16 / - 24 / -	160
Comfort Sleeping cars	TSMK	26.1 x 2.9 x 4.2	55	33 / -	200

Post & luggage cars	ЦМп:6	23.6 x 3.1 x 4.4	47		160
Restaurant cars	ЦМр	23.6 x 3.1 x 4.4	54		160

The coaches are generally clean and comfortable, however their technical conditions are deteriorating due to

- lack of appropriate maintenance, such as :
    - fittings : use of low quality of rubber, all kinds of floor, wall, seat coverings
    - low quality of exterior coatings.
- but also due to their technology, such as : heating system by steam stoves supplying hot water which requires high level of care and which generates condensation on the underframe pipes ;

2.2.3 Freight wagons

2.2.3.1 General characteristics

Four axle wagons constitute the most common type, but high sided wagons with 6-axles, and tank wagons with 6 or 8 axles are also frequently seen.

The wagon is based on one strong steel beam down through the middle. This beam takes all pulling forces, the bogies are fixed to it, and the superstructure of the wagon rests on it. The consequence of this is a simple construction but also a relatively high tare weight. A major advantage is the easiness with which hinges for bottom emptying can be positioned alongside the beam, enabling standard high sided wagons to do the tasks that would otherwise require a hopper. Another advantage of some relevance to this project, is that rebuilding a wagon to another type is fairly simple, as the complete substructure of the wagon, including bogies and couplers, in most cases can be reused as is.

The main types of freight wagons are

- Closed wagons for universal dry cargo use
- Semi-high sided wagons for bulk cargo not sensitive to humidity, i.e. coal, ore, stone etc.
- Flat platform wagons, mostly for transport of military and other vehicles
- Tank wagons for liquids, Oil, Refined products, Milk, and others
- Refrigerators sets, for meat, vegetables and other foodstuff
- Hoppers for bulk cargo sensitive to humidity i.e. grain, fertiliser, etc.

The Russian Broad Gauge allows a standard semi-high sided wagon to accommodate a standard width ISO 20" or 40 " container without any modifications. Even though dedicated container carriers are preferable, this feature opens up for large possibilities until the build up of a dedicated fleet is feasible.

2.2.3.2 Summary of wagon characteristics

Type	Ref	No. of axles	Load limit	tare	Usable space	Time life
Covered wagons	PR	4	60 - 68 t	22 - 26.5 t	90 - 120 m^3	32 years
Low sided wagons	PV	4 6 8	60 - 69 t 94 t 125 t	21 - 25.5 t 32.4 t 43.6 t	50 - 76 m^2 104 m^2 140 m^2	32 years
Flat wagons	PL	4	60 - 70 t	20 - 22.7 t	37 m^2	32 years
Tank wagons	TSS	4 8	50 - 60 t 120 t	21.8 - 25.6 t 48.8 t	50 - 72 m^3 140 m^3	32 years
Refrigerator wagons	XX	4	30 - 49 t	28.5 - 32.5 t	54 - 82 m^3	25 years

Among the « others » are included : car-carriers and wagons carrying :containers, cattle, grains, cement

All wagons have bogies (two wheel-sets).

Speed limit of all types of wagons : 120 km/h

Type of wagon	**Purpose (mainly)**
KR, closed	cotton
PL, platform	Stone
PV, open	Coal
TsS, Tank	Oil and chemicals
PR, closed	Special transportation , incl. container wagons
XX, closed	Refrigerator, transport of vegetables

2.2.3.3 Operation of Refrigerators wagons

The refrigerator, or refrigerated trainsets consists of a set of permanently coupled vehicles. One permanently manned type ZB 5 SU car, containing the refrigeration machinery and 4 type MK 4 SU wagons with technical data as follows:

- Length: 22.080 mm
- Cargo volume: 100 m^3
- Capacity: 39 tons
- Gross weight: 84 tons
- Five levels of refrigeration from -18C° to +13C°

As these wagon sets are travelling all of the Russian Broad Gauge permanently manned, the requirements for servicing the personnel is somewhat unusual. Travelling arrangements for replacement crews and for returning staff have to be organised. A complicated communication network have to be maintained in order to keep in touch with the travelling crews and to know their location. And among the other practical details, a major library has to be maintained for the travelling personnel.

2.3 Rolling stock inventory

This project covers the Rolling Stock Inventory in an area bigger than Europe.

Evidently, the Rolling Stock Inventory will have to rely on information obtained from central sources. It has not been possible in detail to verify this information, based on field studies.

All Rolling Stock in the Region comes from the FSU railways, SZD, so some technical information has been drawn from sources dealing with SZD Rolling Stock.

2.3.1 Traction power inventory

Type	Arm.	Azer.	Geo.	Kaz.	Kyrg.	Tadj.	Turk.	Uzb.
2M 62	1) (50)	24						
TE 3		22	7	130				
2TE 10L				383	11	(8)	182	53
2TE 10M		(32)	6	475	3	(20)	14	176
3TE 10M		(10)		138	3			121
2TE 10U			3	71		(4)	33	
2TE 10V				450	17	(10)	4	81
2TE 116								48
TEP 70				15				
Total Mainline Diesel	0	88	16	1,663	34	42	233	480

Type	Arm.	Azer.	Geo.	Kaz.	Kyrg.	Tadj.	Turk.	Uzb.
VL 8	(38)	207	87					
VL 10	(36)		86					
VL 10U			18					
VL 11		43	41					
VL 22M		1	16					
VL 23		2						
VL 60K VL 60 PK				65				28
2VL 60K								21
VL 80S				402				1
3VL 80S								34
VL 80T				194				
Total: Mainline El.	74	253	248	661	0	0	0	84

A number in bracket means that the figure is estimated

Type	Arm.	Azer.	Geo.	Kaz.	Kyrg.	Tadj.	Turk.	Uzb.
ER 2		74						12
SR 3		1						
ER 9E								33
ER 22	89							
Total: EMU sets	89	75	0	3) 0	0	0	0	2) 45

Type	**Arm.**	**Azer.**	**Geo.**	**Kaz.**	**Kyrg.**	**Tadj.**	**Turk.**	**Uzb.**
TEM 1		1		18				
TEM 2		128	25	423	14	(2)	8	185
TEM 3	(25)							
ChME 3		50	154	67	9	(2)	90	128
TGM 3				3				
Total: Shunters	1) 75	179	179	511	25	4	98	313
Operational	11	112	52	n.a.	25	n.a.	60	n.a.

1) M 62 used as shunter, so listed in total under shunters

2) 12 Uzbek EMU's are for the 3 kV DC current

Diesel Multiple Units and Shunting Electrics have not been located in the Region

2.3.2 Passenger coach inventory

Type	Arm.	Azer.	Geo.	Kaz.	Kyrg.	Tadj.	Turk.	Uzb.
Soft passenger	-	-	69	57	9	10	24	27
Hard passenger	-	-	977	1,823	464	326	339	1,263
Restaurant/Buffet	-	-	44	102	31	14	17	66
Baggage/Post	-	-	69	-	20	1	7	59
Others	-	-	17	203	5	4	14	39
Total	298	875	1,176	2,185	529	355	401	1,454

2.3.3 Freight wagon Inventory

Type	Arm.	Azer.	Geo.	Kaz.	Kyrg.	Tadj.	Turk.	Uzb.
Closed	-	6,453	3,901	17,820	682	557	2,856	8.970
Semi-high	-	5,860	2,284	39,510	688	619	2,118	7.025
Flat	-	4,942	2,224	14,130	479	334	3,510	4.927
Tank	-	4,948	2,284	11,570	251	21	3,937	4.484
Refrigerators (sets)	-	2,280	752	2,240	-	52	700	1.905
Hoppers	-	-	1,910	-	-	-	724	-
Others	-	5,377	2,886	15,760	516	581	1,317	5.218
Total	4,835	31,313	19,831	101,300	2,616	2,164	15,162	32.529

2.3.4 Availability of rolling stock

Locomotives	Arm	Azer	Geo.	Kaz.	Kyrg	Tadj	Turk	Uzb	Total
Electric									
Total	74	253	248	738				84	1,397
Available	46	252	91	665				84	1,138
Required in 96	23	53	87	356				27	546
Diesel									
Total		88	16	1,595	34	46	233	481	2,493
Available		30	5	1,350	34	46	120	481	2,066
Required in 96			3	548	14	24	102	152	843
Shunting									
Total	75	179	179	733	23	41	98	794	2,122
Available	11	112	52	480	23	41	90	794	1,602
Required in 96	10	100	30	400	12	15	80	251	888

Passenger coaches	Arm	Azer	Geo.	Kaz.	Kyrg	Tadj	Turk	Uzb	Total
Total	298	875	1,176	2,185	529	355	401	1,454	7,273
Available	198	400	566	2,100	450	300	270	1,310	5,594
Required in 96	134	400	600	2,000	110	190	500	400	4,335

Wagons	Arm	Azer	Geo.	Kaz.	Kyrg	Tadj	Turk	Uzb	Total
Total	4,800	31,000	21,500	108,000	2,616	2,112	12,800	32,500	215,330
Available	2,400	13,000	3,600	60,000	1,889	2,000	12,800	26,800	122,490
Required in 96	1,675	5,200	2,700	57,000	1,880	2,000	12,200	9,700	92,360

2.3.5 Age of rolling stock

The information on the age of rolling stock obtained from the railways have proven to be less precise and complete than for most of the other information obtained.

There are several examples of an indicated delivery date of a locomotive, that is either years before production started, or years after it ended. Some of this may be due to transfer of locomotives from one railway administration to another, where it is the transfer date that is in the books, or it can be the date of a heavy rebuild, for instance after accidental heavy damage or when individual locomotives are permanently coupled and given a new class and number that is officially registered as the delivery date.

For this reason it has been assessed that the best presentation would be to accumulate all information into a general picture, and then highlighting specific groups of very old or new stock.

	Arm	Azer	Geo.	Kaz.	Kyrg	Tadj	Turk	Uzb	Total
Electric all types									
less than 10 years	0	0	0	290					290
betw. 10 and 20	0	43	10	343					396
more than 20	74	210	49	105					438
Diesel all types									0
less than 10 years	0	0	4	485	3	0	41		533
betw. 10 and 20	0	0	0	1110	27	46	25		1208
more than 20	0	88	1	0	3	0	167		259
Shunting									0
less than 10 years	0	0	0	140	0	0	10		150
betw. 10 and 20	0	89	26	593	11	41	84		844
more than 20	75	90	26	0	12	0	4		207

3. Maintenance

3.1 Maintenance organisation

3.1.1 Policy

The maintenance policy was defined in Moscow and presently in most cases it is managed by the Transport Ministries, who, generally are still applying the former maintenane policy. The former procedures and normative rules were set up to ensure high reliability whatsoever the price to be paid.

The current management is split in independent and autonomous geographical districts. Their budgets are allocated by the main office of the railways, which is responsible for human resources, and for running and maintenance costs.

The districts are in charge of the train operation, infrastructure and rolling stock maintenance.

Most of all the locomotive depots and workshops (also called operation depots) deal with operation, management of drivers, first levels of maintenance (TO, TR1 and TR2 cycles) and when fitted with relevant equipment and facilities they perform higher levels of maintenance.

This means that a depot is not only a maintenance shop but it handles the complete haulage of trains within a certain district in accordance with a fixed schedule.

Evidently, the assignment of drivers and locomotives for the train operation is a major part of the tasks in a depot. It takes a considerable amount of management attention.

Passenger coach depots are also operation depots, all coach operating staff is attached to the depots.

Under the FSU organisation, the wagons were not attached to any networks. They were maintained by the nearest depot of its current location when the date for maintenance written on each of them was reached.

Today, when the next maintenance activity is due, the vehicle may not leave the country where it is located. In consequence, several countries may not have their wagons returned back from foreign countries where they are waiting for maintenance. The country of origin is often not able to pay for the maintenance to that foreign country, moreover, they really do not need those wagons, thus, they are not very keen to negotiate the return of those wagons.

3.1.2 Budget

The depots pay for the maintenance carried out on their attached even though it is carried out in central workshop or abroad. Overhauls carried out in foreign countries are time consuming, costly and paid in hard currency. Furthermore, the depot budget covers not only the maintenance, but also the operation such as driving crews and energy for the traction power.

To finance all this, the depot budget is based on a complicated system of unit costs, including among other things : mileage run and maintenance tasks carried out.

However, this unit cost calculation, from the former management does not take into account parameters such as inflation. Moreover, as money is often short within the railways, usually, only a fraction of this amount is actually received by the depots.

The managers themselves have not been trained to manage such a budget (exploitation and investment), they were trained to follow the requirements of "the Plan, which was a different way of management.

3.1.3 Monitoring

In most of the depots the follow up of maintenance activities and rolling stock failures is carried out manually on vehicle booklet and train operation record books. Failures are often recorded on vehicle booklet, but results of repairs are not recorded. The driver teams are the only people who have a good knowledge of their locomotives. The passenger coaches and refrigerator attendants are also the only people to follow their vehicles.

Concerning the wagons, in many countries, the only maintenance follow up is still consisting of the date, place and type of last maintenance activity painted on the vehicle. In the smallest countries, the wagons are attached to a specific depot which ensures a better follow up of maintenance activities but, neither any follow up of failures nor spare parts

A lot of information are recorded but few are analysed. In particular, reliability (M.T.B.F. - Mean Time Between Failure), weakest components and spare parts real consumption are not known.

A lot of information are recorded but analysis is difficult.

3.1.4 Ancilary activities

Many depots and workshops are operating non-railway related facilities such as schools, hospitals, and vacation hotels as social obligation. Such activities are currently developed and extended with all kinds of other non-railway activities such as agricultural activities in order to generate revenue for the prime operation.

3.2 Maintenance procedures

The preventive maintenance of all kind of rolling stock is basically consisting of three levels :

- TO 1, TO 2, and TO 3 : Technical inspections at stations and terminals
- TR 1, TR 2, and TR 3 : Light or running maintenance at depots
- KR 1 and KR 2 : major overhaul at workshop

KR2 is very similar to KR1, it was the "plant inspection" or half life overhaul which is certainly not compulsory.

Redundancy in maintenance inspections, high frequency of preventive maintenance and unconditional replacement of spare parts were carried out to ensure a 100% reliability.

The economic efficiency was not a priority, nevertheless, tremendous traffic certainly allowed the railways to reach satisfactory efficiency rate per unit of service (ton.km and passenger.km).

Moreover, such policy does not requires any spare part management or efficient maintenance management system.

The wagons and coaches maintenance frequencies depend on the delay between operation and not on the distance run by the vehicles. Concerning the locomotive, they were related to distance and delay. However, due to the decrease of traffic, the annual distance run is low and the maintenance is nowadays only related to the time.

In several areas it seems that maintenance is too much developed, e.g. opening of bearings, exchange of electric cables, disassembly of electric motor, remove of diesel engines.

Without any maintenance management systems thus, without any data on reliability and detailed knowledge of the quality of the various components it is difficult to judge whether the maintenance procedures lead to over-maintenance.

All maintenance intervals, procedures and activities were defined centrally, and the maintenance classes and intervals drawn up in the following is defined in these overall maintenance planning schedules.

This method was well functioning in a command economy environment, where all activities were parts of an overall planning that controlled the complete society. As all transport production activities were defined, it was possible to define all necessary maintenance activities to fit this. As a consequence, in this system there is absolutely no incentive to make changes and thus, to reduce the maintenance resource consumption. Problems for the editor of the rulebook only occurred when maintenance requirements were too low, not when resource consumption was too high. For the time being, most of the railways are not in a position to fulfil the plan and they should adapt it.

Due to lack of relevant monitoring system and spare parts management, they face a lot of difficulties in the maintenance management. As a result, the standstill time for maintenance purpose differs widely from the procedures (e.g. from 5 days to more than 40 days). Moreover, due to the lack of original spare parts, the reliability of the rolling stock is decreasing and most of the maintenance organisations are complaining that they have to increase the frequency of inspections.

3.2.1 Locomotives

Type	Tasks	Location
Inspection		
TO 1	Inspection by loco driver	In station or yard
TO 2	Inspection and lubrication	In depot over pit
TO 3	Inspection and lubrication Check of diesel engine, motor brushes, electrical brake	In depot over pit
Running maintenance		
TR 1	Inspection of components, lubrication of all moving parts. Cleaning of motors and check of fuel injection, turbo charger, cardan axles and auxiliary equipment.	In depot over pit
TR 2	As TR 1 plus check of bogies and gears in situ.	Depots fitted with specific facilities and tolling.
TR 3	as TR 2 plus removal and check of bogies, wheels and running gear, replacement of diesel engine, refurbishment of brake system	
Major Overhaul/Capital Repair		
KR 1	Major Overhaul. As TR 3 plus exchange of cables	In workshop or factory
KR 2	Capital Repair. Complete dismantling of locomotive. Exchange of all worn out parts.	In factory

In the following table, the intervals in kilometres or time between preventive maintenance activities for the different kinds of locomotives are shown. This is the general picture, minor differences due to specific classes or operative conditions might exist.

	Mainline Diesels	Mainline El 25 kV	Mainline El 3 kV	Shunters	EMU´s
TO 1	Daily	Daily	Daily	Daily	Daily
TO 2	Every 3 days	Every 3 days	Every 3 days	Every 3 days	Every 3 days
TO 3	7.500 km	8.000 km	11.000 km	30 days	5 days

	maximum 18 days	maximum 17 days			
TR 1	30.000 km maximum 2 months	40.000 km maximum 2 months	22.000 km	7 months	50 days
TR 2	120.000 km maximum 10 months	200.000 km maximum 9 months	165.000 km	15 months	150.000 km
TR 3	240.000 km maximum 18 months	400.000 km maximum 18 months	330.000 km	30 months	300.000 km
KR 1	720.000 km maximum 5 years	800.000 km maximum 4 years	650.000 km	7 years	600.000 km maximum. 4 years
KR 2	1.440.000 km maximum. 10 years	2.400.000 km maximum 10 years	2.000.000 km maximum 12 years	15 years	1.800.000 km

3.2.2 Passenger coaches

Type	Tasks	Location
Inspection		
TO 1	Inspection by train steward	In station or yard
TO 2	Technical service, change of couplers, check of brake system, general lubrication	In depot
TO 3	As TO 2, plus lifting of the coach and dismantling the bogies. Check and lubrication of bogies, bearing and axles. Painting. Check of all passenger related items	In depot with lifting facility
Major Overhaul/Capital Repair		
KR 1	Major Overhaul	In workshop or factory
KR 2	Capital Repair	In factory

In most of the concerned countries TO2 and TO3 have been merged in an annual DR maintenance.

In the following table, the intervals between preventive maintenance activities and overhaul are shown. This is also the general picture, minor differences due to specific types of coaches might exist

TO-1	Before entering operation
TO-2	Every 6 months
TO-3	Every 12 months
KR-1	Every 5 years

KR-2	Every 20 years

The passenger trains are usually clean and comfortable, but they don't have an attractive looking, which, so far, is not among the first consideration for the satisfaction of the customers, but improvements of quality of service and attractiveness will have to pay attention on the external attractiveness of the passenger coaches.

3.2.3 Freight wagons

Type	Tasks	Location
Inspection		
TO 1	Inspection of wagon before loading	In station or yard
TO 2	Inspection of wagon after loading	In station or yard
TO 3	Inspection by technician	In depot or major yard
Light maintenance		
TR 1	Inspection by special order	In depot
TR 2	Detailed inspection	In workshop
Major Overhaul/Capital Repair		
KR 1	Major Overhaul. Refrigerator wagons only	In workshop
KR 2	Major Overhaul	In workshop

In the following table, the intervals in time between preventive maintenance activities and overhaul are shown. This is again the general picture, minor differences due to specific classes or operative conditions might exist

TO 1	Before loading
TO 2	After loading
TO 3	Every 6 month
TR 1	At request
TR 2	Every year
KR 1	Every 5 years
KR 2	Every 8 years

TR 2 is not carried out the first three years after delivery, and the first two years after KR 1/KR 2.

3.3 Structure of maintenance facilities

Wide spread facilities (locomotive depots every 250 km) and wide spread shunting area (at least 3 parallel tracks, often 8 or 12, every 15 km) allow light repairs and inspections and high level of preventive maintenance.

The current spacing of locomotive depots have been defined to allow a driving crew (drivers - locomotives) to go and come back within one shift.

That quantity of depots was justified by the large locomotive fleets. An average of 60 locomotives (most of them being double units) were attached to each depot which is reasonable for running maintenance and small repair, taking into consideration the priority given to reliability under FSU organisation.

Due to the decrease of traffic, the number of locomotive depots has become in excess of what is required for the light maintenance and standard repairs.

As most of the overhauls were done at the producers premises, there are very few major overhaul shops in the TRACECA countries.

The workforce have generally a good skill and the workshops are most often fitted with full relevant tooling and maintenance equipment. The main workshops able to carry out the upper level of running maintenance (TR3) could be able to perform the KR2 maintenance used to be done at the factories, even though evidently supplementary equipment and additional skill and routine are needed in some places.

The general cleanliness of the shops does not comply with Western standard. Moreover, for some sensitive equipment such as bearings or motors, improved conditions could be appropriate.

It should also be mentioned that little care is borne in the protection of the environment i.e. no collection or waste lube oil, no cleaning of welding gas fumes or diesel engine exhausts etc. and in the depots nobody wear personal protection gear (Hard hats, hearing protection, or safety shoes). The workforce used working in such situation, nevertheless, accidents and quality are likely to suffer such environment.

Most of the workshops and depots are poorly maintained, the access paths for rolling stock and equipment are run down, the heating systems are not working properly, some of the machinery are getting old and require maintenance.

The quantity of handling tools is usually not sufficient.

Maintenance of locomotives, coaches and wagons are carried out in shops independent of each other. Each depot or workshop is fitted with all specialised equipment and all specific tooling required to carry out all the level of maintenance the workshop is designed for. As a consequence of this, it is possible to find countries that have up to 7 separate specialised workshops:

- two types of depots for locomotives:
  - depots with capabilities of TO3/TR1
  - depots for TR2 and for TR3
- workshop for KR 1 (only Tashkent in TRACECA region)
- construction plan for KR 2 (only Tbilisi in TRACECA region)
- depots for passenger coach running maintenance (DR)
- workshops for passenger coach overhaul (KR)
- depots for wagon running maintenance: TR
- workshops for wagon overhaul (KR)

The best equipped workshops carry out all maintenance activities from the TO inspection to the KR1 overhaul.

Typically each of the depot has its own wheel lathe, bearing shop, workshop for component repairs and spare parts which in fact, are more or less identical.

This is, of course a very expensive way to maintain a fleet and in addition specialists on for example brake systems are spread over three workshops.

No modern painting shops have been seen in the whole area. Painting is performed every year on passenger coaches in the DR depot. The quality of such painting is poor which explains such a high frequency. By applying modern equipment and using high quality of paint, the painting coat could last at least 10 years.

3.4 Inventory of maintenance facilities

Locomotives	Arm.	Azer.	Geo.	Kaz.	Kyr.	Tadj.	Tur.	Uzb.	Total
Running maintenance	2	6	7	42	2	3	3	11	76
Heavy maintenance	-	-	2	7	-	-	3	5	17

Coaches	Arm.	Azer.	Geo.	Kaz.	Kyr.	Tadj.	Tur.	Uzb.	Total
Depot for DR	1	1	1	6	2	2	2	2	17
Workshops for KR	-	-	1	1	-	-	1	1	4

Wagons	Arm.	Azer.	Geo.	Kaz.	Kyr.	Tadj.	Tur.	Uzb.	Total
Depot for TR	2	4	3	21	5	2	4	8	49
Workshops for KR	-	-	3	-	1	-	1	5	12

3.5 Spare parts procurements

The major complains of the workshop management is the lack of spare parts in order to carry out the maintenance tasks specified in the procedures. Second hand spare parts are often used. Such spare parts come from idle vehicles or from worn spare parts repaired by the depot itself.

Even though the statement is "we cannot get spare parts" it must be stressed that this is not a complete description of the situation. The previous suppliers of spare part are most often still producing and most of them have plenty of excess capacity.

So, the problem is not locating potential suppliers but, the basic problem is funding the procurement in hard currency.

Formally, the spare parts supplies were not necessarily what was needed. And what was delivered, most often came in quantities far above the needs for a long time to come but, the available quantities of the most needed spare parts are now running seriously out.

But the consequence of this is that spare parts supplies have never before been a top management problem, the spare parts supplies have functioned without funding. So evidently, funding is hard to obtain.

Another problem is the lack of specifications which are only in Moscow and in the factories. The consequence is that it is impossible to get new suppliers

Evidently, there are also logistic problems.

Authorisation for operating wagons and passenger coaches outside their home country (also locomotives, but they normally do not leave their countries of attachment) should be certified by a Russian Quality Control Office. It is stated that they only certify Russian producers of spare parts.

Nevertheless, a considerable amount of spare parts are currently being produced or heavily refurbished by the depots which are not certified. Without any technical specifications and quality control, such production is reported to be of a short quality which increases the number of failures ; the frequency of maintenance is increased to compensate the decrease of quality.

Local production of spare parts is not only limited by certification of manufacturer but also by qualification and capabilities. For the most sophisticated spare parts the Technical Specifications are not available, which prevent only manufacturer from producing them. Some specific equipment or components could be required which also prevents from local manufacturing.

4. Manufacturing

4.1 Overall

Apart from the Tbilisi plant of DC electric locomotives, no productions of vehicles or equipment have been localised in the TRACECA region. Some attempts for local production have been reported but due to lack of technical specifications or certifications those attempts were limited and no productions have been developed.

Some agreement for local co-operation have been signed, but no results have been reported. External support is certainly required.

Most of the FSU rolling stock manufacturing plants were located in Ukraine, the Check Republic, and Russia. One plant for electric locomotives is located in Tbilisi; The "Lenin" Locomotive Construction Plant.

4.2 Lenin" locomotive construction plant

This facility, located in Tbilisi, occupies a site of 47 hectares. In the days of the FSU, it was capable of building 150 electric locomotives per year. The facility was built in the late 1950s/early 1960s and the buildings are spacious.

Construction of the VL10 type locomotives commenced at the plant in 1961 and the VL11 model followed from 1975. And a higher powered version, the VL 15 were built from 1985 on. In total the plant has built some 3,500 locomotives and supplied 30% of the locomotives for the FSU.

Currently, they are not building main line electric locomotives although they have the capability to construct three designs; VL10, VL11 and VL 15. The last two VL11 locomotives constructed are still on hands as the Transport Co-ordinating unit has no funds to purchase them. However, an order for two industrial shunting locomotives is currently being filled for China; one being complete and awaiting inspection and the other well advanced. Further orders for this type of locomotive are being pursued with the Russian Federation and Pakistan.

There are currently 6 of the VL11 type of locomotive undergoing repairs in the shop and a further 4 are awaiting attention. These units have been "robbed" of parts by the railway to keep other units in service. In addition a solitary VL15 prototype, which has proved unsuitable for operation in Georgia is being dismantled for reclamation of components and sale of the items which it is not possible to use on standard models.

The plant was designed to be totally self sufficient and had its own machining and forging capability. All mechanical parts except wheels were manufactured in the plant, the latter being sourced from Russia. The facility had the capability to produce 90% of the brake equipment required for locomotives, the other 10% coming from Russia.

All electrical machines such as traction motors and compressor motors were manufactured in-house as well as electrical switch gear and wiring harnesses.

The staff has been reduced from 5,000+ to around 2,500 in total, of which 10% are technical and administrative personnel. in addition to the General Manager, the "Top Team" consists of a Chief Engineer, Deputy GM (Production Engineering) and Deputy GM (Commercial & Supply). There are Department Heads for each of the main areas of Technical, Industrial and Construction, and each shop area has a Superintendent. The cash flow situation is currently so bad that the staff have not been paid for five months.

Due to financial and supply problems, there are raw material and spare parts shortages in all areas. There is a critical shortage of wheels, bearing and batteries. However this plant has some tape controlled lathes which are used for batch production of turned items, but output is limited by availability of raw material. In general the machinery in the plant is in a reasonable shape.

Being idle for several years, the plant would not be able to restart a locomotive production. Thorough maintenance of buildings, machinery and tooling would be required.

The buildings have been used for maintenance of other kinds of vehicles or have also been used for production of other equipment.

Moreover, as it has already been stated, the technology of the VL series locomotives does not fit the requirements of the new market oriented environment of the railway management, therefore even though the buildings can be used for locomotive production , it is likely that major investments in the plant are required.

4.3 General rolling stock production development

When looking at the general development of rolling stock production, there are different situations for coaches/wagons and for traction power.

For the production of coaches/wagons, there seems to be limited activities for creating joint ventures or new production facilities. Why this is so, is not evident. Several of the prime suppliers of coaches/wagons are situated in the border countries of Eastern Europe, and are no more in the market as suppliers. Either they have been closed down, or they have located other fields of activity.

For traction power transfer of know how and venture for construction, supply of locomotives, or engine exchange or refurbishment are in negotiation or progress.

Many of these activities, are surrounded with a lot of secrecy until the final commercial deal has been settled. Further co-operation is on the way, especially within the fields of know-how transfer within the technology of semiconductor transformers, three-phase traction motors, microprocessor control and frame-hung traction motors.

5. Estimated operating costs

The evaluation is performed using estimates of economic costs, which represent resources consumed in the TRACECA Region. For this purpose, financial costs incurred by the railway companies are adjusted (where available data make this possible) to exclude taxes and subsidies that represent transfers between groups in the economy rather than actual consumption of resources. Costs are estimated at mid 1995 price levels, in USD, using where necessary the following USD exchange rates (applying in mid 1995 unless otherwise stated):

Armenia	407 Dram
Azerbaijan	4,300 Manats (in 1996)
Georgia	1.25 Lari (1996)
Kazakhstan	60 Tenge
Kyrghyzstan	11.0 Som
Tadjikistan	Varied between about 100 and 200 Roubles
Turkmenistan	310 Manats
Uzbekistan	4,642 Old Som

5.1 Energy

The fuel consumption for TRACECA Region diesel mainline locomotives is reported, on average, to be about 6 kg (7.1 litres) per 1,000 trailing gross tonne km. It appears to have risen by 20% from about 5 kg (5.9 litres) per 1,000 gross tonne km since 1990 (Kazakhstan Rail Study Report, Mercer, 1994). Higher figures would be expected in mountainous areas (about double in heavily graded sections). The present consumption is higher than that reported in other countries (e.g. a base figure of 6.0 litres per 1,000 trailing gross tonne km is reported in "Railways and Energy", World Bank Staff Working Paper No. 634, 1984, but between 5.0 and 6.0 litres per 1,000 gross tonne km in flat terrain with predominately freight traffic). These figures suggest that fuel consumption in the TRACECA Region is 18-40% higher than railways under similar conditions in other countries, partly due to poor maintenance (20%) and partly due to the inferior level of technology used in the CIS locomotives (up to 20%).

It is assumed that in the long term the fuel consumption of CIS diesel locomotives remains constant at current levels - the potential reductions that could be achieved by restoring maintenance standards being balanced by the increases expected with age.

Shunting locomotives in the TRACECA Region are reported to consume about 20 kg (24 litres) per operating hour, or 84,000 litres per year assuming 3,500 operating hours per locomotive.

Prices of diesel fuel vary in accordance with government pricing policy. The current price in Uzbekistan is only 16 Sum per litre, which at a black-market exchange rate of USD1 = 140 Sum (which indicates the approximate real value of foreign currency in that country), amounts to only USD 0.11. This is much less than the 1996 world market price of diesel (about USD 0.20 fob ports in Europe and Persian Gulf, based on a crude oil price of USD 25 per barrel, but assumed to be USD 0.25 in the TRACECA Region to allow for distribution costs). In some other countries the price is closer to the world price (e.g. in Kyrghyzstan, the price is USD 0.30 at the prevailing exchange rate).

The electric locomotives in the TRACECA Region are reported to have a consumption of about 12 kWh per trailing 1,000 gross tonne km (less than that reported in other countries - e.g. 23 kWh per trailing 1,000 gross tonne km for passenger/freight trains according to "Railways and Energy", World Bank Staff Working Paper No. 634, 1984, and between about 15 and 22 for freight trains under similar terrain in France). The low consumption could be attributable to the large distances between stops and the generally lower speeds. The consumption is reported to have risen from 11 kWh per gross tonne km since 1990 (Kazakhstan Rail Study

Report, Mercer, 1994). The price of electric energy appears to be generally quite low by international standards. For example, in Uzbekistan, the current price is only 1.75 Sum per kWh (USD 0.012), while in Kyrghyzstan it is only 0.11 Sum per kWh (USD 0.009), which is far below the range reported in the World Bank Working Paper (between USD 0.03 and 0.06 about 15 years ago, equivalent to between USD 0.05 and 0.09 now, after allowing for about 3% annual inflation). It would appear that electricity is subsidised to a large extent in the TRACECA Region.

Based on the above observations the energy costs of railways are summarised in Tables 1.1 to 1.3, where passenger trains are assumed to have 20% higher fuel consumption per 1,000 gross tonne km because of their higher speed. Lubricant costs are assumed to be 10% of the fuel costs for diesel locomotives (in the TRACECA Region, lubrication oil consumption is reported to be 3% by volume of fuel oil).

Table 1.1 Estimated Energy Costs for Main Line Diesel Trains

Locomotive Type	Consumption Rate	Financial Cost		Economic Cost	
	litres per 1,000 gross tonne km	USD per litre	USD per 1,000 gross tonne km	USD per litre	USD per 1,000 gross tonne km
Freight	7.1	0.10 - 0.20	0.7 - 1.4	0.25	1.8
Passenger	8.5	0.10 - 0.20	0.8 - 1.7	0.25	2.1

NOTE (1) It is assumed that in the long term the financial cost of fuel would equal the economic cost estimated above.
(2) The figures refer only to easy terrain as found in Central Asia. In the Caucuses the average consumption is assumed to be 50% higher because of the mountainous terrain.

Table 1.2 Estimated Energy Costs for Shunting Locomotives

Locomotive Type	Consumption Rate	Financial Cost		Economic Cost	
	litres per hour	USD per litre	USD per hour	USD per litre	USD per hour
Diesel Shunting	24	0.10 - 0.20	2.4 - 4.8	0.25	6.0

NOTE (1) It is assumed that in the long term the financial cost of fuel would equal the economic cost estimated above.
(2) Assuming 3,500 working hours/year, this gives 84,000 litres/locomotive/year.

Table 1.3 Estimated Energy Costs for Main Line Electric Trains

Locomotive Type	Consumption Rate	Financial Cost		Economic Cost	
	kWh per 1,000 gross tonne km	USD per kWh	USD per 1,000 gross tonne km	USD per kWh	USD per 1,000 gross tonne km
Freight	12.0	about 0.01	about 0.12	0.05 - 0.10	0.60 - 1.20
Passenger	14.4	about 0.01	about 0.14	0.05 - 0.10	0.72 - 1.44

NOTE (1) It is assumed that in the long term the financial cost of electricity would equal the economic cost estimated above.
(2) The figures refer only to easy terrain as found in Central Asia. In the Caucuses the average consumption is assumed to be 50% higher because of the mountainous terrain.

5.2 Spare parts and other materials

5.2.1 Main line and shunting diesel locomotives

The average maintenance cost of a twin unit 4,500-6,000 HP (3,600t tractive effort) diesel locomotive in the TRACECA Region has been estimated from the expected financial cost (including taxes) of repair and maintenance work over the life of the locomotive, as shown in Table 1.4. The estimates are based on quoted prices for repair work on Kyrghyzstan locomotives in Kazakhstan workshops in 1996 and are thought to include realistic costs for spare parts. Actual quotations vary according to the amount of work required to be carried out, especially for capital repairs KR1 and KR2. To reduce variations in estimates, the cost breakdown into labour, materials and other components was calculated from typical proportions found in several quotations, and applied to representative figures for total costs. Other quotations, from other countries, are much less and do not appear to cover the full cost of the required spares. For example, KR1 quotes of only USD 30,000-60,000 per unit are made in Russia and Ukraine, while other quotations for TR3 are as low as about USD 5,000, implying virtually no spare parts costs at all.

Table 1.4 Estimated Current Maintenance Contract Prices of Main Line Two-Unit Diesel Locomotives in the TRACECA Region (1996)

Type of Maintenance Task	Cost of Task US$ (Before profit/tax)	Planned Tasks /loco/year	Annual Cost per Loco (US$) Labour	Materials	Overheads	Sub Total	Profit/ Tax
KR1/2	142,910	0.13	1,858	16,349	372	18,578	10,766
TR3	50,070	0.27	1,352	11,897	270	13,519	7,834
TR2	34,820	0.4	2,089	11,142	696	13,928	8,071
TR1	6,330	0.8	1,013	3,545	506	5,064	2,935
TO3	1,585	5.0	1,981	4,755	1,189	7,925	4,593
TOTAL PERIODIC			8,293	47,688	3,033	59,014	34,199

NOTE (1) Profit is calculated as 35% of other costs. Tax is 17% of the sum of other costs and profit.
(2) Labour cost includes social insurance but not bonuses and benefits paid from profits.
(3) Total maintenance cost (excluding profit and tax) would be about $76,720 assuming 30% additional cost for lower level servicing and unplanned repairs, including $10,780 for labour, $62,000 for materials and $3,940 for other costs.

For a typical utilisation of 100,000 km per locomotive per year, this represents a spare part cost before tax (and excluding the profit element) of about USD 0.62 per locomotive km, or USD 0.31 per unit km (assuming two units per locomotive in the TRACECA Region). These figures are at the lower end of the range of figures obtained on other railways (between about USD 0.3 and 0.8 per unit km depending on working conditions, design of equipment and standard of maintenance, and whether or not taxation is included).

In practice, recent recorded costs in the TRACECA Region appear to be significantly less, although unfortunately there are few reliable data which separate locomotive costs from maintenance costs of other rolling stock, which could confirm this. From the many low quotations for planned maintenance it seems likely that materials costs are often only 50% of that estimated from Table 2.4. The best available estimate is that spare parts costs are currently USD 0.2 per unit km, indicating that possibly spare parts are not priced at current replacement levels but at the cost at the time of procurement, planned maintenance tasks are being postponed, stocks of spares are being run down, or some spares are being reconditioned rather than replaced. Discussions with engineers in the Region confirm that few new spare parts are being purchased and that extensive cannibalisation of locomotives is being carried out because of the shortage of finance.

In the long term materials cost of existing locomotives can be expected to increase because of rising demand, rising costs in the CIS and the increasing age of the locomotives. It is assumed that the combined effect of these factors is to increase the above estimated materials cost by about 20% to USD 0.36 per unit km. The long run economic materials cost of maintaining a typical two unit main line diesel locomotive in the TRACECA Region would therefore be USD 0.72 per km.

The equivalent cost for a shunting locomotive would be about USD 0.36 per km, or roughly USD 6,300 per year assuming about 17,500 km over 3,500 working hours.

The financial costs would be more than this because of the inclusion of taxes: about USD 0.86 per km for a mainline locomotive and USD 0.43 for a shunting locomotive (USD 7,500 per year).

5.2.2 Electric locomotive spare parts

Maintenance costs of electric locomotive are usually about 25% of those of equivalent diesel locomotive according to "Railways and Energy", World Bank Staff Working Paper No. 634, 1984. The representative electric models such as the AC twin unit locomotive with 6320-6520 kW and 4,000t tractive effort, (or equivalent DC model with 5,120 kW) are slightly more powerful. Even so, there is little evidence to confirm that such a low ratio of diesel to electric maintenance costs applies in the TRACECA Region. It is therefore assumed that the spare parts cost of electric locomotives is 70% that of main line diesel locomotives. That is USD 0.50 per km in economic terms, and USD 0.60 in financial terms.

5.2.3 Freight wagon spare parts

Estimating wagon costs are difficult not only because of the lack of suitable cost data in the TRACECA Region, but also because a large proportion of wagons are out of use (and being extensively cannibalised) and wagon km data is not kept for individual wagons or wagon fleets (but rather for a mix of fleets operating in particular countries). There is little doubt that recent expenditure per wagon is much less than that expected to keep the whole fleet running.

Typical figures for spare parts costs obtained in other countries usually vary between USD 0.010 and 0.025 per wagon km, depending on the level of technology and operating conditions. In the TRACECA Region available data suggest expenditure of only USD 0.005 per wagon km. Allowing for the simple nature of the wagons and poor operating conditions, it would be expected that the long run financial spare parts cost for TRACECA wagons would be USD 0.02 per km. The equivalent economic cost would be USD 0.016.

5.2.4 Passenger coach spare parts

In most countries the coaches spare parts costs are roughly double those of wagons, implying a range of between USD 0.02 and 0.05 per km. In the TRACECA Region, recent costs appear to be only about USD 0.02 per km. This is more than four times the recorded wagon spare parts cost (rather than twice, as found in other countries), indicating greater use of new spare parts and/or less postponement of maintenance tasks. This seems reasonable given that passenger traffic has fallen much less than that of freight and so there would be less surplus passenger stock to cannibalise. A figure of USD 0.04 per km is therefore assumed for the long run financial spare parts cost (USD 0.032 per km for the economic cost).

5.3 Maintenance staff and overheads

5.3.1 Locomotives

Recent recorded maintenance staff costs give little indication about future costs because staffing levels are generally based on the number of rolling stock units operated and traffic carried over five years ago before the considerable fall in activity occurred. Furthermore recent salaries are low, partly because staff receive include bonuses and various fringe benefits such as clinic, recreational and housing facilities. Significant rises can be expected in the future, especially as economic growth resumes.

Current average salaries for maintenance staff are about USD 100 - 140 per month, but vary between country in the TRACECA Region (sometimes being as low as USD 50). Social insurance payments are often 30 - 50% in addition to this, and bonuses are often paid out of profits, contributing perhaps a further 30 - 50% of basic salary depending on the practice adopted by the railway. Allowing for changing salary conditions and economic growth, real future salaries can be expected to be double or so this level in about ten years time (partly through replacing some of the many current benefits that staff receive with increased salaries). It is assumed that, including social payments and bonuses, average maintenance salaries rise to USD 350 over this period.

Current ratios of locomotive maintenance staff (excluding drivers) per locomotive unit vary between about 3.8 and 5.3, but if only operating units are included then the ratio would be about double these figures (about nine). Based on the estimated annual maintenance staff cost in Table 2.4 of USD 10,780 per locomotive (including social insurance), the number of required staff is about three staff per locomotive unit (assuming an average salary of USD 120 plus 30-40% social insurance costs).

These staffing figures mainly reflect diesel locomotive maintenance requirements and there are no available recent figures that distinguish diesels and electrics. Typical figures found on other railways are about 3 - 5 maintenance staff per locomotive unit, and such figures could be achieved in the TRACECA Region if management is improved. However because of the difficulty in adapting to the reduced traffic level with modern maintenance practises it is likely that staff levels would be higher, especially while salaries remain relatively low. Although, under current conditions, high staffing levels of about nine staff per unit will continue to apply, it seems reasonable to assume about five staff per operating unit (excluding those which are surplus to requirement) in the next ten years or so with improved management. Electric locomotives are assumed to require similar staff as diesels.

In accordance with the assumptions, the expected maintenance staff costs are as shown in Table 1.5. Because of the improved productivity, labour costs fall despite increased salaries.

Table 1.5 Locomotive Maintenance Staff Cost per Year per Locomotive

Locomotive Type	Current Cost (USD)	Long Term Cost (USD)
Mainline Diesel	50,800	42,000
Mainline Electric	50,800	42,000
Shunting	25,400	21,000

NOTE (1) Assuming, at present, nine staff per locomotive unit, USD 120 basic salary, plus 40% social insurance, plus 40% bonus payments.
(2) Assuming in the long term, five staff per locomotive unit, and salary of USD 350, including social insurance and bonuses.

It is not possible to estimate meaningful figures for maintenance overhead costs in the TRACECA Region because the accounting system does not easily allow these to be identified (especially given the diverse nature of railway activities outside the core railway business). It is possible, from the poor condition of facilities and the widespread subsidies for electricity, accommodation and other capital items, that recorded overheads would underestimate true costs. The fall in traffic would probably have increased overheads as a proportion of other costs.

Based on the allowance for overheads included in the contract prices in Table 2.4, current annual overheads per locomotive unit amount to about USD 2,000. However this represents a lower limit because substantial additional add-on charges for profits are also included in the contract prices, some of which could be used for workshop and other overheads.

Because of the lack of reliable data on overheads, expected workshop overheads have been approximately estimated from costs of a new locomotive workshop being considered for a TRACECA country. This would have sufficient capacity for carrying out major overhauls (KR1 and TR3) for a fleet of up to about 120 locomotive units, having a floor area of about 8,200 m^2 (about half for the main workshop which includes space for dismantling/assembling one (two unit) locomotive, carrying out bogie repairs, and carrying out engine repairs, while the rest would be used for component repair shops). The estimated construction cost of the workshop (at an assumed rate of USD 700/m^2) would be USD 5.74 million, plus USD 0.90 million for equipment. It is estimated that the annual running costs of the workshop would be as shown in Table 1.6.

Table 1.6 Estimated Annual Running Costs for a Locomotive Workshop

Item	Cost Basis	Amount (USD per year)
Building maintenance	2% of value	115,000
Building lighting and heating	2% of value	115,000
Equipment maintenance	5% of value	45,000
TOTAL (excluding amortisation)		275,000
Building Amortisation	40 years at 12%	688,000
Equipment Amortisation	20 years at 12%	118,000
TOTAL (including amortisation)		1,081,000

This represents a minimum cost per unit (excluding depreciation and interest charges) of USD 2,300 per year, or 10% of average maintenance staff costs (about USD 23,000, including bonuses, in Table 2.5). A further 10% approximately would have to be allowed for running depot facilities, plus about 10% for headquarters costs, giving a total of 30%. It could be argued that in the TRACECA Region these overhead costs would be very low because buildings are neither heated nor maintained. However in the long run many existing buildings, which are in very poor condition, would have to be extensively repaired if they are to continue in use. In fact, it seems more reasonable to argue that overhead costs in the TRACECA Region would be much higher than assumed above because of the poor state of the buildings, which could double building maintenance and other costs, increasing overheads by an additional 10%, giving a total of about 40% of maintenance staff costs.

This is confirmed by experience in other countries where it is not uncommon to allow about 30 - 50% of salary (including social payments) to cover overheads such as heating and lighting of workshops, building maintenance and headquarters management expenses (before adding depreciation and interest costs). However because of surplus capacity in many workshops in the TRACECA Region, it is possible that workshop running costs per unit would be double that estimated above, raising overheads to 70% if rationalisation is not possible. However it is assumed that with rationalisation it would be possible to limit overheads with existing facilities to 40%.

The overall financial maintenance labour and overhead cost per mainline or shunting locomotive is summarised in Table 1.7. These are assumed, for simplicity, to represent economic costs.

Table 1.7 Estimated Maintenance Overheads Cost for Locomotives

Locomotive Type	Annual Staff Cost/Locomotive ($)		Workshop Overheads/ Locomotive ($)	
	Current	Long Term	Current	Long Term
Mainline Diesel	50,800	42,000	20,320-35,600	16,800-29,400
Mainline Electric	50,800	42,000	20,320-35,600	16,800-29,400
Shunting	25,400	21,000	10,160-17,800	8,400-14,700

NOTE (1) Allowing 40-70% of long term staff costs (including bonuses) for overheads.
(2) The workshop overhead cost (for heating, lighting and building costs of the main workshop but not for the running depot or headquarters costs) is equivalent to USD 275,000 -390,000 per year per locomotive workshop bay (for a twin unit locomotive), depending on the condition of the buildings.
(3) For running depot bays, the overhead cost would be about 15-30% the above figures - about USD 40,000-80,000 per bay if the buildings are in good condition (USD 60,000 - 120,000 if not), depending on the extent to which the running depot was equipped with component repair shops.

5.3.2 Freight wagons

There are currently about 0.10 - 0.15 freight wagon maintenance staff per wagon in the TRACECA Region, but the number per active wagon is about double this (0.25). With modern wagon designs in high income countries with efficient railways, this ratio can be as low as 0.05, but figures of about 0.1 are common. It is assumed that railways in the TRACECA Region can also achieve such as level of staffing over the next few years through staff redundancies and rationalisation/modernisation of facilities and procedures. Assuming the same salaries as for locomotive maintenance staff, staff salary costs per wagon would decrease from USD 705 to 420 per wagon: the projected increase in salary from USD 235 to 350 being more than compensated for by the reduction in staffing from 0.25 to 0.1.

Expected workshop overheads have been approximately estimated from costs of a new wagon workshop being considered for a TRACECA country. This would have sufficient capacity for carrying out major overhauls (capital repairs) for a fleet of up to 20,000 wagons (15,000 wagons are assumed in practice), having a floor area of about 7,000 m^2 (including an area of about 5,600 m^2 for 20 wagon bays and about 1,400 m^2 for a blacksmith shop). The estimated construction cost of the workshop (at an assumed rate of USD 700/m^2) would be USD 5.0 million, plus a similar amount for equipment. It is estimated that the annual running costs of the workshop would be as shown in Table 1.8.

Table 1.8 Estimated Annual Running Costs for a Wagon Workshop

Item	Cost Basis	Amount (USD per year)
Building maintenance	2% of value	100,000
Building lighting and heating	2% of value	100,000
Equipment maintenance	5% of value	250,000
TOTAL (excluding amortisation)		450,000
Building Amortisation	40 years at 12%	600,000
Equipment Amortisation	20 years at 12%	650,000
TOTAL (including amortisation)		1,700,000

This represents a cost per wagon (excluding depreciation and interest charges) of USD 30 per year, or 10% of average maintenance staff costs (about USD 300 per wagon, including bonuses, estimated above), assuming buildings in good condition. A further 3% approximately would have to be allowed for minor running depot facilities, plus about 10% for headquarters costs, giving a total of 23%. If allowance is made for the poor state of the buildings in the TRACECA Region, which could double building maintenance and other costs, overheads could reach 26% of maintenance staff costs. If allowance is made for possible under-utilisation of workshops due to lack of rationalisation following the fall in traffic, then overheads could reach 50% of staff costs.

The results are summarised in Table 1.9.

Table 1.9 Estimated Maintenance Labour and Overheads Cost for Wagons

	Staff/Wagon	Average Salary incl. Social Costs ($)	Annual Staff Cost/Wagon ($)	Workshop Overheads/ Wagon ($)	Total Annual Costs/Wagon ($)
Current	0.25	235	705	180-350	885-1,055
Long Term	0.10	350	420	110-210	530-630

NOTE
(1) Assuming same salaries as assumed for locomotive staff.
(2) Allowing 26-50% of staff costs for overheads.
(3) The workshop overhead cost (for heating, lighting and building costs of the main workshop but not for the running depot or headquarters costs) is equivalent to USD 22,500-27,500 per year per wagon bay, depending on the condition of the buildings.
(4) For running depot bays, the overhead cost would be about 15-30% the above figures - about USD 3,400-6,800 per bay if buildings are in good condition (4,100-8,300 if not) depending on the extent to which the running depot was equipped with component repair shops.

5.3.3 Passenger coaches

There are currently about 3.0 - 4.5 passenger coach maintenance staff per coach in the TRACECA Region, but the number per active coach is about 50% higher than this. Common figures found on other railways are between 1 - 3 per coach. It is assumed that railways in the TRACECA Region can achieve a figure of about 3 per coach over the next few years through management improvements.

The same average salary is assumed for coach maintenance as for locomotive maintenance. Overheads are assumed to be intermediate in level to those found for wagons and locomotives. The results are summarised in Table 1.10.

Table 1.10 Estimated Maintenance Labour and Overheads Cost for Coaches

	Staff/Coach	Average Salary incl. Social Costs ($)	Annual Staff Cost/Coach ($)	Workshop Overheads/ Coach ($)	Total Annual Costs/Coach ($)
Current	5.5	235	15,500	4,650-9,300	20,150-24,800
Long Term	3.0	350	12,600	3,780-7,560	16,380-20,160

NOTE
(1) Staff salaries are assumed to be the same as for locomotives.
(2) Allowing 30-60% of staff costs for overheads.
(3) The workshop overhead cost (for heating, lighting and building costs of the main workshop but not for the running depot or headquarters costs) is equivalent to USD 50,000-60,000 per year per coach bay, depending on the condition of the building.
(4) For running depot bays, the overhead cost would be about 15-30% the above figure - about USD 7,500-15,000 per bay if the buildings are in good condition (USD 9,000-18,000 if not), depending on the extent to which the running depot was equipped with component repair shops.

5.4 Train crew

Numbers of drivers and assistants in the TRACECA Region are typically about five per locomotive, reflecting the generous way particular crews (of one driver and one assistant for each main line locomotive) are presently allocated to particular locomotives. The ratio of staff per locomotive actually in use is even higher. On other railways, ratios of three or less drivers per locomotive are achieved through use of single manning. Although there is scope for reducing staff in the TRACECA Region through such measures, there is also scope for increasing locomotive utilisation through removing the allocation of particular crews to particular locomotives, which would tend to increase staff per locomotive.

Assuming that single manning is introduced without changing crew allocation practice, it is assumed that three staff would be required per locomotive. However if crews are no longer allocated to particular locomotives it is assumed that, with single manning, five drivers would be required per locomotive.

Based on a current average salary of USD 235, including insurance and bonuses as assumed for maintenance staff, the current train crew cost is estimated as USD 14,100 per year. In the long term this could reduce from productivity improvements, despite increased salaries. Assuming a long term salary of USD 350, as assumed for other staff, and introduction of single manning, an annual cost per locomotive of USD 12,600 would be incurred with the present practice of allocating drivers to locomotives, and USD 21,000 would be incurred if scheduling constraints were reduced to allow more efficient use of locomotives by any driver.

Chapter 2. Evaluation of Development Alternatives

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1. General approach

Prior to recommend any restructuring strategy and to propose investments, several alternatives of change have been analysed. The present chapter defines the proposed alternatives, then technical and economical analysis have been performed to give the framework of long and short term change strategies.

Future maintenance plans could involve improvements concerning :

- management/institutional improvements in the short term, including maintenance and operating staff productivity improvements and introduction of better procedures, which will improve rolling stock availability and utilisation and affect maintenance and operating costs,
- rationalisation and improvement of existing facilities in order to support the above maintenance improvements,
- development of new maintenance facilities where justified,
- refurbishment of certain rolling stock to prolong its useful life in order to meet future demand at least investment cost,
- the introduction in the long term of new rolling stock with new technology (and possibly the introduction of components with new technology in the short term),
- development of manufacturing facilities for rolling stock and for spare parts.

To assess, in outline terms, the economic implications of these plans, the approximate future capital and operating costs have been compared for two alternative development options:

Alternative 0 - a "Do Minimum" option in which insignificant investment occurs in rolling stock and maintenance and current maintenance strategies remain unchanged,

Alternative 1 - (a) implementation of the recommended maintenance strategy, with management improvements in the short term, (b) continued use of present rolling stock with refurbishment and adapting of equipment to meet future demands, with no introduction of new technology equipment, and (c) rationalisation and development of facilities to meet the future maintenance needs of the rolling stock,

Comparison of the capital and operating costs of these two alternatives, indicates the potential benefits of introducing maintenance management improvements with minimal investment under Alternative 1. Because of the considerable excess capacity of rolling stock, there is little need, especially in the short term, for acquiring new rolling stock. Nevertheless a further alternative could be considered which includes the introduction, over the long term, of new rolling stock (or perhaps certain components) of modern design. Unfortunately the scope for such evaluations is limited because:

- there is insufficient information about how modern equipment or components would perform under conditions encountered in the TRACECA Region,
- there is even a lack of reliable information about how current rolling stock performs in the Region on which to base accurate long term projections of future costs and utilisation,
- the benefits of introducing new technology are strongly dependent on factors such as future traffic levels, extent to which management improvements will be introduced, and the extent to which railway infrastructure is improved, which cannot be predicted.

Although such limitations prevent, at present, any meaningful detailed evaluation of long term options concerned with acquisition of different technologies of rolling stock, an assessment has been made of the potential cost savings which could arise from the introduction of a new generation of rolling stock in the long term.

For this purpose the following additional alternative has been defined:

Alternative 2 - (a) implementation of the recommended maintenance strategy, (b) the complete replacement by 2005 of the current fleet of rolling stock with a new fleet using modern technology, and (c) rationalisation and development of facilities to meet the needs of the new fleet.

This alternative, which involves scrapping the whole of the existing fleet by 2005, before the normal economic lifetime for much of the fleet, should not be considered as a realistic option. Rather it should be used to illustrate, through comparison of costs of Alternatives 0 and 2, the capital requirements and potential operating cost savings associated with introducing a new generation of modern technology rolling stock, while introducing similar maintenance management improvements.

For each alternative, the long term capital cost requirements are assessed over the period between 1998 and 2005 (inclusive) for rolling stock and maintenance facilities. Long term annual operating costs, including annual amortised capital costs, are compared for 2005.

2. Definition of alternatives

2.1 Common assumptions

2.1.1 Overall

A number of assumptions have to be made when comparing alternative rolling stock provision and maintenance strategies. These cover likely policies of governments towards the railways, future traffic levels, extent to which improvements in infrastructure will be made and the types of service that the railway will develop in response to customer demand. These factors tend to interact and are the subject of separate ongoing studies under the TRACECA programme and so, at this stage, only provisional indications are available about them. It is likely that eventually the recommendations about the various studies would have to be co-ordinated to arrive at the best overall strategy for the railways.

2.1.2 Policy

It is assumed that governments in the TRACECA Region continue with economic reforms that allow increased management autonomy among railway and other transport operators, to compete on the same basis with minimal distortions due to general subsidies (as opposed to those targeted for particular purposes such as in the case of certain passenger services), subject to their meeting minimum safety and environmental standards. It is assumed that, as for all modes, railway transport users pay for the infrastructure that they use in order to provide the finance for the infrastructure and to ensure fair competition between modes. It is assumed that public sector organisations are subject to increased financial accountability to encourage efficiency and fair competition with the private sector.

2.1.3 Traffic

Under the present uncertain economic situation it is difficult to make reliable traffic forecasts for the railway. The prospects for economic recovery vary between countries in the Region, and the relationship between economic growth and bulk traffic (which is the staple traffic of the railway) is not particularly strong.

Trends in rail traffic show that the drastic fall in freight rail traffic in the TRACECA Region has continued in recent years, at least up to 1995. There is further evidence that in many countries the fall has continued since 1995. The fall in passenger traffic has been less strong but, since freight services are widely considered to be cross-subsidising passenger services, there are doubts about the potential for any long term growth in passenger traffic.

In the absence of suitable traffic forecasts (especially from the TACIS study concerned with long distance freight in the TRACECA corridor), a simple scenario has been assumed for future traffic levels:

(a) freight traffic is assumed to remain constant at the 1995 level until 2000 (or recovers back to that level), and then increase by 10% over the following five years (at an average annual rate of about 2%),

(b) passenger traffic is assumed to remain constant at 1995 levels.

2.1.4 Infrastructure

Substantial improvements in existing rail infrastructure are assumed to take place, focusing on rehabilitating existing infrastructure rather than extending it. Therefore no major changes in network length or extent of electrification are assumed.

Because of the improvement in infrastructure, main line operating speeds are assumed, under all alternatives, to increase in the long term to a maximum of 100 km/h for freight trains and 140 km/h for passenger trains (only 100 km/h in the Caucasus for both types of trains because of the adverse terrain). Some improvement is assumed to be achieved in the short term in Central Asia but, because of the poor state of infrastructure in the Caucasus, it is assumed that less improvement in operating conditions would be achieved in the short term. It should be noted that, with these assumed infrastructure improvements, the operating maximum speeds of trains would become limited by the capabilities of the existing rolling stock. One advantage of introducing new technology rolling stock would be that slightly faster trains could be operated.

2.1.5 Operating strategy

Improved or more efficient services are assumed to be provided under all alternatives, such as more train-load freight services that do not require re-marshalling at every yard. This is assumed to reduce the need for shunting locomotives.

Higher frequency, but shorter, long distance passenger services are also assumed to be operated as described later.

2.2 Assumptions for each alternative

2.2.1 Maintenance Strategy

No improvement in maintenance strategy is assumed for Alternative 0, resulting in excess numbers of staff and maintenance activity. Under Alternatives 1 and 2, a component-based maintenance system is assumed to be implemented in the short term.

2.2.2 Equipment Utilisation

In Alternative 0, it has been assumed that for the short and long term:

- The commercial speed (averaged over the whole journey time between starting and stopping) could be increased with operational modifications, partly due to the assumed infrastructure improvements. Some improvement is assumed in the short term even without any infrastructure improvement in the Asian area. In the Caucasus area, the infrastructure is also expected to be rehabilitated to allow higher speeds (but in the immediate short term, the estimated rolling stock fleet reflects existing conditions).
- The limited daily running time of the locomotives is linked to the structure of the maintenance organisation. Any improvement would involve major changes in the maintenance organisation, which is not taken into consideration in this alternative.
- The mean load of the freight trains will decrease slightly, in order to maintain a frequency acceptable to most customers.
- The turn around time of wagons is not reduced, and the performance achieved during the FSU days cannot be recovered due to lower traffic.

- The timetables of passenger trains are assumed to be updated in accordance with new requirements. In the evaluation, all services are assumed to be performed with the existing types of coaches.

Under Alternative 1, restructuring of train operation and maintenance procedures are implemented in the short term, which will allow by 2000:

- An increase in the commercial speed in most of the TRACECA countries.
- An increase in the average operational time of the locomotives.
- A slightly lower turn around time of wagons and coaches. It is assumed that these values cannot reach the values of former times when the traffic was much higher, providing possibilities for a very high utilisation of wagons and coaches.

Since the maintenance procedures are tied to the technology of the rolling stock, it will be difficult to increase the time between inspections and overhauls. The time allocated for each maintenance operation is already tight, so they cannot be reduced. The restructuring of maintenance will allow a reduction in the scale of depots and workshops, but a network of depots with minimum facilities will be necessary to deal with light repairs and first level inspections. The management restructuring and improved spare parts control will reduce maintenance costs and increase service reliability.

Nevertheless, in the long term, even with improved infrastructure, it will not be possible to reach the highest operational performances due to the technology of the rolling stock.

The following additional improvements could be expected under Alternative 2, compared to Alternative 1:

- A further increase in average speed;
- Consequently, a reduced turn around time of wagons;
- Reduction of maintenance tasks and increase of maintenance intervals;
- Reduction in operating and maintenance costs;

This increased level of train operation performance is possible with the introduction of new technology provided that the infrastructure has been improved. In the previous alternative the improvement of the infrastructure will also allow the current rolling stock to be utilised more efficiently (up to the limits of the existing technology).

The productivity of the personnel and the rolling stock increase only due to the further increase of speed allowed by the new technology. In the previous alternative, the management restructuring is assumed to have achieved substantial increases in productivity of personnel and equipment. Therefore, the daily operating time of equipment cannot be increased any more.

2.2.3 Equipment Acquisition

For Alternative 0 it is assumed that there would be no purchase of new rolling stock, although some adaptation and reallocation of tank wagons is required to meet demand. Instead, under this minimal investment alternative, the existing rolling stock would be repaired as and when required in order to maintain services, even though it would be more economical to replace it with new stock.

Under Alternative 1, improvements in utilisation will enable the railways to cope with the increase in freight traffic with minimal acquisition of new equipment. Some rehabilitation of wagons and coaches is assumed in order to provide the vehicles required for developing certain markets (such as oil transport and inter-city passenger services). Some limited acquisition of locomotives (of traditional CIS design) is also assumed. Although it is possible that new locomotive engines could be fitted to existing diesel locomotives resulting in lower maintenance and operating costs, such effects are not considered in the evaluation because it is by no means clear to what extent such rehabilitation activity would be economically beneficial.

Under Alternative 2, there is a substantial acquisition programme for rolling stock between 2000 and 2005 (all locomotives, wagons, coaches being replaced with modern designs)

2.2.4 Maintenance Facilities

Under Alternative 0, by comparing the existing maintenance facilities to the estimated number needed, it is assumed that although some low cost modifications are made in order to increase the productivity of the workshops, this would constitute a negligible overall capital cost.

Since the number and location of depots are extremely tied to the maintenance organisation, in the "Do Minimum" Alternative 0, it is assumed that none of the workshops or depots are closed although many would be reduced in scale, resulting in savings in running costs of buildings and equipment.

Under Alternative 1, refurbishment of certain key workshops is assumed to be required to implement the proposed component maintenance system. Some new workshops are also proposed where there is a lack in the TRACECA Region. In the particular case of the Lenin locomotive manufacturing workshop in Tbilisi, investment is assumed to take place in order to carry out passenger coach maintenance and to restart production of locomotives there. Under Alternative 2, similar workshop development is assumed to occur, adapted to the needs of the modern technology rolling stock. In addition depots that have a long term future under the proposed maintenance system are assumed to be refurbished. In general this involves higher amounts of investment than under Alternative 1, but these investments are concentrated at fewer workshops and depots.

3. Technical analysis

This section compares the above three alternatives in terms of the strategic objectives described in Section 1 of this chapter.

3.1.1 Alternative 0

Without significant maintenance improvement, this "business as usual" alternative would be expected to increase long-run maintenance and operating costs and reduce profitability through:

- lack of maintenance productivity improvements due to continued lack of specialisation of workshops and competition in services,
- deterioration of rolling stock condition (which despite robust designs, would result in high rehabilitation costs or even premature replacement),
- poor utilisation rates of rolling stock, increasing operating requirements,
- under-utilisation of workshops that will continue to deteriorate in condition and offer unsatisfactorily working conditions.

Despite the undoubted resourcefulness of the railway maintenance staff, this would certainly result in poor railway services and high risk of accidents. This in turn could have knock-on effects in terms of lower traffic levels, which would lower profitability even further. There would also be a high risk of financial crises that would threaten jobs. Intervention by government to alleviate the situation would incur high costs.

3.1.2 Alternative 1

The introduction in the short term of a wide range of maintenance improvements, especially as part of a broader reform programme of the railways, would increase productivity of both maintenance and operations. Substantial cost improvements can be expected through:

- improved maintenance productivity and effectiveness through workshop specialisation and competition in workshop services,
- preservation of rolling stock to the end of its economic working life,
- reduction in rolling stock requirements through higher utilisation rates,
- reduction in overhead and staff costs related to maintenance.

Better pay and working conditions for staff could also be expected under this alternative. Higher levels of customer service would also follow, together with the prospect of higher traffic levels. Investment in better technology could also be anticipated to achieve satisfactory returns. Depending on the results of monitoring maintenance performance of existing technology rolling stock and of trials with modern technology rolling stock, some technological improvements could be introduced. The scope for this is difficult to anticipate because of the absence of information about the future performance of existing rolling stock and about the performance of modern rolling stock technology under conditions encountered in the TRACECA Region. The most likely application could be the introduction of engines and other major components into existing locomotives (trials of which in the CIS have already begun). It seems likely that under this alternative, overall capital requirements would be minimal. Since profitability can be maintained or even enhanced, there would be minimal need for government intervention.

3.1.3 Alternative 2

Similar improvements to Alternative 1 can be expected in the short term as the maintenance management improvements are implemented. In the long run, further improvements in utilisation can be expected from the increased operating speeds permitted by using modern rolling stock in conjunction with the expected infrastructure improvements.

There are three possible different strategies that can be pursued within the framework of this project:

- introduce modern traction power "off-the-shelf", resulting in potentially massive replacement of existing traction power,
- pursue the possibilities for making joint-venture productions in the TRACECA area, with the goal of merging the best of both worlds,
- let Russia and Ukraine take the lead in such developments, as there are several traction power joint-venture activities in progress already.

The first strategy has major risks associated with uncertainties about how foreign rolling stock would perform under TRACECA Region conditions. This could cause massive problems that the railway system would be unprepared for.

Whether to go for the second or the third solution, depend to a large extent on the overall industrial strategy for the region. Seen from the point of view of traction power procurement, the setting up a dedicated "TRACECA supplier", will create a monopoly problem, and will thus be in conflict with the overall goal of the market reforms. Competition between several potential suppliers will normally produce better prices and service.

However the scope for further improvements from using modern technology will be rather limited (mainly applying to passenger rather than freight trains). There is scope for lower consumption of spare parts and fuel, and reductions in staff through less maintenance activity required by modern rolling stock. However these benefits will be offset initially by the higher unit costs of spare parts (many of which would have to be procured from the manufacturer rather than competing, independent suppliers) and the need for new workshop facilities. More pertinently, this alternative would incur an enormous capital cost of several billion USD. Even if such a large investment could achieve a worthwhile investment, it seems unlikely that the countries of the TRACECA Region could cope with such a huge investment in railways over the next ten years.

4. Assessment of costs

4.1 Approach

4.1.1 Capital costs

For each alternative, possible capital costs have been considered for a variety of investment projects described, in outline form, in the proposals for each country (described in the appendices). For both Alternatives 1 and 2 it is assumed that restructuring railway management, including the cost of a management information system (MIS) would incur a cost in each country. Costs under these two alternatives would also be incurred for developing depots and workshops, and for improving the rolling stock, as described below. Investment under Alternative 0 is limited to some adaptation of wagons to meet demand.

The main workshop and depot projects for Alternative 1 consist of:

- restructuring Yerevan depot in Armenia (USD 10 million),
- refurbishing, in Azerbaijan, two locomotive depots (USD 5 million each) plus wagon and coach depots,
- refurbishing the Lenin Plant in Georgia for locomotive manufacturing (USD 50 million) and for coach overhauls (USD 5 million), plus refurbishing other depots in that country,
- in Kazakhstan, adapting one depot for electric locomotive overhauls (USD 50 million), refurbishing the Almaty passenger coach workshop (USD 20 million), construction of a paint shop (USD 10 million), plus refurbishing other depots,
- in Uzbekistan, refurbishing of locomotive depots (USD 10 million) plus several wagon and coach depots, and
- refurbishment of several depots in Kyrghyzstan, Tadjikistan and Turkmenistan.

Similar projects are assumed for Alternative 2, costing double the amounts assumed above (based on the expectation that only about half of the facilities would be refurbished, but that those that would be treated would incur costs about four times as great due to the specialised equipment and other adaptations required for the new technology).

In addition, the following capital investments are considered for rolling stock:

- rolling stock acquisition (under Alternative 2), and
- rolling stock refurbishment of coaches (under Alternative 1) and refurbishment of tank wagons (under Alternatives 0 and 1).

It should be noted that the following projects are assumed to be implemented, as committed projects, under all alternatives:

- a new electric locomotive workshop in Uzbekistan to serve the whole Central Asian Region, and
- a new wagon repair shop in Kazakhstan (modified as described later in the report).

The costs for the workshop projects are rough, order of magnitude estimates, based on typical levels of expenditure on workshops that are required to sustain maintenance of a fleet of rolling stock (about 10% of the normal fleet replacement costs).

The capital costs of rolling stock for Alternative 1 have been based on the particular circumstances of each railway, as described in the proposals for each country (described in the appendices). For Alternative 2, the cost is based on the total fleet required for operation under this alternative, as estimated in these proposals for each country. No allowance is made for disposal value of displaced rolling stock which would tend to over-estimate the net cost of this alternative. However the value of the existing rolling stock is unlikely to be greater than about 10% of the value of the new rolling stock.

The wagon conversion costs and coach rehabilitation costs have been estimated as shown in Table 7.1. Costs of the replacement of all rolling stock under Alternative 2 are summarised in Table 7.2. These costs are based on the following factors.

The typical international price of a new, modern technology 4,000 hp diesel locomotive unit is around USD 2.5 million, capable of replacing a typical two unit TRACECA diesel locomotive on freight and, if necessary, passenger services. Although current prices are not available, because the locomotives are not in production, it is assumed that the two unit TRACECA locomotives that are used at present, could eventually be manufactured for about 80% of this cost (USD 2.0 million).

The above prices refer to the CIF price before taxes. Assuming import taxes of 20%, the actual financial price paid by the railways for the modern locomotive could be USD 3.0 million (maybe only USD 2.0 million for the current model if import duty is not applied).

The prices of an equivalent modern 4,000 kW electric locomotive would be similar to the figures given above for the modern diesel locomotive. The prices for shunting locomotives would be about 40% of these.

The typical economic cost of a modern freight wagon (of a variety of designs) with 50-60 tonnes capacity is currently USD 60,000 (about double for special types such as refrigerated wagons). The equivalent CIS model is assumed to cost 80% of this, USD 48,000 (although at present it is understood to cost only USD 30,000).

For passenger coaches, current international prices range between USD 0.8 and 1.2 million depending on features such as air-conditioning, and quality of beds/seating and other fittings. An average value of USD 0.9 million is assumed. It is also assumed that equivalent models used at present in the CIS could be acquired for 80% of these prices (USD 0.65 - 1.0 million, with an average of 0.75 million).

Table 2.1 Capital Cost of Rolling Stock Refurbishment (Alternatives 0 and 1)

	Conversion of Tank Wagons		Refurbishment of Coaches	
	Number of Wagons	Economic Cost (USD m)	Number of Coaches	Economic Cost (USD m)
ALTERNATIVE 0				
- Armenia	0	0.0		
- Azerbaijan	1,000	6.0		
- Georgia	0	0.0		
- Kazakhstan	1,000	9.0		
- Kyrghyzstan	0	0.0		
- Tadjikistan	0	0.0		
- Turkmenistan	1,000	4.5		
- Uzbekistan	0	0.0		
All Countries	3,000	19.5		
ALTERNATIVE 1				
- Armenia	0	0.0	80	8.0
- Azerbaijan	1,000	20.0	300	30.0
- Georgia	0	0.0	140	14.0
- Kazakhstan	1,000	30.0	2,000	200.0
- Kyrghyzstan	0	0.0	50	5.0
- Tadjikistan	0	0.0	200	20.0
- Turkmenistan	1,000	15.0	600	30.0
- Uzbekistan	0	0.0	400	40.0
All Countries	3,000	65.0	3,770	347.0

NOTE (1) Estimated economic cost of wagon conversion under Alternative 1 is between USD 15,000 and 30,000 depending on requirements. For Alternative 0, simpler conversions are assumed to cost only 30% of these figures.
(2) Estimated economic cost of coach refurbishment is between USD 50,000 and 100,000, depending on requirements.

SOURCE: Consultants' estimate

Table 2.2 Capital Cost of Rolling Stock Acquisition (Alternative 2)

	Number of Units Acquired					Acquisition Cost USD m
	Diesel Locomotives	Electric Locomotives	Shunting Locomotives	Wagons	Coaches	
COUNTRY						
- Armenia	0	4	25	737	28	104.4
- Azerbaijan	0	18	50	2,745	176	418.1
- Georgia	0	8	25	1,880	42	195.6
- Kazakhstan	274	178	300	54,366	1,516	6,056.4
- Kyrghyzstan	2	0	10	1,480	17	119.1
- Tadjikistan	14	0	12	917	132	213.3
- Turkmenistan	37	0	50	10,067	277	995.8
- Uzbekistan	69	12	250	10,429	267	1,318.5
All Countries	396	220	722	82,621	2,455	9,421.2
COST PER UNIT (USD m)	2.5	2.5	1.0	0.06	0.9	
TOTAL COST (USD m)	990.0	550.0	722.0	4,957.3	2,209.5	9,428.8

SOURCE: Consultants' estimate

4.1.2 Operating costs

Cost estimates are required for evaluating possible future changes in rolling stock acquisition and maintenance policies and practices. Since operating and maintenance practices are closely linked in the railways of the TRACECA Region, the analysis includes an estimate of train crew costs, in addition to those incurred by maintenance.

The primary role of the railways is for freight transport and there is particular interest in developing new freight services in the TRACECA corridor. Therefore the analysis focuses on freight transport costs. Detailed operating costs for particular designs of passenger stock such as Diesel Multiple Units (DMUs) and Electrical Multiple Units (EMUs) are not considered, although overall maintenance and operating costs for passenger services can be approximately estimated from the figures given for locomotive-hauled passenger trains.

Rolling stock costs vary with a number of factors such as design of equipment, age, method of operation, type of maintenance, track conditions, terrain and other environmental factors, and economic circumstances.

Representative average costs for rolling stock in the TRACECA Region have been estimated taking account, as far as possible, of the characteristics of equipment and conditions encountered there. For this reason, use has been made of data collected from the railways in recent years.

Unfortunately available data in the appropriate form are not generally available. However, the consultants have been able to analysed detailed costs from certain railways. Since these railways, understandably, regard such data as commercial secrets and are not willing to allow detailed scrutiny, the data sources cannot always be revealed. Since detailed data can only be analysed for certain railways, the results may not apply in all circumstances.

Furthermore recent recorded costs are not considered to be a reliable indicator of future costs because of

- lack of adequate accounting for costs incurred, for example there is much bartering exchange of spare parts between depots and countries and the real value of spares consumed is often not apparent,
- disruptions to normal maintenance practices, especially cannibalisation of surplus stock, and repair rather than replacement of many spare parts,
- inflation during a year is most often not taken into account in the compiled data,
- deteriorating conditions of rolling stock and track due to financial cutbacks,
- increasing average age of equipment due to lack of purchases of new rolling stock,
- reductions in traffic have resulted in excessive fixed costs for facilities and staff,
- future prices for materials can be expected to vary from present levels as price reform and development of alternative suppliers occurs,
- future labour costs and productivity can be expected to vary as economic development continues.

For these reasons, current costs recorded in the TRACECA Region have been compared with typical costs encountered in other countries under similar conditions, to confirm expected changes in future years. The resulting estimates should give a reasonable indication of the level of costs incurred by the railways.

Costs are estimated at mid 1995 price levels for the following:

- energy (fuel/lubricants and electricity),
- spare parts for locomotives, freight wagons and passenger coaches,
- labour and other maintenance costs,
- traffic staff, and
- rolling stock acquisition.

The above items do not include various fixed costs which would not be expected to change as a result of rolling stock maintenance and acquisition policy, including traffic staff (on trains, stations and in yards), infrastructure provision staff, commercial and other general functions, and headquarters staff not directly concerned with rolling stock maintenance.

4.2 Estimated operating costs of current rolling stock

Operating costs have been analysed in chapter one, summary of those casts are proposed hereafter.

4.2.1 Energy

Table 2.1 Estimated Energy Costs for Main Line Diesel Trains

Locomotive Type	Consumption Rate	Financial Cost		Economic Cost	
	litres per 1,000 gross tonne km	USD per litre	USD per 1,000 gross tonne km	USD per litre	USD per 1,000 gross tonne km
Freight	7.1	0.10 - 0.20	0.7 - 1.4	0.25	1.8
Passenger	8.5	0.10 - 0.20	0.8 - 1.7	0.25	2.1

NOTE (1) It is assumed that in the long term the financial cost of fuel would equal the economic cost estimated above.
(2) The figures refer only to easy terrain as found in Central Asia. In the Caucuses the average consumption is assumed to be 50% higher because of the mountainous terrain.

Table 2.2 Estimated Energy Costs for Shunting Locomotives

Locomotive Type	Consumption Rate	Financial Cost		Economic Cost	
	litres per hour	USD per litre	USD per hour	USD per litre	USD per hour
Diesel Shunting	24	0.10 - 0.20	2.4 - 4.8	0.25	6.0

NOTE (1) It is assumed that in the long term the financial cost of fuel would equal the economic cost estimated above.
(2) Assuming 3,500 working hours/year, this gives 84,000 litres/loco/year.

Table 2.3 Estimated Energy Costs for Main Line Electric Trains

Locomotive Type	Consumption Rate	Financial Cost		Economic Cost	
	kWh per 1,000 gross tonne km	USD per kWh	USD per 1,000 gross tonne km	USD per kWh	USD per 1,000 gross tonne km
Freight	12.0	about 0.01	about 0.12	0.05 - 0.10	0.60 - 1.20
Passenger	14.4	about 0.01	about 0.14	0.05 - 0.10	0.72 - 1.44

NOTE (1) It is assumed that in the long term the financial cost of electricity would equal the economic cost estimated above.
(2) The figures refer only to easy terrain as found in Central Asia. In the Caucuses the average consumption is assumed to be 50% higher because of the mountainous terrain.

4.2.2 Spare parts and other materials

Main Line and Shunting Diesel Locomotives

Table 2.4 Estimated Current Maintenance Contract Prices of Main Line Two-Unit Diesel Locomotives in the TRACECA Region (1996)

Type of Maintenance Task	Cost of Task US$	Planned Tasks	Annual Cost per Loco (US$)				
	(Before profit/tax)	/loco/year	Labour	Materials	Overheads	Sub Total	Profit/ Tax
KR1/2	142,910	0.13	1,858	16,349	372	18,578	10,766
TR3	50,070	0.27	1,352	11,897	270	13,519	7,834
TR2	34,820	0.4	2,089	11,142	696	13,928	8,071
TR1	6,330	0.8	1,013	3,545	506	5,064	2,935
TO3	1,585	5.0	1,981	4,755	1,189	7,925	4,593
TOTAL PERIODIC			8,293	47,688	3,033	59,014	34,199

NOTE
(1) Profit is calculated as 35% of other costs. Tax is 17% of the sum of other costs and profit.
(2) Labour cost includes social insurance but not bonuses and benefits paid from profits.
(3) Total maintenance cost (excluding profit and tax) would be about $76,720 assuming 30% additional cost for lower level servicing and unplanned repairs, including $10,780 for labour, $62,000 for materials and $3,940 for other costs.

In the long term materials cost of existing locomotives can be expected to increase because of rising demand, rising costs in the CIS and the increasing age of the locomotives. It is assumed that the combined effect of these factors is to increase the above estimated materials cost by about 20% to USD 0.36 per unit km. The long run economic materials cost of maintaining a typical two unit main line diesel locomotive in the TRACECA Region would therefore be USD 0.72 per km.

The equivalent cost for a shunting locomotive would be about USD 0.36 per km, or roughly USD 6,300 per year assuming about 17,500 km over 3,500 working hours.

The financial costs would be more than this because of the inclusion of taxes: about USD 0.86 per km for a mainline locomotive and USD 0.43 for a shunting locomotive (USD 7,500 per year).

Electric Locomotive Spare Parts

Maintenance costs of electric locomotive are usually about 25% of those of equivalent diesel locomotive according to "Railways and Energy", World Bank Staff Working Paper No. 634, 1984. The representative electric models such as the AC twin unit locomotive with 6320-6520 kW and 4,000t tractive effort, (or equivalent DC model with 5,120 kW) are slightly more powerful. Even so, there is little evidence to confirm that such a low ratio of diesel to electric maintenance costs applies in the TRACECA Region. It is therefore assumed that the spare parts cost of electric locomotives is 70% that of main line diesel locomotives. That is USD 0.50 per km in economic terms, and USD 0.60 in financial terms.

Freight Wagon Spare Parts

Typical figures for spare parts costs obtained in other countries usually vary between USD 0.010 and 0.025 per wagon km, depending on the level of technology and operating conditions. In the TRACECA Region available data suggest expenditure of only USD 0.005 per wagon km. Allowing for the simple nature of the wagons and poor operating conditions, it would be expected that the long run financial spare parts cost for TRACECA wagons would be USD 0.02 per km. The equivalent economic cost would be USD 0.016.

Passenger Coach Spare Parts

In most countries the coaches spare parts costs are roughly double those of wagons, implying a range of between USD 0.02 and 0.05 per km. In the TRACECA Region, recent costs appear to be only about USD 0.02 per km. This is more than four times the recorded wagon spare parts cost (rather than twice, as found in other countries), indicating greater use of new spare parts and/or less postponement of maintenance tasks. This seems reasonable given that passenger traffic has fallen much less than that of freight and so there would be less surplus passenger stock to cannibalise. A figure of USD 0.04 per km is therefore assumed for the long run financial spare parts cost (USD 0.032 per km for the economic cost).

4.2.3 Maintenance staff and overheads

Locomotives

Table 2.5 Locomotive Maintenance Staff Cost per Year per Locomotive

Locomotive Type	Current Cost (USD)	Long Term Cost (USD)
Mainline Diesel	50,800	42,000
Mainline Electric	50,800	42,000
Shunting	25,400	21,000

NOTE (1) Assuming, at present, nine staff per locomotive unit, USD 120 basic salary, plus 40% social insurance, plus 40% bonus payments.
(2) Assuming in the long term, five staff per locomotive unit, and salary of USD 350, including social insurance and bonuses.

Table 2.6 Estimated Annual Running Costs for a Locomotive Workshop

Item	Cost Basis	Amount (USD per year)
Building maintenance	2% of value	115,000
Building lighting and heating	2% of value	115,000
Equipment maintenance	5% of value	45,000
TOTAL (excluding amortisation)		275,000
Building Amortisation	40 years at 12%	688,000
Equipment Amortisation	20 years at 12%	118,000
TOTAL (including amortisation)		1,081,000

Table 2.7 Estimated Maintenance Overheads Cost for Locomotives

Locomotive Type	Annual Staff Cost/Loco ($)		Workshop Overheads/ Loco ($)	
	Current	Long Term	Current	Long Term
Mainline Diesel	50,800	42,000	20,320-35,600	16,800-29,400
Mainline Electric	50,800	42,000	20,320-35,600	16,800-29,400
Shunting	25,400	21,000	10,160-17,800	8,400-14,700

NOTE (1) Allowing 40-70% of long term staff costs (including bonuses) for overheads.
(2) The workshop overhead cost (for heating, lighting and building costs of the main workshop but not for the running depot or headquarters costs) is equivalent to USD 275,000 -390,000 per year per locomotive workshop bay (for a twin unit locomotive), depending on the condition of the buildings.
(3) For running depot bays, the overhead cost would be about 15-30% the above figures - about USD 40,000-80,000 per bay if the buildings are in good condition (USD 60,000 - 120,000 if not), depending on the extent to which the running depot was equipped with component repair shops.

Freight Wagons

Table 2.8 Estimated Annual Running Costs for a Wagon Workshop

Item	Cost Basis	Amount (USD per year)
Building maintenance	2% of value	100,000
Building lighting and heating	2% of value	100,000
Equipment maintenance	5% of value	250,000
TOTAL (excluding amortisation)		450,000
Building Amortisation	40 years at 12%	600,000
Equipment Amortisation	20 years at 12%	650,000
TOTAL (including amortisation)		1,700,000

Table 2.9 Estimated Maintenance Labour and Overheads Cost for Wagons

	Staff/Wagon	Average Salary incl. Social Costs ($)	Annual Staff Cost/Wagon ($)	Workshop Overheads/ Wagon ($)	Total Annual Costs/Wagon ($)
Current	0.25	235	705	180-350	885-1,055
Long Term	0.10	350	420	110-210	530-630

NOTE (1) Assuming same salaries as assumed for locomotive staff.
(2) Allowing 26-50% of staff costs for overheads.
(3) The workshop overhead cost (for heating, lighting and building costs of the main workshop but not for the running depot or headquarters costs) is equivalent to USD 22,500-27,500 per year per wagon bay, depending on the condition of the buildings.
(4) For running depot bays, the overhead cost would be about 15-30% the above figures - about USD 3,400-6,800 per bay if buildings are in good condition (4,100-8,300 if not) depending on the extent to which the running depot was equipped with component repair shops.

Passenger Coaches

Table 2.10 Estimated Maintenance Labour and Overheads Cost for Coaches

	Staff/Coach	Average Salary incl. Social Costs ($)	Annual Staff Cost/Coach ($)	Workshop Overheads/ Coach ($)	Total Annual Costs/Coach ($)
Current	5.5	235	15,500	4,650-9,300	20,150-24,800
Long Term	3.0	350	12,600	3,780-7,560	16,380-20,160

NOTE (1) Staff salaries are assumed to be the same as for locomotives.
(2) Allowing 30-60% of staff costs for overheads.
(3) The workshop overhead cost (for heating, lighting and building costs of the main workshop but not for the running depot or headquarters costs) is equivalent to USD 50,000-60,000 per year per coach bay, depending on the condition of the building.
(4) For running depot bays, the overhead cost would be about 15-30% the above figure - about USD 7,500-15,000 per bay if the buildings are in good condition (USD 9,000-18,000 if not), depending on the extent to which the running depot was equipped with component repair shops.

4.2.4 Train crew

Based on a current average salary of USD 235, including insurance and bonuses as assumed for maintenance staff, the current train crew cost is estimated as USD 14,100 per year. In the long term this could reduce from productivity improvements, despite increased salaries. Assuming a long term salary of USD 350, as assumed for other staff, and introduction of single manning, an annual cost per locomotive of

USD 12,600 would be incurred with the present practice of allocating drivers to locomotives, and USD 21,000 would be incurred if scheduling constraints were reduced to allow more efficient use of locomotives by any driver.

4.3 Estimated operating costs of modern rolling stock

The potential savings in maintenance spare parts and materials (which could amount to as much as 30% compared to existing equipment used in the TRACECA Region) will be offset by the higher cost, which could also depend on the location of production (within the Region or outside). It is conservatively assumed that most of the potential saving will be offset by higher unit costs of parts, resulting in a 10% overall fall in spares and materials cost per unit km for all types of rolling stock.

The longer period between planned maintenance tasks, better design of equipment to allow staff to carry out maintenance tasks in less time, and less frequent breakdowns will all contribute to lower staff required per unit, perhaps of the order of 20-40%. It is anticipated however that it would be some time before the potential staff savings can be achieved, especially during the transitional phase while the new equipment is being introduced. Therefore a 20% reduction is conservatively assumed (with a proportional reduction in workshop headquarters overheads).

Introducing new locomotives would considerably reduce (by 80% or so) the number of locomotive maintenance facilities required. Smaller falls would also be expected for wagons and coaches. Remaining depots and workshops would need refurbishing, however, requiring capital expenditure as estimated earlier. The effect of improving workshops, and especially the condition of the buildings, would be to reduce annual workshop overheads per bay..

Energy consumption would potentially fall from the use of modern technology, but this would be offset by higher consumption rates caused by higher speeds. Typically, average commercial speeds of freight trains are projected to rise by 10% from 50 to 55 km/h, while passenger train speeds are projected to rise by 30% from 70 to 90 km/h. According to diesel fuel consumption measurements at different speeds for trains of given power and weight (described in "Railways and Energy", World Bank Staff Working Paper No. 634, 1984), this would be expected to increase fuel consumption per gross tonne km by about 10% for freight trains and 30% for passenger trains. On the other hand, from the relatively high consumption of CIS equipment described earlier which would be expected to become worse as the fleet increases with age, the use of new technology could be expected to reduce fuel consumption under given conditions by 20%. The net effect is therefore assumed to be a 10% fall in fuel consumption for freight trains and a 10% rise in fuel consumption for passenger trains. On the same basis, shunting locomotives would be expected to consume 20% less.

4.4 Summary of operating cost assumptions

The expected unit operating costs in 2005 for Alternative 1 are those described earlier in this chapter for existing equipment in the long term, and are summarised in Table 2.11. Note that running depot overheads per bay are those applying for buildings in poor condition, reflecting the fact that little improvement can be anticipated due to limited capital budgets. However it is assumed that running depot overhead costs are minimised through concentrating maintenance under the recommended component maintenance system. This could reduce maintenance overheads by 50% according to the analysis described earlier, but a more conservative figure of 30% is assumed for evaluation purposes. Main workshop overheads per bay are assumed to be those applying to buildings in good condition because of the workshop improvement programme recommended under Alternative 1: this is estimated to reduce overheads per bay by about 20-30% according to the figures given earlier.

The basic cost estimates for the TRACECA Region are modified for the Caucasus countries to reflect the mountainous terrain which would increase energy and maintenance costs. It is assumed that wagon and coach maintenance costs would be increased more than locomotive maintenance costs because the former are particularly sensitive to terrain (being strongly influenced by brake and wheel costs).

Table 2.11 Assumptions Concerning Economic Operating Costs for Alternative 1

Item	Unit	Diesel Locomotives	Electric Locomotives	Shunting Locomotives	Wagons	Coaches
Spares and Materials Cost	USD/km	0.72	0.50	6,300[(1)]	0.016	0.032
Maintenance Staff	No./unit	10.0	10.0	5.0	0.1	3.0
Workshop Overheads	USD/bay/year					
- Main		275,000	275,000	137,000	22,500	50,000
- Running Depot		84,000	84,000	42,000	5,800	12,600
Diesel Fuel Consumption	l/gross t km					
- freight		7.1	n/a	84,000[(1)]	n/a	n/a
- passenger		8.5				
Electricity Consumption	kWh/gross t km					
- freight		n/a	12.0	n/a	n/a	n/a
- passenger			14.4			
Locomotive Crew	No./loco	5	5	2.5	n/a	n/a

NOTE (1) Shunting locomotives are estimated to consume annually, USD 6,300 of spare parts and 84,000 litres of fuel.

(2) For the Caucasus countries, the mountainous terrain is assumed to increase energy costs by 50%, maintenance costs of wagons and coaches by 30% and locomotive maintenance costs by 10%.

Overall operating costs have been estimated by multiplying these unit costs (e.g. spares cost per unit km) by number of production units (unit km). Production has been estimated from the projected freight and passenger traffic levels, taking account of anticipated changes in utilisation of rolling stock described earlier. It is assumed that the proposed improvements do not affect number of traffic staff (other than locomotive crew) so that, for instance, no reduction in passenger train staff is assumed to be attributable to changes in maintenance or design of passenger coaches.

For Alternative 0, the following modifications are made to the assumptions in Table 2.12:

- maintenance staff numbers per unit and headquarters overheads are assumed to be 30% higher because of less rigorous rationalisation programmes recommended under Alternative 1,
- diesel and electric fuel consumption is assumed to increase a further 10% because of (a) maintenance standards would be worse if the maintenance improvements recommended under Alternative 1 are not implemented, and (b) more fuel per gross tonne km would be wasted through increased idle operation under the current inefficient scheduling system,
- running depot overheads would not be reduced by 30% due to the centralisation of maintenance under the component maintenance system recommended under Alternative 1, and
- main workshop overheads are assumed to be those applying to buildings in poor condition and are not reduced by 20-30% as assumed for Alternative 1.

No change in number of drivers per locomotive is assumed because of limited productivity improvements expected under Alternative 0, so the scope for reducing number of drivers to only three per locomotive under the present scheduling system is not realised in practice. The assumptions for Alternative 0 are summarised in Table 2.4.

Table 2.12 Assumptions Concerning Economic Operating Costs for Alternative 0

Item	Unit	Diesel Locomotives	Electric Locomotives	Shunting Locomotives	Wagons	Coaches
Spares and Materials Cost	USD/km	0.72	0.50	6,300[1]	0.016	0.032
Maintenance Staff	No./unit	13.0	13.0	6.5	0.13	3.9
Workshop Overheads	USD/bay/year					
- Main		390,000	390,000	195,000	27,500	60,000
- Running Depot		120,000	120,000	60,000	8,300	18,000
Diesel Fuel Consumption	l/gross t km					
- freight		7.8	n/a	92,400[1]	n/a	n/a
- passenger		9.3				
Electricity Consumption	kWh/gross t km					
- freight		n/a	13.2	n/a	n/a	n/a
- passenger			15.8			
Locomotive Crew	No./loco	5	5	2.5	n/a	n/a

NOTE (1) Shunting locomotives are estimated to consume annually, USD 6,300 of spare parts and 92,400 litres of fuel.

(2) For the Caucasus countries, the mountainous terrain is assumed to increase energy costs by 50%, maintenance costs of wagons and coaches by 30% and locomotive maintenance costs by 10%.

For Alternative 2, the following modifications are made to the assumptions in Table 2.13, in accordance with the arguments given for the effects of new technology:

- spares and materials consumption is assumed to fall by 10%,
- staff numbers per unit are assumed to fall by 20%,
- running depot overheads per bay would fall to the levels expected for buildings in good condition because of the refurbishment programme proposed under this alternative (causing overheads per bay to fall by up to 50%),
- freight train energy consumption would fall by 10%, while passenger train consumption would rise by 10%, and shunting loco consumption would fall by 20% for the reasons given earlier.

Table 2.13 Assumptions Concerning Economic Operating Costs for Alternative 2

Item	Unit	Diesel Locomotives	Electric Locomotives	Shunting Locomotives	Wagons	Coaches
Spares and Materials Cost	USD/km	0.65	0.45	5,700[1]	0.014	0.029
Maintenance Staff	No./unit	8.0	8.0	4.0	0.08	2.4
Workshop Overheads	USD/bay/year					
- Main		275,000	275,000	137,000	22,500	50,000
- Running Depot		40,000	40,000	20,000	3,400	7,500
Diesel Fuel Consumption	l/gross t km					
- freight		6.4	n/a	67,000[1]	n/a	n/a
- passenger		9.4				
Electricity Consumption	kWh/gross t km					
- freight		n/a	10.8	n/a	n/a	n/a
- passenger			15.8			
Locomotive Crew	No./loco	5	5	2.5	n/a	n/a

NOTE (1) Shunting locomotives are estimated to consume annually, USD 5,700 of spare parts and 67,000 litres of fuel.

(2) For the Caucasus countries, the mountainous terrain is assumed to increase energy costs by 50%, maintenance costs of wagons and coaches by 30% and locomotive maintenance costs by 10%.

4.5 Results

4.5.1 Costs for alternative 1

The net costs for Alternative 1 are shown in Table 2.14. Annual operating and maintenance costs (in 2005) are shown separately from the total additional capital expenditure anticipated compared to Alternative 0. Detailed cost calculations are given for each country in the appendices.

These figures indicate that this alternative would incur an additional capital cost between 1998 and 2005 of USD 739 million, but it could achieve annual cost savings over Alternative 0 of USD 222 million, due to the management improvements. The main capital cost component is rolling stock refurbishment (especially for passenger coaches), with a significant contribution from workshop refurbishment costs. About half of the cost savings are derived from maintenance staff cost savings. Much of the rest is attributable to lower energy costs resulting from the improved maintenance and operating efficiency achievable under Alternative 1.

These figures confirm that this alternative should be attractive in economic terms, generating a high ratio of benefits (in the form of annual cost savings) to capital costs, of the order of 30%. This result is found in all the countries.

4.5.2 Costs for alternative 2

The net costs for Alternative 2 are shown in Table 2.15. In this case the annual cost savings are even greater than for Alternative 1, reaching USD 401 million, which is almost double that achieved under the other alternative. However the capital cost of this option is extremely high, at USD 9.8 billion (which is 13 times that of Alternative 1).

As before, the major cost savings are associated with maintenance staff costs and energy costs. Much of the capital cost associated with Alternative 2 is associated with wagons and coaches: the figures in Table 2.2

indicated that the capital costs of replacing the wagons and coaches constitute 53% and 23% respectively of the total cost of Alternative 2 and would therefore place a particularly large financing burden on the railways.

The incremental benefits of Alternative 2 compared to Alternative 1 are USD 179 million per year (USD 401 million minus USD 222 million), which are much less than the incremental capital costs of USD 9.1 billion (USD 9.8 minus USD 0.7 billion). The ratio of incremental benefits to incremental costs is therefore only about 2%.

TABLE 2.14 SUMMARY OF COSTS FOR ALTERNATIVE 1 - MAINTENANCE IMPROVEMENTS (US$ thousands)

	Armenia	Azerbaijan	Georgia	Kazakhstan	Kyrghyzstan	Tadjikistan	Turkmenistan	Uzbekistan	All Countri
ANNUAL ECONOMIC COSTS IN 2005									
Spares and Materials	195	9	2,955	21,530	-546	293	-49	-4,611	19,776
Maintenance Staff	-4,018	-11,314	-17,225	-48,206	-2,907	-3,692	-13,657	-10,808	-111,827
Workshop Overheads	-335	-1,398	-1,895	-12,568	-352	-536	-2,560	-3,585	-23,230
HQ Maintenance Overheads	-402	-1,131	-1,723	-4,821	-291	-369	-1,366	-1,081	-11,183
Operating Staff	-441	-966	-1,533	-4,851	-263	-326	-1,701	-1,995	-12,075
Energy	-369	-1,575	-397	-62,901	-205	-3,479	-4,321	-10,517	-83,765
TOTAL	-5,370	-16,376	-19,818	-111,818	-4,563	-8,108	-23,654	-32,597	-222,304
ECONOMIC CAPITAL COST 1997 - 2005									
Restructuring/MIS	1,000	3,000	3,000	5,000	1,000	1,100	3,000	5,000	22,100
Rolling Stock	28,000	44,000	44,000	221,000	5,000	20,000	80,500	40,000	482,500
Workshops	10,000	15,000	16,000	114,000	2,000	1,500	4,000	22,000	184,500
Manufacturing Facilities	0	0	50,000	0	0	0	0	0	50,000
TOTAL	39,000	62,000	113,000	340,000	8,000	22,600	87,500	67,000	739,100

NOTE: (1) The estimated costs are the costs of Alternative 1 minus the costs of Alternative 0.

TABLE 2.15 SUMMARY OF COSTS FOR ALTERNATIVE 2 - MAINTENANCE IMPROVEMENTS AND NEW TECHNOLOGY (US$ thousands)

	Armenia	Azerbaijan	Georgia	Kazakhstan	Kyrghyzstan	Tadjikistan	Turkmenistan	Uzbekistan	All Countri
ANNUAL ECONOMIC COSTS IN 2005									
Spares and Materials	68	-472	-1,093	8,188	-679	16	-239	-6,199	-410
Maintenance Staff	-5,815	-15,394	-21,063	-82,687	-3,436	-4,370	-19,429	-18,211	-170,404
Workshop Overheads	-448	-1,749	-2,350	-24,158	-438	-629	-3,581	-5,898	-39,250
HQ Maintenance Overheads	-581	-1,539	-2,106	-8,269	-344	-437	-1,943	-1,821	-17,040
Operating Staff	-546	-1,470	-1,995	-10,542	-326	-389	-1,974	-2,709	-19,950
Energy	-552	-2,873	-956	-116,610	-409	-6,070	-7,072	-19,545	-154,086
TOTAL	-7,874	-23,498	-29,563	-234,077	-5,631	-11,878	-34,237	-54,383	-401,141
ECONOMIC CAPITAL COST 1997 - 2005									
Restructuring/MIS	1,000	3,000	3,000	5,000	1,000	1,100	3,000	5,000	22,100
Rolling Stock	104,420	412,100	195,600	6,047,360	119,100	213,320	991,320	1,318,540	9,401,760
Workshops	20,000	30,000	32,000	228,000	0	3,000	8,000	44,000	365,000
Manufacturing Facilities	0	0	50,000	0	0	0	0	0	50,000
TOTAL	125,420	445,100	280,600	6,280,360	120,100	217,420	1,002,320	1,367,540	9,838,860
NOTE: (1) The estimated costs are the costs of Alternative 2 minus the costs of Alternative 0.									

5. Conclusion

These calculations of costs for different alternatives indicate that the strategy of improving management, using existing rolling stock, deserves high priority over the strategy which involves both management improvements and substantial new investment in modern rolling stock. This is because the potential operating and maintenance cost savings from modern equipment do not, in general, outweigh the initial capital costs.

The situation would be different if the existing rolling stock were reaching the end of its economic life: then the choice would be between replacing with modern technology or replacing with existing technology. However with the present surplus of rolling stock, often of only moderate age, there is no question of having to make such a replacement.

Despite this conclusion there could be scope for replacing certain components of rolling stock: especially those on locomotives which reduced both energy and maintenance costs. There may even be a case for replacing certain locomotives although this seems unlikely given the above result. To resolve such issues requires more information about how different equipment performs under the conditions encountered in the TRACECA Region. This in turn requires detailed testing over extended periods of time under controlled conditions. Given the time such testing would require, there is no doubt that, from the economic point of view, the appropriate strategy to adopt at the present time is to implement management changes designed to improve maintenance as assumed under Alternative 1. Once these change have been made, the railways would be well placed to consider aspects of Alternative 2, if circumstances prove to be favourable.

As described above, the improvements in management can be expected to have a substantially greater impact on productivity than the improvements in technology. Since these can be achieved with relatively little investment it follows that the preferred alternative, from a cost-effectiveness point of view, would be Alternative 1.

Chapter 3. Recommendations

Table of contents

1. Background

From a general point of view, the former organisation of the railways was well adapted to their objectives and to their geopolitical environment. Most of the railway managers of the TRACECA region are well aware of that. They have well understood that they have to introduce changes in their organisation. Most of them have already introduced significant changes. The resulting organisations are working, our recommendations do not aim at pointing out the failures of the system, but to advise them on our opinion to further improve the situation, and to solve the problems mentioned by the railways themselves.

To be efficient the recommendations require :

- Infrastructure improvement
- Operation restructuring
- Some rolling stock refurbishment
- Maintenance restructuring and related upgrading of facilities

The effectiveness of those actions will involve increase of operation characteristics, such as :

- Commercial speed
- Lower turn around of passenger coaches and wagons
- Increase of operational time of locomotives

Under those performances the fleets of all kinds of rolling stock and the capacities of maintenance facilitities could be evaluated in terms of quantity and quality.

The capacities of maintenance facilities depend not only on the technology and the quantity of vehicles to be maintained but also on the organisation of the maintenance.

Therefore, this chapter presents :

- Some proposals for operation improvements which could have major effects on the rolling stock management.
- Recommendations in maintenance management
- Recommendations in rolling stock improvements
- Evaluation of rolling stock requiremnents
- Recommmendations in maintenance facilities improvements
- Evaluation of maintenance facilities requirements

2. Operation

2.1 TRACECA railway forum

On an overall level, the relations between the TRACECA countries urgently need to be improved.

A forum for railway related discussions needs to be organised.

On a senior executive level, the co-ordination and the overall guidelines for a number of lower level activities need to be established. This senior executive level, will then monitor and approve work done on the lower levels.

Of special relevance to this project, is to deal with:

- Maintenance co-operation
- Co-ordinated procurement plans.
- Time schedules.
- Independent Wagon Entities.
- Jointly owned companies to take over some of the maintenance levels.

2.2 Passenger traffic

Thorough traffic forecasts are required to determine the relevant services to be scheduled and the frequency of the services. Then the rolling stock could be defined in terms of :

- Performances of the locomotives and passenger coaches
- Types and arrangement of vehicles
- Comfort and ancillary services to be provided onboard
- Arrangement of trains

Moreover, the quality of travelling on railways will have to be improved, or the customers will find other means of travel.

2.2.1 Timetables

The timetables will have to be amended to suit the changing traffic needs. This must be done continuously.

2.2.2 Travelling speed

The travelling speed for train travel will have to be increased. It can and must be considerably higher than the current travelling speed. To do so, the following measures have to be taken :

a) Train speed on all major lines must be kept free from local permanent speed limits, caused by steep switches at sidings, complicated station roads or similar.

b) Train speed on all major lines must be kept free from local temporary speed limits caused by wear and tear/lack of maintenance in the permanent way or the substructure.

c) Normal station stops must be cut to a minimum. No unnecessary waiting time. No unnecessary changes of locomotives. No unnecessary delay. A station stopping time of less than two minutes should be obtainable.

d) The longer stops for supplies (water, coal, foodstuff etc.) must be cut in number and duration.

e) The feasibility of increasing the line speed on a long term basis must be investigated. Care must be taken, as increasing the line speed of the passenger trains to more than some 110 - 120 km/h will seriously reduce the capacity for freight transports on a busy line.

Be very aware that the impacts of a, b, c and d are far greater than the impact of e, within a considerable time frame.

Be also very aware that removing obstacles of the types a & b will cut the energy consumption for locomotives.

It should be pointed out that some of those measures have alfeady be taken in some areas of the TRACECA region and in some Russian services.

2.2.3 Train comfort

The comfort of train travel must be improved. Today, train travel has the image of being outdated and uncomfortable, among part of the population that could be described as the future "trend-setters".

Even though this is not always justified, a serious effort must be made to improve the comfort and especially the image of train travel. The interior and exterior of passenger vehicles can be improved considerably utilising local skills and resources.

a) Upgrading the maintenance, so that the vehicles are actually in reasonable operating condition when leaving the depot.

b) Upgrading the cleaning during the longer trips. Specially the cleaning of toilets during the travel is a necessity.

c) Improving the appearance of the passenger stock. Also this can be done, drawing on local resources without external assistance.

2.3 Freight traffic

As the passenger traffic, the freight traffic should be analysed in terms of :

- Origin-destination flow demand
- Type of services : bulk trains, containers, express services, etc.
- Quality of services : punctuality, security en-route

However, there are two main goals to be pursued within the freight traffic.

- Increase the shipper-to-receiver speed.
- Increase the profitability of the freight traffic

To increase the commercial speed, the unnecessary stopping times should be reduced by :

- Reducing time at stations and sidings. Re-scheduling the timetables can reduce the need for crossing and overtaking.
- Reducing time for the Hot Box & Brake tests that are carried out now, by increasing the number of automatic surveillance points and/or by upgrading the bearings and the maintenance.

Moreover, it was reported that for a quite considerable amount of cargo, no fee for the transport is actually paid, but debts are only being registered. Whether this is considered as a social obligation or just as "something that we have always done", is not quite clear.

Evidently, this is one of the causes for the problems of the railways. Lack of income means lack of funds. And funding is necessary for spares to be procured, for staff salaries, for diesel and electric power etc. Furthermore, new owner of privatised entities often refuses to pay old debts generated when being a state enterprise, this practice will have to be abandoned immediately.

The effect of this on the future transport volumes is not easily assessed as no valid information on the magnitude exists.

To have locomotive and crew waiting is unproductive costs. Increased end-to-end speed will be achieved both by current and new shippers and will allow to reduce the required fleet of wagons.

Through running of small block trains should be developed, even though this may mean running shorter trains. If it is possible to run a 1.000 ton train through from shipper to receiver, this is far less cost consuming than running 3.000 ton trains, that have to be shunted several times on the way. Further again, real travel speed is considerably increased.

Some new cargo types can be expected that will need either rebuilding available vehicles, or procuring new vehicles. Especially container carriers can be expected to come in demand within a short term time frame, but as mentioned, containers can be carried on flats or semi-highs due to the larger width than compared to similar Western vehicles.

2.4 Separate wagon entities

2.4.1 General approach

In order to care for some of the more specialised kinds of rolling stock in an economical way, it is needed to assemble all the maintenance from all or most of the TRACECA region in one or a few specialised workshops, taking care of the maintenance levels two and three.

It is a clear possibility to extend the responsibility of such specialised workshops to also include the operation of such special groups of vehicles, which may create independent specialised units catering for all aspects of their kind of rolling stock.

Whether this being as pure maintenance shops, as combined maintenance/wagon leasing companies or as companies operating the vehicles and hiring locomotive services from the relevant railways, must depend on a detailed analysis of the legal and operational possibilities and the interests of the participating railways.

2.4.2 Refrigerator sets

The most evident example is the refrigerated train sets. These sets consist of a permanently manned compressor wagon that runs in the middle of 4 - 6 cooling wagons as a permanently coupled set. Operation of these sets is a quite complicated business as they travel all over the Russian Broad Gauge network permanently staffed. This personnel is replaced approximately once a month, earlier if the set is back home, ready to leave, later if the set is on it way home and is expected soon.

But else, a replacement crew is to be organised, and sent to the location of the refrigerator set and the crew to be replaced must have their home travel organised.

Apart from the practicalities of having personnel in operation in this way, a number of support services for the personnel and their relatives have to be organised..

All of the eight railways possess such train sets, but the total number of aprx. 10.000 sets does not justify more than one maintenance entity on each side of the Caspian Sea.

The process of establishing such entities should be started. It should be considered to transform these into separate cross-country organisations that operate and maintain these sets, and purchase the locomotive services from the different railways.

2.4.3 Tank wagons

One further example is the tank wagons. One entity could be caring for the tank wagons operating in the Baku area, and there are several other possibilities in the Central Asian region.

In order to "isolate" a number of tasks and challenges, closely connected to specific types of specialised freight wagons or to specialised kinds of services, separate entities should be created to handle these problems within the enclosed environment of a smaller entity.

The more tasks of these kinds are isolated, the more resources will be available within the mother railway, to handle the tasks and challenges of freight operation on the overall.

These freight wagon entities can come in different operational ways :

- **A Wagon Leaser** - It owns and maintains the wagons, and hires these out to the shippers. The shipper will then organise transportation of the wagons for the railway within normal freight trains in normal mixed freight traffic.
- **A Wagon Operator** - It owns and maintains the wagons and operates them normally in block trains. The shipper has nothing to do with the railway. The operator buys locomotive services for his train from the railway.
- **A Traffic Operator** - It owns and maintains not only the wagons but also his own traction power. The operator will then buy the right-of-way from the railway. The operator may own and maintain tracks, for instance shunting sidings or branch lines to mines etc.

These entities may have several legal shapes - owned by one or several railways - joint ventures with foreign partners - joint ventures with factories or mines etc.

Whatever the arrangement is, the ownership and the responsibility for part of the fleet will have to be transferred from the general railway administration, to these specialised units.

Groups of wagons running in closed operation, equipped for specialised traffic, or in other ways different from the general multi purposes, multi traffic freight vehicle should be identified.

For these groups of vehicles, it is recommended to establish separate units handling the wagons.

They will have the following responsibilities:

- Maintaining the vehicles - performing major maintenance at available depots.
- Selling the services of this fleet of vehicles.
- Hiring traction power. Or even operating locomotives within the company.
- Operating a stabling area and a shunting yard for wagons not in operation.
- Replacing/extending the fleet of vehicles when necessary.

This can be done in several ways as the following examples will illustrate.

2.5 Refrigerated trainsets

They are sets of wagons permanently coupled : 4 or 6 cooling wagons running coupled to a compressor wagon, feeding them with cooling media.

These sets are permanently staffed. A 2 man crew lives in a set for a month before being replaced.

Evidently such operation is highly specialised. It is recommended to transfer all refrigerated trainsets in the region(s) to a specialised company that will then have the following duties:

- Staffing the vehicles and caring for the travelling personnel.
- Organising replacement crews wherever the sets are at the time of replacement.
- Maintaining the specialised vehicles - procuring the standard maintenance at available depots.
- Selling the services of this fleet of vehicles.
- Hiring locomotive services wherever the trainsets travel.
- Operating a stabling area and a shunting yard for sets not in operation.
- Replacing/extending the fleet of vehicles when necessary.

The railway administrations will then get a share of this separate entity in accordance with the value of the equipment that they provide for this unit.

A maintenance facility for this purpose is already in progress in Cimkent, and as it further is Kazakhstan that owns most of the refrigerated stock, this is suggested as basis for such a separate entity.

The few single refrigerated wagons running, should evidently be included in the set-up.

2.6 Tank wagons

A simpler but similar situation exists for the tank wagons.

Even though they are of a more simple technology than the refrigerated stock, the operation and maintenance of tank wagons is considerably more complicated than most railway freight stock.

Cleaning tank wagons is also a speciality requiring dedicated equipment and personnel.

It is recommended to establish 2-3 wagon leasing companies for tank wagons, each one having a maintenance facility and operating one or more cleaning installations according to the individual needs.

Each of the entities will then have the following responsibilities:

- Maintaining the specialised vehicles - procuring the standard maintenance at available depots.
- Selling the services of this fleet of vehicles.
- Hiring locomotive services wherever the wagons travel.
- Operating a stabling area and a shunting yard for wagons not in operation.
- Assisting each other with maintenance and cleaning for tank wagon travelling over larger distances (at reasonable rates)
- Replacing/extending the fleet of vehicles when necessary.

Each railway administration will then get a share of separate entities that they will join in accordance with the value of the equipment that they provide for the given unit.

Building a maintenance facility for this purpose is already in progress in Djambul, and a further has been studied in Baku.

Evidently these entities must be geographically opportune in relation with the tank wagon traffic in operation.

3. Rolling stock improvements

3.1 Passenger coaches

No new long distance vehicles are needed on a short term basis.

The passenger coach conditions are deteriorating rapidly, therefore, it is required to take measures to improve their conditions. Those measures could be taken during the overhaul of the vehicles

Coach refurbishment to be carried out during overhaul :

- Current heating system based on local heating from a coal fired stove should be replaced by an electric system supplied either by the locomotive or by a special power supply wagon (except for a few) is. This system is dirty, space consuming, polluting and inefficient. Evidently this system requires much attendance during travel. This modification will allow to :
  - Increase the comfort of passengers
  - Reduce the cost of operation and maintenance
  - Reduce air pollution
- General appearance of the vehicles. It is possible to upgrade the interior and exterior of the vehicles, without a major technical effort, and with resources available locally. These changes should include such areas as colour scheme, seating comfort, information signs, decorations etc.
- Current paint work is done with very simple means, a well-equipped painting shop can not only improve the appearance of the vehicle, it can also increase the time between repainting up to 10 -15 years.
- Replacing the double glassed windows with an air proof double glassing, will not only increase the appearance and the ability for the passengers to look through the windows. It will also reduce the cleaning and maintenance of the windows.

On a long term basis, It is suggested to establish Intercity stock as a pool of coaches, jointly operated by the involved railway administrations or by an independent operator. Each administration supplies a number of refurbished coaches according to the proportion of coach-km run within each country.

developed

3.2 Tank wagons

The available quantity of tank wagons cover the current needs but they are not too much in excess. In some areas, shortage of tank wagons could appear rapidly. Kazakhstan railways plan to build new wagons in Aralsk.

Wagon refurbishements are required in order to maintain the maximum number of wagons in good conditions. Therefore, it is recommended to :

- Upgrade the Baku's tank wagon workshop. It will be able to cover the Caucasus demand
- Implement a workshop in Aralsk able to rehabilitate wagons for Central Asia needs. Fufther studies will be required to increase and modify the production capacity of this workshop so as to produce new wagons.
- Transfer of know how will be required in Djambul (Kazakhstan) to convert production of silos into tank for wagons.
- Initiate negotiations to transfer tank wagons from Caucasus countries to Central Asia countries. Expertise of wagons to be transfered will be necessary prior to negotiations.

	Available in 1996	Required in 1996
Armenia	n.a.	n.a.
Azerbaijan	2.280	4.948
Georgia	752	2.284
Kazakhstan	2.280	11.570
Kyrghyzstan	n.a.	251
Tadjikistan	52	21
Turkmenistan	700	3.937
Uzbekistan	1.905	4.484

It should be attempted to isolate the ownership of these vehicles in separate companies, that specialises in operation and maintenance of these vehicles. This will enable a joint operation between the countries.

The most evident example of this is the refrigerated wagon sets but the same idea should be pursued within a number of other units.

The procurement of new vehicles will then be the responsibility of these units.

3.3 Locomotives

3.3.1 Introduction of a new technology

In the long term time scale, the need for considerable replacement of locomotive will be necessary. The introduction of modern western technology will probably be feasible and justifiable to some degree.

Introducing modern Western locomotive is not a simple thing, whether it is diesel or electric traction.

Even though superior in performance, and in economy a modern traction unit is a complicated machine to operate and maintain.

Furthermore, in order to fully utilise the possibilities of the new locomotives, there is a further set of conditions that will have to be met:

- The infrastructure must be brought up to a standard where the speed and traction capabilities are not limited by speed restrictions caused by temporary defects in the track.
- The infrastructure must be brought up to a standard where the speed and traction capabilities are not limited by permanent speed restrictions, for instance caused by too steep switches at the end of passing sidings etc.
- The operational pattern must be changed, so that the obtainable travel speed is not hampered by long station stops or by changes in locomotives.

So, in order to be prepared for a general replacement starting to be implemented from 2005 onwards, it is necessary to start preparing this conversion process within the short time scale.

3.3.2 Locomotive pilot projects

Two pilot projects, (one for diesel and one electric) introducing modern Western should be launched, in order to gain experience to the transformation of technology, that will come later. Tests for replacement of diesel engins with Western engins are already in progress in Kazakhstan. Introduction of new electric locomotives are presently in negotiation in Uzbekistan.

Taking an existing loco from Western countries and placing it in the Central Asia" is likely to cause serious problems. It will not provide the economical and operational advantages, that possibly can justify the investments.

The modern Western technology needs to be adapted to perform properly. The current mode of operation needs to be seriously changed, in order to gain the operative advantages possible.

Maintenance facilities need to be extensively adapted to meet the requirements of the new traction power.

All involved operation and maintenance staff, both management and workforce, need to be thoroughly trained.

So prior to a massive replacement, to following steps should be taken:

- Two small fleets (15 - 20 units) of Western style locomotive should be introduced in two pilot areas. One dieselelectric, one electric.
- In order to prepare for this, a thorough analysis of the infrastructure and maintenance in these same areas must be done. This will result in a recommendation as to check changes are necessary, in order to run the new locomotives with good results.
- Furthermore, the operation pattern and practices must similarly be described in detail, and all measures necessary to operate the new fleet with high efficiency must be implemented. It is strongly recommended that these changes be not only implemented for the new fleet. It must be valid for the complete operation and maintenance in the pilot areas. And all necessary changes must be implemented and in operation prior to the arrival of new locomotives.
- Before signing any supply contract, it is imperative to obtain assistance from experienced rolling stock procurement experts in order to secure that the supplier is totally obliged to supply locomotives that will actually operate in the present environment. And that he has no possibilities whatsoever for escaping amending, changing and rebuilding the supplied locomotives , until they can actually perform. It is a clear possibility that must be considered, to include the responsibility for the operation and maintenance of the vehicles.
- An extensive training programme must be included in the contract for both operation and maintenance staff. This training must be carried out locally, in order to involve the personnel actually to be involved in the everyday operation and maintenance of the new equipment. Preventive maintenance programmes and spare parts procurement must be a part of it.
- A rebuilding/upgrading of the maintenance facilities must be to be included further in the contract to service the new traction power, not only an electronic equipment workshop.

After the new locomotives have been put into operation, a major scheme of follow up on the results and experiences must carried out.

- The technical performance of the new locomotives within the present environment must be mapped out in detail.
- All possible changes and amendments for the infrastructure must be deeply investigated. This may also mean implementing a number of changes such as power supply, and to test the resulting performance, both for new and current equipment.
- All experience gathered from the changes in the maintenance structure, must be collected. They must be carefully assessed and adjusted, in order to optimise the performance. Again, this does not only relate to the new equipment, but also whether problems are generated for the current stock

All collected experience must be collected and assessed on an overall basis. Considering this, the specification for new locomotives and the specifications for changes in the supporting structures and organisation can be updated.

Then, further orders for locomotives can be granted. Preferably to two further suppliers in order to broaden the experience basis. To the extend possible, suppliers producing locomotives merging the European and the Russian technology, should be chosen. Several possibilities of this kind are under development in Russia, and ADTranz is pursuing similar possibilities in Ukraine. The remarks from 1.3 are still very valid.

In parallel to these, all further changes described in 3 should be implemented unless this has been done previously.

A follow-up programme must be set up. The follow-up action on the performance of the delivered equipment must be detailed. This further follow-up should be less detailed, but still securing that all useful information is gathered.

An overall conclusion should be made, based on the experience. This conclusion must then be the basis for the overall locomotive procurement strategy in the region.

3.4 Requirements for the next 10 years

The number of traction units taken over from the SZD was so improtant, that even with some equipment being abandoned, an excess number of locomotive units will be available for the years to come.

4. Maintenance management

4.1 Maintenance management

Operation must be separated from maintenance. The maintenance facilities must be optimised and turned into smaller units with well-defined obligations and responsibilities and with the means of optimising these units.

Non-railway related activities must be sold or branched off. Funding must come forward either through realistic budgets or by well-defined payment for services.

Quality Control and Quality Assurance must be introduced in order to replace the participation of the drivers in the maintenance activities.

In the following, it is assumed that there is a separate train operation entity responsible for train operation, whether this is a separate legal entity of some structure or a separately responsible department within the mother railway is not of major importance for these recommendations. The key point is the that responsibilities are split and well defined, and that services are paid and based on market prices.

The maintenance functions aims at :

- ensuring the availability of the rolling stock, minimising the time for maintenance. The vehicles not in maintenance must be available for operation for any relevant direction, distance and services.
- ensuring the reliability of the rolling stock minimising failures occurring during operation.
- ensuring the reliability of all safety related functions.
- maintaining comfort and cleanliness of the vehicles.

The rolling stock maintenance itself is constituted by several functions, dealing with both rolling stock and equipment.

It is proposed to split the main functions of maintenance as ;

- line inspection : security check, inspection of trains, small repairs ;
- depot : inspections and repairs of locomotives, wagons and passenger coaches ;
- workshop : overhauls of locomotives, wagons and passenger coaches, repairs of main equipment ;
- specialised shops : repairs and maintenance of equipment.

The operation of trains is not a maintenance function. It is operation, and the drivers should be attached to a train operation function.

These functions evidently already exist, but they are not split as proposed. The tasks and responsibility of these two functions are often mixed. The budgets for the two activities are managed by the headquarters as one account.

4.2 Equipment oriented maintenance

The objective of the maintenance organisation is to reduce idle time of equipment and vehicles.

One of the way to minimise idle time is to implement an <u>equipment oriented maintenance</u>

All equipment does not require the same time for maintenance. Therefore, smaller equipment that requires long maintenance should not immobilise the vehicles as such.

All equipment does not have the same maintenance frequency. Therefore, the overhaul of a vehicle should not depend upon the equipment having the highest frequency.

The proposed organisation depends on the exchange of equipment for overhaul during running maintenance. The overhaul of the complete vehicle is then carried out based on the maintenance condition of components or equipment not easily detachable from the vehicle, or when the body of the vehicle requires overhaul.

For a better efficiency, the rolling stock should be amended to comply with this maintenance structure.

The maintenance of "loose" equipment can then be contracted to the best specialised shop.

4.3 Business units

The following organisation proposes to split the maintenance functions into specialised business units.

This proposed organisation ensures :

- better distribution of activities between countries ;
- better quality together with cost efficiency due to specialised lines of business, aiming at reaching efficiency in a single direction ;
- enlarge possibilities in a market oriented organisation ;
- allowing an external entity, manufacturer or foreign specialist to make a Joint Venture or to take over one of these functions.

It is based on the assumption that independently responsible entities take care of the operation.

4.3.1 First level : Line inspection

4.3.1.1 Functions

- ensure the availability and check the conditions of the safety related features on the rolling stock before operation and after shunting operations or change of locomotive ;
- ensure the cleanliness and the comfort of the passenger trains and all locomotives ;
- filling up of consumables: fuel, oil, sand, water, at the expenses of the train operators.

The line inspection is under the full responsibility of station operation to ensure security of passengers, customers and personnel and to ensure reliability of timetables.

4.3.1.2 Framework and facilities

The line inspection is carried out by the driver and train assistant with the assistance of technicians when necessary.

It is performed in stations or terminals, in marshalling yards, or wherever necessary.

In major stations, terminal stations and yards, rolling stock technicians and minor spare parts are available. Here, it is possible to carry out light repairs in order to restore safety conditions and availability of the train. These functions were wide spread, but it is stated that nowadays, they are neglected. They are still performed but not with the care and the spare part availability that used to be. It is recommended to select a limited number of such service facilities, and upgrade them. There is no needs for heavy tooling or vast facilities, Just a number of key spare parts and a clean and safe walkway along a dedicated track.

In some remote areas, and in main passenger or freight stations, a small dedicated "service station" doing small repairs, refilling of oil, sand and water, and doing cleaning functions could be implemented. It should have personnel facilities, light tooling equipment and key spare parts. Parts of depots to be abandoned could be adapted for such purposes, but in much reduced form.

The first level maintenance should also care for the cleanliness of the trains. Main stations, terminal stations and yards have dedicated cleaning facilities to carry out a comprehensive cleaning. Workers should be available in major intermediate stations to upgrade the cleanliness of trains when necessary, for instance, they should check the conditions of toilets of the passenger coaches when a train stops for more than 10 minutes.

4.3.1.3 Budget

The line inspection does not have is own budget. Its budget is integrated in the station operation or running operator budget.

4.3.1.4 Relationship with other entities

Depots and train operators :

Negotiate preventive actions or repairs

Participate in assessment of failures occurred in the rolling stock, so as to determine the origin of the failures and its consequences

Station operators :

Negotiate and plan actions to be carried out

4.3.2 Second level : Depots

4.3.2.1 Objectives

It is the objective of the depot to secure the reliability of a vehicle, whether locomotive, passenger coach, freight wagons, or EMU, so that it will reach the next preventive maintenance inspection without any unscheduled repairs in the meantime.

The frequency of the maintenance levels is to be thoroughly monitored and adjusted in order to obtain the longest possible period between two maintenance actions, without conflicting with the above.

However, it should be pointed out that too infrequent maintenance will most often not cause immediate trouble, but only after a number of maintenance cycles. A shortest periodicity is costly and useless.

4.3.2.2 Functions

The functions of the depots are:

- Technical inspections
- Small repairs, exchange of components when required.
- Exchange of equipment when it reaches the time for preventive maintenance
- Performance of small modifications on the vehicles.
- Reviews of all requests and observations risen during the operation of the vehicle. Usually, all actions to upgrade comfort of operators, attractiveness of the vehicles and tune up of equipment.
- Quality control.

4.3.2.3 Framework and facilities

The idle time for maintenance of a vehicle is a compromise between :

- The needs of the operation. The vehicle is withdrawn from service and represents an investment that is not revenue earning for that period.
- The volume of work to be performed on the vehicle
- The staff assigned to the vehicle.

The tasks carried out during depot maintenance do not require specialised or heavy tooling. As many tasks as possible should only be exchange of components which are then refurbished at the level 4 shops.

Access to a vehicle should be easy. Elevated tracks fitted with lateral and underground pits and scaffoldings are compulsory. The more recient depots of the TRACECA region are already fitted with such equipment, the oldest should be upgraded. Most of the depots visited are fitted with side pits, not often with elevated structures, in those cases scaffoldings could be constructed locally.

4.3.2 4 Quality control

The depots should be fitted with a quality control entity which :

- Checks that requests of operators and first level maintenance have been dealt with.
- Ensures the quality of the tasks carried out in the depot, this quality control, currently ensured by the drivers should be done by a specific team
- Monitors the failures occurred during train operation in order to ensure relevant actions, adjust the maintenance programmes
- Checks that requests of operators and first level have been taken into consideraton ;
- Participates in analysis of failures in operation, in order to determine the reasons for failure and to assign responsibility
- Performs quality control on all supplies, whether new or refurbished parts, or supplied services
- Checks the quality of the overhaul carried out by the workshops.

4.3.2.5 Budget

The depots must have their own budget in accordance with the tasks performed. They must be able to get rid of excess personnel and appoint the skilled staff they need, or to procure the relevant services externally if feasible.

They bear all expenses or taxes related directed to the personnel but do not deal directly with personnel welfare, accommodation, hospitals, vacation centres etc.

They manage all the production costs, and maintenance contracts, repair or refurbishment of equipment to external entities or they procure the specific components if needed.

They are fined for non compliance with quality commitments and for unjustified delays in returning rolling stock for operation.

Their incomes come only from maintenance carried out on rolling stock. There should be no auxiliary activities.

4.3.2.6 Relationship with other entities

Train operations :

- commit themselves to a quality level
- negotiate the intervals for vehicle maintenance
- evaluate the results of the maintenance and agrees relevant actions to improve it
- negotiate the maintenance costs
- advise the train operating unit on investment plans and on relevant usage of rolling stock.

External providers

- negotiate and procures spare parts and services
- negotiate the refurbishment of equipment with the fourth level workshops.

4.3.2.7 Monitoring

The depots are fitted with their own Management Information System

It ensures :

- management control
- maintenance production follow up
- failures follow up and control of MTBF
- spare parts consumption control
- quality control monitoring

The Management Information System office is located in the depot. It can be easily reached by managers, quality control inspectors, technicians and engineers. All of them must have access to all of the information.

Nevertheless, the system must be designed so that each of them can directly obtain the information he needs in relation to his function.

4.3.3 Third level : Workshop

4.3.3.1 Functions

Major Overhaul and Capital Repair of vehicles.

Other kinds of heavy repair at request.

Monitoring the reliability and maintainability of vehicles. Advise the operation on future investments for refurbishment or replacement.

Participate in the heavy maintenance scheduling.

Participate in rolling stock procurement.

4.3.3.2 Framework and facilities

The workshop is fitted with equipment required for :

- cleaning the incoming vehicles,
- dismantling of equipment
- maintenance of heavy major equipment, rehabilitation of mechanical parts
- spare parts storage and management

The workshop is fitted with relevant equipment and the personnel is specifically trained to perform the overhaul functions.

Duplication of expensive equipment such as wheel lathes, must be avoided if other nearby maintenance entities have such facilities. Such services should be procured to secure utilisation of expensive equipment and maintenance of skill, and in order to avoid parallel activities for locomotives, passenger coaches and freight wagons.

A workshop is mainly a heavy mechanical and a fitting shop. Electric work only consists of wiring of the vehicles. Electronic skills will have to be developed with the introduction of new technology rolling stock.

All maintenance of dismantled equipment should be performed outside the workshop, for instance, electrical motors, electrical equipment, bearings, dampers.

There are only few workshops in the TRACECA region. However, some railways have adapted or plan to adapt their major depots for overhaul activities. These adapted depots are not fitted with the relevant tooling and the personnel is not well trained to deal with overhaul activities, so further development is needed. The upgrading of depots to workshops needs to be co-ordinated within the region in order to avoid excessive spare capacity for Major Overhaul/Capital Repair.

With sufficient workshops able to carry out Capital Repair activities, repair in the manufacturer's plant will only be required in case of serious structural damage on a rolling stock unit.

4.3.3.3 Quality control

The workshop is fitted with its own quality control entity that is in charge of :

- quality of workshop production ;
- expertise of major failures during operation ;
- monitoring of quality of all supplies, whether new or refurbished parts, consumable or services.

4.3.3.4 Budget

The workshops manage their own budget. They are responsible for their human resources, the procurement of their own spare parts, their own consumable, training, updating of tooling, updating of procedures.

They get revenues only on maintenance tasks performed.

4.3.3.5 Relationship with other entities

Train operators :

Negotiating the tasks to be performed, the quality standards and the adjoining commercial conditions.

Depots :

Transfer of vehicles.

Repair services at request

External providers :

Spare parts and consumable procurement, monitoring of delivery commitments, and quality control of supplies.

Procurement and supply of services.

4.3.3.6 Monitoring

The workshop monitoring and MIS allow them to :

- follow up the failures occurring between overhauls, and to determine the MTBF of the vehicles in order to take relevant actions if necessary
- plan the overhaul production and negotiate the timing of the transfer of the vehicle ;
- manage the procurement of new and refurbished spare parts.

Since most equipment are no more permanently installed in the same vehicle, a thorough follow up of the whereabouts of all equipment is required

4.3.4 Fourth level : Specialised shops

The fourth level of maintenance deals with the refurbishment of dismantled spare parts, components or complete functional units. It shall be heavily stressed that it will not be feasible to establish such entities for all kinds of equipment in all countries. For many kinds of equipment, several countries will have to rely on the same entity, just as the workshops for locomotives, passenger coaches and freight wagons will have to support the same entity.

4.3.4.1 Functions

By repair or refurbishment, to upgrade the conditions of specific equipment dismantled from the vehicles, to a specified condition.

Procurement of spare parts related to this equipment.

Assist in adjusting maintenance actions and maintenance intervals.

4.3.4.2 Framework and facilities

Each 4th level workshop is specialised in one type of equipment.

Tooling, cleanliness, training of personnel must be well adapted to the equipment to be maintained.

The 4th level workshops can be located on the area of a depot or a workshop, being developed from the existing shops. However, it must only be a practical renting of facilities, the 4th level workshops must not have any daily managerial or accountancy connections to the depot or workshop.

The 4th level workshop can be a joint venture between the railway and an external manufacturer, or can have a number of other legal structures.

4.3.4.3 Quality control

The quality control department of the shop is in charge of :

- quality of shop production.
- expertise on repetitive failures of the equipment in the operation.
- quality control of the suppliers of spare parts and services.

4.3.4.4 Budget

The 4th level workshop is an independent entity, so they manage their own budget.

They only get revenues by supplying refurbished equipment to the depots and workshops.

4.3.4.5 Relationship with other entities

According to their speciality, they can provide equipment, spare parts and services to the operators, depots or workshops if required.

They negotiate prices, commitments and commercial conditions with depots and workshops whatsoever their location.

4.3.4.6 Monitoring

Each specialised shop is fitted with its own monitoring and Management Information System.

The monitoring system allows them to :

- follow-up on the failures of their equipment in order to determine the MTBF and to take relevant actions.
- manage their own spare part procurement.

4.4 Management Information System

The current target for the maintenance is to fulfil the requirements from the old maintenance structure. The current programmes have been centrally designed. This means that it is a desk job, and that it has been developed with a limited amount of contact with the people presently doing the maintenance work.

There has been no incentive for the authors to take risks or to cut expenditures. Such programmes reflect a level of maintenance where the authors are very certain that they cannot be blamed for an insufficient maintenance programme.

Furthermore, these programmes were valid for the complete SZD area, it had to take a large number of operational, environmental and climatic conditions into account. This evidently also makes such a programme grow.

Forced by the external conditions, these requirements are not being followed but the choice on which parts of the old maintenance programmes do not follow is dictated more by the availability of spare parts and the possibilities of the workshop in question. So the cut in the maintenance is dictated by the resources and spare parts availability.

There are no traces that anyone is actually monitoring the reasons for problems during operation, and adjusting the maintenance accordingly. This will have to be done.

The railways are in need to cut costs, so revising the maintenance programmes is urgently needed. Such cuts cannot be done sensibly, without having collected experience for some time. Experience on the operational performance, and experience with the state of specific kinds of equipment on the rolling stock, when coming in for maintenance.

The experience from the operational performance can say which kinds of equipment are being under-maintained, and thus causes problems in operation.

Experience from the maintenance can tell similar tales of excess maintenance. Currently items are being changed or dismantled for repair based on the requirements in the maintenance programmes. A qualified evaluation of the actual condition of the items, when coming in for maintenance will definitely lead to the fact that many maintenance intervals can be extended considerably.

The proof of this is that the current considerable cuts in maintenance based on funding and spares availability problem, have not caused the operational problem that should have been expected if there were no excess maintenance.

In addition to saving maintenance costs, cutting maintenance may generate two possible negative effects that has to be cared for properly.

Extending maintenance intervals will in some cases end up in too long intervals resulting in either operational problems or consequential damage to the rolling stock. If managed carefully, this risk can easily be outweighed by the savings in maintenance.

Stretching the maintenance intervals to the limit will also increase considerably the reliability and quality requirements for the maintenance. Currently, overrunning of maintenance intervals does only rarely seem to cause problems. Pressing the intervals, will mean that overrunning the intervals can cause serious operational problems or consequential damage, and it will mean that when maintenance is done, it will have to be done properly and carefully with the best quality spare parts whether new or refurbished.

Developing a good maintenance programme is a long and complicated balance between risk and consequences.

The main tool is a detailed and thorough knowledge of the rolling stock.

This knowledge comes from collecting hands-on experience with the state of the rolling stock for maintenance and detailed information from the experience in operation.

This information and experience gathering must urgently be initiated.

This will allow for the old schedules to be adjusted, up or down, so that the maintenance effort actually provides the best possible operative reliability for the resources spent.

For this purpose, a computer based Management Information System for maintenance is urgently needed.

For the management of the four maintenance levels and for the railways, it aims at :

- monitoring the availability of the rolling stock in order to monitor the efficiency of the maintenance functions ;
- measuring the quality of service provided to the railway customers;
- providing basis for investment decisions for rolling stock and maintenance facilities.

For each level of maintenance, it is required for :

- maintenance production scheduling and monitoring ;
- follow-up of failures and repair times, also called monitoring of Mean Time Between Failures and Mean Time To Repair ;
- monitoring spare parts consumption, and spare parts procurement
- providing basis for decisions for adjusting maintenance activities and maintenance intervals.

4.5 Spare parts management

On a long term basis, the target for the TRACECA region must be to be widely independent from outside sources for general spare parts representing the major part of the value of the spare parts procured, not necessarily for all spare parts. For the existing rolling stock this should be possible, but this will be more difficult for a new rolling stock, especially locomotives,.

Evidently the funding necessary for the procurement of spares must come forward from the mother railway. If the maintenance shops are to set up non-railway oriented business activities in order to acquire funding for spare parts or commodities, then long term development initiatives as described does not have any sense.

One further long term target to accompany the above is that within a 10 year time scale, there should not be any spare part production left in the main railway organisation. Such units should be branched off as legally independent entities, preferably under private ownership. This is described in the chapter on 4th level workshops.

The spare part supply is very often mentioned as a major problem. Most often, however, this is not a logistic problem. It is a basic matter of acquiring the necessary funding for spare parts from the mother railway or from workshops and depots.

So, funding of spare parts has never been a management concern before, but now, this area is in serious need of both management attention and funding.

It is a top management task to secure sufficient funding for spare parts from the mother railways that to some extend claims that they are profitable. The current development may cause serious damage to the performance and the lifetime of the rolling stock and it will set the reliability and safety of the operation at risk.

4.6 Spare parts procurement departments

Spare part consumption plans based on the old maintenance schedules exists. Considering this, and on the known/estimated prices, the yearly total value of planned spare parts consumption per item can easily be calculated.

Considering this, the spare parts are grouped into more general types of spare parts: brake equipment - windows - couplers - wiring - wheels - and so on. General types that one kind of factory is likely to be able to supply.

This list is then prioritised by spare part types of the highest value supplemented by the types most urgently needed.

This list is to be continuously updated, as maintenance plans are revised, and information on spare parts and suppliers are gathered.

The spare parts' procurement department will then have to (In consecutive order):

1. Make an overall survey of the production companies within the borders of the country, locate producers of items of similar nature to the needed spare parts, and start a development process to adapt the located production to the needs of the railway.
2. Considering the acquired knowledge of the production possibilities, producers with a production technology of a nature, similar to what is needed must be located. For these, the adaptations of the technology should be initiated in order that these in due cause, will be able to supply needed spare parts.
3. If no potential suppliers can be located, the feasibility of procuring the needed technology and know-how should be investigated. This, of course, is only feasible for kinds of spares that do not require high level know-how or large capital investment.

If a production can be started in this way, it should be branched off as a separate entity as soon as possible.

In parallel to these investigations the spare part procurement organisation should:

1. Keep the other similar organisations at other railways informed of their finding as they themselves should use the possibilities to use information from the others. To the extend possible, located suppliers should be supported by several railways.
2. Develop the knowledge, the skills and the routines for trading with the neighbouring countries, and eventually also for trading with the rest of the world.

And this second item is no simple task, in an environment with very limited support facilities such as shippers, currency transfer systems etc. and where the legal set of rules for commercial trade is still in the developing phases.

So the procurement process:

- Defining an order and getting it accepted.
- Obtaining cash for down payment.
- Getting this changed to the relevant currency.
- Travelling to the supplier and making the payment.
- Follow up on the production.
- Organising final payment.
- Organising the transport from the supplier.
- And getting all this into the accountancy system.

Require specialised skills. The practical problems are endless, and need specialised experienced personnel. No-one in the maintenance organisations is experienced in such procurement, and they should leave this to a specialised entity.

5. Maintenance facilities requirements

5.1 Structure of the maintenance facilities

On a long term basis, the maintenance facilities must be adjusted to the above proposed four levels of maintenance. This will mean that the number of maintenance facilities needs to be reduced, and the remaining facilities strengthened.

It will be necessary to establish a long term development plan, mapping out the long term need for the different levels of maintenance, and determine which facilities are to handle which kinds of maintenance for which parts of the overall fleet in the area.

It is evident, that some co-operation in-between countries, will be necessary for the higher levels of maintenance.

The facilities chosen must be developed in terms of equipment and skills. Most of the facilities seen need a general shine-up in order to bring them up to a good standard. Only a limited number needs major work that cannot be performed with skills and resources available locally.

As new locomotives are introduced, the maintenance facilities need to be upgraded accordingly. In the beginning only in limited number, but being extended gradually, as new locomotives begins to be in more widespread use. A major problem will be the implementation of electronics workshops and electronics maintenance technical requirements far above and beyond what is currently in daily operation.

It is only feasible to perform the highest levels of maintenance in a few places, so this will have to be done in co-operation between some of the countries. This same situation will apply to some of the 4. level shops.

5.2 Quantity and location of maintenance facilities

Facilities	Arm.	Azer.	Geo.	Kaz.	Kyr.	Tadj.	Tur.	Uzb.	Total
Second level									
Locomotive depots	1	2	2	19	2	2	2	3	33
Passenger coach depots	1	1	1	3	1	1	1	1	10
Wagon depots	2	2	1	7	1	2	2	4	21
Third level									
Locomotive workshops	-	-	1	1	-	-	-	2	4
Passenger coach workshops	-	-	1	1	-	-	1	-	3
Wagon workshops	1	1	1	7	1	1	1	4	17

Fourth level									
Diesel engines				1					1
Electric motors			1	1				1	3
Electric and electronic components	1				1		1		3
Brake system		1						1	2

6. Rolling stock manufacturing

6.1 Manufacturing structure

In the former times, investments for new rolling stock were fairly easy to obtain, providing that it was introduced in the investment planning in (very) due time. It was a simple management task to secure a stable flow of new rolling stock.

Even though the amortisation figured in the books, there was not much attention being paid to whether replacements of old stock were actually economically feasible or whether the volume of new rolling stock ordered was the absolute necessary minimum for the operation. Now, new rolling stock has ceased to come forward "on its own"

It is only natural that the railway management is seeking new ways of renewing the fleet. The old one does not work anymore. But the pressure on running an economically feasible railway, including the amortisation of new rolling stock, has drastically changed the balance between renewal and maintenance.

So funding for the basic maintenance of the existing rolling stock should be ranked considerably higher than attempts to renew the fleet. It is not evident that such renewal is economically feasible. But preserving the operational value of the current stock is evidently feasible or the railway should be closed.

The consequence is that the most economical service lifetime of the rolling stock is considerably prolonged compared to what was considered optimal in the FSU. This again has the consequence that the need for replacement comes later and thus that the previous volume of production of rolling stock is by far no longer needed.

As described previously, there are several Joint Ventures in development, specially within the locomotive production. Judging from the limited information available, it is the assessment that there will be a considerable excess capacity within the field of locomotive production in the FSU within a few years. Several of the Joint Ventures in development are based on large Russian companies that have actually maintained some production over the past years, meaning that they still have a reasonable number of skilled workers and an operational plant. In addition, several of these Joint Ventures are well advanced in the implementation process.

Concerning the production of passenger coaches, some initiatives are known in Russia..There were less focus on the continuous replacement of these kinds of rolling stock in the FSU, the difference between what was previously regarded to be the service lifetime, and what is now economically feasible, is not as significant as with the locomotives.

So replacement needs will still be a considerable amount of vehicles. Furthermore, several suppliers were located in countries outside the CIS, for instance GDR. The risk of developing excess production capacity for passenger coaches and freight wagons is considered to be low.

To this, one can add the fact, that a production of wagons or coaches on a limited scale is by far easier to be economically feasible than a small scale production of locomotives.

6.2 Manufacturing requirements

Until 2005, no manufacturing plan is required. Tests can be done to prepare the next period.

From 2005, some vehicles should be produced to replace the ofdest ones. The following table gives an estimate of the yearly production to be planned. The estimate is based on a yearly production of 10% of the mean term requirements of Alternative 1 and Alternative 2.

Type of vehicle	Number of vehicles to produce per year
Electric locomotives	50
Diesel locomotives	30
Shunting locomotives	75
Wagons	320
Passenger coaches	8,200

Chapter 4. Action plan

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1. Recommended actions

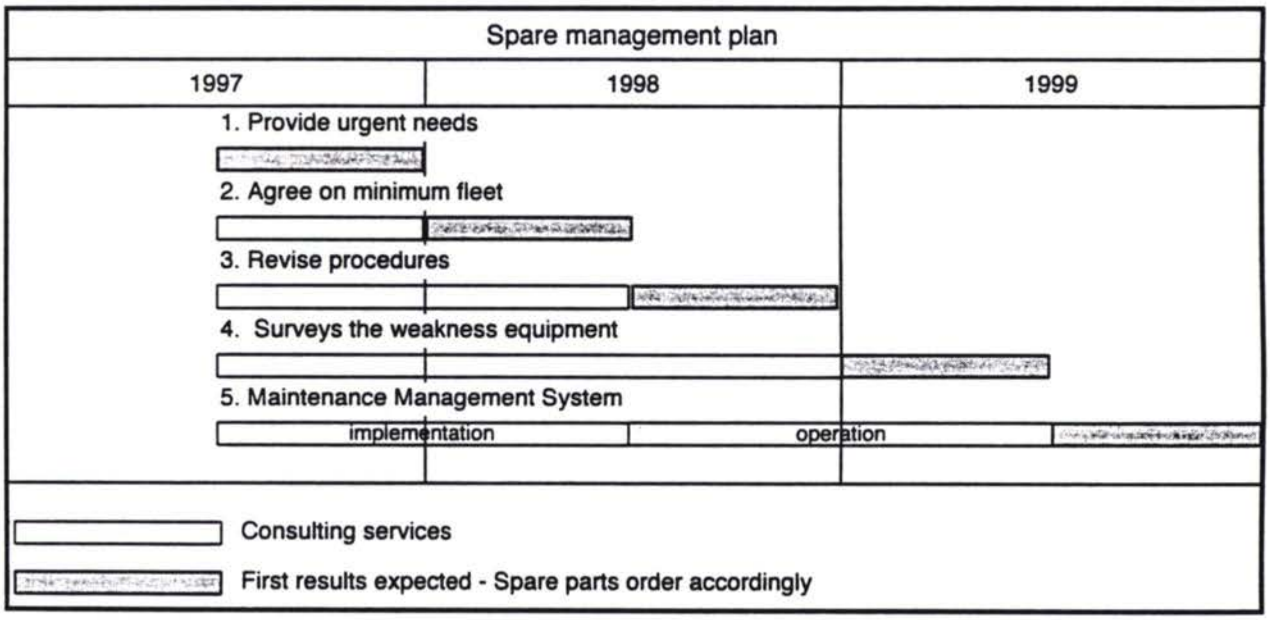
1.1 Management

1.1.1 Spare parts management

On a short term basis, some actions have to be taken in order to solve urgent deficiencies and to keep the railways running longer. Simultaneous actions are proposed :

- Provide the most urgent needs of spare parts from original sources in order to ensure the reliability of the maintenance.
- Agree on the minimum fleet of rolling stock to be maintained and, only for that rolling stock, purchase spares according to the current maintenance rules.
- Analyse spare consumption and weaknesses of components.
- Revise the maintenance rules in order to limit the unconditional replacement of spare parts and to limit over maintenance.
- Implement an efficient maintenance management system so as to order the relevant quantity of spare at the right moment and store the minimum but the required quantity of spare parts.
- Perform surveys in order to find out the real causes of failures of the weakest components and take measures to reduce consumption when possible. Some of those measures could be :
  - Optimise the periodicity of replacement : change the periodicity of unconditional replacement or introduce conditional procedures of replacement
  - Modify the weakest equipment
  - Adapt component from other providers who could supply more reliable components than the original ones.

The results of those actions may not be expected immediately. Therefore, the following action plan is proposed so as urgent decisions are applied :



1.1.2 Management Information System (M I S) implementation

M I S is required in every depot, workshop and specialised shop to :

- Follow up the performances and reliability of the vehicles, equipment or components produced or attached to that entity
- Perform statistics and management board to facilitate decision making and spare parts management
- Plan the production of the entity and schedule the operations to be carried out shortly

The implementation of an efficient M I S requires a thorough analysis of :

- Computer and software
- Training
- Test in a pilot area prior to be applied everywhere.

1.1.3 Implementation of business units

Taking into consideration the large scale of such restructuring, the implementation of a maintenance organisation in business units should be tested in a pilot area prior to be applied in the whole area.

Then, for each level of maintenance :

- Define the organisational chart, and the functions and responsibilities of each position of the chart.
- Define the procedures, the relationships between each position of the same entity and the relationships between the entities of the four levels.
- Define the qualifications required for each position, and analyse the existing qualification of the personnel. Develop a training plan and a plan for appointment of new personnel where required.
- Define the tooling and equipment required by the new functions, including the quality control and monitoring.
- Develop one pilot shop for each level. The Management Information Systems should be independent, but must be able to draw information from a later common database.

1.1.4 Specialised workshop implementation

Whatsoever the way follows to implement the maintenance organisation in 4 levels, specialised workshops (4th level), can be implemented all over the area.

Specialised workshops need to be implemented for the "back-shop" maintenance and rehabilitation of spare parts dismantled from locomotives in operation. When possible, these maintenance shops should be branched of from the primary organisation of the railway, either as entities owned by the railway, or as separate entities in their own right.

In particular, implementation of specialised workshops are recommended for the maintenance of :

- Traction motors and generators
- Electric equipment
- Batteries
- Brake equipment and pneumatic equipment
- Compressors
- Bearings

Joint venture with Western manufacturers would facilitate the introduction of new management, modern tooling, and new technology when required. In that case, detailed studies are required to determine the suitable technology to be applied :

- Introduction of Western components

- Replacing of equipment by new one from a complete new technology
- Use the same technology.

Without any collaboration with a Western specialist, it seems difficult to introduce a new technology. In that case, the unavailability of the Technical Specificaitons and original spare parts would constitute a major constraint, limiting the efficiency and the credibility of the new specialised workshop to provide services to neighbouring railways.

1.2 Rolling stock

1.2.1 Wagons

Refurbishement of tank wagons will have to be initialised within 3 to 5 years.

Preparation of container plateforms will have to be initialised as soon as the requirements will be known.

1.2.2 Passenger coaches

Major overhaul of coaches including refurbishement of heating system, glazing, general apparence of the vehicles will have to be performed during overhaul of vehicles and could last about 10 years. It is recommended to carry out those overhaul in Almaty, Yerevan and Tbilisi, where workshops are able to do so if good quality components are provided.

1.2.3 Locomotive pilot tests

Tests of Western diesel engins are already in progress in Kazakhstan. The tests should be followed up to be applied in other countries in case of satisfactory results.

Negotiations are already in progress in Uzbekistan to acquire a new generation of AC electric locomotives.

Negotiations are also in progress in Georgia to set up a production of electric locomotives in Tbilisi plant. It is recommended to test the new generation of locomotives prior to initiate the production.

1.3 Maintenance facilities

1.3.1 Upgrading of depots and workshops

Restructuring the maintenance in business units will involve closing several depots, reducing the activities of some others and upgrading those which should be kept working.

Detailied plans are proposed for each country. They are developed in annexe.

About half of the depots are proposed to be closed, however, in remote area it is recommended to keep a portion of the facilities so as to be able to perform line inspections (TO1, TO2) and small repairs. This measure is required as long as this technology of locomotive is used. This measure could also allow to solve human resources problems when depots will have to be closed. It will constitute an intermediate situation for personnel rid of.

The upgrading of the remaining depots will consist of :

- Set up an office for Quality control and Monitoring staff. This office will be fitted with computers and measure and test apparatus.

- Refurbishement or replacement of old machinery when required.. However, the number of depots and workshops is too high to have allowed the Consultant to visit all of them. Therefore, several actions are proposed, but they do not constitute a comprehensive list. It should also be pointed out that most of the depots and workshops visited in Central Asia are in good conditions and do not need extensive refurbishement.
- In most of the depots and workshops visited, more care should be borne for cleanliness and security of personnel. For that purpose, maintenance of buildings and machinery should be developed. Such measure will certainly increase the productivity in the facility and will reduce accidents of personnel.

1.3.2 Specific modifications

Specific modifications will be necessary to implement a maintenance organisation in business units and to implement specialised shops. Modifications could include :

- Implementation of administrative facilities to accommodate : new management staff, maintenance management system, quality control staff and accountancy.
- Procurement and installation of computers required for the preceding functions.
- Modifications of some facilities to split the maintenance functions : move of machinery, split of spare parts storage areas, specific access could be required, etc,...

1.3.3 Paint shop

The implementation of a modern paint shop is recommended in Central Asia in order to increase the vehicle availability and the quality of the painting which could withstand between 10 to 15 years. This paint shop will serve every kind of vehicles of the existing technology as well as all of the future one. It is recommended to implement such paint shop within the next 3 to 5 years.

The paint shop will use high quality painting and will be fitted with :

- Surface preparation area to : remove old paint coating, apply a protection coating and put paper sheets and paper strips on all part to be protected.
- Closed and clean room for painting. The room could be fitted with electrostatic painting equipment which ensures a better quality of painting and a better protection of workers. The temperature and hygrometry of the room should be controled in order to secure drying.
- Post painting area to remove all protections and re-assemble fittings.

The fleet of Caucasus country is not large enough to justify, in a short term basis, such investment. However, good quality paint and good painting preparation (in particular removal of old paint and application of a protection coating) will ensure satisfactory painting which will provide a better apparence of the vehicles and a better withstanding of the coating. Once in the lifetime, each vehicle may be sent to a specialised paint shop.

1.4 Manufacturing

1.4.1 Tbilisi locomotive plant

It is recommended to encourage the negotiations of a joint venture with a Western manufacturer to re-open the Tbilisi plant in order to produce new generation of electric locomotives. That production is not necessary a comprehensive production of all equipment and component as it was. Production of new electric locomotives for Caucasus countries will be required within 10 to 15 years. Negotiations, tests, implementation should start as soon as possible in order to reach such target.

1.4.2 Almaty passenger coach plant

It is also recommended to encourage the negotiations of a joint venture with Western manufacturer to set up a passenger coach plant in Almaty. Production of new generation of coaches will be required within 5 to 10 years. Prior to settle any agreement, it is recommended to perform a thorough traffic forecast and to restructure the passenger services. Specilfic design, such as inter-city coaches could be required. Coaches with ability to run at 200 km/h should be designed to match the objectives of future operation.

1.4.3 Local manufacturing development

Specific consulting services are required to determine :

- The components to be produced locally
- The quantity and the technology of those components
- The best location for such a production.

2. Investment plan

2.1 Management

It includes :

- implementation of Management Information System (incl. Maintenance Management System)
- Procedures definition
- Management training
- Negotiate a location and type of specialised workshop to implement a 4th level structure

Restructuring should be implemented on a short term basis (1 to 5 years)

in millions USD	Arm.	Azer.	Geo.	Kaz.	Kyr.	Tadj.	Tur.	Uzb.	Total
Materials	0.1	0.2	0.2	1	0.1	0.1	0.2	0.3	2.2
Consulting	0.4	1.8	1.8	2	0.4	0.4	1.8	2.7	11.3
Implementation of a specialised shop (consulting)	0.5	1	1	2	0.5	0.5	1	2	8.5
Total	1	3	3	5	1	1	3	5	22

2.2 Rolling stock investment plan

in millions USD	**Arm.**	**Azer.**	**Geo.**	**Kaz.**	**Kyr.**	**Tadj.**	**Tur.**	**Uzb.**	**Total**
Urgent need of spare parts	2.5	4	3.75	5.25	1.05	1.05	2.75	2.8	23.15
Passenger coaches refurbishment	8	30	14	200	10	10	30	45	347
Tank wagon refurbishment	5	7.5	-	25	-	-	7.5	-	45
Test of modern traction power	-	-	5	5	-	-	-	-	10
Total	15.5	41.5	22.75	235.25	11.05	11.05	40.25	47.8	425.15

2.3 Maintenance facilities investment plan

in millions USD	**Arm.**	**Azer.**	**Geo.**	**Kaz.**	**Kyr.**	**Tadj.**	**Tur.**	**Uzb.**	**Total**
Facilities upgrading	5	15	16	100	2	1.5	4	22	165.5
Pilot workshops (3rd/2nd level tests)	-	-	-	-	-	-	-	4	4
Locomotive workshop	-	-	10	10	-	-	-	10	30
Paint shop	-	-	-	10	-	-	-	-	10
Implementation of specialised shops (4th level)	10	10	10	10	10	-	10	10	70
Total	15	25	36	130	12	1.5	14	46	279.5

2.4 Manufacturing investment plan over the next 10 years

in millions USD	Arm.	Azer.	Geo.	Kaz.	Kyr.	Tadj.	Tur.	Uzb.	Total
Consulting in local manufacturing development	-	-	3	5	-	-	3	3	14
Locomotive plant	-	-	50	-	-	-	-	-	50
Passenger coach plant	-	-	-	50	-	-	-	-	-50
Total	-	-	53	55	-	-	3	3	114

End of part 2