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Rail Maintenance Central Asia:
Infrastructure Maintenance 2

# Draft Final Report

July 1997

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Module C

# DRAFT FINAL REPORT

| | | |
|---|---|---|
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| Project Number: | TNREG 9310 | |
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# Module C

## Feasibility Study for the Chardzhev Bridge (Turkmenistan)

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**ANNEXES**



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## Executive Summary

Having completed both technical and economic evaluations of the Chardzhev Bridge and the transport corridor of which it forms part, the following points summarise the Consultant's principal findings.

### *Future Regional Economic Activity and Future Traffic Levels*

Various scenario forecasts have been developed to project the levels of traffic which can be expected to pass over the Amu Darya River at Chardzhev within the next ten years or so. Such forecasts do, however, contain considerable risks (see next comment) which need to be taken into account.

The most **optimistic** traffic forecast scenarios give the following results:

**Rail traffic** will increase from the present 22-23 train pairs daily to 47 (i.e. double)

**Road traffic** will increase by 2005 to double and to 2010 to triple present levels.

### *Risks and Assumptions*

**The Consultant wishes to draw attention to the uncertainty of attempting to project future economic activity in an environment such as that in Turkmenistan, where there is little experience of market economic processes.**

Attempting to forecast traffic levels over the Amu Darya at Chardzhev involves additional risk factors, besides those influenced solely by economic activity in Turkmenistan, particularly:

- changes in economic activity in neighbouring countries (influencing transit traffic)
- future changes in modal split (rail:road)
- construction of additional river crossings at other locations such as Kerki
- construction of alternative rail routes in neighbouring countries (e.g. Uzbekistan)
- construction of additional rail routes within Turkmenistan (e.g. North-South Corridor)
- development of international trade by Iran
- resolution of civil war and conflicts in Afghanistan and Tadjikistan

### *Physical Condition of the Rail Bridge*

The surveys undertaken by the Consultant show that there are short-term measures which should be taken urgently to ensure continued operation, but that realistically **the bridge should be replaced within the next ten years.** Furthermore, the **existing piers should not be utilised for a new bridge**.

The necessary short-term measures have been communicated to the appropriate Railway authorities who have noted the urgency of the situation.

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***Route Capacity in Relation to Traffic Forecasts***

Both of the existing river crossings **will need to be replaced** to cope with the projected level of traffic beyond 2005.

- the existing rail bridge **has insufficient capacity** given the need to restrict train sizes, speeds and axleloads in view of its present condition
- the existing pontoon road bridge is a serious bottleneck and **is already operating at virtually full capacity**

Therefore, to cope with projected traffic levels, **replacement of both existing rail and road river crossings is required** as soon as possible.

***Financial and Economic Analysis:***

The estimated capital outlay for the recommendations contained in this report amount to approximately USD100million over the next ten to fifteen years. This figure includes the recommended refurbishment of the existing bridge and the construction of its replacement. In addition more funds must be budgeted than at present for the upkeep of the bridge so that future problems can be avoided.

It must be decided whether the Railway is to be the owner of the crossing or the Government through the appropriate ministry. In connection with this decision it must be further decided whether a toll is to be charged to road traffic users to offset the costs of operating and maintaining the new structure. The present pontoon bridge is privately owned and tolls are levied for its use.

Using the current tariff structure for tolls on the pontoon bridge as a guideline, it is estimated that at this level the revenues so generated will be sufficient to cover operating costs should such a decision be taken.

In the case where it should be decided not to levy tolls, the annual costs for upkeep of the bridge, together with depreciation charges, will amount to approximately USD3.5 million once construction has been completed and these charges will need to be covered by the Railways operations or through Government assistance.

***Investment Strategy***

As mentioned above it must be decided whether ownership of the bridge is to be in the hands of the Railway or the Government.

It is presumed that, independent of the question of ownership, outside financing will be required for the measures recommended. Under existing conditions it is expected that the debt financing of these measures will amount to between USD6 million and USD7 million per annum, depending on the conditions negotiated. This level is expected to be progressively reached between the years 2006 and 2012.

The financing of this debt will not be totally covered by the net revenues from tolls raised for use of the bridge if the tariffs remain at their current levels. Should it be decided therefore, that the level of the tolls charged should not be increased or that the use of the bridge be free, a commitment must come from either the Government or the Railway to undertake the repayments, or a portion thereof.

Since the financial and accounting systems currently used are essentially those in force in the former Soviet Union, a detailed audit of the financial situation and the results of operations of the Railway will need to be undertaken in connection with the funding of the recommended measures.

***Final Recommendation***

It is strongly recommended that the engineering option **'combined road and rail bridge on the site of the existing pontoon crossing'** be adopted and implemented as soon as possible, along the lines suggested in this report.

## Abbreviations and Conventions used in this Report

### *Conventions:*

All costs and prices are expressed in US Dollars (USD) or Turkmenistan Manat (TMM) at the exchange rates shown in *Annex A: Currencies Used in Cost Calculations:.*

All units of measurement are in the Metric System unless otherwise shown.

Place names are transliterated from Cyrillic into Latin characters according to English language conventions (other than for locomotive classes and other technical abbreviations where this would prove confusing). Current (post-independence) names are used throughout, with previous names given in brackets where appropriate. The commonly used spelling of Chardzhev has been used in this report; the Consultant is aware that the new Turkmenistan orthography renders the name as Çärjew but has used the older spelling to avoid confusion and hopes that no offence is caused thereby.

### *Abbreviations:*

| | |
|---|---|
| ADT | Average Daily Traffic (vehicles per 24 hour period) |
| ARE | Austria Rail Engineering |
| ATS | Austrian Schilling |
| BoQ | Bill of quantities |
| C&W | Carriage and Wagon |
| CG | Cross girder |
| CIS | Commonwealth of Independent States |
| d.c. | direct current |
| DEM | Deutsche Mark |
| DS | Downstream |
| DWA | Deutsche Waggonbau AG |
| EBRD | European Bank for Reconstruction and Development |
| GDP | Gross Domestic Product |
| GVW | Gross Vehicle Weight |
| HV | High voltage |
| ISDN | Integrated Services Digital Network |
| km | kilometres |
| kWh | kilowatt hour |
| KZT | Kazakstan Tenge |
| LC | Lower chord |
| LF | Lower flange |
| LG | Longitudinal girder |
| Mbit | megabit, or 1000 bits |
| MG | Main girder |
| PABX | Private Automatic Branch Exchange |
| TDDY | Turkmenistan State Railway |
| tkm | tonne kilometres |
| TMM | Turkmenistan Manat |

| | |
|---|---|
| TRACECA | Transport Corridor Europe Caucasus Asia |
| UC | Upper chord |
| UF | Upper flange |
| US | Upstream |
| USD | United States Dollars |
| USSR | Union of Soviet Socialist Republics |

# 1 Introduction

## 1.1 About this Report

This Report summarises the research and recommendations made by the consulting group consisting of the following companies:

DE-Consult, Deutsche Eisenbahn-Consulting GmbH, Germany
Austria Rail Engineering (ARE), Austria

in association with Systra, France

and with the following local partners:

Turkmentransmost, Ashgabat, Turkmenistan
Turkmenzheldorproject, Ashgabat, Turkmenistan
Lebapskoye Road Operation Authority, Chardzhev, Turkmenistan
Turkmendorproject, Chardzhev, Turkmenistan

This consulting group is referred to in the following Report collectively as 'the Consultant'.

The following Report is produced in accordance with the contract issued by the European Union's Tacis Programme for the TRACECA States, Project Number TNREG 9310, 'Rail Maintenance Central Asia, Infrastructure Maintenance 2 Project'. This Project was broken down into three primary modules:

**Module A:** Feasibility Study for upgrading the Aktau-Bejneu line in Kazakstan

**Module B:** Proposals and training to improve freight and passenger traffic on the TRACECA route

**Module C:** Feasibility Study for the Chardzhev Bridge (Turkmenistan)

This Report is concerned entirely with **Module C** as above described.

## 1.2 Consultant's Personnel and Timescale of Study

The initial research and field work for the Project was commenced by the Consultant's local partners (see 1.1 above) in Ashgabat and Chardzhev from May 1996 onwards. No other local partner was involved in this module of the Project.

The Consultant's European experts worked in Ashgabat and on site in Chardzhev, all within Turkmenistan, together with the local partners from late August to November 1996.

The European experts engaged in this module of the Project were:

Mr Frank Prescha, Project Manager
Mr Norman Griffiths, Team Leader
Dr Jutta Völker, Transport Economist
Mr Fritz Brandstetter, Bridge Specialist
Mr Bernard Draper, Cost and Tariff Specialist
Mr Günter Fleischmann, Infrastructure Planner
Mr Frédéric Davanture, Investment Planner

The final on-site input to the Project was completed by the Investment Planner in April-May 1997.

The Consultant was impressed with the professionalism and experience of the discussion partners. This was true for the Consultant's partners as well as the Railway Organisation's staff.

# 2 Traffic and Revenue Forecasts

## 2.1 Volume and Structure of the Present Traffic

### 2.1.1 Brief Overview of Relevant Socio-Economic, Economic and Transport Data of Turkmenistan

***Population***

Turkmenistan is a Central Asian country bordering in the south on Iran and Afghanistan. The neighbouring countries in the north are Uzbekistan, Tadjikistan and Kazakstan.

The population in 1995 was approximately 4.45 million, the average growth since 1991 being around 100,000 per annum. About 45% of the population is in urban areas.

Turkmenistan is divided into five administrative districts (Velayats) plus the city of Ashgabat:

- Balkan
- Akhal
- Mary
- Dashkovuz
- Lebap.

Chardzhev is the second biggest city and the centre of the Lebap Velayat.

***Table 2-1: Population in Turkmenistan***

| Population ('000 inhabitants) | 1990 | 1992 | 1994 | 1995 |
|---|---|---|---|---|
| Turkmenistan in total | 3,622 | 3,808 | 4,361 | 4,450 |
| of which Lebap Velayat | 734.4 (in 1989) | 795.4 | 911.2 | 930.6 |
| of which city of Chardzhev | 164 | 169 | 176 | 176 |

*Source:* *The Economy of Turkmenistan 1994, Statistical Yearbook Goskomstat Ashgabat 1996*

***Economy***

The economy of Turkmenistan is characterised by a considerable decline following the break-up of the USSR, and is in a very difficult situation at present.

GDP has fallen significantly over the last few years:

1993/1992 by - 10.0%
1994/1993 by - 18.8%
1995/1994 by - 13.9%

The Gross Domestic Product totalled TMM 464,458 million (at market prices) in 1995, which averaged USD 100 per capita.1

The decline in economic performance can be demonstrated in the following table:

***Table 2-2: Economic Development of Turkmenistan***

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|
| Production of national income (1990 = 100) | 100 | 95 | 130 | 104 | 80 | 83 |
| Industrial production (1990 = 100) | 100 | 105 | 89 | 93 | 70 | 75 |

*Source:* *The Economy of Turkmenistan 1994, Statistical Yearbook Goskomstat Ashgabat 1996*

As in other ex-USSR Central Asian countries, Turkmenistan has also experienced a rapid decline in its agricultural output since 1989.

The level of the economic base of Turkmenistan is not high, but the country possesses important natural resources (gas, sulphur, magnesium and some crude oil). The solid base of raw materials in the country favours modern industrial development.

Current policy is to give priority to the development of production complexes for polyethylene, fire proofing and construction materials and for the development of facilities for the production of fertiliser. Other areas of growth are the production and processing of cotton, plastic materials and food products.

Economically, it was decided that priority should be focused on the solution of elementary problems such as the supply of food and basic consumables for the population.

The external trade of Turkmenistan has developed positively in recent years. The main trading partners are other CIS-countries.

[1] Source: *Länderreport Turkmenistan-Wirtschaftstrends zur Jahresmitte 1996, Bundesanstalt für Auslandsinformation 1996*

***Table 2-3: External Trade of Turkmenistan***

| | | **1994** (1) | **1995** (2) | **1996 (Jan.-June)** (3) |
|---|---|---|---|---|
| Export | USD million | 1,722 | 1,737 | 950 |
| | 1994=100 | 100 | 101 | 110*) |
| of which CIS-countries | USD million | 1,310 | 1,172 | 684 |
| | Share of CIS-countries per year (%) | 76 | 68 | 72 |
| Import | USD million | 673 | 720 | 543 |
| | 1994=100 | 100 | 107 | 161 |
| of which CIS-countries | USD million | 345 | 629 | 196 |
| | Share of CIS-countries per year (%) | 51 | 87 | 36 |

*) Estimate for the whole year on the base of the first half-year

*Sources:* *(1) Short-Term Economic Indicators Transition Economies No. 4/1996 OECD, Centre for Co-operation with the Economies in Transition, Paris 1996*
*(2) Report about the Activities in the Field of External Trade of Turkmenistan in 1995, Goskomstat Ashgabat 1995 (unpublished)*
*(3) Socio-Economic Results of Turkmenistan in January-July 1996 (Statistical Bulletin) Goskomstat Ashgabat 1996*

99% of Turkmenistan exports consisted of natural gas (61%), cotton and cotton products (28%), oil products (6%) and electric energy (4%) in 1995.

Turkmenistan imports are characterised by a high share of trade with other CIS-countries. The main commodities of these imports were machines and industrial equipment, textile products and metals in 1995.

***Freight Traffic***

The freight traffic volume by rail has been decreasing since the beginning of the 1990s due to the economic changes in the whole area of the former Soviet Union. The transported freight volume totalled 13.5 million tonnes in 1995, compared to 30.6 million tonnes in 1985. That is a decrease of 56% in eleven years.

Approximately 50% of freight traffic volume is currently construction materials, 25% oil and oil products.

Road traffic is generally involved in local distribution, with an average trip distance of 15.1 km., but road traffic volume is growing quickly.

The volume of freight traffic by road was 210 million tonnes in 1994, a reduction of 4% in comparison to 1985.

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In the first seven months of 1996, rail traffic was 20% less than the corresponding period in 1995, whereas road traffic was 34% higher.2

The following table shows the annual transport volumes by rail and road in Turkmenistan 1985-1995.

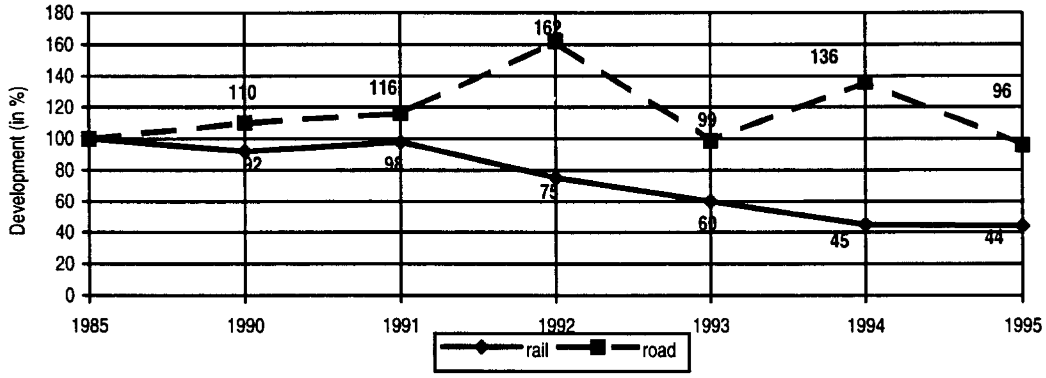
***Table 2-4: Freight Traffic in Turkmenistan (million tonnes)***

| **Year** | **1985** | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** |
|---|---|---|---|---|---|---|---|
| **Railway** | | | | | | | |
| Volume in total | 30.6 | 28.1 | 30.0 | 22.8 | 18.4 | 13.9 | 13.5 |
| *of which:* | | | | | | | |
| Oil and oil products | 7.5 | 6.2 | 7.7 | 5.4 | 4.2 | 3.5 | n.a. |
| Construction materials | 17.5 | 15.9 | 14.6 | 11.1 | 8.9 | 7.0 | n.a. |
| Grain | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | n.a. |
| **Road** | | | | | | | |
| Volume in total | 219.6 | 240.8 | 253.8 | 356.7 | 218.1 | 298.9 | 210.3 |

*Sources:* - *The Economy in Turkmenistan in 1994, Statistical Yearbook Goskomstat Ashgabat 1996*
- *Turkmenistan in Figures in 1995, Goskomstat Ashgabat 1996*

The following diagram shows the relative development of transport volumes by rail and road in the period from 1985 to 1995.

***Figure 2-1: Development of Freight Traffic by Rail and Road (index 1985=100)***




2 Source: Socio-Economic Results of Turkmenistan in January-July 1996 (Statistical Bulletin) Goskomstat Ashgabat 1996

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***Passenger Traffic***

In comparison with freight, the development of passenger traffic shows different trends:

- long-distance traffic by rail increased from 1985 to 1994 by 26%; 3.4 million passengers were carried in 1994.
- local rail traffic has been decreasing since 1985. The 1994 volume was approximately one-third of that in 1985.
- bus traffic has shown a decline in passenger numbers but an increase in average distance travelled, indicating strengthening in demand for the medium and long-distance services.
- air traffic shows a small decline in passenger numbers (from 2.1 million in 1985 to 1.9 million in 1994) but also a reduction in average journey distance (from 1386 km per traveller in 1985 to 1083 km in 1994). One of the reasons of this development is probably the independence of Turkmenistan from the former central administration in Moscow and the consequent reduction in business trips between Turkmenistan and Moscow.

***Table 2-5: Passenger Traffic in Turkmenistan***

| | | 1985 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|
| **Railway traffic** | | | | | | | |
| Long-distance traffic | (million passengers) | 2.7 | 2.6 | 2.7 | 2.5 | 3.0 | 3.4 |
| | 1985 = 100 | 100.0 | 96.2 | 100.0 | 92.6 | 111.1 | 125.9 |
| Suburban traffic | (million passengers) | 4.4 | 5.6 | 2.9 | 3.4 | 1.9 | 1.4 |
| | 1985 = 100 | 100.0 | 127.3 | 65.9 | 77.2 | 43.2 | 31.8 |
| **Bus traffic** | | | | | | | |
| Volume | (million passengers) | 337.7 | 309.3 | 273.9 | 252.1 | 273.1 | 280.3 |
| | 1985 = 100 | 100.0 | 91.6 | 81.1 | 74.6 | 80.9 | 83.0 |
| Average travel distance | (km) | 8.9 | 11.6 | 13.1 | 13.7 | 12.6 | 13.6 |
| **Air traffic** | | | | | | | |
| Volume | (million passengers) | 2.1 | 2.2 | 2.1 | 1.5 | 1.7 | 1.9 |
| | 1985 = 100 | 100.0 | 104.8 | 100.0 | 71.4 | 81.0 | 90.5 |
| Average travel distance (km) | | 1,386 | 1,572 | 1,635 | 1,302 | 1,125 | 1,083 |

*Source:* *The Economy in Turkmenistan in 1994, Statistical Yearbook Goskomstat Ashgabat 1996*

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### 2.1.2 Short Description of Traffic Connections via the Chardzhev Bridges and their Catchment Area

Near the city of Chardzhev two bridges cross the Amu Darya River: the railway bridge and the pontoon bridge for road vehicles.

Both bridges connect the left bank of the Amu Darya River with its right bank and have a major importance for rail and road traffic, because they form part of an international transport link, as well as for local traffic between local communities. These are situated on the right bank of the Amu Darya and the city of Chardzhev, the capital of the Lebap Velayat and an important regional centre.

The Turkmenistan-Uzbekistan border (Farap-Khodshdavlet) is situated about 30 km north of the bridges.

Figure 2-2 gives an general overview of the relevant traffic network (rail and road) in Turkmenistan in general and the traffic routes running via the Amu Darya River between Chardzhev and Farap.

***Railway Bridge***

The Chardzhev rail bridge is the only such crossing of the Amu Darya River in the Central Asian region. Several railway routes converge on this bridge (see Figure 2-2)[3]:

**1. Farap - Chardzhev**

This section is significant for local traffic between the localities situated on the right bank of the Amu Darya and the city of Chardzhev on the left bank of the river, especially the village of Farap, the District of Farap (subsequently named Farap Etrap) and the community of Dzheykun (part of Chardzhev city) and the city of Chardzhev itself, the capital of the Lebap Velayat and the political, economic and cultural centre of the whole region.

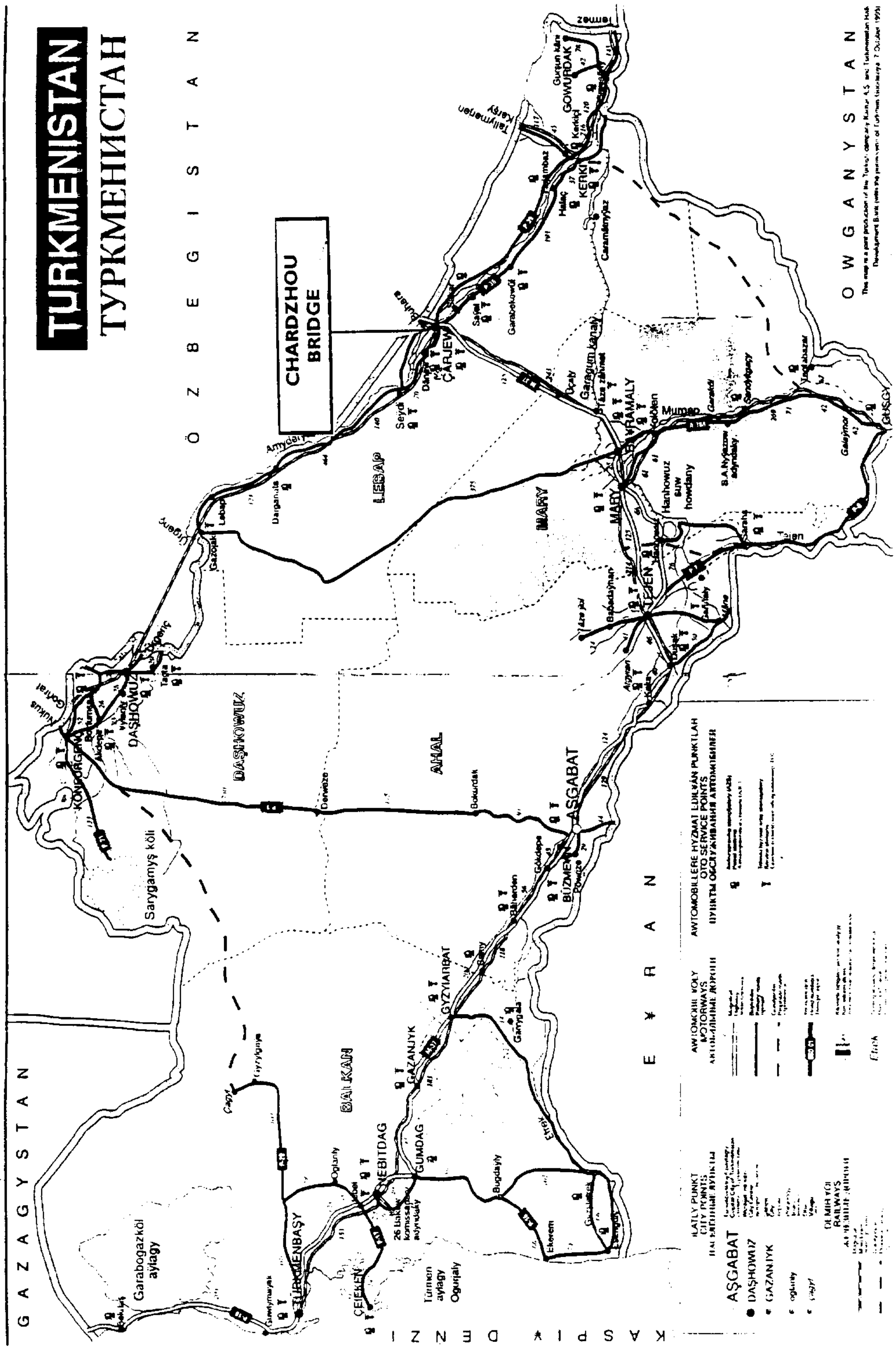
**2. Farap - Mary - Ashgabat - Turkmenbashy (Krasnovodsk)** ➠ *Rail ferry connection to Baku (Azerbaijan)* ➠ *Transcaucasia* ➠ *Seaports on the Black Sea /Poti* ➠ *Europe*

This route is a section of the defined Transcaspian Transport Corridor between Uzbekistan, Turkmenistan, Azerbaijan and Georgia. Moreover the connection is important for transportation from/to Europe and Turkey.

**3. Farap - Mary - Tedshen-Serakhs** ➠ *Meshed /Iran* ➠ *Teheran* ➠ *Seaports on the Persian Gulf* ➠ *Turkey* ➠ *Europe*

[3] Information supplied by TDDY

***Figure 2-2: Traffic Network of Turkmenistan***



This connection is a significant section of the international transport corridor known as the 'New Silk Road'. The connection has a growing importance for international transport between the Central Asian countries, the Asian part of Russia, China, Mongolia to Iran, and especially to the seaports on the Persian Gulf; and to the Indian subcontinent and further East Asian countries. The opening of the new Turkmenistan-Iran border crossing between Serakhs and Meshed in 1996 has led to new transport links between the above countries via Chardzhev.

A comprehensive description of the 'New Silk Road' link is given in Chapter 2.2.2.

**4. Farap-Chardzhev-Gazodshak (Turkmenistan/Uzbekistan border)** ➠ *Pinyak /Uzbekistan* ➠ *Transit via Uzbekistan* ➠ *Tashaus* ➠ *Uzbekistan (Kungrad)* ➠ *Kazakstan (Bejneu-Makat)* ➠ *Astrakhan (Russia)*

This route is important for traffic between various parts of Uzbekistan, because at present there is no direct railway connection within Uzbekistan between the East Uzbek region (Tashkent, Samarkand, Bukhara etc.) and the Karakalpakia region (Nukus, Urgentzh). All traffic must be routed through Turkmenistan and via the railway link over the Chardzhev Bridge. Such traffic can be considered as 'corridor traffic' via the Chardzhev Bridge.

There is currently a project to reduce the present corridor by constructing a new railway link within Uzbekistan (see Chapter 2.2.2).

**5. Farap-Chardzhev-Mary-Kuzhgy** ➠ *Afghanistan*

This link running via the Chardzhev bridge is also very important for transport between the Central Asian countries and Afghanistan.

**6. Chardzhev-Farap** ➠ *Khodshadavlet -Transit via Bukhara - Nizhan (Uzbekistan)* ➠Talimardzhan- Kelif ➠ *Tadjikistan*

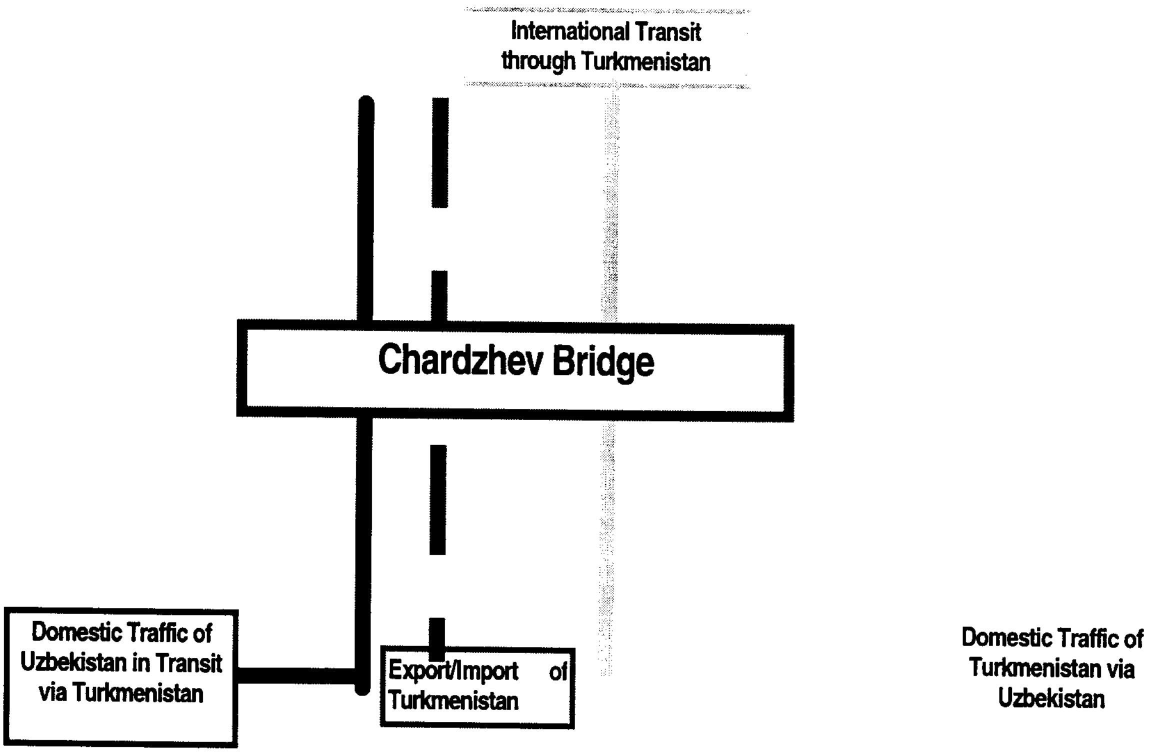
This railway link is significant for traffic from central and western Turkmenistan towards the east of the country since there is no direct railway link; all traffic has to be routed over the Chardzhev Bridge and through Uzbekistan.

The connection is also important for transport between Tadjikistan and Turkmenistan as well as to Turkmenbashy seaport and the seaports on the Persian Gulf.

A direct railway link between Chardzhev and Kerki on the left bank of the Amu Darya River is under construction in order to avoid the need to transit Uzbekistan territory (see chapter 2.2.2).

The following figure gives an general overview about the main transport routes running via the Chardzhev Railway Bridge.

*Figure 2-3: Rail Traffic Flows using Chardzhev Bridge*




***Road Pontoon Bridge***

The pontoon bridge is significant for

- international traffic within Central Asia and between Central Asia and Iran, Turkey etc.
- local traffic (freight and passengers) between the communities on the right bank of the Amu Darya (as for the railway bridge).

The pontoon bridge is crossed by the M37 Turkmenbashy - Ashgabat - Chardzhev (➠Uzbekistan➠Central Asia) road. This road forms a significant connection for:

- **domestic traffic** within Turkmenistan, especially between Turkmenbashy, Ashgabat, Mary and Chardzhev
- **international traffic** between the other Central Asian countries, the Asian part of Russia and Turkmenbashy-Transcaucasus-Europe, Iran/seaports on the Persian Gulf/Turkey.

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From the M37 road there are several connecting roads with significance for the traffic via the pontoon bridge, e.g.

| | |
|---|---|
| R36 | Chardzhev (M37) - Kerki - ➠ *Uzbekistan/ Tadjikistan/ Afghanistan* |
| R35 | Chardzhev (M37) - Dargan-Ata- Akhak ➠ *Uzbekistan* |
| R39 | Farap(M37) - Khodzhambaz - Kerkichi |

Moreover there are further roads in southern Turkmenistan which are important for international road traffic:

| | |
|---|---|
| R7 | Tedzhen-Serakhs (➠ *Iran)* |
| A388 | Mary - Kuzhgy (➠ *Afghanistan*) |

The next figure shows the road routes which are significant for the road bridge near Chardzhev.

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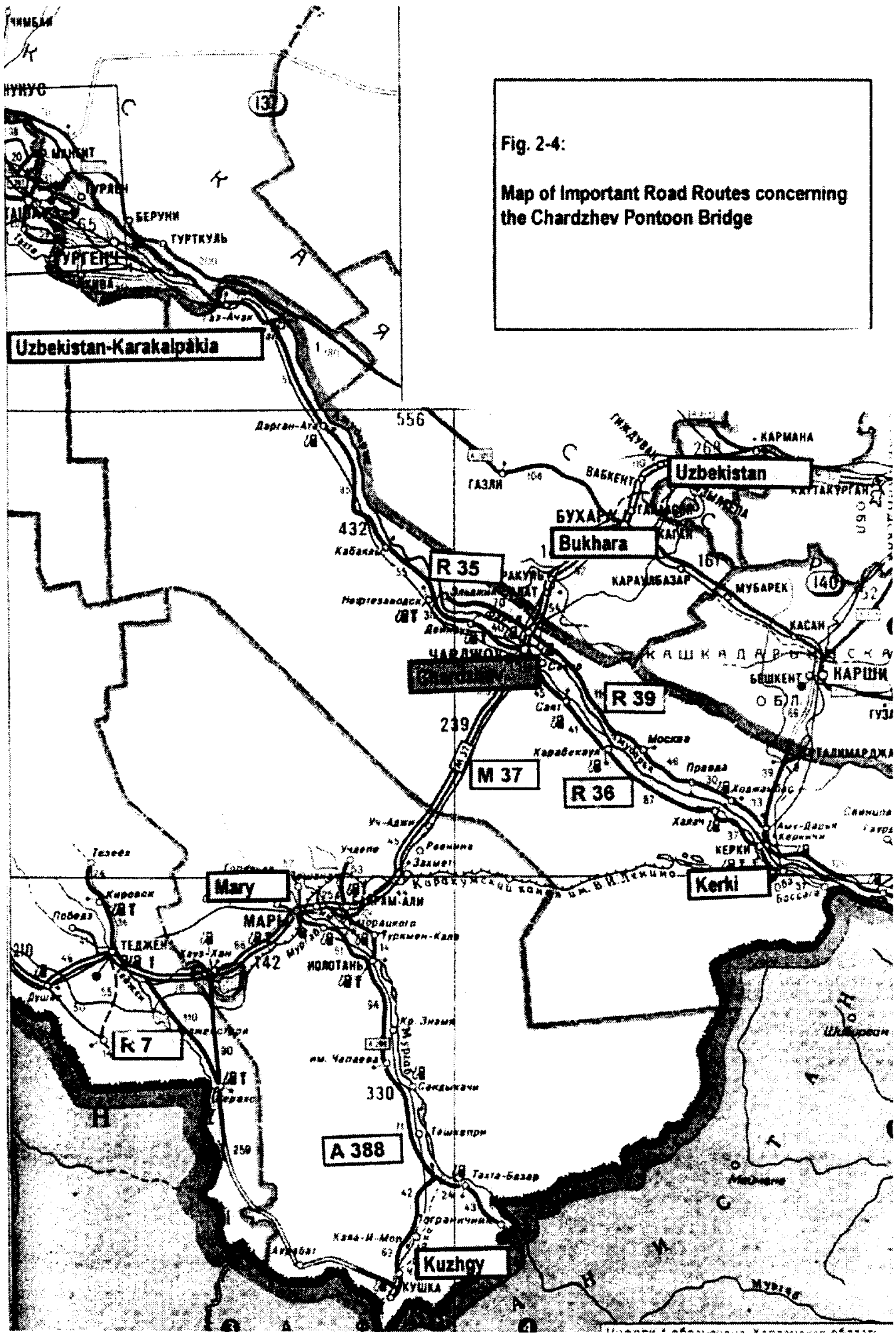
***Figure 2-4: Map of the Important Road Routes concerning the Chardzhev Pontoon Bridge***



The pontoon bridge is particularly important because there are no fixed crossings over the Amu Darya River within Turkmenistan.

In total there are five alternatives to the Chardzhev-Farap pontoon for the Amu Darya River crossing, using other pontoon bridges and by ferries:

- Kerki - Kerkichi (pontoon bridge and ferry for small lorries and buses, not allowed for large trucks)
- Karabekhaul-Burdalik (ferry only)
- Petevert-Mekan (ferry only, 20 km from Chardzhev)
- Eltchik-Seidi (ferry only)
- Lebap -Turkmenistan border to Uzbekistan (ferry only)

The owner of the pontoon bridges and the river ferries is the Turkmenistan Shipping Company, which replaced the former ferry between Chardzhev and Farap by the present pontoon bridge.

A toll is payable for the use of the pontoon bridge; there are different tariffs for Turkmenistan and for foreign vehicles (see Chapter 2.1.4.5).

***Catchment Area of the Chardzhev Bridges***

The bridges are situated in the Lebap Velayat of Turkmenistan, which has 930,000 inhabitants, but the direct catchment areas of the bridges are smaller.

The following communities and administrative units are located In the direct catchment area of the bridges:

- city of Chardzhev as capital of the Lebap Velayat on the left bank of the Amu Darya River

- the community of Dsheykun (to Chardzhev) on the right bank.

- the Farap Etrap with 33 villages

In the direct catchment area there are 230,550 inhabitants (see the following table):

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***Table 2-6: Inhabitants in the Catchment Area of the Chardzhev Bridges***

| | | **Inhabitants (1996)** |
|---|---|---|
| Lebap Velayat in total | | 930,600 |
| of which: | Chardzhev city | 176,000 |
| | Farap Etrap (33 villages in total) | 48,250 |
| | among them: Farap, centre of the Etrap | 11,313 |
| | Dzheykun (to Chardzhev on the right bank of Amu Darya River | 6,300 |

*Source: Administration of the Lebap Velayat*

Because the Chardzhev bridges are situated about 30 km from the Turkmenistan-Uzbekistan border, the Uzbekistan border regions of Alat and Karakul (Bukhara Oblast) are also significant as a catchment area of the bridges.

The population on both sides of the Turkmenistan-Uzbekistan border near Chardzhev is composed of both ethnic Turkmenis and Uzbeks. Ethnic Uzbeks make up some 10-15% of the total population of the Lebap Velayat.

There about 169,000 inhabitants in the Uzbekistan border regions of Alat and Karakul.

The following two figures show the catchment area of the bridges and the location of the bridges crossing the Amu Darya River.

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*Figure 2-5:* ***Catchment Area of the Railway and the Pontoon Road Bridge near Chardzhev***

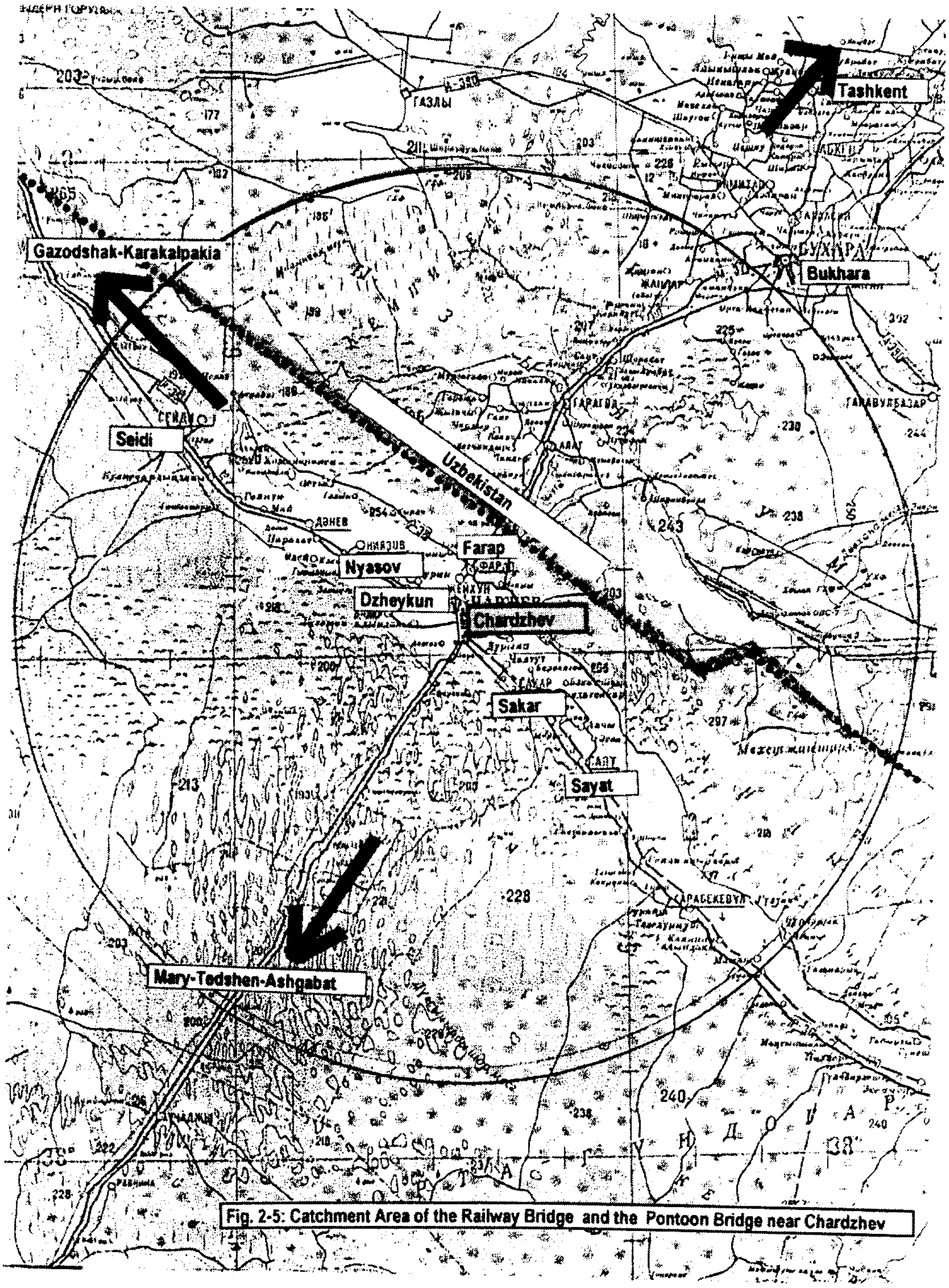


Fig. 2-5: Catchment Area of the Railway Bridge and the Pontoon Bridge near Chardzhev

*Figure 2-6: Location of Railway Bridge and the Pontoon Bridge*

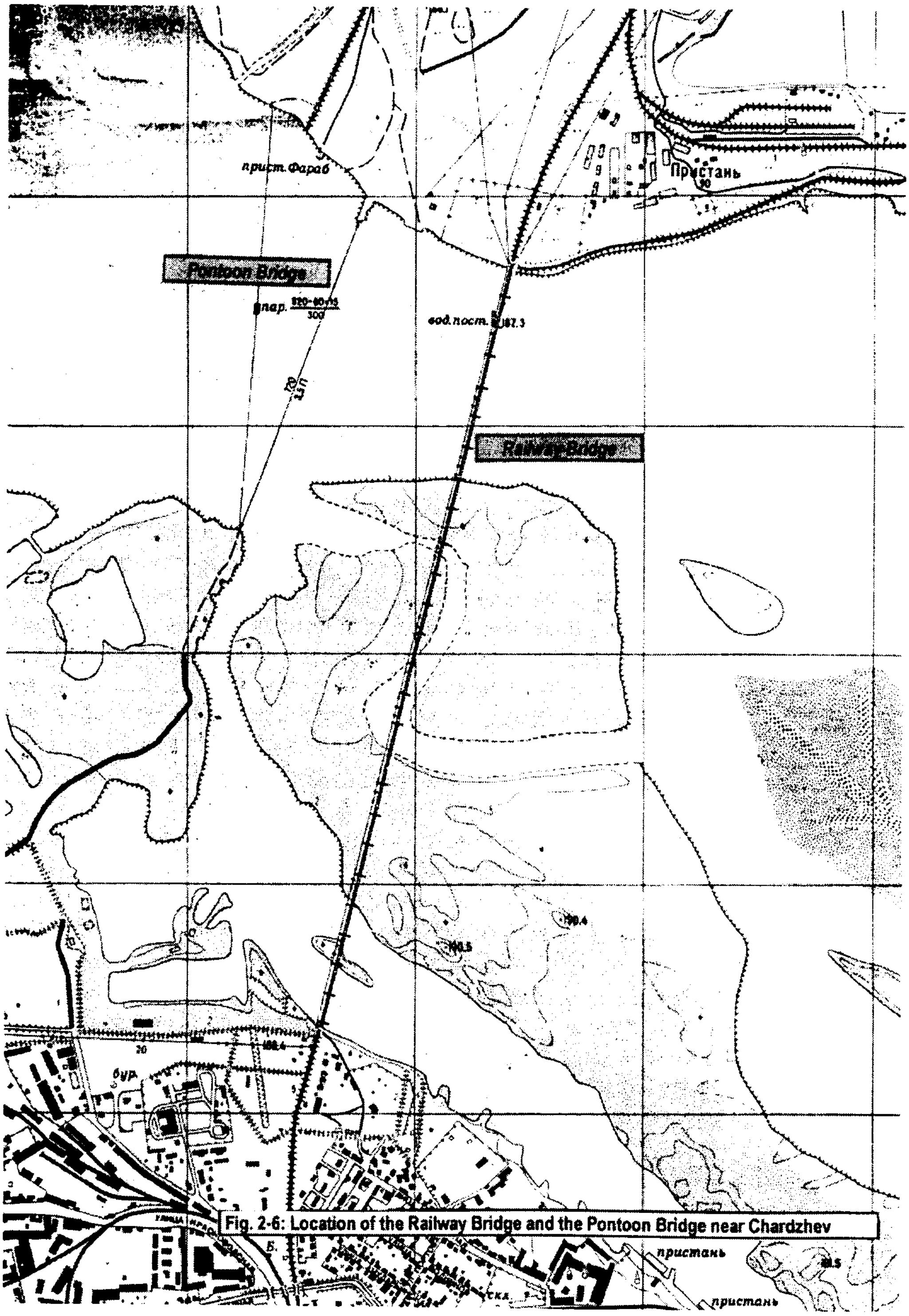


Fig. 2-6: Location of the Railway Bridge and the Pontoon Bridge near Chardzhev

### 2.1.3 Feight and Passenger Traffic Volume via the Chardzhev Railway Bridge[4]

#### 2.1.3.1 Capacity

The capacity of the Chardzhev Railway Bridge is 17 train pairs daily. The present traffic on the railway bridge is very low in comparison to 1989. At present the bridge is used by 12-15 train pairs daily, of which[5]:

4 pairs of freight trains on average (6 pairs maximum)

8-9 pairs of passenger trains (of which 6 pairs are local trains)

At present, the railway bridge is used to about 70% of its capacity. Therefore there is still an unused reserve.

The trains using the bridge could have a maximum length of up to 1050 m.

#### 2.1.3.2 Freight Traffic

***Characteristic Data of Freight Trains via the Railway Bridge***

In 1995 about 1,460 pairs of freight trains[6] used the bridge, an average of four pairs per day.

In general the freight traffic via the bridge is characterised by the following data :

***Table 2-7: Characteristic of Freight Trains via the Railway Bridge***

| | |
|---|---|
| Number of freight trains per day | 4 pairs on average/ 6 pairs maximum |
| Type of trains:<br>inter marshalling-yard train<br>pick-up train | <br>3 pairs on average/ 5 pairs maximum<br>1 pair |
| Weight of freight trains | 3,200 tonnes gross weight (direction Chardzhev-Farap) |
| | 4,200 tonnes gross weight (direction Farap-Chardzhev) |
| Number of wagons per train | 57 |

*Sources: - TDDY, Department of Freight Commercial Services*
*-TURKMENZHELDORTRANS*

[4] Source: TDDY
[5] Source: TURKMENZHELDORPROJECT on the basis of information by TDDY
[6] The data in this chapter was supplied by TDDY in general. Where suitable data was not available, it was calculated by the Consultant and agreed with appropriate TDDY representatives.

***Volume and Traffic Flows***

The transported freight traffic volume was 4.9 million tonnes via the bridge in 1995, carried in 125,800 loaded wagons.

In general the following types of freight traffic flows use the bridge :

***1. Domestic Traffic Flows between Central and Eastern Turkmenistan (Corridor Traffic via Uzbekistan)***

There is no direct railway connection between east Turkmenistan and the rest of the country. Domestic traffic to east Turkmenistan travels as 'corridor traffic' from Chardzhev via the Turkmenistan-Uzbekistan border crossing point (Farap-Khodshadavlet), thence in transit through Uzbekistan (Bukhara-Karshi) to the Uzbekistan-Turkmenistan border at Nishan/Talimardshan and then into eastern Turkmenistan (Kerki/Kerkitchi/Govurdak). This route is also important for transit traffic to Tadjikistan and Afghanistan.

Some 40,800 loaded wagons were transported in 1995, equating to an annual volume of 2.04 million tonnes[7].

***2. Export and Import Traffic flows between Turkmenistan and other Central and East Asian Countries, to Russia, to other European CIS countries and to Europe***

The rail volume was 1.77 million tonnes in 1995, of which 0.9 million tonnes was export and the remainder import traffic. Thus 32.2% of the whole external trade of Turkmenistan was transported via the Chardzhev bridge, i.e. 24.5% of the exports and 40.8% of the imports in 1995.

About 85% of the Turkmenistan export volume over the railway bridge was oil products. Such commodities as construction materials, metals, grains and chemicals dominated imports, as shown in the next table.

[7] It was necessary to estimate this figure, since TDDY was unable to supply tonnage information. The estimate was carried on the basis of the number of loaded wagons, supplied by the Commercial Freight Department of TDDY, and an average load per wagon of 50 tonnes. The average load of a wagons was confirmed by TDDY.

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***Table 2-8: Export and Import via Farap Border Crossing by Rail in 1995***

| Commodity | Export | | Import | |
|---|---|---|---|---|
| | ('000 tonnes) | (%) | ('000 tonnes) | (%) |
| Cotton, cotton products | 46.9 | 5.2 | 0.3 | 0.0 |
| Oil, oil products | 756.3 | 84.5 | 148.3 | 17.0 |
| Salt, stones, cement, soils, construction materials | 21.9 | 2.4 | 234.9 | 26.8 |
| Fertilisers | 6.5 | 0.7 | 38.5 | 4.4 |
| Chemicals | 23.1 | 2.6 | 92.0 | 10.5 |
| Metals | 7.4 | 0.8 | 102.3 | 11.7 |
| Equipment, machines | 0.8 | 0.1 | 10.6 | 1.2 |
| Grain | | | 97.8 | 11.2 |
| Flour | | | 42.2 | 4.8 |
| Sugar | | | 24.1 | 2.8 |
| Other food and beverages | 22.0 | 2.5 | 38.8 | 4.4 |
| Miscellaneous general freight products | 10.6 | 1.2 | 45.3 | 5.2 |
| Volume via Farap border crossing by rail | **895.5** | **100** | **875.0** | **100** |

*Source:* *Customs Statistics of Turkmenistan (unpublished)*

The Farap route is important for the Turkmenistan railway system and the international trade of Turkmenistan, because about

59% of all exports of oil products and
15% of all cotton fibre exports

are transported on the Chardzhev-Farap route and thus via the Chardzhev Bridge.

About 68% of the total export volume via Farap by rail was destined for the Central Asian CIS countries, the main commodities being oil and oil products. The export of cotton fibre via Farap by rail is not important, the total export volume amounting to 46,900 tonnes (23,800 tonnes of this being to Switzerland).

Imports via Farap by rail show a similar regional structure to exports:

About 61% of all rail imports via Farap came from the Central Asian CIS countries (especially Uzbekistan and Kazakstan). The commodity breakdown is different in comparison to the exports:

314,900 tonnes were imported from Uzbekistan, including 140,100 tonnes of oil from the Bukhara region of Uzbekistan to the refinery in Seidi near Chardzhev. In 1996, this volume was much higher and amounted to 500-600,000 tonnes.

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Imports from the Ukraine totalled 229,400 tonnes, particularly construction materials. metals and miscellaneous general freight (clothes, shoes etc.).

Imports from Kazakstan were 76,500 tonnes of grain, 53,900 tonnes of chemicals and 45,000 tonnes of construction materials in 1995.

The main regional structure of export and import by rail via Farap is shown in the following table.

***Table 2-9: Main Regional Structure of Export and Import by Rail via the Farap Border Crossing in 1995***

| **Origin/destination** | **Export (direction Chardzhev-Farap)** | | **Import (direction Farap-Chardzhev)** | |
|---|---|---|---|---|
| | Volume ('000 tonnes) | Main commodities | Volume ('000 tonnes) | Main commodities |
| Central Asian CIS countries including | 596.2 | Oil products, construction materials, chemicals | 536.2 | Crude oil, grain, construction materials, fertiliser, chemicals |
| Tadjikistan | 278.8 | | | |
| Kazakstan | 58.6 | | 205.9 | |
| Uzbekistan | 145.0 | | 314.9 | |
| Other CIS countries including: | 153.8 | Oil products | 302.2 | Construction materials, chemicals, grain, flour, sugar, other food and beverages, general freight |
| Russia | 138.4 | | 72.0 | |
| Ukraine | 7.7 | | 229.4 | |
| Afghanistan | 62.6 | Oil products | | |
| Central European countries | 33.4 | Cotton fibre | 10.6 | Food and beverages |
| South European countries | 0.9 | Oil products | 11.6 | Metals, food and beverages |
| Baltic Republics | 13.2 | Oil products | | |

*Source: Customs Statistics of Turkmenistan in 1995 (unpublished)*

### 3. Corridor Traffic from/ to Uzbekistan via Turkmenistan

The railway connection between central/eastern Uzbekistan and the Uzbekistan region of Karakalpakia (around the cities Urgentsh, Nukus and Dashkovus) is currently only possible via Turkmenistan.

There is, therefore Uzbekistan corridor traffic between the border crossing points Khodshadavlet (Uzbekistan)/Farap (Turkmenistan) via Chardzhev bridge, Seidi to the border crossing point Gazodshak (Turkmenistan)/Pitnyak (Uzbekistan), in the Karakalpakia region.

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The volume of this traffic amounted to only 0.8 million tonnes in 1995 and was very low in comparison to 1989.

***Table 2-10: Uzbekistan Corridor Traffic via Turkmenistan using Chardzhev Railway Bridge in 1995***

| Direction | Volume ('000 tonnes) | | |
|---|---|---|---|
| | **1994** | **1995** | **1996 (Jan-June)** |
| From Uzbekistan to Karakalpakia(direction Farap-Chardzhev) | 1,100 | 397 | 203 |
| From Karakalpakia to Uzbekistan (direction Chardzhev-Farap) | 810 | 405 | 135 |
| Total | 1,910 | 802 | 338 |

*Source: TDDY, Department of Freight Commercial Services*

### *4. Transit Traffic Flows*

Transit traffic flows using the Chardzhev bridge run from the Central and East Asian countries (e.g. Uzbekistan, Kazakstan, Kyrgyzstan, Tadjikistan, China), Russia, other European CIS countries, Central and Western Europe to the Near East region (especially the Iranian ports on the Persian Gulf), India, Pakistan, Afghanistan, Transcaucasus, Turkey and South Europe.

The importance of railway links via the bridge have grown since the completion of the section Tedshen-Serakhs-Meshed in 1996. This connection formed the final component in the intercontinental land bridge from China via Kazakstan-Uzbekistan-Turkmenistan to Iran, to the ports on the Persian Gulf and to the Indian subcontinent. A significant increase in transit traffic can be expected following resolution of initial organisational problems with this new route.

The railway connections running via the bridge have an important perspective for the future intercontinental freight traffic by rail in the Central Asian region. However, thus far transit traffic flows by rail through Turkmenistan and via the bridge are very low, though they are increasing.

The railway link over the bridge is also important for future transport within the TRACECA Transport Corridor, from Uzbekistan to the seaport of Turkmenbashy and to Europe.

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***Table 2-11: Transit Traffic by Rail through Turkmenistan via the Chardzhev Bridge in 1994-1996***

| Direction | Connection | Volume ('000 tonnes) | | |
|---|---|---|---|---|
| | | 1994 | 1995 | 1996 |
| Chardzhev-Farap | Azerbaijan (via Turkmenbashy)-Uzbekistan | 104 | 119 | 70* |
| Farap-Chardzhev | Uzbekistan-Azerbaijan (via Turkmenbashy)- | 125 | 174 | 150* |
| | Kazakstan-Iran | | | 111** |
| | Uzbekistan-Iran | | | 13** |
| | Russia/ Ukraine-Iran | | | 7** |
| **Total** | | **229** | **293** | **351** |

* Estimate on the basis of the results in the period of January-June
** Projection to the year-end based on TDDY planning

*Source: TDDY, Department of Freight Commercial Services*

***Summary Freight Traffic via the Chardzhev Railway Bridge***

The volume of freight traffic was 5.4 million tonnes via the Chardzhev bridge in 1995. This volume was carried in 125.800 loaded wagons. This volume equates to about 40% of the total freight traffic volume of Turkmenistan in 1995.

The traffic can be categorised as follows.

***Table 2-12: Freight Traffic Flows via the Chardzhev Railway Bridge in 1995***

| Type of Traffic Flow | Volume ('000 t) | Number of wagons | | |
|---|---|---|---|---|
| | | loaded | empty | total |
| 1. Corridor traffic from/to Turkmenistan via Uzbekistan (Farap-Bukhara-Talimardshan v.v.) | 2,040* | 40,800 | | 40,800 |
| 2. Export and import traffic of Turkmenistan:in total *including:* | 1,770 | 55,000** | | 55,000 |
| *Export (Direction Chardzhev-Farap)*<br>*Import (Direction Farap-Chardzhev)* | *895*<br>*875* | | | |
| 3. Corridor traffic from/to Uzbekistan via Turkmenistan (Bukhara-Farap-Gazodshak v.v.) in total *including:* | 802 | | | |
| *Direction Chardzhev-Farap*<br>*Direction Farap-Chardzhev* | *405*<br>*397* | *11,000*<br>*11,000* | | |
| 4. Transit traffic through Turkmenistan in total *including:* | 293 | 7,900 | | |
| *Direction Chardzhev-Farap*<br>*Direction Farap-Chardzhev* | *119*<br>*174* | | | |
| **Freight traffic via the rail bridge in 1995** | **4,905** | **125,700** | **60,100** | **185,800** |

* Estimated on the basis of the number of loaded wagons in this corridor; detailed tonnage data not available

** Estimated on the basis of the structure by commodity, data on the number of wagons not available

*Sources:* - *TDDY, Department of Freight Commercial Services*
- *Customs Statistics of Turkmenistan in 1995*

### 2.1.3.3 Passenger Traffic

***Number of Passenger Trains***

There are three categories of passenger traffic shows using the bridge:

- long-distance international trains between the eastern region of Uzbekistan (Tashkent, Samarkand, Bukhara), Karakalpakia, western Kazakstan and Russia in transit via Turkmenistan
- long-distance traffic between Chardzhev and the eastern region of Turkmenistan (Kelif) via Uzbekistan

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- local traffic between Farap and Chardzhev

There are some 8-9 daily passenger train pairs using the bridge, of which 6 pairs are local trains and the remainder long-distance or international trains.

The number of long-distance trains varies from two to three pairs daily. The connections Kungrad/Nukus-Tashkent (Uzbekistan-Uzbekistan) and Makat/Bejneu-Tashkent (Kazakstan-Uzbekistan) are served daily, all other connections are once or twice a week only.

***Table 2-13: Passenger Trains via the Chardzhev Bridge in 1996***

| Train No. | Route | Number of Trains | Number of Coaches per Train | Number of Places per Train | Average Occupancy Rate in 1996 (%) |
|---|---|---|---|---|---|
| ***Long-Distance Trains/ International Trains*** | | | | | |
| 53/54 | Kungrad/ Nukus-Tashkent and v.v. * | 7 pairs per week | 14 | 688 | 59/ 68 |
| 917/ 918 | Makat/Bejneu-Tashkent and v.v.* | 7 pairs per week | 7 | 405 | 91/ 82 |
| 193/ 194 | Urgentsh-Andishan and v.v. | 1 pair per week | 14 | 648 | 62/ 54 |
| 21/22 | Nukus-Alma Ata and v.v. | 2 pairs per week | 13 | 650 | 92/ 86 |
| ***Long-Distance Traffic/ Turkmenistan Trains*** | | | | | |
| 197/ 198 | Chardzhev-Kelif and v.v. | 2 pairs per week | 11 | 643 | 76/ 72 |
| ***Local Trains*** | | | | | |
| | Chardzhev-Farap and v.v. | 6 pairs daily | 6-9 | 420-560 | 60-70 approx. |

* with different routes on different days

*Sources:* 
- *TDDY, Branch Office of Chardzhev*
- *Timetable 1996*
- *TDDY, Department of Passenger Commercial Services*

In 1996, there were 19 weekly pairs of long-distance trains.

***Passenger Flows via the Railway Bridge***

The volume of passenger traffic has been showing an increasing trend since 1994. The average number of passengers per day grew by 50% between 1994 and 1995.

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***Table 2-14: Average Number of Passengers by Rail Crossing the Chardzhev Bridge***

| **Type of Traffic** | **Direction** | **Number of passengers per day on average** | | |
|---|---|---|---|---|
| | | **1994** | **1995** | **1996 January-July** |
| ***Long-distance traffic*** | Chardzhev-Farap | 2213 | 3202 | 2643 |
| | Farap-Chardzhev | 2053 | 2720 | 2371 |
| | ***Both directions*** | ***4266*** | ***5922*** | ***5014*** |
| ***Local traffic*** | Chardzhev-Farap | 1066 | 1797 | 2310 |
| | Farap-Chardzhev | 1066 | 1797 | 2310 |
| | ***Both directions*** | ***2132*** | ***3594*** | ***4620*** |
| ***Passenger traffic in total*** | Chardzhev-Farap | 3279 | 4999 | 4953 |
| | Farap-Chardzhev | 3119 | 4517 | 4681 |
| | ***Both directions*** | ***6398*** | ***9516*** | ***9634*** |

*Sources:* - *TDDY, Branch Office of Chardzhev*
- *TDDY, Department of Passenger Commercial Services*

The railway plays a major role for the mobility of the local population due to low car ownership (e.g. about 50 cars per 1000 inhabitants within the Farap Etrap)[8], the small number of bus routes and the distances involved in long-distance traffic.

The *local traffic* via the railway bridge is an important element of the mobility for people within the Chardzhev-Farap region because there are no regular public bus services. The sole alternative to using the railway is by car or by non-public buses between Farap and Chardzhev.

Local rail passengers start in Farap and generally travel to Chardzhev, fulfilling the classic role of commuting to work and school, shopping, visiting friends and relatives, and attending medical facilities.

There are few instances of Chardzhev inhabitants visiting Farap.

The mobility of the inhabitants of Farap Etrap including the community of Dzheykun in 1996 was 26.6 trips per inhabitant by rail. The railway has a 74% share of the local traffic market.

Long-distance traffic crossing the bridge is very important for both Uzbekistan and Kazakstan, because the railway connections between eastern Uzbekistan (Bukhara, Tashkent) and western Uzbekistan (Urgentzh, Nukus) and also western Kazakstan (Makat, Bejneu) runs via Turkmenistan and via the Chardzhev bridge.

[8] Source: Socio-economic data of Lebap Velayat given by the Lebap Velayat Authority (1/1/1996)

### 2.1.4 Traffic via the Pontoon Road Bridge over the Amu Darya River at Chardzhev

#### 2.1.4.1 Methodology and Approach of Data Collection

Although data from various sources and in divers forms concerning traffic over the pontoon bridge exists, it was not considered suitable for the analysis and the forecast for this project.

There is no existing information regarding the structure of the road traffic by types, origin/destination etc. Therefore two types of census (**counting** and **interview survey**) were prepared and carried out in order to obtain data concerning the present road traffic via the pontoon bridge.

The **counting** includes information on all vehicles using the pontoon bridge. The **interview survey** of selected vehicles gives extra information about the structure of the road traffic.

The **counting** and **interview survey** were undertaken over three days during July and August 1996 (29th-31st July and 7th-9th August). The results of the **counting** showed that, for some unexplained reason, 29th July was not representative, in that the traffic on this day was lower than the traffic on all following days. Therefore the counting results of this day had to be eliminated.

The **counting** of vehicles using the bridge was carried out from 0600 to 2000 hours. All vehicles crossing the bridge were counted by type and by direction. The total number of vehicles in 24 hours was extrapolated based on results of 14 hours counting.

The daily traffic variations over the bridge in the counting period was normal, the variations being between +2.9% (maximum) and -1.0% (minimum) during an average day.

The **interview survey** of selected vehicles was carried out on the base of the following key points:

- use of a questionnaire: See Annex K: Questionnaire for Survey of Users of the Chardzhou Pontoon Bridge
- survey of a selected number of vehicles (each fifth vehicle in general)

The **counting** and **interview survey** were undertaken with the support of two local subcontractors: the Lebapskoye Road Operation Authority and the Turkmendorproject Institute, Chardzhev branch office.

Altogether the 1769 vehicles were included in the **interview survey** (over six days in total, each day from 6 to 20 hours). These included:

- 984 freight vehicles, of which:

| | |
|---|---|
| 236 | 2-axle vehicles |
| 138 | 3-axle vehicles |
| 620 | >3 axle vehicles |

### 2.1.4 Traffic via the Pontoon Road Bridge over the Amu Darya River, Chardzhev

#### 2.1.4.1 Methodology and Approach of Data Collection

Although data from various sources and in divers forms concerning traffic over the pontoon bridge exists, it was not considered suitable for the analysis and the forecast for this project.

There is no existing information regarding the structure of the road traffic by types, origin/destination etc. Therefore two types of census (**counting** and **interview survey**) were prepared and carried out in order to obtain data concerning the present road traffic via the pontoon bridge.

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The daily traffic variations over the bridge in the counting period was normal, the variations being between +2.9% (maximum) and -1.0% (minimum) during an average day.

The **interview survey** of selected vehicles was carried out on the base of the following key points:

- use of a questionnaire (see *Fehler! Verweisquelle konnte nicht gefunden werden.*)
- survey of a selected number of vehicles (each fifth vehicle in general)

The **counting** and **interview survey** were undertaken with the support of two local subcontractors: the Lebapskoye Road Operation Authority and the Turkmendorproject Institute, Chardzhev branch office.

Altogether the 1769 vehicles were included in the **interview survey** (over six days in total, each day from 6 to 20 hours). These included:

- 984 freight vehicles, of which:

  236 2-axle vehicles
  138 3-axle vehicles

620 >3 axle vehicles

- 785 passenger vehicles, of which:

  658 passenger cars
  127 buses

Therefore some 18.9% of all vehicles crossing the pontoon bridge in the period were included in the **interview survey**.

This volume was calculated on the basis of

- the results of the counting and survey on six days and in 14 hours daily
- traffic estimations from 2000 to 0600 hours

The above extrapolation is based on a short counting of the number of vehicles (one day) in the time between 2000 and 2200 hours.

The missing data regarding traffic from 2200 to 0600 hours has been calculated on the basis of estimations of the expected traffic volume during the night, based on the counted traffic volume from 2000 to 2200 hours and on estimations of the Consultant's local partners.

The results of these calculations have been compared with a methodology which is used in Germany for similar calculations[9]. The calculation of the figure of the Average Daily Traffic in 24 hours (ADT) was made according to the following formula:

$$ADT = b \cdot Q$$

Q = traffic volume during the daily period with the highest traffic volume (four hours)
b= 3.5 (defined coefficient)

The Consultant's calculation corresponds approximately with the calculation on the basis of the German methodology.

#### 2.1.4.2 Total Road Traffic Volume via the Pontoon Bridge

***Volume by Number of Vehicles***

Road traffic using the pontoon bridge amounts to 2,023 vehicles on an average working day in both directions during a 24 hour period. The traffic in each direction is of approximately the same level.

[9] *Richtlinie für die Anlage von Straßen RAS Teil: Querschnitte RAS - Q 96; Forschungsgesellschaft für Straßenwesen, Arbeitsgruppe Straßenentwurf, Ausgabe 1996*

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Passenger cars form the highest proportion of vehicles using the bridge, being 54% on average. The proportion of freight traffic vehicles is 34%, of which trucks with more than three axles account for 15%.

There is an equal balance in direction for passenger cars, buses and 3-axle trucks. However, there are more trucks of over three axles travelling north than south.

***Table 2-15: Average Daily Traffic by Vehicle Type (ADT) via the Pontoon Bridge***

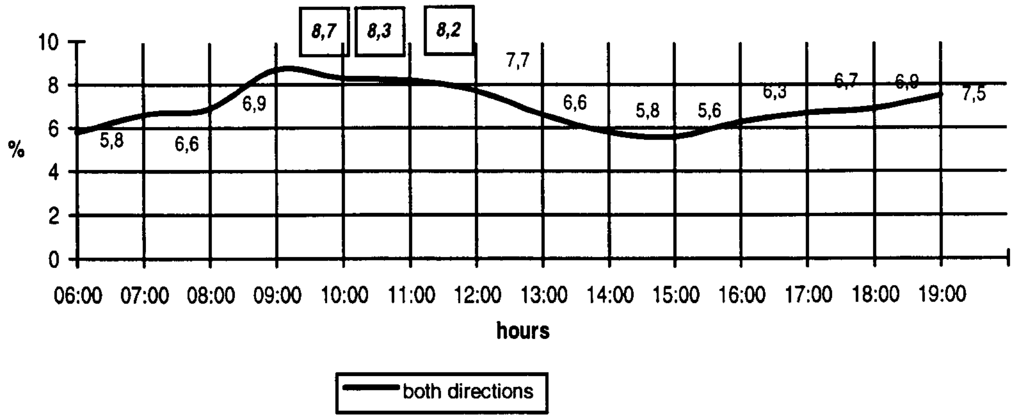
| **Vehicle Type** | | **ADT by Direction** | | **ADT total** | **Traffic Volume by Vehicle Type (in%)** |
|---|---|---|---|---|---|
| | | **Chardzhev-Farap** | **Farap-Chardzhev** | ***Both directions*** | |
| Utility (2-axle) | < 2 tonne payload 1.9-2.6 tonne GVW | 119 | 146 | ***265*** | **13** |
| Truck (3 -axle) | 2 - 8 tonne payload 5.8 - 17.8 tonne GVW | 57 | 61 | ***118*** | **6** |
| Truck (>3 axle) | > 8 tonne payload 17.8 - 38.0 tonne GVW | 184 | 116 | ***300*** | **15** |
| Passenger car | | 568 | 536 | ***1,104*** | **54** |
| Bus | | 39 | 40 | ***79*** | **4** |
| Other vehicles types | | 87 | 69 | ***156*** | **8** |
| Total | | 1,054 | 968 | ***2,022*** | **100** |

*Source: Consultant's survey*

The variation of the number of vehicles is not high during the day between 0600 and 2000 hours. There is a peak between 0900 and 1200, but this is not excessive. In the night the traffic volume is obviously lower than by day.

The following diagram shows the variation in the traffic volume per day on average

***Figure 2-7: Diurnal Variations of Traffic Volume via the Pontoon Bridge***




***Volume of Traffic by Axles***

The number and types of vehicles do not equate precisely to the dynamic loading of the bridge. Therefore the number of axles per average day was calculated.

***Table 2-16: Average Daily Traffic by Axles and Standard-Axle Vehicles via the Pontoon Bridge***

| **Vehicle Type** | **Number of Axles** (in general) | **Number of Axles by Direction** | | **Number of Axles in Total** | **Structure of Traffic Volume by Axles (in%)** |
|---|---|---|---|---|---|
| | | **Chardz hev-Farap** | **Farap-Chardz hev** | ***Both direction s*** | |
| Utility (2-axle) | 2 | 238 | 292 | ***530*** | **11** |
| Truck (3 -axle) | 3 | 171 | 183 | ***354*** | **7** |
| Truck (>3 axle) | 5 | 921 | 580 | ***1,501*** | **31** |
| Passenger car | 2 | 1,137 | 1,072 | ***2,209*** | **46** |
| Bus | 2 | 78 | 80 | ***158*** | **3** |
| Other vehicles types * | 2 | 174 | 138 | ***312*** | **6** |
| Total | | 2,719 | 2,346 | ***5,066*** | **100** |

* tractors and motorcycles.

Referring to the number of axles it should be noted that the proportion of freight traffic vehicles amounts to 49% and is little higher than the proportion of passenger cars.

The modal split between freight and passenger traffic by axles is 49% freight traffic: 49% passenger traffic (including buses).

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### 2.1.4.3 Pontoon Bridge Traffic Capacity Utilisation

The Consultant estimates that the present pontoon crossing is, during daylight hours, loaded to about 90-95% of its capacity.

The principal constraints on vehicle access are dictated by the nature of the bridge itself, in that, because the pontoons float, there must be a minimum distance between each pair of heavy goods vehicles using the bridge, otherwise the pontoons tilt and cause an irregular transition from one pontoon to the next. In practise, regulation of such traffic is accomplished by restricting the sale of toll tickets accordingly.

Because the bridge is unlit, truck drivers are reluctant to use it during the hours of darkness for safety reasons.

Private cars, being much lighter than trucks, are able to use the pontoon crossing without regulation and indeed are frequently inserted between pairs of trucks.

Therefore, in considering future traffic levels and demand for road crossing capacity, the fact that the existing pontoon bridge is operating at virtually full capacity during the day needs to be kept in mind.

### 2.1.4.4 Traffic Structure using the Pontoon Bridge

***Freight Traffic***

International traffic amounted to two thirds of the total road freight traffic using the bridge (68%), of which 24% concerned export and import of goods to and from Turkmenistan and 76% transit from/to other countries via Turkmenistan.

The proportion of the domestic traffic using the pontoon bridge was 32%, of which 89% was traffic within the Lebap Velayat and the remainder between Lebap Velayat and other regions of Turkmenistan. It was observed that domestic traffic is carried predominantly on two and three axle trucks. It is estimated that the main proportion of domestic traffic includes distribution of consumer, industrial and agricultural goods. At the same time, small trucks (2-axle) can be used for passenger traffic.

This basic structure shows, that the pontoon bridge has considerable importance for domestic and international traffic, with an increasing level of transit traffic.

The transit traffic has the following main characteristics:

- Iran - Uzbekistan both directions 34.6% proportion of total transit traffic
- Turkey - Uzbekistan both directions 32.5% proportion of total transit traffic
- Iran - Kazakstan both directions 16.0% proportion of total transit traffic

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Two thirds of the vehicles crossing over the bridge have their origin or destination in Uzbekistan.

The next table provides an overview of the main regional structure of the freight road traffic via the pontoon bridge.

***Table 2-17: Structure of Road Freight Traffic via the Pontoon Bridge***

| Route | Proportion of total road freight traffic (%) | |
|---|---|---|
| ***Domestic traffic*** | ***32.1*** | ***100.0*** |
| of which: | | |
| within Lebap Velayat | | 88.8 |
| with other regions in Turkmenistan | | 11.2 |
| ***External trade of Turkmenistan (export/import)*** | ***16.1*** | |
| ***Transit traffic*** | ***51.8*** | ***100.0*** |
| of which: | | |
| Iran - Uzbekistan | | 19.3 |
| Uzbekistan - Iran | | 15.3 |
| Turkey - Uzbekistan | | 13.1 |
| Uzbekistan - Turkey | | 19.4 |
| Iran - Kazakstan | | 7.8 |
| Kazakstan - Iran | | 6.2 |
| Kazakstan - Afghanistan | | 2.0 |
| Uzbekistan - Afghanistan | | 2.4 |
| Turkey - Afghanistan | | 2.4 |
| **Total** | **100.0** | |

*Source: Consultant's Survey*

The above mentioned main transit connections accounted for 90% of the total transit via the bridge.

The description of the structure by commodity on the base of the results of the survey is difficult, because not all data is representative. Therefore the conclusion is concentrated on relevant and representative data.

***Domestic Traffic***

Domestic freight traffic has the following characteristics:

- traffic within the Lebap Velayat includes distribution transport with small vehicles in general.
- main commodities were construction materials, food and beverages, as well as other consumer goods.

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- the same situation exists in domestic traffic between other Turkmenistan Velayats.

***External Trade of Turkmenistan by Road via the Border Crossing Farap***

This assessment is based on the customs statistics for 1995 and 1996 (January-June), as the results of the survey are not representative.

The volume transported via Farap border crossing and via the pontoon bridge is very low. The proportion of external trade traffic by road via Farap amounted to 0.4% of total exports and 0.3% of total imports. In the first six months of 1996 there was a considerable decline in external trade transport by road via Farap.

***Table 2-18: Export and Import Traffic by Road using Farap Border Crossing***

| | Volume ('000 t) | including |
|---|---|---|
| Export 1995 | 14,300 | 9,020 tonnes cotton to Pakistan |
| Export Jan-June 1996 | 480 | |
| Import 1995 | 6,350 | 2,260 tonnes from Uzbekistan<br>1,910 tonnes from Israel<br>1,380 tonnes from Russia |
| Import Jan-June 1996 | 950 | |

*Source: Customs Statistics of Turkmenistan 1995 and 1996 (unpublished)*

The results of the transit traffic survey are not completely representative, but the following structure could be assumed:

- the main commodities were food and agricultural products (about one third).
- the transport of high-value goods such as machinery and equipment etc. has a high impact on road transit traffic via the pontoon bridge.
- the transport of various consumer goods is of some importance.

The structure by vehicle types shows a high proportion of small vehicles in domestic traffic and a high proportion of large trucks in the international traffic. Over 90% of the trucks in transit traffic are over 17.8 tonnes GVW.

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***Table 2-19: Structure of Road Freight Traffic via the Pontoon Bridge by Vehicle Type***

| **Traffic category** | **Vehicle Type (%)** | | | |
|---|---|---|---|---|
| | **Utility 2 axles** | **Truck 3 axles** | **Truck > 3 axles** | **Total** |
| Domestic traffic within Lebap Velayat | 70.1 | 19.1 | 10.8 | 100 |
| Domestic traffic between other Turkmenistan regions | 45.7 | 40.0 | 14.3 | 100 |
| Export/import traffic | 21.5 | 20.3 | 58.2 | 100 |
| Transit traffic | 0.8 | 7.8 | 91.4 | 100 |

*Source: Consultant's Survey*

The breakdown of vehicles by country of registration shows a high proportion of vehicles registered in Turkmenistan (38%), in Iran (32%) and in Turkey (19%).

Vehicles registered in Kazakstan accounted for 3.5%. The proportion of vehicles with registration in Uzbekistan was 5.5%.

***Passenger Traffic***

Passenger traffic using the pontoon includes traffic by car and by bus. There is no local public bus service between Farap and Chardzhev, hence bus traffic running via the pontoon is non-public local (industrial and agricultural companies etc.) as well as long-distance non-public and public traffic.

The following table gives an overview of the regional structure of the passenger traffic.

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*Table 2-20:* ***Regional Structure of Passenger Traffic by Car and by Bus via the Pontoon Bridge***

| Traffic Category | | Structure (%) | |
|---|---|---|---|
| | | **Traffic by Car** | **Traffic by Bus** |
| *Total* | | *100.0* | *100.0* |
| of which: | | | |
| **Domestic Traffic** | **Total** | **77.0** | **47.0** |
| | *of which:* | | |
| | Domestic traffic within Lebap Velayat | 69.5 | 40.9 |
| | Domestic traffic between Lebap Velayat and other Velayats | 6.6 | 6.1 |
| | Domestic traffic between other Velayats via the bridge | 0.9 | - |
| **International Traffic** | **Total** | **23.0** | **53.0** |
| | *of which:* | | |
| | Traffic with origin in Turkmenistan | 13.1 | 9.6 |
| | Traffic with destination in Turkmenistan | 6.2 | 17.4 |
| | Transit traffic | 3.7 | 26.1 |
| | *of which* | | |
| | *Uzbekistan - Iran* | *1.1* | *10.5* |
| | *Iran - Uzbekistan* | *0.6* | *5.2* |

*Source: Consultant's Survey*

In comparison with freight traffic, the passenger traffic via the bridge has a different regional structure.

The car traffic regional structure is as follows:

- modal split between domestic and international traffic was 77.0% : 23.0%.
- 90.3% of the domestic traffic is traffic within the Lebap Velayat, especially traffic between Chardzhev and Farap Etrap/Dzheykun and 8.7% domestic traffic between other Turkmenistan Velayats via the bridge.
- 83.9% of international passenger traffic by road is traffic with origin or destination in Turkmenistan; 16.1% transit traffic through Turkmenistan.
  Bus traffic shows different regional characteristics:

- the proportion between domestic and international traffic was 47.0% : 53.0%.
- 87.0% of domestic traffic is traffic within Lebap Velayat, especially traffic between Chardzhev and communities on the right bank of Amu Darya River, and 13% is domestic traffic between other Turkmenistan Velayats via the bridge.
- international traffic by bus has the following structure:
  - 50.9% traffic from/to Turkmenistan abroad and 49.1% transit traffic
  - more than 60% of transit traffic by bus is between Iran and Uzbekistan.

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The international traffic between Turkmenistan and other countries by car and by bus is characterised by a significant proportion of traffic between Turkmenistan and Uzbekistan. The reasons are strong ethnic links between the people on both sides of the border. About 106,000 ethnic Uzbeks live In the Lebap Velayat, which is 11.6% of the population[10].

***Table 2-21: Passenger Traffic between Turkmenistan and Uzbekistan by Road via the Pontoon Bridge***

| Traffic Category | Proportion of Total Passenger Traffic (%) | | International Traffic (=100%) | |
|---|---|---|---|---|
| | Car | Bus | Car | Bus |
| International traffic originating/terminating in Turkmenistan | 23.0 | 53.0 | 100.0 | 100.0 |
| *of which:* | | | | |
| from/to Uzbekistan, Bukhara region | | | 64.8 | 51.5 |
| from/to other regions of Uzbekistan | | | 28.5 | 32.2 |

*Source: Consultant's Survey*

The average car occupancy rate was 1.17 persons, but this figure varies somewhat by purpose of travel, as shown in the next table.

***Table 2-22: Occupancy Rates in the Passenger Traffic by Car via the Pontoon Bridge***

| Traffic Category | | Car Occupancy Rate ( persons/car) |
|---|---|---|
| ***Total*** | | ***1.17*** |
| of which: | | |
| **Domestic Traffic** | Domestic traffic within the Lebap Velayat | 1.13 |
| | Domestic traffic between Lebap Velayat and other velayats | 1.12 |
| | Domestic traffic between other velayats via the bridge | 1.0 |
| **International Traffic** | **Average** | **1.44** |
| of which: | Traffic with origin or destination in Turkmenistan | 1.16 |
| | Transit traffic | 2.0 |

*Source: Consultant's Survey*

[10] Source: Results of the Population Census in Turkmenistan, Goskomstat Ashgabat 1996

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The analysis of the passenger car traffic via the pontoon by travel purposes shows the following situation:

- within the Lebap Velayat, one third of domestic traffic is for **holidays and visiting friends and relatives**
- only 20% of journeys are for **business**
- domestic traffic between the Lebap Velayat and other regions of Turkmenistan, and that between other regions of Turkmenistan, includes a high proportion of **business** travel
- **business** is the main category by car for international traffic.

***Table 2-23: Analysis of Passenger Car Traffic by Journey Purpose***

| **Traffic Category** | | **Purpose of Journey (%)** | | | |
|---|---|---|---|---|---|
| | | **Business** | **Holidays, Visiting Friends and Relatives** | **Private** | **Other** |
| **Domestic Traffic** | within Lebap Velayat | 20.2 | 34.1 | 24.1 | 21.6 |
| | between Lebap Velayat and other velayats | 49.0 | 34.0 | 10.6 | 6.4 |
| | between other velayats via the pontoon | 66.7 | 22.2 | - | 11.1 |
| **International Traffic** | Traffic with origin or destination in Turkmenistan | 48.7 | 26.0 | 20.9 | 4.4 |
| | Transit traffic | 61.7 | 20.0 | 8.3 | 10.0 |

*Source: Consultant's Survey*

### 2.1.4.5 Tariffs for Using the Pontoon Bridge

The pontoon bridge is subject to a toll for usage. The owner, the Turkmenistan Shipping Company, specifies the charges.

There are differential prices for inhabitants of Turkmenistan and foreigners; the tariff for Turkmenistan inhabitants is very low.

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The next table gives an overview of the prices, which are based on US Dollar rates, for using the pontoon bridge. It should be noted that these prices were valid up to September 1996; since then, the Turkmenistan Shipping Company has introduced a new tariff[11].

***Table 2-24: Selected Prices for Using the Pontoon Bridge on the Basis of the Tariff from May 1996***

| **Category** | **Tariff for Turkmenistan Inhabitants** | | **Tariff for Foreigners** | |
|---|---|---|---|---|
| | TMM | USD | TMM | USD |
| Passenger | 20 | 0.005 | | |
| Passenger cars, all types | 200 | 0.05 | 18,000 | 4.50 |
| Buses, different types | 1,800-6,400 | 0.45-1.60 | | |
| Tourist coaches | - | - | 100,000 | 25.00 |
| Freight 50 kg, transported in trucks | 60 | 0.015 | | |
| Freight 1 tonne, transported in trucks | | | 7,000 | 1.75 |
| Trucks 3.5 - 7.0 tonnes | | | 40,000 - 48,000 | 10.00 - 12.00 |
| Trucks 10 - 20 tonnes loaded | | | 100,000 | 25.00 |
| Trucks 10 - 20 tonnes empty | | | 80,000 | 20.00 |
| Trucks over 20 tonnes | | | 100,000 - 120,000 (or market prices) | 25.00 - 30.00 |

*Source: Tariffs No. 1 and No. 2 of 22.05.96, Turkmenistan Shipping Company Chardzhev*

The operation of the pontoon bridge is very profitable for the Turkmenistan Shipping Company. In 1995 the proceeds amounted to TMM217.9 million (about USD 55,000)[12]. The costs of operation are very low, since the pontoons themselves are low-cost and personnel costs are also low.

[11] Because of the expected competition in the case of a new road bridge the Turkmenistan Shipping Company did not provide the new tariff, valid since October 1996. But there is information that the new tariff takes into consideration the changed proportion between the TMM and USD and a low increase of the prices (by 5%).
[12] Source: Turkmenistan Shipping Company, September 1996

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## 2.2 Traffic Forecast

### 2.2.1 General Approach to the Traffic Forecast

Each of the different categories of freight traffic flows running over both Chardzhev bridges will have its own development trend, and therefore the traffic forecast has been constructed individually for each type of traffic flow.

Because the planned TRACECA Forecasting Model[13] was not available in time for this study, it was necessary for the Consultant to prepare his own forecast. The basis for this forecast was:

- information, data, and assessment of expected economic development
- expected development of the external trade
- planned infrastructure projects with impact on the future traffic flows via the bridges
- existing studies and forecasts relevant to these bridges
- assessments made by Turkmenistan governmental and regional authorities.

The forecast horizon was defined by the Consultant as 2005. This relatively short horizon results from the uncertainty and unstable development in the Central Asian region. A longer forecast horizon would include still more uncertainties and would be unreliable.

The forecast for different types of traffic has been carried out on the basis of a series of defined scenarios.

The projected traffic flows have been discussed with representatives of TDDY, the Turkmenistan State Highway Department and the Department of Transport and Communication of the Council of Ministers.

The forecast for future passenger traffic running via the railway and the road bridge has also been calculated for the different levels and types of passenger traffic flows.

Wherever necessary, modelling calculations were also incorporated. For some levels it was necessary to define potential future traffic supply, since the future traffic demand could not be calculated on the basis of the input data.

The forecasts of socio-economic development were carried out on the basis of data provided by the Administration of the Lebap Velayat.

In general terms, although transit freight traffic by road can be expected to increase significantly and partly at the expense of rail, there are opportunities here for TDDY to

[13] TRACECA Project 'Regional Traffic Forecasting Model' which was intended to form the basis for this present study.

market intermodal services (piggyback, swapbodies etc.) in an imaginative way in order to increase its market share.

### 2.2.2 Transport Corridors and Planned Infrastructure Projects in Central Asia with Relevance to the Chardzhev Bridges

***'New Silk Road' Transport Corridor***

Following the opening of the railway route between Tedshen/Serakhs and Meshed (Iran) in May 1996, there is now a direct land transport route between China (Beijing) and Iran (Meshed-Teheran-Persian Gulf) via Kazakstan, Uzbekistan and Turkmenistan. The length of this route, at 10,800 km, is the second longest railway line in the world.

The route via Serakhs is very significant, because

- it is possible to transport freight from China, other East Asian states and the Asian part of Russia to the Central Asian states and to Iran, to Turkey and the Indian subcontinent via a direct railway connection.
- it is the shortest route for the Central Asian states and Russia (Siberia and Far East) to the ports on the Persian Gulf (e.g. Bandar Abbas and Bandar Khomeini).

The present freight transit volume via this route is still very low, but it is expected to grow significantly in the next few years.

The connection between Tedshen and Meshed is a single-track line with 25 tonne axle load. The maximum speed for freight trains is 80 km/h.

***Transcaspian Transport Corridor***

The Governments of Uzbekistan, Turkmenistan, Azerbaijan and Georgia have agreed to the establishment of the Transcaspian Transport Corridor running between Tashkent-Ashgabat-Turkmenbashy-Baku-Poti. This corridor is an integral part of the existing Transport Corridor Europe Caucasus Asia (TRACECA). The Transcaspian Transport Corridor runs along the existing railway route Tashkent-Samarkand-Bukhara- (Chardzhev Railway Bridge)-Chardzhev-Mary-Ashgabat-Port of Turkmenbashy(-Ferry via the Caspian Sea)-Baku-Poti. From Poti it is possible to continue to western Europe.

A first marketing offer in this corridor is the 'Trans-Caucasian-Logistic-Express' between Poti and Baku. This container train runs once weekly in both directions with high reliability and guaranteed transport times.[14]

This corridor should activate the land-sea-route from Central Asian CIS-states to Europe via Turkmenistan and the Transcaucasian region to the port of Poti on the Black Sea.

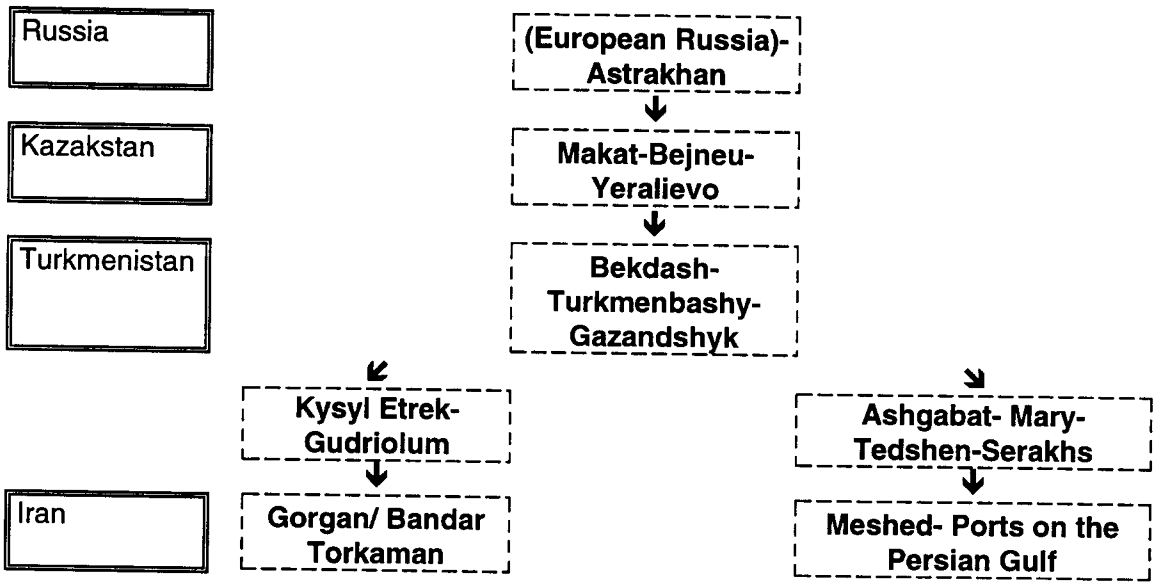
[14] Source: *Zuverlässige Verbindung für Containertransporte, Deutsche Verkehrszeitung No. 35* of 22.03.97, page 10

The use of this corridor is encouraged by the participating railways through tariff reductions of up to 40%.

***North-South Corridor Russia -Kazakstan-Turkmenistan-Iran***

The Governments of Russia, Kazakstan and Turkmenistan have signed an agreement to build a *railway corridor between Russia and Turkmenistan/Iran via Kazakstan* known as the North-South Corridor[15].

The planned corridor will run via the following routes:




The new route would be important for future traffic, mainly between European Russia, Kazakstan and Iran via Turkmenistan.

The North-South Corridor will connect especially the Russian South Ural industrial zone (Magnitogorsk, Orenburg, Ufa, Chelyabinsk, Yekaterinenburg) with Iran by rail directly. Its further importance for other European countries will depend on the future development of external trade between these countries and Iran, India and Pakistan and the ability of the route to compete with established shipping routes. It is assumed that this new connection could replace the existing, currently interrupted connections via the Transcaucasian region.

The new corridor would shorten the distance between Kazakstan and Turkmenistan by 1,085 km.

[15] Sources: Kolyshkina/ Artamkina: *Neue Wege in den Iran*, in: Rail international No. 8-9/1996
Feasibility Study for the Railway Connection Astrakhan-Bekdash-Turkmenbashy-Gazandshik-Kysyl Etrek-Tedshen-Serakhs, Report to part II Traffic Volume GIPROTRANSTEI Moskva 1995 (in Russian)

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The development of this corridor requires the construction of new railway connections Yeralievo - Turkmenbashy (443 km) and Gazandshyk - Kysyl Etrek (222 km)- Gorgan/ Bandar Torkaman.

According to the Government of Turkmenistan[16] the construction of the planned new link between Yeralievo and Turkmenbashy will probably be organised and financed by internationally. At present the financing of this project is not secured, but the expectation is very high. The planned branch line from Gazandzhyk to the Iranian border near Kysyl Etrek should be financed by the Government of Turkmenistan.

***Completion of the Railway Route Chardzhev (Zerger) - Kerki in Turkmenistan (under Construction)***

This railway route will run for 120 km between Chardzhev (Zerger station) and Kerki in eastern Turkmenistan along the left bank of Amu Darya River. The connection between the railway stations of Kerki and Kerkichi (on the right bank of the river) will be achieved by construction of a further railway bridge via the Amu Darya River.

The railway route between Chardzhev and Kerki is under construction; so far some 40 km have been constructed. The route should be completed by 1998, the bridge by 2000/2001.[17] The Kerki bridge should be a single-track railway bridge primarily, but a combined bridge is planned.

The completion of the new railway route and the Amu Darya bridge near Kerki will have the following effects:

- direct railway transport between central and east Turkmenistan as well as between central Turkmenistan and Tadjikistan/Afghanistan (Termes border point) will be possible without the present transit through Uzbekistan
- costs for transit via the Uzbekistan railway network will be avoided
- the loading of the Chardzhev Bridge will be reduced, since the new railway route will be connected to the existing route Bukhara-Chardzhev-Mary near Zerger upstream of the existing Chardzhev crossing

The new railway route has considerable economic importance to Turkmenistan because of the significant resources of various raw materials in the eastern part of the country.

***Project for Construction of a New Railway Route Ushkuduk -Beruni - Turtkul - Sultanuizdak (-Nukus) in Uzbekistan***

This railway route will create a direct railway connection between the railway routes Tashkent- Samarkand and Makat-Bejneu -Nukus.

[16] Information from the Vice-Prime-Minister and Minister for Transport, Construction and Communication of March 1997
[17] Source: TDDY in September 1996

After the completion of this route it will be possible

- to reduce the present Uzbekistan transit between Tashkent/Samarkand and the Uzbekistan Karakalpakia region via Turkmenistan (reduction of the present corridor traffic via the Chardzhev Bridge) and thereby avoid transit costs
- to go from China, Siberia and the Far East, the eastern and central regions of Kazakstan, as well as eastern Uzbekistan, to the Uzbekistan Karakalpakia region and western Kazakstan without transiting through Turkmenistan and via the Chardzhev Bridge

The railway route Ushkuduk - Sultanuizdak should be completed by 2000[18].

***Improvement of the International Main Road Network in Turkmenistan***

The Turkmenistan Government has suggested to the UN commission ESCAP that the road between Chardzhev and Turkmenbashy (M37) be integrated in the planned network of TransAsian Highways. Up to now the financing of this measure is not secured, but it is expected through international financing.

This route could develop as a competitive route for the existing railway routes through Turkmenistan.

***Plans for Creating an Almaty-Istanbul Highway***

This planned highway, from East to West, connects China with Turkey. The vital importance of this route has been recognised and pointed out to members of OECD. The implementation of the route is not expected in the near future, but it could subsequently mean a competitive route to the railway routes through Turkmenistan.

### 2.2.3 Rail Freight Traffic

#### 2.2.3.1 Significant Freight Flows via the Chardzhev Railway Bridge

The traffic connections by rail running over the Amu Darya River near Chardzhev are important for the following categories of traffic:

- Turkmenistan's external trade with CIS states, Europe and Asia via the border point of Farap
- Transit traffic flows
- domestic traffic of Turkmenistan in transit through Uzbekistan

18 Source: TDDY in September 1996

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- domestic traffic of Uzbekistan in transit through Turkmenistan

The future development of these freight flows will be influenced by the implementation of infrastructure projects and transport corridors created in Central Asia. Due to the importance and the impacts of these projects on the future traffic via the Chardzhev Bridge it is necessary to consider the relevant infrastructure and transport corridor projects.

#### 2.2.3.2 Turkmenistan Freight Export and Import by Rail via the Chardzhev Bridge

***Estimates of Freight Growth Rates***

The external trade of Turkmenistan with the CIS-countries as well as with China and other Asian states is important for freight flows via the Chardzhev Bridges. The export-import-analysis shows that the main trade partners of Turkmenistan in this region are the Central Asian CIS countries.

The forecast of the future external trade of Turkmenistan as regards the Chardzhev bridges is very difficult. Due to an unstable and uncertain political and economic situation in the Central Asian region (countries in economic and political transition), information on projected economic growth is quite limited. Data exists for the short-term period to 2000, but no further.

It is expected that there will be stability in the medium or long-term, but the consequences for the growth and the structure of external trade flows are difficult to estimate.

Because of these difficulties, the Consultant utilised various information and data from other studies and sources concerning the expected development of the economy and Turkmenistan external trade.[19]

The forecast of import/export freight traffic via the Chardzhev bridges is based on the following key points:

- the basis of the forecast consists of the present export and import freight flows via the Chardzhev railway bridge (see Chapter 2.1.3.2).
- projected GDP growth rates for the Central Asian countries were obtained from the World Bank, which projects that the Turkmenistan GDP will increase by 3.5% p.a. in the period 1996-2000. No projections were available for later periods. For the purposes of this analysis it was assumed that a growth of 3.5% p.a. will continue in the period after 2000.

[19] The following study was used: Feasibility Study: Turkmenbashy Port Development Phase I, Draft Report Submitted to: Turkmenistan Sea Administration; by: Louis Berger Inc. in association with Institute of Economics of the Council of Ministers of Turkmenistan et al. , 1996 The suitability of the results of this study for the forecast of freight flows via the Chardzhev Bridges was discussed with and confirmed by the Council of Ministers of Turkmenistan, Transport and Communications Department.

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- the rate of growth of export/import for different commodities has been estimated (slower or faster than the growth of GDP), in Table 2-25.

As a result of these estimates and considering the available data the following growth rates by commodity have been estimated:

***Oil and Oil Products***

The production of oil and oil products has grown since 1993. The export of oil products is important for rail freight (85% in 1995).

Based on an interview with governmental authorities, very low growth of oil exports up to 2000 is expected (0.5% p.a.) and in the period from 2001 to 2010, growth by 1 to 10% p.a.

A different approach is taken to the import of oil and oil products. Of importance for the Chardzhev rail bridge are significant imports of crude oil from Bukhara to the refinery in Seidi. The volume of these imports was very low in 1995, but in 1996 it was growing (500,000-600,000 tonnes). Therefore the 1996 volume was taken as the basis for the future import volumes. Given the capacity of the refinery, it is estimated that imports of crude oil to Seidi could grow by 1% p.a. approximately.

***Cotton and cotton products***

Several new plants were completed in Turkmenistan in the last few years. Exports are expected to grow more slowly than production, because a large part will be absorbed in Turkmenistan textile factories in the period after 2000. Therefore, the following export growth rates of cotton and cotton products are assumed: 4% p.a. to 2000, 2% p.a. to 2005 and 1% p.a. after 2005.

***Salt***

The export of salt, particularly to Russia and to the Central Asian countries, for the development of agriculture, can be foreseen. A constant yearly growth rate of 4% p.a. is expected

***Chemicals***

An increase of 4% p.a. in export and import of chemicals is expected in the period to 2010.

***Fertilisers***

The export of fertilisers via Farap is not important, since the primary destination is Kazakstan. Most imports come from Uzbekistan.

An increase in production of fertilisers in Turkmenistan is planned, therefore a significant growth of fertiliser export to CIS and other countries by 10% p.a. to 2000 and 4% p.a. thereafter has been projected[20].

The Turkmenistan Government has several long-term programmes for agricultural development which may lead to a significant import demand for fertilisers. Therefore, imports are also expected to increase, but growth is assumed to be more moderate than exports, 2% p.a. in the period to 2010.

***Construction Materials***

In 1995, Turkmenistan exported primarily cement and gypsum by land. The volume was low in comparison to imports. It is estimated that demand will grow in the CIS-countries due to the expected economic stabilisation in the medium-term. Therefore, the export of building materials will grow by 6% p.a. to 2010. The import of construction materials will grow at a slower rate than the GDP, by 3% p.a.

***Project Equipment***

Significant direct foreign investment in Turkmenistan is expected in the next few years, and therefore a faster growth of imports than GDP, by 5% p.a. to 2010.

***Grain and Flour***

The Government of Turkmenistan prepared a plan for reaching self-sufficiency in grains by the year 2000. In consequence of this plan, the demand for imported grain and flour will decrease. Therefore a moderate growth of import by only 0.5% p.a. is projected

***Sugar***

The Turkmenistan Agriculture Ministry projects a moderate growth of sugar imports, not exceeding 2% p.a.

***Other foods and beverages***

A moderate import growth of this commodity of about 3-4% p.a. is projected.

***Miscellaneous General Freight***

The Government has introduced ambitious economic and industrial development programmes. Therefore it is expected, that the growth rates of exports will develop more slowly than the GDP and the import rates will grow faster than the GDP. It is estimated that exports will grow by 3% p.a. and imports 4% p.a.

[20] However, these forecasts should be treated with caution, as fertiliser production is also planned to increase in many other CIS countries over the same period (cf. fertiliser production in Aktau, Kazakstan, in Module A of this Study).

***Table 2-25: Expected Growth Rates of Turkmenistan Exports and Imports***

| **Commodity Group** | **Export** | | **Import** | |
|---|---|---|---|---|
| | **Growth Rate (% p.a.)** | | **Growth Rate (% p.a.)** | |
| | Period 1996-2000 | Period 2001-2010 | Period 1996-2000 | Period 2001-2010 |
| Oil and oil products | 0.5 | 1-10 | 1 | 1 |
| Cotton, cotton products | 4 | 2% p.a. to 2005, 1% p.a. thereafter | | |
| Salt | 4 | 4 | | |
| Chemicals | 4 | 4 | 4 | 4 |
| Fertilisers | 10 | 4 | 2 | 2 |
| Construction materials | 6 | 6 | 3 | 3 |
| Project freight, equipment's | | | 5 | 5 |
| Grain, flour | | | 0.5 | 0.5 |
| Sugar | | | 2 | 2 |
| Other food and beverages | | | 3-4 | 3-4 |
| Miscellaneous general freight | 3 | 3 | 4 | 4 |

*Sources:* *- Feasibility Study: Turkmenbashy Port Development Phase I, Draft Report*
*- Information given by the Turkmenistan Government*

On the basis of these estimates, for the 'optimistic' scenario (as defined below), the Turkmenistan import/export freight volume via the Chardzhev rail bridge will amount to 2.8 million tonnes in 2005.

***Table 2-26: Forecast Volume of Turkmenistan Exports and Imports via Farap and the Chardzhev Railway Bridge***

| | | **Volume** | | |
|---|---|---|---|---|
| | | ***1995*** | ***2000*** | ***2005*** |
| Export by rail | '000 tonnes | 895.5 | 908 | **1,055** |
| Import by rail | '000 tonnes | 875.0 | 1,505 | **1,735** |
| Total freight traffic by rail | '000 tonnes | 1,770.5 | 2,413 | **2,790** |
| *Growth* | | | *+36%* | ***+58%*** |

*Source:* *Calculations based on the Feasibility Study:*
*Turkmenbashy Port Development Phase I, Draft Report; and Customs Statistics 1995*

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A 58% growth of existing traffic levels for import/export traffic by rail by 2005 is therefore projected.

### 2.2.3.3 Transit Flows via the Chardzhev Rail Bridge

The significance of the rail routes using the Chardzhev Bridge is likely to grow for international transport, particularly given the planned infrastructure developments. These can be summarised in the following table:

***Table 2-27: Future Transit Connections via the Chardzhev Railway Bridge***

| From | To | | | |
|---|---|---|---|---|
| | Persian Gulf | Indian subcontinent | South Europe, Turkey | Transcaucasian countries |
| Central Asian CIS-countries | ● | ● | ● | ● |
| China, Mongolia, Japan | ● | ❍ | ● | ● |
| Russia (Asian) | ● | ● | ● | ● |
| Russia (European), Europe (exc. south Europe) | ❍ | ❍ | - | - |

Legend: ● high significance for land transport
❍ limited significance due to possible use of existing or planned alternative or competitive routes

***Significant Development Trends***

It is clearly difficult to forecast the future level of freight transit traffic using the Chardzhev Bridge. The economy of the Central Asian CIS states is going through a period of transformation and it is clearly very difficult to assess and to quantify the future export and import flows of these countries and their importance to the Bridge.

In general the following trends have a significant influence on the development of future transit traffic using the Bridge:

- growth of exports and imports from the Central Asian CIS states to the ports on the Persian Gulf and transport via the new railway connection Tedchen- Serakhs-Meshed
- increase of transport between Uzbekistan and Europe within the defined Transcaspian Transport Corridor
- increase of competition between international rail and road transport, in which a significant proportion of traffic is either rail-friendly bulk commodities (cotton, ores, salt, metals, other raw materials etc.) or else is carried over long distances, or both
- growing transport between China and the Indian subcontinent by land, especially by rail due to the long transport distances

- increasing efficiency of the Transcaspian Transport Corridor including port of Turkmenbashy and rail ferry connection Turkmenbashy-Baku
- completion of the planned infrastructure projects with particular relevance to the Chardzhev Rail Bridge (see Chapter 2.2.2)

#### 2.2.3.4 Future Transit Freight Flows by Rail

***1.Transit Freight Flows to/from Serakhs Border ("New Silk Road" Transits)***

According to the Feasibility Study for the North-South-Corridor (Astrakhan-Bekdash-Turkmenbashy-Gazandshik-Kysyl Etrek-Tedshen-Serakhs)[21], the forecast freight volume along the 'New Silk Road' route via the border at Serakhs should amount to 6.2 million tonnes in total in 2005, including 4.2 million tonnes to Iran and 2.0 million tonnes from Iran[22]. The share of transit volume through Turkmenistan is calculated at 4.5 million tonnes (3.1 million tonnes north-south and 1.4 million tonnes south-north).

The forecast transit volume will run via several routes to Serakhs:

*Route 1* via the planned new route along the Caspian Sea including the construction of the missing link between Yeralievo-Bekdash-Turkmenbashy

*Route 2* via the route Bejneu-Nukus-Chardzhev railway station (south of the Chardzhev Railway Bridge)-Mary-Tedshen-Serakhs

*Route 3* via the 'New Silk Road' China-Kazakstan-Uzbekistan -*Chardzhev Railway Bridge*-Mary-Tedshen-Serakhs

Because of the present uncertainties surrounding the construction of the new connections within the planned North-South Corridor, the forecast concerning the Chardzhev Railway Bridge requires two variants:

Variant I Construction of the railway line Yeralievo-Bekdash-Turkmenbashy

Variant II No new railway line Yeralievo-Bekdash-Turkmenbashy[23]

[21] Source: Feasibility Study of the Railway Connection Astrakhan-Bekdash-Turkmenbashy-Gazandshik-Kysyl Etrek-Tedshen-Serakhs, Report to part II Traffic Volume, GIPROTRANSTEI Moskva 1995 (in Russian)

[22] This figure does not consider the planned line Gazandshyk-Kysyl Etrek. In case of the construction of this branch line the volume via Serakhs will be reduced.

[23] According to information of the Turkmenistan Government; the Kazakstan and Turkmenistan Government are very interested in constructing the new railway link. The financing of this link is not yet assured, but the Turkmenistan Government is at present looking for international support.

***Variant I***

It can be expected that traffic on the planned North-South Corridor will originate and/or terminate in European Russia and in West Kazakstan. A portion of the Uzbekistan exports and imports will run via the Nukus route to Serakhs (Route 2), which will not use the Chardzhev Bridge.

In the case of ***Variant I*** the expected freight volume via the Chardzhev Bridge could be 1.9 million tonnes in 2005, including 1.2 million tonnes north-south and 0.7 million tonnes south-north (see Table 2-28).

***Variant II***

In the case of ***Variant II*** it is estimated that

- in comparison to Variant I it is possible to transfer a small part of the transit traffic from Route 3 to the Chardzhev Bridge route: 50% of the transit traffic from/to Russia and 50% of the transit traffic Indian Subcontinent-Europe
- the higher share of the forecast transit flows via the new route along the Caspian Sea will primarily change to other existing alternative routes, e.g. Russia -Transcaspian Transport Corridor-Serakhs and Astrakhan-Makat-Bejneu-Nukus-Chardzhev Station-Mary-Serakhs.

In consideration of these estimates a transit volume of 2.7 million tonnes, of which 1.8 million tonnes north-south and 0.9 million tonnes south-north, via Chardzhev Bridge in 2005 (see Table 2-28) is forecast.

***Table 2-28: Freight Transit Flows „New Silk Road" via the Chardzhev Bridge in 2005 (in million tonnes)***

| Route | Direction N-S | Direction S-N | Direction total | including: | Variant I N-S | Variant I S-N | Variant I total | *Variant II N-S* | *Variant II S-N* | *Variant II total* |
|---|---|---|---|---|---|---|---|---|---|---|
| Total transit via Turkmenistan | 3.08 | 1.38 | 4.46 | **Total exports and imports of CIS-countries** | **1.76** | **0.44** | **2.20** | ***1.76*** | ***0.44*** | ***2.20*** |
| | | | | *of which:* | | | | | | |
| | | | | Russia | 0.50 | 0.20 | 0.70 | *0.50* | *0.20* | *0.70* |
| | | | | Kazakstan | 0.59 | 0.08 | 0.67 | *0.59* | *0.08* | *0.67* |
| | | | | Uzbekistan | 0.55 | 0.14 | 0.69 | *0.55* | *0.14* | *0.69* |
| | | | | Tadjikistan *) | 0.12 | 0.02 | 0.14 | *0.12* | *0.02* | *0.14* |
| | | | | **Total international transport** | **1.32** | **0.94** | **2.26** | ***1.32*** | ***0.94*** | ***2.26*** |
| | | | | *of which:* | | | | | | |
| | | | | Indian subcontinent-Europe | 0.94 | 0.50 | 1.44 | *0.94* | *0.50* | *1.44* |
| | | | | Indian subcontinent -China,Mongolia, Japan | 0.38 | 0.44 | 0.82 | *0.38* | *0.44* | *0.82* |
| of which: | | | | | | | | | | |
| Transit via the new routes along the Caspian Sea (Route 1) | | | | | 1.50 | 0.60 | 2.10 | *0* | *0* | *0* |
| Transit via Nukus (Route 2) | | | | | 0.40 | 0.10 | 0.50 | | | |
| Transit via Nukus and other alternative routes | | | | | | | | *1.30* | *0.45* | *1.75* |
| **Transit via New Silk Road (Route 3) = Transit via Chardzhev Bridge** | | | | **Total exports and imports of CIS-countries** | **0.80** | **0.24** | **1.04** | ***0.93*** | ***0.24*** | ***1.17*** |
| | | | | of which: | | | | | | |
| | | | | Russia | 0.12 | 0.10 | 0.22 | *0.25* | *0.10* | *0.35* |
| | | | | Kazakstan | 0.29 | 0.04 | 0.33 | *0.29* | *0.04* | *0.33* |
| | | | | Uzbekistan | 0.27 | 0.08 | 0.35 | *0.27* | *0.08* | *0.35* |
| | | | | Tadjikistan * | 0.12 | 0.02 | 0.14 | *0.12* | *0.02* | *0.14* |
| | | | | **Total international transport** | **0.38** | **0.44** | **0.82** | ***0.85*** | ***0.69*** | ***1.54*** |
| | | | | of which: | | | | | | |
| | | | | Indian subcontinent-Europe | 0 | 0 | 0 | *0.47* | *0.25* | *0.72* |
| | | | | Indian subcontinent -China,Mongolia, Japan | 0.38 | 0.44 | 0.82 | *0.38* | *0.44* | *0.82* |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Total** | | **1.18** | **0.68** | **1.86** | ***1.78*** | ***0.93*** | ***2.71*** |

* This volume is not relevant for the Chardzhev Bridge, if the railway route Chardzhev-Kerki and the Kerki bridge is completed by 2005.

*Source: Recalculation from North-South Corridor Feasibility Study*

It should be noted that these volumes will be reduced by the forecast export/import volume of Tadjikistan (0.14 million tonnes), should the railway route Chardzhev (Zerger)-Kerki and the bridge via the Amu Darya River between Kerki and Kerkichi be completed. In this case, it will be possible to transport the freight from Tadjikistan to Serakhs via the new line and therefore avoid the Chardzhev Bridge.

### *2. Transit Freight Flows within the Transcaspian Transport Corridor*

#### *Transport between Uzbekistan and Azerbaijan*

The Governments of Uzbekistan and Azerbaijan have agreed that over the next ten years, some 1 million tonnes of cotton per year will be supplied from Uzbekistan to Azerbaijan, in exchange for 1 million tonnes of sulphur per year in the opposite direction. Transport should be by rail (Uzbekistan-Azerbaijan 25,000 wagons per year; Azerbaijan-Uzbekistan 17,000 wagons per year). [24]

This traffic will go entirely via the Chardzhev Bridge.

#### *Traffic from Central Asian CIS Countries to Turkmenbashy Seaport*

It is expected that the freight turnover in the Turkmenbashy seaport by 2005 will include a volume of about 0.32 million tonnes, which will originate in the Central Asian CIS states[25].

Exports of 241,000 tonnes of fertilisers and 80,000 tonnes of construction materials are forecast. It is assumed that these commodities are generally rail-friendly, and that the transport from Central Asian CIS countries will be carried out by rail. This volume is significant for the traffic via the Chardzhev Bridge.

#### *Exports of Raw Materials from the Central Asian CIS Countries to Turkmenbashy Seaport*

In the future, beyond 2005, a growing volume of transit traffic is expected to use the Chardzhev Bridge as a result of investment plans in the Central Asian countries for increasing production and export of various raw materials (salt, marble, construction materials etc.). The uncertainty surrounding these plans and the sources of the necessary

[24] Source: TDDY, Department of Freight Traffic and Commercial Services
[25] Source: Feasibility Study Turkmenbashy Port Development, Phase I, Draft Report Exhib.A.4
Submitted by: Louis Berger International Inc. et. al. March 1996 by order to the Turkmenistan Sea Administration

investment dictates that this traffic cannot be included in the forecast for the Chardzhev Bridge.

***Summary of the expected transit volume in the Caspian Transport Corridor affecting Chardzhev Bridge in 2005***

***Table 2-29: Expected Transit Volume in the Caspian Transport Corridor via the Chardzhou Railway Bridge in 2005***

| | Volume (million tonnes) |
|---|---|
| Export of cotton from Uzbekistan to Azerbaijan | 1.00 |
| Import of sulphur to Uzbekistan from Azerbaijan | 1.00 |
| Export of fertiliser through Turkmenbashy Seaport | 0.24 |
| Export of construction materials through Turkmenbashy Seaport | 0.08 |
| **Total** | **2.32** |

### 2.2.3.5 Development of 'Corridor Freight Traffic'

***Corridor Freight Traffic between Central and Eastern Turkmenistan via Uzbekistan***

Given the construction of the new railway route from Chardzhev (Zerger) to Kerki and the planned bridge between Kerki and Kerkichi, it could be expected that the present 'corridor traffic' through Uzbekistan will no longer be necessary. Should this be the case, future traffic between central and eastern Turkmenistan will run on the left bank on the Amu Darya River will not need to use the Chardzhev Bridge.

According to TDDY, completion of the new bridge by 2005 is uncertain because of the lack of financing. In this event it would be necessary to continue to use the existing corridor route via Uzbekistan and the Chardzhev Bridge.

The estimate of future traffic flows from/to eastern Turkmenistan is based on the following development factors:

- the present freight volume of 2.0 million tonnes volume is lower than in previous years. It is, however, expected that this volume will again grow, given the existence of important raw materials such as potassium carbonate near Govurdak in eastern Turkmenistan.

- according to TDDY there are (unquantified) plans to export such raw materials (about 1 million tonnes) to southern Iran.

Therefore, should the bridge between Kerki and Kerkichi not be finished by 2005, the estimated freight volume from/to eastern Turkmenistan via Uzbekistan can be estimated as 3.0 million tonnes (2. 0 million tonnes present volume and 1.0 million tonnes export to Iran).

***Corridor Freight Traffic between Eastern Uzbekistan and the Uzbekistan Karakalpakia Region via Turkmenistan***

The project to construct a new railway connection between Ushkuduk and Sultanuizdak (→ Nukus) has the consequence that the present Uzbekistan corridor traffic through Turkmenistan and via the Chardzhev Bridge will be reduced. It is estimated by TDDY that the reduction will amount to 30-40%. The present level of this corridor freight traffic is 0.8 million tonnes, compared to a maximum volume of 3.0 million tonnes in 1989.

It is estimated that this maximum volume will not be repeated. Therefore a potential increase to approximately 2.0 million tonnes is estimated, of which 30-40% will be transit traffic via Turkmenistan. As a result of the new railway route, it can be expected that a freight volume of 0.6-0.8 million tonnes will transit the Chardzhev Bridge in 2005.

#### 2.2.3.6 Definition of Scenarios for the Expected Freight Traffic via the Railway Bridge

In considering planned new infrastructure projects which are relevant to future traffic levels via Chardzhev Bridge and the uncertainty of their completion by 2005, it is necessary to define three basic scenarios for the 2005 traffic forecast:

***Scenario A***

- establishing the North-South Corridor and completion of the missing links in this corridor
- completion of the railway link Chardzhev (Zerger)-Kerki
- completion of the new bridge between Kerki and Kerkichi
- completion of the Ushkuduk-Sultanuizdak route

***Scenario B***

- establishing the North-South Corridor and completion of the missing links in this corridor
- completion of the railway link Chardzhev (Zerger)-Kerki
- failure to complete the new bridge between Kerki and Kerkichi
- completion of the Ushkuduk-Sultanuizdak route

*Scenario C*

- failure to complete the North-South Corridor
- completion of the railway link Chardzhev (Zerger)-Kerki
- failure to complete the new bridge between Kerki and Kerkichi
- completion of the Ushkuduk-Sultanuizdak route

### 2.2.3.7 Summary of the Freight Traffic Forecast via the Chardzhev Bridge

The freight traffic forecast to use the Chardzhev rail bridge for the year 2005 can be summarised as:

**Scenario A:** 7.4-7.6 million tonnes

**Scenario B:** 10.6-10.8 million tonnes

**Scenario C:** 11.4-11.6 million tonnes

***Table 2-30: Expected Rail Freight Volume via the Chardzhev Bridge in 2005***

| **Traffic flows** | **Scenario A (million tonnes)** | ***Scenario B (million tonnes)*** | ***Scenario C (million tonnes)*** |
|---|---|---|---|
| Turkmenistan export/import | 2.79 | *2.79* | *2.79* |
| 'New Silk Road' transit | 1.72 | *1.86* | *2.71* |
| Transcaspian Transport Corridor | 2.32 | *2.32* | *2.32* |
| Corridor traffic from/to eastern Turkmenistan via Uzbekistan | - | *3.00* | *3.00* |
| Corridor traffic from/to Uzbekistan | 0.60-0.80 | *0.60-0.80* | *0.60-0.80* |
| **Total** | **7.43-7.63** | ***10.57-10.77*** | ***11.42-11.62*** |

Because of the difficulty of attempting to estimate future freight traffic in Central Asia, there are certain influencing factors which could lead to higher traffic volumes:

- the Central Asian economies stabilise faster than expected
- external trade using land transport between China, Mongolia, Japan and the Indian subcontinent grows more than expected
- external trade using the Transcaspian Transport Corridor resumes more quickly

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### 2.2.3.8 Number of Freight Trains via the Chardzhev Railway Bridge

The future loading of the rail bridge is a function of the daily number of trains. The number of freight trains was therefore calculated on the following basis:

- the expected future freight volume is as defined in the above Scenarios A, B and C
- the average wagon load is 45 tonnes, as advised by TDDY, reflecting a high proportion of cotton and general freight.
- trains consist of 57 wagons (850 metres), as at present
- the share of empty wagons is estimated at one third of the number of loaded wagons. This figure is the same as present traffic via the Chardzhev Bridge and was confirmed by TDDY.
- the average gross train weight is 3,200-4,200 tonnes.
- the number of freight trains currently using the bridge varies from four to six, a variation of up to 50%. This figure is abnormal, however, and in part reflects the low base level of the train service (i.e. each extra train is +25%).

The normal value used for infrastructure planning is +20-25% in general[26]. It can however be expected that due to the high proportion of grain and cotton transport (which are seasonal) the variation will be higher than normal, and therefore an average figure of +30% has been estimated.

Considering these factors the number of freight trains using Chardzhev Bridge in 2005 has been estimated as follows:

[26] Source: Information by TURKMENZHELDORTRANS

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***Table 2-31: Number of Freight Trains via the Chardzhev Railway Bridge in 2005***

| | | **SCENARIO A** | | **SCENARIO B** | | **SCENARIO C** | |
|---|---|---|---|---|---|---|---|
| | | Option low | Option high | Option low | Option high | Option low | Option high |
| Freight volume total in 2005 | million tonnes | 7.43 | 7.63 | 10.57 | 10.77 | 11.42 | 11.62 |
| Average load per wagon | tonnes /wagon | 45 | 45 | 45 | 45 | 45 | 45 |
| Number of loaded wagons | wagons | 165,111 | 169,556 | 234,889 | 239,333 | 253,778 | 258,222 |
| Share of empty wagons to loaded wagons | % | 50 | 50 | 50 | 50 | 50 | 50 |
| Number of empty wagons | wagons | 82,556 | 84,778 | 117,444 | 119,667 | 126,889 | 129,111 |
| Wagons in total (loaded and empty) | wagons | 247,667 | 254,333 | 352,333 | 359,000 | 380,667 | 387,333 |
| Number of wagons per train | wagons / train | 57 | 57 | 57 | 57 | 57 | 57 |
| Number of trains p.a. (exc. fluctuation) | | 4,345 | 4,462 | 6,181 | 6,298 | 6,678 | 6,795 |
| Average number of trains per day | | 12 | 13 | 17 | 18 | 19 | 19 |
| *Maximum value of fluctuation* | | +30 | +30 | +30 | +30 | +30 | +30 |
| Number of trains per year | | 5,649 | 5,801 | 8,036 | 8,188 | | 8,834 |
| **Average number of trains per day** | | **15.48 → 16** | **15.89 → 16** | **22.02 → 22** | **22.43 → 23** | **23.79 → 24** | **24.20 → 25** |

The expected average number of freight trains via Chardzhev Bridge will therefore be:

- **Scenario A:** 16 trains per day
- **Scenario B:** 22-23 trains per day
- **Scenario C:** 24-25 trains per day

The number of trains takes into consideration probable seasonal variations.

### 2.2.4 Road Freight Traffic

#### 2.2.4.1 Development Factors

In the Tacis Study 'Review of Control and Financing of Road Improvement' the following average annual growth rates were estimated for development of traffic using the road network of Turkmenistan:

***Table 2-32: Projected Road Freight Traffic Growth Rates***

| Vehicle types | Average annual growth rate (% p.a.) | |
|---|---|---|
| | Period 1994-2000 | Period 2001-2010 |
| 2-axle vehicles | 5.0 | 6.0 |
| 3-axle vehicles | 6.0 | 7.0 |
| > 3-axle vehicles | 6.0 | 7.0 |

*Source:* *Review of Control and Financing of Road Improvement, Final Report, Kocks Consult GmbH et al. 1995 (in Russian), Table A 5.11*

The planning for the development of future road infrastructure in Turkmenistan is generally based on these growth rates, which are, however, an average for the whole of the country.

As an example, road freight in the M37 Chardzhev-Farap-Uzbekistan border section grew by 8.3% p.a. between 1991 and 1994 and was faster than the average growth for road freight traffic[27].

Therefore the following development tendencies are assumed for future road freight traffic via a new road bridge:

- it is expected that the future international road freight traffic crossing the Amu Darya River will grow more dynamically than domestic traffic, because the international trade in the Central Asian region is growing very quickly.
- it is also expected that the modal split will follow the general international trend, which means a faster growth of road traffic in comparison with rail traffic especially for consumer goods, industrial semi-finished and finished products, food and beverages etc.
- it is estimated that the future growth rate could amount to 10-12% p.a. to 2005. This rate corresponds with the growth in the period 1991-1994 and takes into account the expected dynamism in international road transport.
- the fastest growing sector is transit traffic with its origin and destination outside Turkmenistan.

[27] Source: Kocks-Consult Study, Table A 5.8

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domestic traffic by road via the Amu Darya River will grow at a slower rate than international traffic. The domestic traffic includes two types:

- domestic freight traffic within the Lebap Velayat with origin or destination in those communities which are situated on the right bank of the Amu Darya (communities in the Farap Etrap and elsewhere).

The purposes of this traffic are supply to the population living in this area. as well as transport of agricultural and industrial products originating in this region. A moderate growth of around 6-7% p.a. to 2000 and 7-8% p.a. in the period after 2000 can be expected. Therefore it is assumed that this transport will grow at a lower rate than international transport, but faster than the expected traffic growth projected by Kocks Consult (see above). The reason for this development is that the population in the region on the right bank of the Amu Darya is expected to grow by 2.2% p.a. and it is necessary to distribute more consumer goods etc.

Domestic freight traffic also includes the category ‘other vehicles’. These are motorcycles, tractors and other motorised agricultural equipment. The number of these vehicles amounted to 156 on an average day in 1996. It is expected that this kind of traffic will remain constant and not increase.

- domestic freight traffic between other regions of Turkmenistan

The volume of this traffic is very low at present.. It is expected that this traffic grow at the same rate as other domestic traffic within the Lebap Velayat.

Taking into account the above factors, the following growth rates have been assumed:

***Table 2-33: Expected Growth Rates of Road Freight Traffic Crossing the Amu Darya River***

| Type of Traffic | Annual Average Growth Rates (%) | | | |
|---|---|---|---|---|
| | *LOW Variant* | | *HIGH Variant* | |
| | Period 1996-2000 | Period after 2000 | Period 1996-2000 | Period after 2000 |
| Domestic traffic within the Lebap Velayat and with other regions of Turkmenistan | 6.0 | 7.0 | 7.0 | 8.0 |
| International traffic | 10.0 | 10.0 | 12.0 | 12.0 |
| Domestic traffic by ‘other vehicles’ | as for 1996 (no change) | | | |

#### 2.2.4.2 Future Road Freight Traffic Crossing the Amu Darya River at Chardzhev

On the basis of the above mentioned development factors and variants, the following growth of road freight traffic crossing the Amu Darya River near Chardzhev is forecast:

***Table 2-34: Projected Daily Road Freight Traffic on the Amu Darya River Crossing at Chardzhev***

| Type of Traffic Flows | Status Quo | LOW Variant | | HIGH Variant | |
|---|---|---|---|---|---|
| | 1996 | *2000* | *2005* | 2000 | 2005 |
| | **Average Daily Traffic (vehicles in 24 hours)** | | | | |
| Domestic traffic within Lebap Velayat and with other regions in Turkmenistan | 311 | *393* | *551* | 408 | 599 |
| Domestic traffic by 'other vehicles' | 156 | *156* | *156* | 156 | 156 |
| International traffic | 372 | *545* | *877* | 585 | 1032 |
| Total | 839 | *1094* | *1582* | 1149 | 1787 |
| | **Development (%)** | | | | |
| Total (except 'other vehicles') | | *+37* | *+109* | +45 | +138 |
| of which: International traffic | | *+46* | *+136* | +57 | +177 |

The Average Daily Traffic is expected to grow further; up to the year 2010 by +220% in the LOW Variant and +295% in the HIGH Variant.

### 2.2.5 Local Passenger Traffic over the Amu Darya River

#### 2.2.5.1 Local Passenger Traffic Development Factors

The future level of local passenger traffic ('local traffic') crossing the Amu Darya River will be influenced by the following main factors:

***Population Growth***

The Amu Darya River crossings are significant to the population on the right bank of the Amu Darya River, especially in the administrative district known as Farap Etrap, and the community of Dzheykun (Chardzhev).

There are currently 54,550 inhabitants[28] in this significant catchment area. An annual growth of 2.2%. is projected by the administration of the Lebap Velayat. On this basis the population, which is important for the future local traffic crossing the Amu Darya River, will reach 65,900 inhabitants in 2005.

The size of the population of the city of Chardzhev has little influence on local traffic crossing the river, since most of the city's inhabitants live and work in the town or on the left bank of the river and therefore have no need to cross the bridge. Moreover Chardzhev is the capital of the Lebap Velayat (administrative district) and functions as a centre for culture, education,

[28] Source: Administration of Lebap Velayat, Chardzhev, Transport Department

health, shopping etc. In Farap Etrap, by way of contrast, there are no important industrial plants, cultural and health centres etc.

***Private Car Ownership***

There are at present some 2,742 passenger cars (in state and private ownership) in the Farap Etrap. This equates to a motorisation rate of 50.3 cars per 1,000 inhabitants. This rate is very low in comparison with the international level.

The authority of Lebap Velayat estimates an annual growth of passenger cars by 95 vehicles. Therefore a motorisation rate of 53.1 passenger cars per 1,000 inhabitants is forecast for 2005.

***Modal Split***

Local traffic between Farap Etrap and Chardzhev includes rail, non-public bus traffic[29] and private passenger car. Rail traffic is the only public transport option since there are no public bus services[30].

Should a new road bridge be built, it can be expected that a new network of local bus services will be established between Farap and Chardzhev, which will abstract some traffic from rail. This can also be expected to lead to a reduction in non-public bus traffic as some of the functions are taken over by the public services.

The future modal split between individual and public traffic is influenced of the future motorisation rate as well as the services and fares in the public transport by rail and by bus.

***Mobility in the Catchment Area***

At present 6,217 people cross Amu Darya River daily, by public or private transport. These can be summarised as:

- 4,610 by rail in local trains between Chardzhev and Farap via the railway bridge
- 867 by passenger cars (767 cars) via the pontoon bridge
- about 740 by non-public buses via the pontoon bridge [31]

Additionally, 150 people cross the pontoon bridge as pedestrians daily.

The mobility of inhabitants of Farap Etrap (trips = one way per average working day) currently amounts to 0.1140 trips per inhabitant per average working day, of which:

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[29] For example, commuter buses operated by schools, industrial combines, etc.
[30] There is a public bus service only from/to Uzbekistan; the buses are not for local traffic.
[31] Sources: Number of rail passengers in local traffic give by TDDY
Number of passengers by car: Result of road traffic census via the pontoon bridge in July and August 1996

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- 0.0845 trips by local rail (public transport)
- 0.0159 trips by passenger cars (individual transport)
- 0.0136 trips by bus (non-public traffic)

This means that the average annual number of trips per inhabitant totals 35.9[32], of which:

- 30.9 trips by rail (public transport) and bus (non-public transport)
- 5.6 trips by passenger car (individual transport).

The future traffic volume via the bridges is calculated using two variants:

**Variant I** The total mobility of inhabitants will grow by 10%.
**Variant II** The total mobility of inhabitants will grow by 20%.

In both variants, the fact that the motorisation rate is growing is taken into account.

### 2.2.5.2 Future Local Traffic via the Bridges over the Amu Darya River

A modelling calculation was carried out, considering the above mentioned development factors.

The volume of local traffic between Farap Etrap and Chardzhev crossing the Amu Darya River in 2005 is expected to be:

[32] Taking into account that the number of trips on weekends is lower than on an average working day: Saturdays 75% and Sundays 50% of the volume of an average working day.

***Table 2-35: Number of Local Trips between Farap Etrap and Chardzhev using the Amu Darya River Crossing***

| | Index | 1996 | 2005 | |
|---|---|---|---|---|
| | | | Variant I Mobility +10% | Variant II Mobility + +20% |
| Inhabitants of Farap Etrap incl. Dzheykhun | Number of inhabitants | 54,550 | 65,900 | 65,900 |
| Motorisation rate | Passenger cars (cars per 1000 inhabitants) | 50.3 | 54.6 | 54.6 |
| ***Daily trips per inhabitant*** | Average daily trips per inhabitant | 0.1140 | 0.1254 | 0.1368 |
| of which: | | | | |
| by rail | | 0.0845 | 0.1065 | 0.1162 |
| by bus | | 0.0136 | | |
| by car | | 0.0159 | 0.0189 | 0.0206 |
| ***Annual Trips per inhabitant*** | Annual trips per inhabitant | 35.9 | 39.5 | 43.1 |
| of which: | | | | |
| by rail or by bus | | 30.9 | 33.5 | 36.6 |
| by car | | 5.0 | 6.0 | 6.5 |
| **Trips of all inhabitants = passengers** | **Average daily trips** | 6217 | 8264 | 9015 |
| of which: | | | | |
| by rail | | 4610 | 7017 | 7656 |
| by bus | | 740 | | |
| = public transport | | | | |
| by car = private transport | | 867 | 1247 | 1359 |

In comparison with the current situation it is assumed that Variant II is the most realistic for the medium-term horizon of 2005.

Moderate growth of mobility by inhabitants of Farap Etrap is expected, reflecting the growing attractiveness of Chardzhev as an employment and cultural centre.

Therefore V*ariant I* has been defined as the *base variant* for the following calculations of the future number of vehicles crossing the Amu Darya River by various transport means.

It is expected that the future local traffic between Chardzhev and Farap Etrap will consist of

- public traffic by railway
- public traffic by bus, following construction of a new crossing

- private traffic by passenger car

The future *modal split* of public transport (railway:bus) between Chardzhev and Farap Etrap will depend on the traffic policy of the local and regional authorities, the services provided by transport companies and fare levels.

In order to estimate future modal split, a modelling calculation has been made, since obviously future public transport provision and fare levels cannot be estimated. The modelling calculation has the following assumptions:

- at present there are no public bus services between Chardzhev and Farap, only non-public buses

In the event of the construction of a new road bridge, it is expected that a system of public bus routes between Chardzhev and Farap Etrap will be established.

- it is expected that the railway will also transport local passengers between Chardzhev and Farap in future.
- in order to assess the future modal split for local traffic and the number of vehicles crossing the Amu Darya River, various modelling variants have been defined and calculated for services by bus and rail:

***Variant: Rail-dominant local traffic***

- three bus departures in each direction for completion of rail traffic only (6 buses daily)
- local trains at 2-hourly intervals in each direction (9 daily train pairs)

***Variant: Mixed rail/bus traffic***

- departures by bus at 1-hour intervals in each direction
- departures by local trains at 2-hourly intervals in each direction

***Variant: Bus-dominant local traffic***

- departures by bus at 30-minute intervals in each direction
- departures by rail in the peak hours in the morning and in the afternoon only

The daily service time in an average working day was defined as being from 0500 to 2100.

The number of places in a bus is defined as 55 (of which 45 seats), with an average occupancy of 75%.

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The average number of passengers in a train was calculated as the difference between the total public passenger volume and the volume by bus, divided by the number of daily trains.

This input has been discussed with the local authorities in the Lebap Velayat.

It can be assumed that this basic data is realistic for future local traffic between Chardzhev and Farap.

The expected number of cars comprising the *private local traffic* was calculated on the basis of the number of persons per day and an average occupancy rate of 1.13 per car (as a result of the traffic census, see Chapter 2.1.4.4).

The following pattern of local traffic can therefore be projected:

***Table 2-36: Expected Number of Road Vehicles and Trains in Local Traffic between Chardzhev and Farap Etrap Crossing the Amu Darya River on an Average Working Day in 2005 (Variant I Future Traffic Volume in Local Traffic with a Growth of Mobility by +10%)***

| | **Variant of Expected Future Modal Split** | | |
|---|---|---|---|
| | ***Rail-dominant*** | ***Mixed Rail/ Bus*** | ***Bus-dominant*** |
| **Number of vehicles** | | | |
| Buses via the road bridge | 6 | 34 | 66 |
| Trains via the railway bridge | 18 | 18 | 12 |
| Passenger cars via the road bridge | 1104 | 1104 | 1104 |
| **Number of passengers** | | | |
| By bus in total/ average occupancy rate per bus | 248 / 41.25 | 1403 / 41.25 | 2723/ 41.25 |
| By rail in total/average occupancy rate per train | 6770 / 376 | 5615 / 312 | 4294 / 358 |
| By car in total/ average occupancy rate per car | 1247 / 1.13. | 1247 / 1.13 | 1247 / 1.13 |

International experience in local traffic organisation, e.g. in Germany, suggests that the variant 'mixed rail/ bus services' would be the most logical concept for the improvement of local services this area. Therefore this variant is taken into account in assessing the future capacity of the bridges crossing the Amu Darya River.

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### 2.2.6 Long - Distance Passenger Traffic Crossing the Amu Darya River

#### 2.2.6.1 Major Influences and Uncertainties

The volume of long-distance passenger traffic crossing the Amu Darya River at Chardzhev will in the future depend on several factors, such as:

- changes in population
- socio-economic development in general
- car ownership (motorisation rate)
- improvement of socio-economic conditions for the population in Central Asia, e.g. development of wages and household incomes, standard of living, prices
- future service levels and fares by rail, by bus and by plane
- changes in border and customs regulations enabling or restricting the free movement of goods and people
- free convertibility of currencies

The assessment of the development of all of these factors is influenced by a number of political and economic uncertainties, which combine to inhibit the application of modelling calculations.

Therefore, the future traffic volume has been projected on the basis of expected public transport services, and by estimates based on the present traffic volume by private cars.

#### 2.2.6.2 Railway Passenger Traffic

The future long-distance traffic will generally decrease via the Chardzhev bridge if the planned railway routes in Turkmenistan (Chardzhev-Kerki bridge-Kerkichi) and Uzbekistan (Ushkuduk-Sultanuizdak) are completed (see chapter 2.2.2).

Following completion of the new railway link between Uchkuduk and Sultanuizdak (→ Nukus) passenger trains between Tashkent and Karakalpakia will run via the new route directly, avoiding the Chardzhev bridge.

Otherwise it should be expected that there will be a demand for new connections from/to Uzbekistan via the Chardzhev bridge in the following directions:

- Samarkand-Bukhara-**Chardzhev**-Karakalpakia to serve the section Bukhara - Karakalpakia via Chardzhev

- Tashkent-**Chardzhev**-Serakhs-Iran (as tourist service)
- Tashkent-**Chardzhev**-Ashgabat-Turkmenbashy (ferry) in order to connect Uzbekistan via the Caspian Sea to the Transcaucasus

The frequency of these long-distance services might be from once weekly to once daily. For the purposes of this analysis, a once-daily operation is assessed.

Should the Kerki bridge not be finished by 2005, the trains between Chardzhev and Kelif will continue to run via Uzbekistan and via the Chardzhev bridge.

Because of the uncertainties already explained, two scenarios for future long-distance traffic via the Chardzhev bridge have been developed:

**Scenario A** Completion of the new link Uchkuduk-Sultanuizdak
Completion of the Kerki bridge

**Scenario B** Completion of the new link Uchkuduk-Sultanuizdak
No completion of the Kerki bridge

***Table 2-37: Long-Distance Passenger Trains via the Chardzhev Railway Bridge in Future (daily train pairs)***

| Route | Scenario A | Scenario B |
|---|---|---|
| Chardzhev-Kelif | 1 | - |
| Samarkand-Bukhara-Chardzhev-Karakalpakia | 1 | 1 |
| Tashkent-Ashgabat-Turkmenbashy (ferry)-Transcaucasus | 1 | 1 |
| Tashkent-Chardzhev-Mary-Serakhs-Iran | 1 | 1 |
| **Maximum daily long-distance passenger train pairs** | **3** | **4** |

*Source: Consultant's development of TDDY base figures*

The maximum number of long-distance train pairs crossing the bridge will therefore be 3 or 4 per day.

### 2.2.6.3 Road Passenger Traffic

The following development trends for long-distance road passenger traffic can be projected:

- **long-distance traffic** will increase faster than the **local traffic.**

- cars between various Velayats (**domestic long-distance traffic**) using the road bridge will increase, particularly with the expected growing motorisation rate and the expected increase in disposable income

It can also be expected that a new road bridge will be much more attractive to users when compared with the existing pontoon bridges and ferries over the Amu Darya. The new bridge can therefore be expected to generate additional traffic in its own right.

Therefore, a growth of **long-distance domestic traffic** between other Velayats across the Amu Darya River at Chardzhev from +100% (low case) to +200% (high case) includes newly generated traffic as described above.

- **international private traffic** by passenger cars will grow, but more slowly than the domestic traffic, partly because of the higher car occupancy rate for such traffic (2.0 persons per car)

The level of **international traffic** between Turkmenistan and Uzbekistan via Farap is relatively high at present (213 vehicles daily), therefore it can be expected that traffic will grow with the population, the motorisation rate and the standard of living. The assumed growth of international traffic by passenger cars will be about +50% (low case) and +100% (high case).

- **transit traffic** is estimated to grow by +200% (low case) and by +300% (high case), recognising the increased journey opportunities and business commerce.

- **international bus traffic** will also increase:

Lebap Velayat authority is planning to introduce new bus services between Chardzhev and Uzbekistan 4 times daily. This will mean 8 extra buses per day via the bridge.

Additionally, the present international bus traffic from/to Turkmenistan can also be expected to increase. Growth of +100% (low case) and +200% (high case) is therefore projected.

- **transit traffic by bus** might rise faster than international Turkmenistan traffic; an estimated growth rate similar to that by private car (low case +200%, high case +300%) is projected.

As a result of these assumptions, the following long-distance road traffic via the Chardzhev bridge is projected:

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***Table 2-38: Expected Traffic Volume of Long-Distance Passenger Traffic by Road***

| **Transport mode** | **Traffic flows** | **Development index 1996 = 100** | | **Average daily vehicles** | | |
|---|---|---|---|---|---|---|
| | | **low case 2005** | **high case 2005** | **actual 1996** | **low case 2005** | **high case 2005** |
| **Passenger car** | Domestic traffic between other Velayats | 200 | 300 | 83 | 166 | 249 |
| | International traffic from/to Turkmenistan | 150 | 200 | 213 | 319 | 426 |
| | Transit | 300 | 400 | 41 | 123 | 164 |
| | **Total** | | | **337** | **608** | **839** |
| **Bus** | International traffic from/to Turkmenistan | 200 | 300 | 20 | 40 + 8 | 60 + 8 |
| | Transit | 300 | 400 | 20 | 60 | 80 |
| | **Total** | | | **40** | **108** | **148** |
| ***All vehicles*** | | | | ***377*** | ***716*** | ***987*** |

The expected total volume of long-distance passenger road traffic crossing the Amu Darya River at Chardzhev can thus be expected to grow by approximately 100% (low case) and by 200% (high case).

**It is important to note that the above forecast traffic levels are *average daily values* and do not take account of daily, weekly or seasonal peaks, which at present are very low.**

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### 2.2.7 Summary of the Expected Traffic Volume via the Bridges crossing the Amu Darya near Chardzhev

#### 2.2.7.1 Railway Bridge

The following three scenarios are projected for the future traffic via the railway bridge:

***Table 2-39: Additional Factors Affecting Forecast Scenarios***

| Characteristic | Scenario A | Scenario B | Scenario C |
|---|---|---|---|
| Establishing the North-South Corridor and completion of the missing links in this corridor | *yes* | *yes* | **no** |
| Completion of the railway link Chardzhev (Zerger)-Kerki | *yes* | *yes* | *yes* |
| Completion of the new bridge between Kerki and Kerkichi | *yes* | **no** | **no** |
| Completion of the Ushkuduk-Sultanuizdak route | *yes* | *yes* | *yes* |

As a result of the forecast, a growth in railway traffic by 141-204% is projected:

Scenario A 141-161%
Scenario B 182-196%
Scenario C 182-204%

***Table 2 - 40: Projected Number of Trains via the Railway Bridge***

| Type of Traffic | Number of trains daily | | | |
|---|---|---|---|---|
| | Current | Scenario A | Scenario B | Scenario C |
| Freight | 8 | 16 | 22-23 | 24-25 |
| Passenger long-distance | 2-3 | 3 | 4 | 4 |
| Passenger local | 12 | 12*-18** | 12*-18** | 12*-18** |
| ***Total*** | ***22-23*** | ***31-37*** | ***38-45*** | ***40-47*** |

* Passenger local traffic: 'rail dominant' variant
** Passenger local traffic: 'mixed rail/bus' as well as 'bus dominant' variants

It is assumed that **Scenario B** is the most realistic scenario, in which case the loading of the railway bridge would double in comparison to 1996. The number of trains daily would therefore be 38-45 (including the seasonal/daily factor $\psi$), whereas the present capacity of the bridge is 17 train pairs = 34 trains per day. Considering the high value of variation $\psi$ and the ability for technological improvement in operations it is estimated that the present single-line capacity of the bridge is sufficient for the period up to 2005. Further growth in freight traffic may be expected beyond this year, in which case measures for increasing the bridge capacity need to be introduced.

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### 2.2.7.2 Road Bridge

The projected traffic via the road crossing will increase by between 69% and 95% approximately by 2005. After 2005 further growth in road traffic can be expected, recognising the improvement of the socio-economic conditions, the growing motorisation rate, the stabilisation of political and economic conditions and the improvement of living standards in Central Asia.

***Table 2-41: Projected Number of Vehicles using the Road Crossing by 2005***

| **Category** | **Number of Vehicles per Day ADT** | | | | |
|---|---|---|---|---|---|
| | **1996 Actual** | **Forecast 2005** | | | |
| | **All vehicles types** | **Trucks, small goods vehicles** | **Passenger cars** | **Buses** | **Total** |
| Freight Traffic | 839 | 1582-1787 | | | 1582-1787 |
| Passenger long-distance traffic | 337 cars/ 40 buses | | 608-839 | 108-148 | 716-987 |
| Passenger local traffic | 767cars/ 39 buses | | 1104 | 6*-66** | 1110-1170 |
| ***Total*** | ***2022*** | ***1582-1787*** | ***1712-1943*** | ***114-214*** | ***3408-3944*** |

* Passenger local traffic: 'rail dominant' variant
** Passenger local traffic: 'mixed rail/bus' as well as 'bus dominant' variants

It can therefore be expected that traffic growth will continue beyond 2005, and that a volume in 2010 of roundly three times the 1996 level would be a realistic projection.

Once again, it should be clearly understood that the above forecasts are *average daily totals* and do not reflect daily, weekly or seasonal variations, which are beyond the Consultant's Terms of Reference.

Nevertheless, it can be clearly seen that significant growth in motor traffic over the river crossing can be expected within the next few years, and that the existing pontoon bridge (which is already operating at almost full capacity during the day) is clearly inadequate for such a purpose.

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# 3 Inspection Report On Bridge and Potential for Refurbishment

## 3.1 General

### 3.1.1 Situation and Technical Characteristic of the Bridge

The bridge across the Amu-Darya River was built in the years 1898 to 1901 to connect the town of Chardzhev in the west with Farab on the eastern bank.

Twenty five truss girder bridges (numbered 1 to 25) with a span of 66.136 m are situated on double concrete filled tube piers. All truss spans are of the same type: straight lower chords, upper chords with variable system height, so the axis of the upper chord is between 7.506 and 9.144 m above the lower chord axis. The ascending and descending diagonals and verticals connect the gusset plates with a distance of 4.724 m. The axis of the main girders have a length of 5.537 m. Between the main girder lower chords, cross girders are arranged every 4.724 m which carry longitudinal girders 1.829 m distant. Upper and lower wind bracings made of angles and also lurch bracing give horizontal stiffness (see photos F2-13 to -15, F6-18).

All connections are riveted except such parts which were added subsequently to replace damaged parts and which are bolted (photo F1-23).

The upper chord is built up by double wall riveted hat plate profile and the lower chord by a reversed hat profile similar to the upper chord. The diagonals and verticals are either formed as a double-T-section laced by flat iron or as laced plate+angle section. The end frame diagonals are of a hat section. See photo F1-31 to -37, F6-20 to -24.

Cross girders and longitudinal girders are made as riveted plate girders with angle flanges, the end cross girders strengthened by additional cover plates.

The bearings are of cast iron. The fixed bearings are on the western pier whereas the movable bearings are on the eastern pier of each span. See photo F1-17 to -20.

A runway with rails to push a small trolley is arranged outside the main girders on the upstream side (photo F1-30, F6-21, -26 and -29).

The bridge deck between the rails is partly covered with a wooden floor, partly with corrugated iron.

An inspection car is intended to run on I-beam rails below the lower flange but the resistance due to friction is heavy enough to prevent movement other than by the strength of ten members of staff.

Some of the spans carry high voltage current masts on their upper flange (see photo F1-08 and F6-33).

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The spans are resting on piers made of concrete filled double tubes with boxes between (photo F2-20, -24, F4-34 to -37).

On both banks of the river access spans of plate girders of 11.89 m length are situated.

Numbered schematic drawings are attached in Annex A: Bridge System And Notations.

### 3.1.2 Visits of Consultant's Expert

The Consultant's expert employed to produce a comprehensive judgement of the condition of the bridge is an experienced specialist in steel bridges with long residence abroad. In written as well as verbal reports he has documented the condition of the bridge in general and in detail, together with sketches and photographs. The summary of his report is given below.

### 3.1.3 Investigation Programme

It was intended to select the spans which are self-evidently in the worst state. Such spans needed to be investigated thoroughly, with the remainder being inspected only if they were conspicuously poor.

The spans which were therefore selected are

- span 0
- span 3
- span 13
- span 15
- span 23

Some other spans were also checked at random

The Consultant also directed a test loading of one bridge span and documented the deflection of the structure. The results of the measurement were checked by computer and manual calculation.

## 3.2 Summary of Present Bridge Condition

### 3.2.1 State of the Steel Structure

The steel structure was designed with sufficient strength to sustain the design loads over a long period (at least 100 years). However, it is probable that the quality of the construction material (which could not be judged by the Consultant) and the workmanship, plus corrosion damage, have resulted in the present condition, as documented in the following description

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and in Annex B: Photographic Documentation and Annex D: Summary of Former Inspections..

Some particular problems discovered by the Consultant:

- the structure shows some weakness when a train passes over the bridge; this is caused by **weak connections (loose rivets, rust swelling etc.)**. This weakness produces movement in the connections of the elements which will cause further defects in the form of new cracks.

- many of the rivets which were found defective were replaced by bolts which are probably high strength friction grip (HSFG) bolts. In normal riveted structures the plate surfaces in the connection itself are coated with a minimum of one layer of paint. If an HSFG bolt is applied on a structure painted between the force bearing surfaces, the friction coefficient is not more than 0.20 instead of 0.40 to 0.45 on a normal raw (sandblasted) surface. Therefore it is highly likely **that these replacing HSFG bolts cannot undertake the full load of the former rivets** if they are not installed correctly, i.e. machined and brought into a carefully reamed hole (tolerance hole to shaft 0.01 to 0.02 mm). If this is not the case, which can be assumed, the remaining rivets have to take over a considerable overload or the whole joint becomes very weak as a load passes over. This can again produce new cracks.

- a form of strengthening shown on photo F1-13 with a round bar welded to a strengthening plate. Such elements are **extremely liable to fatigue cracking**, as abrupt cross-section changes and poor on-site welding provoke damage, especially if situated near the load carrying track. Strengthening in such a form should be avoided.

- a very serious problem is **the corrosion of the structure and the current form of corrosion protection**. As described below, the special cement used for this purpose is not suitable. Correct sandblasting and four coats of paint of an approved quality should be applied if further defects are to be avoided.

### 3.2.2 Description of the Current State of the Piers

The piers are made of steel plate tubes which are riveted together and stiffened by bracings. The inside is filled with non-reinforced concrete.

Generally the piers show signs of heavy corrosion outside as well as inside the plate shell. One pier has been hit by a ship and the cladding is deformed. Other piers have large leaks where water can intrude into the inside. It is impossible to determine the state of the piers below the water level or inside the steel tube. The local experts report that a large amount of stone or concrete packing was introduced into some piers but the stones have now been swept away and can be found scattered in the river bed downstream.

There is a great danger that during high water levels erosion and deepening of the bottom of the river will occur, as the protecting stone packing does not exist.

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## 3.3 Detailed Description of the Bridge Condition

### 3.3.1 General

The general state of the bridge steel structure can be summarised as follows:

- many defects have been found on-site by the Consultant and are also confirmed by inspection reports made available to the Consultant

- the structure was designed with a high safety margin and its stress level would be low enough to carry heavier loads, if there were not the defects and detail faults which are described here. These faults can cause fatigue cracks which cannot be detected due to the special cement coating which is applied at present.

- the following report does not identify every individual defect but does show characteristic features of the structure.

### 3.3.2 Concerning all Spans

In all spans the edge stiffening angles of the cross frame connecting main girders and upper bracing are cut off to give more clearance for larger wagons (photo F6-18, -19). This angle has not been reinstalled in every case, and even where it has there are considerable eccentricities in the connections.

Many of the connecting angles between the cross girder and LC are cracked and have been strengthened by additional angles, where the rivets are replaced by bolts.

The connection between cross girder and longitudinal girder is strengthened in a more modern way by poor quality welding with round bars going through holes in the cross girder web (photo F1-12, -13).

Eighty percent of the rail-fastening bolts are loose.

### 3.3.3 Bearings

The bearings are made of grey cast iron and are in good condition. The moveable bearing is situated on the Farab side of every span except the access spans (see below). It consists of an upper part which rests on a round steel whipper. This is embedded in a central body with a flat lower plane running over 6 rollers. The rollers go over a lower plate which is situated on the piers' header stones. The fixed bearings (on the Chardzhev side) are rocker bearings. The upper part of every bearing is fixed with 4 bolts on the LC of the MG, the lower plate is secured against shearing with 4 vertical round bars (recorded by the local experts, but not visible).

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The 2 mm thick lead inlay between upper plate and LC of MG is squeezed out (which is a common and well known fact of lead inlay) - see photo F1-17.

The lower plates of the bearings rest on 8 mm thick lead which below is lined with a special concrete under pressure which has only recently been executed (photo F1-20).

### 3.3.4 High Voltage Cable Cantilevers

These cantilevers are connected to the UC in span 1 between 2' and 3', in the other spans between 12' and 13' by replacing the rivets with bolts, but some of the bolts are missing and have not been replaced (photo F1-23).

### 3.3.5 Spans

***Span 0*** (photo F8-24)

This span is a plate girder as described above. The main girders are in good condition (except for the painting). The legs of the LC bracing angles are deformed and bent (photo F2-13 to -15).

***Bearings:***

All 4 bearings are defective (photo F2-10). This is perhaps a consequence of the situation of the bearings: the fixed bearings are arranged diagonally - at Chardzhev end DS and on Farab side US, the movable bearings accordingly opposite. The subsequent constraint could have caused the damages.

| | |
|---|---|
| A2: | Concrete block with cracks and chipping. Vertical gab 4 mm. |
| A1: | (photo F8-26, -33, -34). Concrete block is loose on the stone. No cracks. |
| B2: | (photo F2-10, F9-05, -06). Lower plate deviates 5 mm from bridge axis direction. Vertical movement 2 mm. The lower bearing plate has a crack with 13 mm gap throughout. The concrete base is not fixed on the stone. |
| B1: | (photo F8-25, -27 to -31). The concrete below the bearings sounds to be hollow if hit by hammer (photo F8-31, HOHL = hollow). Cracks in the header stone of the piers are filled up with grout but not treated further (photo F2-12). Lower bearing plate deviates 5 mm from bridge axis direction. Concrete base not fixed on the stone. |

***Span 3***

This span is over land. The general aspect shows a well designed bridge with the characteristics of a riveted structure.

The piers are riveted double steel tubes with angle bracings between the shafts. They are filled with concrete, but at the surface there seems to be poor cement portion. No signs of

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reinforcement. The bracing and the tube walls are heavily corroded - estimated 1 mm thickness loss. The box between the tube piles is full of water and also heavily corroded (see example on photo F2-24).

The lower plates of the bearings are inserted in the stone of the pile heads and grouted (photo F1-20). No shear connectors are visible and it is not known by the local experts if there are any. The lead inlay is squeezed out (photo F1-17, F2-05).

At the end nodes of the main girder there are some badly formed rivet heads. At the verticals and diagonals some rivets were removed and replaced with bolts. No loose rivets or bolts could be detected but in some cases the rivet holes have not been refilled (photo F1-10). A similar method was used to fix the HV cantilever at the UC. There are also holes which are not filled (photo F1-23).

Strengthening of some structure elements (as the connection longitudinal to cross girder) is executed with angles which are bolted or with welded bars and gussets (photo F1-11 to -13). Such action evidently should improve defects as warping or torsion of angles or plates (photo F1-11).

Some deformations (curvature) of bracings between LC elements seem to come from the time of construction (photo F1.15, -16).

On DS side angle cantilevers which carried the footway are cut off and replaced with bolted and welded consoles (photo F1-14).

In many cases the angle which carries the inspection car rails are cracked or deformed heavily (photo F2-07, F6-13, -14 of other span). The supporting angle of the telephone console is loose also.

Very frequent signs of corrosion can be seen (except of the UC which is in good state but coating is full of cracks): photo F1-09, -10, -26 to -29, F2-01. The present painting consists of a special grout of unknown consistency and is full of cracks and not very resistant. Behind this coating very often the steel is rusty. Sometimes the special grout or cement is used to fill wide gaps (photo F1-22).

***Span 13***

This span shows similar characteristics to the other spans.

Some loose and outstanding rivets have been detected (photo F6-04, -16).

At some diagonals deformation of bracing flats can be seen (photo F6-21, -22).

LC heavy pitting (localised corrosion) due to acid influence is shown on photo F6-11, -12. The suspension angle of the inspection rail is broken (photo F6-13, -14).

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Corrosion is visible at various locations especially below rail level (photo F6-01, -02, -03, -05, -06, -07, -09, -11, -12, -15, -17, -32), but also at the diagonals where narrow gaps filled with special cement exist (photo F6-20, -24, -27, -30, -37). Rust has puffed up the angle legs due to volume extension and effects proceeding of corrosion (photo F6-32, -34, -35).

***Span 15***

Every gusset plate of LC shows signs of rust wherever the above mentioned special grout was applied. At LC gusset plate of vertical 11-11' a plate was riveted in which is 60% eaten away probably due to an attack of (battery?) acid or similar. Also one rivet had only 14 mm of the shaft and the lower head remaining. The verticals and diagonals do not have loose rivets as some of them were replaced by bolts. The total span is barely free from rust but only the surface of the coating is treated as no proper tools are available (no sandblasting, no wire brushes - only small pick axes).

The lower bracing near the movable bearing has a 3 mm deep rust flaw. The end cross girder at the fixed bearing is not strengthened and is deformed.

***Span 23***

The inspection car cannot be used as the rails (U 200) are bent due to collisions from ships which have not been repaired (in the spans 22, 23, 24 and 25). The support angles of the inspection rails are deformed (photo F4-16). As the rope winch cannot be used up to ten workmen have to move the car.

The cross girder connection to LC DS and also US shows warping (photo F4-07 to -09, -11, -12). The bracing between the longitudinal girders has loose connections, corroded, some of the rivets are missing (photo F4-10). Rivets are also missing at the end girder (photo F4-12, -23).

The LC is totally spoiled with birds droppings and other waste (photo F4-15, -26, -27).

Corrosion exists at every vertical to LC connection and at cross girders and diaphragms (photo F4-24, -25).

Strengthening of various elements of the structure has been made in a similar way to other spans (photo F4-05, -06, -08, -11, -12, -14, -28, -29, -31).

The structure above the rail level is in good condition, no loose rivets detected, riveting was executed very well.

***Span 26*** (Short span on Farab side, photo F7-25 to -27, F8-22)

No faults on the steel structure are visible, all rivets are firm. Painting is thin, some minor rust spots.

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***Bearings:***

B2: (Photos F7-12, -13, -14, -17, -18, -20). The concrete block has cracks and chippings. Between the upper and lower bearing plate a 7 mm lining plate is inserted, which can be easily moved. Vertical free motion is possible (photo F7-20). The concrete base has no connection to the stone below.

B1: (photo F7-22, -24). Lower plate is cracked. Vertical free motion together with concrete base 1,5 mm. Water channel behind the bearings has to be cleaned. Distortion of upper bearing plate is evident.

A1: (photo F7-30, -32, F8-00). Should be fixed bearing but concrete base moves on the stone (vertical movement 2 mm). Concrete base shows chippings and cracks so that the reinforcement is visible.

A2: (photo F7-31). Vertical movement is 4 mm when trains pass. Cracks in the stone.

### 3.3.6 Piers

It is reported that the real state of the piers deviates from the state documented in the original design drawings. Some reinforcing plates or bars could have been inserted inside the steel tubes which are not shown on the drawings. It is also not known whether the damage and holes which are now strengthened and closed by plates have caused some deterioration inside the piers.

It was also reported that a great amount of rubble stone was deposited at the foot of some piers in the main stream which needs to be renewed again as it was swept away. The present state is not exactly known. The water depth diagrams over the years show considerable changes which indicates a permanent change in the situation. Also the main stream changes between the piers.

Plate cladding of the piers 15 mm thick is in some spots totally eaten away due to corrosion and strengthened with plates (photo F4-32 to -34). Pier 24 was hit by a ship which damaged and bent the cladding (photo F4-36, -37).

Where not otherwise stated the following general comments can be made:

All piers are of the same construction type: riveted steel tubes with bracings, filled with concrete, no reinforcement. Correct position of the bearings is centric on the top of the pier, grouting in good state. Stone good, no cracks.

***Pier 1:***

Bottom: Rests on land, made of concrete with stone cladding.

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***Pier 2:***

Bottom: Rests in stagnant water. Corrosion signs inside and outside.

***Pier 3*** (photo F8-35, -36):

Same as for pier 2.

***Pier 4*** (photo F10-03, -04:

Bottom: Access from land possible, with water ditch 2 m. Corrosion signs inside and outside. Inside filled with water.

***Pier 5*** (photo F10-06):

Bottom: Staircase to land, sand surrounding (no water ditch). Heavy corrosion signs inside and outside.

***Pier 6*** (photo F9-01):

Same as for pier 5.

***Pier 7*** (photo F10-09, -10, -12, -13):

Bottom: Access possible, water ditch. Heavy corrosion signs inside and outside. Concrete filling defective.

***Pier 8*** (photo F10-14, -15):

Bottom: Access possible, water ditch. Heavy corrosion signs inside and outside.

***Pier 9***:

Bottom: Access possible, dry ditch. Heavy corrosion signs inside and outside.

***Pier 10***:

Bottom: Access possible, sand surrounding. Heavy corrosion signs inside and outside.

***Pier 11***:

Same as for pier 10.

***Pier 12*** (photo F10-17, -18):

Bottom: Access possible, sand surrounding. On Chardzhev side a 2.5 m buckling approx. 120 mm deep. Heavy corrosion signs inside and outside.

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***Pier 13*** (photo F10-21):

Bottom: Access possible, water ditch. Heavy corrosion signs inside and outside.

***Pier 14***:

Same as for pier 13.

***Pier 15***:

Same as for pier 13.

***Pier 16***:

Same as for pier 13.

***Pier 17***:

Same as for pier 13.

***Pier 18***:

Bottom: Access possible, sand surrounding. Heavy corrosion signs inside and outside.

***Pier 19***:

Top: Bearing for 320 mm excentric from pier centre. Grouting renewed and in good state. No defects of stone.
Bottom: Access possible, water ditch. Very heavy corrosion inside and outside. Hole at water level 2,5 m long (photo F10-22, -23).

***Pier 20***:

Same as for pier 13.

***Pier 21*** (photo F10-24):

Same as for pier 13.

***Pier 22***:
Bottom: Access not possible, pier rests in running water. Heavy corrosion signs inside and outside.

***Pier 23*** (photo F8-11 to -13):

Bottom: Access with boat, corrosion defects.

***Pier 24*** (photo F4-36, -37, F8-06 to -09, F8-15, -16):

Bottom: Access with boat, pier rests in running water. Pier was hit by ship, heavy defects with buckling and bent parts. Corrosion inside and outside.

***Pier 25*** (photo F4-32 to -34, F8-01 to -03):

Bottom: Access with boat. Corrosion signs. Welded patches on various places. As plates are not weldable the welding is faulty.

***Pier 26***:

Pier on land, made of stone.

### 3.3.7 Proof Load Measurement

The proof loading was arranged at span No. 1 on 11th September, 1996, at 09:30.

Length of the span 66,1 m.

| | | |
|---|---|---|
| Initial measurement | at point 0 | 1399 mm |
| | at point 7 | 1350 mm |
| | at point 14 | 1384 mm |

| | | |
|---|---|---|
| Temperature: | air | $36^{\circ}$ C |
| | structure | $27^{\circ}$ C |

***Loading***:

1. Two locomotives: length 33 m, total mass 276 tonnes in centric position of span 1
2. Four locomotives: length 66 m, total mass 552 tonnes over total span 1

***Measurement***:

1. without locomotives: left MG 1987 mm
   right MG 1987 mm

with 2 locomotives left MG2015 mm
right MG 2015 mm
Deflection therefore 28 mm

2.without locomotives right MG 1971 mm

with 4 locomotives right MG 2009 mm
Deflection therefore 38 mm

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***Longitudinal movement of the bridge end*:**

Measured between movable bearing of the span 1 to fixed bearing of span 2:

| | | | |
|---|---|---|---|
| Distance | without load | | 1063 mm |
| 1. | With 2 locos | 1058 mm | movement 5 mm |
| 2. | With 4 locos | 1054 mm | movement 9 mm |

A comparative computation is appended in Annex C: Check Computation

## 3.4 Evaluation Of Alternative Options

*See Annex G for illustrating drawings and Annex H for time tables.*

### 3.4.1 Refurbishment

Refurbishment of the railway bridge only can be a limited measure to save costs at the present time. Within the next 10 years the railway bridge should be replaced by a new one (see chapter 3.3).

### 3.4.2 Construction of road bridge only or road bridge as first stage of combined bridge

A fixed bridge for road vehicles to replace the present floating one is an absolute necessity.

It is strongly recommended that when constructing the road bridge, if the railway bridge is not built simultaneously, the piers should be prepared in such a way that at least one track of the railway bridge can also be positioned on the same pier. In addition the width of the piers should be such that in the future a second track can be laid (see chapter 5.5.1).

### 3.4.3 Location

Locations for future rail and road traffic:

There are three different options to be considered for the location of new bridges:

Option N1 crosses the river Amu Darya about 15km east of the city of Chardzhev

Option N2 crosses about 200m to 300m west of the existing railway bridge using the area of the pontoon bridge.

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Option N3 is shorter than N1 but also about 8km east of the city of Chardzhev.

Option N1 starts north of the existing railway bridge at km 4075 of the railway line, turning south east and crossing the river as mentioned about 15km east of Chardzhev.

The total length of this option will be approx. 38km. The advantage of this solution will be for the road traffic, in that transit traffic will pass outside of the city and will minimise the pollution in Chardzhev. The disadvantage for the railway line will be that the existing station of Chardzhev will be a dead-end, otherwise two new bridges will have to be constructed. A separated railway bridge near the existing one and a road bridge along the option N 3.

Option N2 is using more or less the same corridor as the existing one. A combined road and railway bridge was designed by the Moscow Bridge Institute, Gipotransmost and other institutes in 1982.

The advantage of this feasibility study is that the existing railway installations can be used and only about 4km of new railway line will have to be constructed. The local traffic for cars and buses as well as local trucks can pass from the centre of Chardzhev to the other side of the river Amu Darya.

The disadvantage of this option: The whole transit traffic will pass through the main part and populated area of Chardzhev. To avoid the enormous amount of trucks passing through town, a bypass will have to be designed and constructed at the same time as the new corridor is opened.

Option N3 starts at the same point as N1 but includes a shorter bypass of the city. The total length of this option will be app. 31km.

The advantage and disadvantage are almost the same as for the option N1.
(see annex F map at a scale 1:100.000 with the different options)

The location of the bridge influences the costs in that the total length is one of the main parameters (see chapter 5.5.1). In chapters 3 to 5 only those costs are considered which are in connection with the fabrication and erection of the piers and the steel bridges. In this light option N2 should be preferred. However all other aspects should also be considered in their totality.

Conclusions: Option N2 is recommended also from the infrastructural aspects. The existing Railway network need not be changed, Chardzhev Station in the centre of the city will provide the local and in the future also the transit passenger traffic as well as freight traffic.

Chardzhev II can also remain as at present and it might be useful to construct a container and freight terminal for the future extension of the traffic. To minimise the disadvantage of

the transit traffic passing through the centre of the town a new bypass west of the station Chardzhev II must be designed and constructed within the whole project.
(see annex F map at a scale 1:100.000)

## 3.5 Previous Inspections

### 3.5.1 Results of Inspection of Bridge

It can be stated that the bridge is under permanent supervision as reported to the Consultant, and this is confirmed in the translated report.

This report refers in Part I Chapter 1.1 to the design and erection of the bridge, in Chapter 1.2 to the previous inspections which took place in 1928, 1947, 1952, 1959, 1966, 1980, 1984.

Part II refers to the results of the last very thorough inspection in 1990-91 by the experts of "Bridges and bridge construction laboratory of MIIT".

In general the results of the inspection were similar to those obtained at the present time but are more extensive.

In *Annex D: Summary of Former Inspections* some of the results of the investigation are summarised, in order to provide a quick overview for decision making.

## 3.6 Feasibility Of Life Extension

### 3.6.1 Short-Term Measures

For the remaining years of the bridge's life, but starting immediately, the following measures should be undertaken:

- the piers should be checked regularly at least after each high water situation. In particular, the state of the piers which are situated in the main water flow must be kept under supervision with regard to inclination and signs of vibration. The heavy leaks at water level should be repaired to prevent a sudden collapse in a period of low water level.

- the structure should be checked regularly, at least every 6 months, to detect new cracks, loose bolts and rivets. Such checks should be concentrated on the connection between longitudinal girders and cross girders, and cross girders to main girder lower chord. The rivets and the straightness of horizontal bracing between the longitudinal girders should be observed. The rivets of the lower chord in the region of point 5 to 9 and also the connection of diagonals 0 - 1' and 1' - 2 should be checked.

- the axle loads should not be increased but preferably decreased as the number of cracks and loose rivets detected during previous inspections is a warning signal. For the same reason, as the Consultant's expert stated on site, the trains should be divided into parts having a lower loading than each span.

- the corrosion situation of the bridge is also alarming. Corrosion flaws are serious starting points of fatigue cracks, and as the structure is very carefully encased in the above-mentioned special cement envelope (which is absolutely opaque) there is a danger of cracks going undetected. A thorough protective treatment is unavoidable and should be carried out as soon as possible: totally removing the existing coating by means of careful sandblasting (all other means are inadequate) and subsequently — within 24 hours —applying the first coat of paint. This should be followed by three further coats of paint (including edge protection). The airless spray method must be used as the design details of some elements show very narrow gaps which could not be covered otherwise. Where some pocket holes or boxes exist dewatering borings should be executed to enable water flow.

### 3.6.2 Long-Term Measures

The lifetime of bridge structures of a similar design can be more than 100 years, as examples from Germany and other countries show, but very careful corrosion protection and regular inspection (which is done in this case) are prerequisites.

Because of the thick cement covering, it is not possible to predict the results of an inspection during sandblasting, when the exact state of the structure is visible.

Given the results of the above investigations, **the bridge should be replaced within the next 10 years** or at least renewed to a large extent. Experience gained from similar structures shows that renewing of riveted structures is very complicated and costly, so in this case a totally new structure would be cheaper. Any renewal should enclose all connections between longitudinal and cross girders and to the main girder lower chord and the lower chord itself (due to its very heavy corrosion damages). This recommendation is made despite not knowing the evidence after sandblasting of the structure.

It is **not recommended** to place a new structure on the existing piers without thorough investigation of the river bottom and of the state of steel plate tubes and interior concrete. There are strong suspicions that the load carrying capacity is very low due to the effect of water intrusion and corrosion.

# 4 Review Of Moscow Bridge Institute Feasibility Study ("MBIFS")

## 4.1 Technical Aspects

*See Annex G for illustrative drawings and Annex H for time tables.*

### 4.1.1 General

At least three different options for a new bridge have been worked out by the Moscow Bridge Institute:

**Option N1** Bridge crossing the river Amu Darya 15 km east of the city of Chardzhev.

Spans 110 + 8 x 2 x 132,75 + 110 m = 2344 m total length.

**Option N2** Bridge crossing the river about 250 m west of the existing railway bridge (at present this is the location of the pontoon bridge).

Version 1A and 1B: spans 27 x 66 m = 1782 m total length.
Version 2A and 2B: spans 88 + 6 x 2 x 132,75 + 88 m = 1769 m.

**Option N3** Bridge crossing the river 8 km east of the city of Chardzhev; shorter than option N1.

Spans 7 x 2 x 132,75 m = 1858,5 m total length.

The following chapters contain some remarks regarding systems and costs.

### 4.1.2 Choice of Bridge Length

It is a clear fact that the total costs of the bridge are less if the bridge is shorter and the spans are approximately equal. Therefore the following considerations deal with the option N2 which contains the minimum bridge length.

To obtain the approximate costs of the other options a linear extrapolation can be applied.

### 4.1.3 Choice of System

**Choice of bridge type**

In accordance with the MBIFS the choice of a steel deck is recommended due to
- durability
- possibility of easy repair
- less weight

- erection possibilities.

Therefore composite structures (reinforced concrete + steel) or prestressed concrete structures are less recommended in this special case.

**Comparison between single and multiple spans**

In general a single span system is more material consuming than a continuous girder system. The savings of a continuous girder structure can be approx. up to 30 % compared with a single span solution.

Therefore also in the case of 66-m-spans the girders should be connected to act as continuous.

- The advantages of a single span solution are:

  A breakdown of one span does not influence the adjacent spans

  The transition joints between the bridges are less in size.

- The advantages of multiple span continuous girders are:

  Less weight of steel

  Lower number of transition joints (however more movement = greater size)

**Version 4**

This version should not be considered for execution as the following disadvantages occur:

- Long approach ramps with 4 % slope
- In case of fire (gasoline tanker) the railway line is also interrupted
- In case of damage of one span both the railway and the road line are interrupted.

**System of main girder**

It is recommended to use truss girders with triangular main system and vertical intermediate hangers to produce spans of approx. 5 m of the secondary system (= longitudinal girders carrying the track). Such a system is shown on the drawings of the MBIFS.
In order to avoid the effects of fatigue and also oscillations, the system height of the truss girders should be about 12 m. The MBIFS drawings show a total height of 15 m which is deemed to be on the safe side.

The vertical stayer which supports the upper chord is likely to be unnecessary as the slenderness of the chord is approx. 30 which leads to a buckling coefficient of 1,08. Due to fatigue the allowable stress should be reduced also for such an amount.

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**System of track carrying elements / railway**

The span of longitudinal girders is assumed to be about 5 m which is a value used in some recent steel bridges. Longer spans result in difficulties of deflection, of the effects of fatigue and have problems with joints.
It is recommended to use a closed bridge deck with ballast 0,5 m high. It has the following advantages (however it is more expensive):

- Increased lifetime of rails due to elastic bedding
- Less wear and tear of the wheels
- Considerable noise reduction
- Better fatigue characteristics of the whole structure due to increased permanent load.

The ballast is resting on a deck plate of 20 mm thickness which is standard for railway bridges in Austria and Germany now. The deck plate is supported by 2 longitudinal girders of T-section and some flat stiffeners.

**System of deck carrying elements / road**

The bridge deck is built up as an orthotropic deck. The distance of the longitudinal girders is governed by the stipulation

$$b \leq 25 \cdot t_{deck},$$

where b is the distance of the supporting elements (welds of the longitudinal girders) and $t_{deck}$ is the thickness of the deck plate. $t_{deck}$ is assumed as 20 mm which causes less number of girders and has more resistance against deck deflection and corrosion wear.

### 4.1.4 Details of design proposal

In addition to the above listed details the following should be taken into account:

**Inspection car**

Rails and openings in the pier heads should be so designed that the car can run over the full length of the bridges driven by a gasoline motor (or by an emergency hand drive). At each abutment a cross shifting apparatus should enable the use of one car for both (or three) adjacent bridges. The car should be equipped with adjustable arms to inspect all parts at the bottom of the structure. To enable the piers to be passed a suspension should provide for turning of the car into a longitudinal direction.

**Replacement and repair of bearings**

To change the bearing stiffeners and support plates hydraulic lifting jacks should be available. Lifting points can be placed on the railway bridges on the main girders near the actual bearing and on the railway bridges at the end of cross girders. The piers will have to be correspondingly reinforced to take over the dead load.

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**Protection of the main structure of the road bridge against damage**

As a recent development, bridges in Central Europe have been equipped with guide walls of plate which are formed in a New-Jersey-wall-like profile. These guide walls are 0,8 m high and their cross section is curved so that deviating cars are led back to the lane without hitting the steel structure and thereby damaging it. In most cases neither car nor guide walls are heavily affected.

Such guide walls also prevent persons crossing from the sidewalk into vehicle range whilst at the same time allowing the possibility of climbing over in case of accidents.

## 4.2 Technical Aspects of Infrastructure Planning

### 4.2.1 Evaluation of Infrastructure Options

The city of Chardzhev lies on the western bank of the river Amu Darya, within Turkmenistan. The border with Uzbekistan is some 20 km beyond the river. The Amu Darya Railway Bridge on the line between Chardzhev and Bukhara in Uzbekistan was built almost one hundred years ago and, although it continues to carry traffic without speed or weight restriction, there are doubts as to its medium term reliability.

**The existing bridge**

The bridge was built during the period 1898 to 1901, when the maximum axle load was 16 tonnes. This bridge is the only railway crossing over the river Amu Darya and ranks among the fifty longest railway river crossings in the world. It now carries trains with axle loads of 25 tonnes.

The only river crossing available to road traffic is a floating pontoon bridge, installed some years ago to replace a car ferry. This is said to be unstable when used by heavy vehicles. The approach roads are not convenient to strategic traffic and are congested with urban traffic. The pontoon must be closed occasionally to allow river traffic to pass and for several days each year because of high flood water. A river crossing by night is also sometimes impossible.

Options for future rail and road traffic:

There are at least three different options for new bridges :

Option N1 is crossing the river Amu Darya about 15km east of the city of Chardzhev
Option N2 is crossing about 200 to 300 metres west of the existing railway bridge using the area of the pontoon bridge.
Option N3 is shorter than N1 but also about 8km east of the city of Chardzhev.

Option N1 starts north of the existing railway bridge at km 4075 of the railway line, turning south east and passing the river as mentioned about 15 km east of

Chardzhev. The total length of this option will be app. 37.2 km. The length of the road will be app 29.3 km.
The advantage of this solution will be for the road traffic, that the transit will pass outside of the city and will minimise the pollution in Chardzhev.

The disadvantage for the railway line will be, that the existing station of Chardzhev will be a dead end, otherwise two new bridges have to be constructed. A separated railway bridge near the existing one and a road bridge along the N 3.

Option N2 is using more or less the same corridor as there is now, a combined road and railway bridge was designed by the Moscow Bridge Institute, Gipotransmost and other institutes in 1982.

The advantage of this feasibility study is, that the existing railway installations can be used and only about 4 km of new railway line have to be constructed. The local traffic for cars and buses as well as local trucks can pass from the centre of Chardzhev to the other side of the river Amu Darya.

The disadvantage of this study: The whole transit traffic will pass in the future the main part and populated area of Chardzhev. To avoid this enormous amount of trucks a bypass has to be designed and constructed at the same time as the new corridor will be opened.

Two alternatives will be worked out and costed, that means the first stage using the existing access of the pontoon bridge, and the extension as alternative 2 including the „Bypass".

Option N3 starts at the same point as N1 but is a shorter bypass of the city. The total length of this option will be app. 30.5 km for the railway and 24.4 km for the road.
The advantages and disadvantages will be nearly the same as for the option N1.
(see Annex F map at a scale 1:100,000 with the different options)

***Conclusions***

Based on the evaluation of the three options, the option N2 should be preferred from the infrastructure planning point of view.

The existing Railway network need not be changed; Chardzhev Station in the centre of the city will provide the local and in the future also the transit passenger traffic as well as freight traffic.

Chardzhev II can also be operated in future as a railway station and it might be useful to construct a container and freight terminal for the future extension of the traffic. To minimise the disadvantage of the transit traffic passing through the centre of Chardzhev a new bypass west of the station Chardzhev II must be designed and constructed within the whole project.
(see Annex F map at a scale 1:100,000)

The first phase should be the construction of a new 2 lane road bridge about 200 to 300 m west of the existing Railway Bridge. At the same time the foundation and the piers should be constructed for the new railway bridge (combined railway and road bridge).The framework for the Railway Bridge can be done at the same time or later on. This depends on the further use of the existing bridge.

***Results***

The option N2 will be recommended with a combined Railway and Road Bridge, that means a single line railway connection and a two lane road bridge serving the present and the future extension of the traffic.

Required Constructions:
- New app. 2 km combined railway and road bridge
- another app.2 km railway connection with the existing line, one km on each side.
- a new bypass for transit traffic and heavy trucks of about 13 km: The length of the new road depends on the terrain and the present road situation. For the time being the existing road connection to the pontoon bridge also could be used on both sides.
- along the bypass a new Road Bridge to pass the existing Railway west of Chardzhev II station.

### 4.2.2 Technical details of the Railway and Road Construction

#### 4.2.2.1 Railway Line

For the new Railway lines of option 1 to 3 at the time being a single track line is proposed. For land acquisition a width of 25 m is calculated including space for a second track whenever it will be necessary and additional a 4.0 m road along the whole line serving for the maintenance of the permanent way.

Therefore for 1.0 km 2.5 ha or 25,000 qm are required.

#### 4.2.2.2 Road Construction

The three options mentioned will serve the transit traffic as well as the local transport. Therefore the same width of the corridor is proposed. As mentioned in the existing report the total width of the span structures on the top , including barriers and railings is 15.5 m for motor roads of category II.

According to this basic data a width of also 25 m is required for the roads. Therefore for 1.0 km 2.5 ha or 25,000 qm are required.

# 5 Economic Analysis And Recommendations

## 5.1 Estimated Investment Cost

*Only option N2 is detailed below. Other options should be extrapolated as indicated above.*

**Comparison of steel structure mass**

| Option N2 variant: | Bridge | MBIFS estimation | TRACECA estimation |
|---|---|---|---|
| **1B** | Railway bridge<br>27 x 66 m | 6.090 tonnes | 7.300 tonnes |
| **2B** | Railway bridge<br>88 + 6x2x132 + 88 m | 11.290 tonnes | 9.640 tonnes |
| **3** | Railway + road bridge<br>88 + 6x2x132 + 88 m | 23.600 tonnes | 23.610 tonnes |

*Discussion of the differences:*

Railway bridges: The TRACECA study indicates a mass 20 % more than MBIFS as ballast and 20 mm deck plates are applied. Also the influence of EUROCODE fatigue approach has such effect.

Railway + road bridge: The increase in bulk for the railway bridge is offset by a decrease in bulk at the road bridge.

### Costs of the bridges

An estimated unit price per metric tonne is given below which can be applied for each of the structures approximately.

### Piers

As a very rough price for a 28 m long (measured in the direction of flow) and 3 m wide pier in partially quick flowing water, depth about 40 m below water level, the following costs are assumed. There is also assumed that 28 m long piers are constructed where either the railway or the road bridge only are erected in a first stage.

| | | TRACECA estimated price |
|---|---|---|
| Average pier costs | per 1 pier | 660.000,- USD |

For 132m-spans the pier costs are increased per 10 %.

### Steel structure

The estimation below is based on the following assumptions:

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Material, manufacturing and delivery are calculated as for Austrian or German sites: The structure is shop welded. The main girder is site bolted, the orthotropic deck is site welded.

Transport costs are estimated as 130,- USD per tonne.

Corrosion protection: Sandblasting Sa 2,5
1st coating Epoxy based material
2nd coating Micaceous iron on epoxy base
3rd coating Micaceous iron on epoxy base
4th coating Poly-urethane
Total coating thickness 240 mym.

| DELIVERY | | TRACECA estimated price |
|---|---|---|
| **Design** (static calc., general design drawings) | per 1 metric tonne | 380,- USD |
| **Material** S235JO, S355J2G3 | per 1 metric tonne | 480,- USD |
| **Fabrication** of a welded and partially bolted structure | per 1 metric tonne | 1.050,- USD |
| **Corrosion protection** (4 coatings) | per 1 metric tonne | 310,- USD |
| **Transport** of parts max. 2.6 x 2,0 x 20 m | per 1 metric tonne | 130,- USD |
| TOTAL | per 1 metric tonne | **2.350,- USD** |

| ERECTION | | TRACECA estimated price |
|---|---|---|
| **Site installation and supervision** | per 1 metric tonne | **260,- USD** |
| **Erection** | per 1 metric tonne | **600,- USD** |
| TOTAL | per 1 metric tonne | **860,- USD** |

| | | |
|---|---|---|
| TOTAL | per 1 metric tonne | **3.210,- USD** |

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**TOTAL COST OVERVIEW**

This table contains only an estimation of pier costs and of steel structure costs; not included are costs of ballast, rails, electric equipment, traffic signs, road surface.

| **Option N1** variant: | Bridge | TRACECA estimation | TRACECA estimated price |
|---|---|---|---|
| 1 | **Railway bridge** | | |
| | 110 + 8x2x132 + 110 m | 12.770 tonnes | 41.000.000,- USD |
| | 17 piers | 17 piers | 12.300.000,- USD |
| | 2 abutments | 2 abutments | 700.000,- USD |
| | TOTAL | | **54.000.000,- USD** |
| 2 | **Railway + road bridge** | | |
| | 110 + 8x2x132 + 110 m | 31.280 tonnes | 100.400.000,- USD |
| | 17 piers | 17 piers | 12.300.000,- USD |
| | 2 abutments | 2 abutments | 700.000,- USD |
| | TOTAL | | **113.400.000,- USD** |

| **Option N2** variant: | Bridge | TRACECA estimation | TRACECA estimated price |
|---|---|---|---|
| 1B | **Railway bridge** | | |
| | 27 x 66 m | 7.300 tonnes | 23.400.000,- USD |
| | 26 piers | 26 piers | 17.000.000,- USD |
| | 2 abutments | 2 abutments | 700.000,- USD |
| | TOTAL | | **41.100.000,- USD** |
| 2B | **Railway bridge** | | |
| | 88 + 6x2x132 + 88 m | 9.640 tonnes | 30.900.000,- USD |
| | 13 piers | 13 piers | 9.400.000,- USD |
| | 2 abutments | 2 abutments | 700.000,- USD |
| | TOTAL | | **41.000.000,- USD** |
| 3 | **Railway + road bridge** | | |
| | 88 + 6x2x132 + 88 m | 23.610 tonnes | 75.800.000,- USD |
| | 13 piers | 13 piers | 9.400.000,- USD |
| | 2 abutments | 2 abutments | 700.000,- USD |
| | TOTAL | | **85.900.000,- USD** |

Option N2 Version 2B would therefore be the cheapest one, however Version 3 is strongly recommended for further development.

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| Option N3 variant: | Bridge | TRACECA estimation | TRACECA estimated price |
|---|---|---|---|
| 1 | **Railway bridge** | | |
| | 7x2x132 m | 10.130 tonnes | 32.500.000,- USD |
| | 13 piers | 13 piers | 9.400.000,- USD |
| | 2 abutments | 2 abutments | 700.000,- USD |
| | TOTAL | | **42.600.000,- USD** |
| 2 | **Railway + road bridge** | | |
| | 7x2x132 m | 24.800 tonnes | 79.600.000,- USD |
| | 13 piers | 13 piers | 9.400.000,- USD |
| | 2 abutments | 2 abutments | 700.000,- USD |
| | TOTAL | | **89.700.000,- USD** |

Results: The option N2 will be recommended with a combined Railway and Road Bridge, i.e. a single line railway connection and a two line road bridge serving the present and the future potential increase in traffic.

Construction Requirements:

- New app. 2km combined Railway and Road Bridge
- another app.2km Railway connection with the existing line, one km on each side.
- a new bypass for transit traffic and heavy trucks of about 13km, the length of the new road depending on the terrain and the present road situation. For the time being the existing road connection to the pontoon bridge also could be used on both sides.
- along the bypass a new Road Bridge to pass the existing Railway west of Chardzhev II station.

### 5.1.1 Basic data for investment calculation of Rail and Road Construction

- **Land Acquisition Costs**

Agricultural land in the area of Chardzhev has to be calculated with 34.0 mio. Manat per 1 ha this is equivalent to 6,400.-- USD, therefore

1.0 km requires 2.5 ha = 16,000.-- USD/km

Within the city of Chardzhev the information for land acquisition costs was not available, so according to European calculations at least the acquisition costs as mentioned above have to be multiplied by factor 10,so resulting in

1.0 km requires 2.5 ha = 160,000.-- USD/km

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- **Railway Construction Costs**

Construction costs per km single track not including expensive structures are estimated with 908.6 mio. Manat equivalent to 172,100.-- USD per km.

Comparing these construction with Kazakstan with 240,000.-- USD, it will be advisable to calculate with app. 200,000.-- USD per km.

- **Road Construction Costs**

Construction costs per km road, also not including expensive structures and bridges are estimated with 5,570.4 mio. Manat equivalent to 1.055 mio. USD (other figures of road construction were given for foreign companies of more than 4.0 mio. USD).

- **Additional Costs**

- Mapping, project, supervision about 15 % of construction investment
- Additional structures 30 % of construction
- Bridges crossing the Amu Darya River
- Other Bridges

- Only for railway construction, signalling and telecommunication 50%

### 5.1.2 Investment Costs for the three options

As Construction costs based on the figures mentioned above the following costs will be used for investment calculation:

- 1.0 km Road construction including land acquisition costs, road construction costs and additional costs
  1,600,000.-- USD excluding bridges

- 1.0 km Railway construction including land acquisition costs, railway construction costs and additional costs
  500,000.-- USD excluding bridges

- 1.0 km additional land acquisition costs in the city of Chardzhev only estimated
  144,000.-- USD(160,000.-- USD - 16,000.-- USD)

- 1m of bridges 30,000.-- USD

- 1km additional rail installation for Bridges
  200,000.-- USD

### 5.1.2.1 Option 1 - Summary

| Infrastructure requirements | length | costs in USD |
|---|---|---|
| Railway access way | 37.2 km | 18,600,000.-- |
| Road access way | 29.3 km | 46,880,000.-- |
| Combined Road-Rail bridge | | 113,400,000.-- |
| Additional bridges | 312 m | 9,360,000.-- |
| Rail installation on the bridge | 2.6 km x 0.2 mio. USD | 520,000.-- |
| TOTAL | | 188,760,000.-- |

### 5.1.2.2 Option 2 - Summary

Alternative 1 without new road passing outside of Chardzhev (Bypass)

| Infrastructure requirements | length | costs in USD |
|---|---|---|
| Railway access way | 2.4 km | 1,200,000.-- |
| Road access way | 2.0 km | 3,200,000.-- |
| Combined Road-Rail bridge | | 85,900,000.-- |
| Rail installation on the bridge | 2.0 km x 0.2 mio. USD | 400,000.-- |
| TOTAL | | 90.700,000.-- |

Alternative 2 including a bypass with a length of app. 13 km

| Infrastructure requirements | length | costs in USD |
|---|---|---|
| Alternative 1 | | 90,700,000.-- |
| bypass | 13.0 km | 20,800,000.-- |
| flyover and bridges | app 200 m | 6,000,000.-- |
| additional land acquisition in the city of Chardzhev | | 1,870,000.-- |
| TOTAL | | 119,370,000.-- |

### 5.1.2.3 Option 3 - Summary

| Infrastructure requirements | length | costs in USD |
|---|---|---|
| Railway access way | 30.5 km | 15,250,000.-- |
| Road access way | 24.4 km | 39,040,000.-- |
| Combined Road-Rail bridge | | 89,700,000.-- |
| Additional bridges | 130 m | 3,900,000.-- |
| Rail installation on the bridge | 2.0 km x 0.2 mio. USD | 400,000.-- |
| TOTAL | | 148,290,000.-- |

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## 5.2 Definition of Operating Costs

In estimating the costs involved for the proposed measures Option N2 Variant No.3 has been taken into consideration, in accordance with the recommendations of the technical experts, and in line with the calculations contained in 5.1 above.

It is therefore assumed that the present bridge will be refurbished and that a road/rail bridge will be constructed in ten years time. It is further assumed that in connection with the construction of the bridge only the minimum prerequisite as far as access roads are concerned will be considered. Any extension of the road network will form part of a general plan of enhancement.

In the absence of any historical data concerning the financial aspects of the bridge's operations the investment expenditures have been taken as a basis for estimating the operating costs. It is considered that to maintain the bridge in good condition the annual charge for maintenance could amount to 1.5% of the investment costs. This estimate is in line with European guidelines for comparable constructions: See Annex I. The depreciation charges are based on a 50 year life on a straight-line basis. Likewise the costs for the refurbishment of the bridge are amortised over ten years, since this is considered the period which the present bridge must last before the construction of a new one. The estimated design and consulting fees have also been amortised over ten years. It could however be argued that these costs form part of the expenditures for the erection of the bridge and be included in the total costs which are depreciated over 50 years. The effect in either case can not be considered as significant in comparison to the total costs of the recommended measures to be taken.

The operating costs calculated in accordance with the above assumptions are contained in Tables 5.3.4 and 5.3.5.

In order to provide the necessary data to enable more exact calculations in the future it is recommended that the Railway reorganise its accounting system to supply detailed information on the bridge's operations. The bridge should in fact be considered as a cost centre, and should tolls be charged for usage of the bridge it should become a profit centre. During the Soviet era such considerations did not have the same importance as under a market oriented system so that considerable steps in this direction still have to be taken.

## 5.3 Cost-Benefit Analysis

### 5.3.1 Alternatives Available

As pointed out in other sections of this report the bridge must be regarded as a strategic necessity for Turkmenistan;- e.g. approx. one third of external trade passed over the railway bridge in 1995 in the form of exports of oil products and imports of various materials and foodstuffs: See 2.1.3.2. The location of the bridge at Chardzhev is the most logical with regard to the traffic flows and the alternatives to a fixed crossing at this point involve a long re-routing of railway traffic and continuing use of the pontoon bridge for road traffic. No other alternatives would seem to be conceivable at present and further use of the pontoon bridge cannot be regarded as feasible in the long-term. Moreover the relevance of the crossing at Chardzhev as part of the "New Silk Road" and Transcaspian Corridor has been established by the Governments of the region. This topic is addressed in Chapter 2.2.2.

#### 5.3.1.1 Do Nothing Scenario

Under the present situation the bridge is not expected to last much longer than ten years; see Chapter 3.4. If nothing is done the bridge will reach a state which will be unsafe for rail traffic beyond this time period. The consequence will be that this traffic will have to be re-routed over the new bridge at Kerki, resulting in an estimated detour of some 500 km for traffic from Bukhara and an additional 200 to 300 km for traffic from Samarkand, thereby adding additional costs and time

## 5.2 Definition of Operating Costs

In estimating the costs involved Option N2 Variant No.3 has been taken into consideration, in accordance with the recommendations of the technical experts, and in line with the calculations contained in 5.1 above.

It is therefore assumed that the present bridge will be refurbished and that a road/rail bridge will be constructed in ten years time. It is further assumed that in connection with the construction of the bridge only the minimum prerequisite as far as access roads are concerned will be considered. Any extension of the road network will form part of a general plan of enhancement.

In the absence of any historical data concerning the financial aspects of the bridge's operations the investment expenditures have been taken as a basis for estimating the operating costs. It is considered that to maintain the bridge in good condition the annual charge for maintenance could amount to 1.5% of the investment costs. This estimate is in line with European guidelines for comparable constructions. See Annex I. The depreciation charges are based on a 50 year life on a straight-line basis. Likewise the costs for the refurbishment of the bridge are amortised over ten years, since this is considered the period which the present bridge must last before the construction of a new one. The estimated design and consulting fees have also been amortised over ten years. It could however be argued that these costs form part of the expenditures for the erection of the bridge and be included in the total costs which are depreciated over 50 years. The effect in either case can not be considered as significant in comparison to the total costs of the recommended measures to be taken..

The operating costs calculated in accordance with the above assumptions are contained in Tables 5.3.3 and 5.3.4.

In order to provide the necessary data to enable more exact calculations in the future it is recommended that the Railway reorganise its accounting system to supply detailed information on the bridge's operations. The bridge should in fact be considered as a cost centre, and should tolls be charged for usage of the bridge it should become a profit centre. During the Soviet era such considerations did not have the same importance as under a market oriented system so that considerable steps in this direction still have to be taken.

## 5.3 Cost-Benefit Analysis

### 5.3.1 Financing Strategies

As pointed out in other sections of this report the bridge must be regarded as a strategic necessity rather than as a commercial proposition. The alternatives involve a long re-routing of railway traffic and continuing use of the pontoon bridge for road traffic. These alternatives are not feasible as long-term solutions.

loss of up to an extra day to the journey. In addition this will be an extra burden on the line from Kerki to Zerger, whose primary purpose is intended to be to provide a link between Central and East Turkmenistan, thereby avoiding passage through Uzbekistan; see Chapter 2.2.

A further consequence of not renewing the bridge will be that local rail traffic will no longer be possible between Chardzhev and Farap on the opposite bank of the river. This will cause hardship to the residents of the area; (over 930,000 in number; see Table 3.2), since many must cross the bridge to work or for domestic reasons. The present daily average is 4,620, as noted in Table 2-14. Furthermore it was as a result of the policies of former governments that communities were set up on the Farap bank and therefore there is an implicit responsibility for the authorities to provide a means of transport to and from Chardzhev.

If there is no possibility to commute by rail between Farap and Chardzhev the logical repercussion will be that commuters will have to travel by bus or private car which will further encumber the pontoon bridge, already accommodating over 2,000 vehicles per day, and result in even greater road traffic bottlenecks.

The state of the pontoon bridge is such that it is already overburdened and potentially dangerous: As noted in Chapter 2.1.4 trucks must wait until each float is free before proceeding in order to prevent dangerous tilting of the floats. Truck drivers are also reluctant to cross at night because the bridge is unlit and potentially hazardous.

In view of all these conditions, action is urgently needed to find a lasting solution, since the financial and social consequences of delay will increase with the passage of time. The logical conclusion would seem to be that a bridge at this crossing point is indispensable, not only from the local socio-economic aspect but also because, as pointed out in Chapter 2, it is a vital link between Central Asia and the West, as well as for traffic en route to and from Iran and points beyond. The new bridge at Kerki would not be a viable alternative to a road/rail bridge at Chardzhev for the reasons mentioned above.

#### 5.3.1.2 Financing Possibilities

The points raised above demonstrate that apart from the financial considerations the social element is also very important. Nonetheless the bridge can contribute to its financing if tolls are charged for its use by road traffic in the same manner as the present pontoon bridge, which would then contribute to the financing of both the road and the rail portions. An attempt has therefore been made to estimate the costs involved in operating the bridge and the possible toll revenues which could offset these costs. The present toll revenues are contained in Table 5.3.1.

Taking the forecasts contained in Chapter 2.2 as a base, the development of the volume of road traffic up to the year 2005 is demonstrated in Table 5.3.2. below. This has been made for both the high and the low variants.

From the figures obtained, an estimate has been made in Table 5.3.3. of the toll revenues which can be expected, based on the tariffs charged by the current operator of the pontoon bridge and presuming that toll revenues will commence on the day the bridge is first opened to road traffic. See Table 2-24. Here again calculations for both the high and the low variants have been made.

These estimates show that toll revenues should be adequate to cover the costs of operating the bridge and provide a reserve for its eventual replacement through depreciation charges, once the bridge is opened to traffic in 2009. See Tables 5.3.4. and 5.3.5 The tables also show the net revenues without taking into account the depreciation charges.

To determine the extent to which these net revenues are sufficient to cover the financial costs involved, the internal rate of return (IRR) and net present values for the combined road and rail bridge has been calculated based on the forecast developments in road traffic and the recommended investment option: See Tables 5.3.6 and 5.3.7 The calculations have been made

In view of the above considerations it is difficult to express the benefits in financial terms. Moreover it is not at this stage clear whether tolls will be charged for the use of the bridge for road traffic, as is the case for the use of the present pontoon bridge.

With these considerations in mind an attempt has been made to estimate the costs involved in operating the bridge and the possible toll revenues which could offset these costs.

Taking the forecasts contained in Chapter 2.2 as a base, the development of the volume of road traffic up to the year 2005 is demonstrated in Table 5.3.1. below. This has been made for both the high and the low variants.

From the figures obtained, an estimate has been made in Table 5.3.2. of the toll revenues which can be expected, based on the tariffs charged by the current operator of the pontoon bridge. See Table 2.1.4.5. Here again calculations for both the high and the low variants have been made.

These estimates show that toll revenues should be adequate to cover the costs of operating the bridge and provide a reserve for its eventual replacement through depreciation charges. See Table 5.3.3.

### 5.3.2 Financial Planning

As outlined in 5.3.1. it may be possible to finance the operations from toll revenues generated by the road traffic using the bridge. If this solution does not prove to be viable these costs must be covered from other sources. These sources can either be:

- The Railway

  or

- The Government.

From the financial information provided it is not possible to judge the extent to which the Railway is capable of covering these expenses, it must however be emphasised that for the long-term proper functioning of the bridge the appropriate funds must be made available for maintenance.

If the Government is to carry the financial burden of operating the bridge, the most likely solution would be either in the form of subsidies for the Railway infrastructure or directly through the Ministry of Transport.

In addition to the operating expenses of the bridge the question of funding must also be addressed.

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taking into consideration a 30 year and a 40 year payback period for the total investment and both the high and the low traffic prognoses.

The calculations show that for both variants the IRR is low and the toll revenues will not be sufficient to make the bridge a commercially viable proposition. In fact the best returns obtained are 7.72% and 7.43% which would hardly be sufficient to cover financing at current rates of interest. The other variants may be considered as too low to finance the investments and the operating expenses.

In Tables 5.3.8 and 5.3.9 the cash flow effect of the investments are shown for three selected interest rates between 5% and 9% for both variants and payback periods. It is assumed that the toll revenues will only be credited to the bridge operations once it is opened to road traffic; i.e.; after the fourth year from the beginning of construction.

The results show that only for the most favourable variant; high traffic volume with loans at 5% interest, are the revenues sufficient to cover all the operating expenses and the financial costs.

### *Road Bridge Operations*

In Tables 5.3.10 and 5.3.11 the effect of separating the road portion of the bridge from the combined bridge is shown, so that the toll revenues offset the costs attributable to the road service only. The result is that IRRs between 13.9% and 16.5% are obtained, which show that the road bridge operations are viable in as far as that financial and operating costs are covered if total revenues are credited to the road bridge operations and the railway portion of the bridge is isolated.

The residual values in each case represent the net book value based on 50 years straight-line depreciation.

Tables 5.3.12 to 5.3.15 show the cash flow effect for the road bridge only, assuming that all the revenues are allocated to the upkeep of the road portion of the bridge and the railway portion separately administered. Toll revenues in this case are high enough to provide a positive cash flow once the bridge is completed. Nonetheless, assuming that the recommendation to refurbish the bridge to allow its further use for the next ten years is accepted, investments amounting to over USD55million will need to be financed before toll revenues are earned.

### *Rail Operations*

The above considerations assume that the toll revenues from the road traffic will be used to finance the combined bridge operations. This form of cross subsidy is however not necessarily the only appropriate method and the befitting solution could be that the railway should be required to bear its portion of the costs.

In Table 5.3.16 the operating costs of the bridge for rail traffic have been estimated. In this case depreciation has been included to introduce an element of repayment of investment costs into the calculation. The calculations show that the costs for rail usage under the forecast scenarios amount to fifteen US cents per passenger and twenty three cents per tonne under the low variant and six cents per passenger and fifteen cents per tonne for the high variant. It is presumed that the costs will only be borne by foreign users of the bridge, as is essentially the case at present. These figures are in marked contrast to the present tolls levied for road transport: USD3.125 per passenger and USD1.75 per tonne; extrapolated from Tables 2-22 and 2-24. These rail costs could therefore be incorporated into the tariffs for international traffic crossing the bridge.

Table 5.3.17 illustrates the shortfall in revenues under differing scenarios already discussed. Taking these figures into consideration and assuming that the rail operations were required to

It is assumed that the Railway will require outside financing for the project in question and this will most likely be provided by a European financial institution such as the EBRD. The financing must be the subject of negotiation by the parties involved and a detailed audit by the lending institution.

At this present stage therefore it can only be speculated as to the form such financing can take. Nonetheless in Table 5.3.5 the effect is demonstrated of two possible financing variants; a loan repayable at 5% interest over 30 years and at the same rate of interest over 40 years. These may be considered as amongst the most favourable terms to be expected.

The calculation shows that the net revenues assumed, even in the case of the high variant, will not be sufficient to cover the financial costs of the proposed investment and therefore other possibilities must be considered to cover the shortfall. These would include:

- Financing out of the Railways other operations
- Subsidies from the Government
- The Government assumes the financial costs; possibly through the Ministry of Transport
- The tariffs are increased to a level sufficient to cover all the costs involved.

In conclusion it is clear that over the next 15 years investments in the order of USD100 million will be necessary to improve the rail and road traffic situation at Chardzhev. In addition the following measures will be necessary:

- More funds must be made available on an annual basis than is the case at present for the proper upkeep of the bridge.
- A more transparent presentation of the financial situation than at present will be necessary for the Railway to convince possible lending institutions of the Railways capacity to manage repayments of any loans provided.
- A detailed audit of the accounts of the Railway must be made to establish its financial situation before any loans are granted.

cover their operating costs, the additional revenues generated would be sufficient to finance at least the high variant at an interest rate of 7.5%.

On the other hand if the bridge were to be regarded from a purely commercial standpoint, it can be argued that rail traffic should be charged for the use of the bridge at the same level as the road users. This would put the road and rail operations on an equal competitive level. In such a case the following annual revenues can be assumed once the bridge is fully operational:

Figs in USD'000s

| | High Variant | Low Variant |
|---|---|---|
| Revenues from road traffic | 8,796 | 7,619 |
| Revenues from rail traffic | 22,239 | 14,218 |
| Total | 31,035 | 21,837 |

The calculation for rail traffic usage being based on the following:

| | High Variant | Low Variant | Calculation |
|---|---|---|---|
| Local Passengers | 13 | 13 | 7656x360x0.005/7017x360x0.005 |
| Long Distance Passengers | 1,903,500 | 1,215,000 | 1,440x423x3.125/1,080x360x3.125 |
| Freight | 20,335,000 | 13,002,500 | 11,620 x 1.75 / 7,430 x 1.75 |
| Total | 22,238,513 | 14,217,513 | |

If this solution were to be accepted the revenues will give an IRR of 31% for the high variant and 22% for the low variant: See Tables 5.3.19 and 5.3.20. If this solution were to be introduced the bridge operator could not be the Railway but would have to be an independent authority or conceivably a private undertaking.

### 5.3.1.3 Toll Levels

As Table 2-24 demonstrates; the present pontoon bridge is essentially financed by the foreign traffic using the bridge. It is not foreseeable that this situation will change with the construction of the new bridge. Salaries and wages in Turkmenistan are likely to remain at levels comparative to those at present, so that no significant increase can be expected in tolls charged to local traffic. It can therefore be assumed that the foreign traffic will continue to provide the revenues for the bridge.

If the road users were to continue to cross-subsidise the rail operations and tolls raised to a level sufficient to cover the estimated shortfall in revenues, the effect would be as demonstrated in Table 5.3.18, where passenger cars could be paying up to seven dollars and freight up to $2.76 per tonne to cross the bridge. It is difficult at this stage to determine whether the users would be prepared to bear these costs and whether at some stage an alternative would be sought.

### 5.3.2 Financial Planning

As outlined in 5.3.1.2. and 5.3.1.3 it may be possible to finance the operations from toll revenues generated by the traffic using the bridge. If this solution does not prove to be viable these costs must be covered from other sources. These sources can either be:

- The Railway from its current operations or

- The Government.

From the financial information provided it is not possible to judge the extent to which the Railway is capable of covering these expenses from its regular operations, it must however be emphasised that for the long-term proper functioning of the bridge the appropriate funds must be made available for maintenance.

If the Government is to carry the financial burden of operating the bridge, the most likely solution would be either in the form of subsidies for the Railway infrastructure or directly through the Ministry of Transport.

In addition to the operating expenses of the bridge the question of funding must also be addressed.

It is assumed that outside financing will be required for the project in question and this will most likely be provided by an international institution. The financing must be the subject of negotiation by the parties involved and a detailed audit by the lending institution.

At this present stage therefore it can only be speculated as to the form such financing can take. Calculations show that the net revenues assumed, even in the case of the high variant, will not be sufficient to cover the financial costs of the proposed investment and therefore other possibilities must be considered to cover the shortfall. These would include:

- Financing out of the Railways other operations
- Subsidies from the Government
- The Government assumes the financial costs; possibly through the Ministry of Transport
- The tariffs are increased to a level which can be regarded as the optimum which the traffic will bear in conjunction with one or more of the other measures suggested above.

In conclusion it is clear that over the next 15 years investments in the order of USD100 million will be necessary to improve the rail and road traffic situation at Chardzhev. In addition the following measures will be necessary:

- More funds must be made available on an annual basis than is the case at present for the proper upkeep of the bridge.
- A more transparent presentation of the financial situation than at present will be necessary for the Railway to convince possible lending institutions of the Railway's capacity to manage repayments of any loans provided.
- A detailed audit of the accounts of the Railway must be made to establish its financial situation before any loans are granted.

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## Module C: Chardzhev Bridge

**Table 5.3.1 Road Traffic Revenues as of May 1996:**

| | Unit Price (Avge) in USD | | Avge Daily Volume | | Avge Annual Volume | | Avge Annual Revenue | |
|---|---|---|---|---|---|---|---|---|
| | Local Users | Foreign Users | Local | Foreign | Local | Foreign | Local | Foreign |
| Local Passengers | 0,005 | | 995 | | 358.054 | 0 | 1.790 | 0 |
| Passenger Cars | 0,050 | 4,500 | 850 | 254 | 306.029 | 91.411 | 15.301 | 411.350 |
| Buses | 1,025 | | 37 | | 13.367 | 0 | 13.701 | 0 |
| Tourist Coaches | | 25,000 | | 42 | 0 | 15.073 | 0 | 376.830 |
| Freight 1 tonne | | 1,750 | 85 | 180 | 30.623 | 64.777 | 0 | 113.359 |
| Trucks 3.5 - 7 tonnes | | 11,000 | 38 | 80 | 13.636 | 28.844 | 0 | 317.283 |
| Trucks 10 - 20 tonnes | | 25,000 | 96 | 204 | 34.668 | 73.332 | 0 | 1.833.300 |
| Other | | | 156 | | 56.160 | | 2808 | |
| Total Income by Category | | | | | | | 33.601 | 3.052.123 |
| Total Income: Local & Foreign | | | | | | | | 3.085.723 |

## Module C: Chardzhev Bridge

### Table 5.3.2 Estimated Growth in Traffic:

### High Variant

| Avge Annual Volume | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1996 | | 1997 | | 1998 | | 1999 | | 2000 | |
| **Annual Increase** | | | 7% | 12% | 7% | 12% | 7% | 12% | 7% | 12% |
| Local Passengers | 358.054 | 0 | 383.117 | 0 | 409.936 | 0 | 438.631 | 0 | 469.335 | 0 |
| Passenger Cars | 306.029 | 91.411 | 327.451 | 102.381 | 350.372 | 114.666 | 374.898 | 126.133 | 401.141 | 141.269 |
| Buses | 13.367 | 0 | 14.302 | 0 | 15.304 | 0 | 16.375 | 0 | 17.521 | 0 |
| Tourist Coaches | 0 | 15.073 | 0 | 16.882 | 0 | 18.908 | 0 | 20.799 | 0 | 23.294 |
| Freight 1 tonne | 30.623 | 64.777 | 32.767 | 72.550 | 35.061 | 81.256 | 37.515 | 89.381 | 40.141 | 100.107 |
| Trucks 3.5 - 7 tonnes | 13.636 | 28.844 | 14.591 | 32.305 | 15.612 | 36.182 | 16.705 | 39.800 | 17.874 | 44.576 |
| Trucks 10 - 20 tonnes | 34.668 | 73.332 | 37.095 | 82.132 | 39.691 | 91.988 | 42.470 | 101.186 | 45.443 | 113.329 |
| Other | 56.160 | 0 | 60.091 | 0 | 64.298 | 0 | 68.798 | 0 | 73.614 | 0 |

| Avge Annual Volume | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2001 | | 2002 | | 2003 | | 2004 | | 2005 | |
| **Annual Increase** | 8% | 12% | 8% | 12% | 8% | 12% | 8% | 12% | 8% | 12% |
| Local Passengers | 506.882 | 0 | 547.433 | 0 | 591.227 | 0 | 638.526 | 0 | 689.608 | 0 |
| Passenger Cars | 433.233 | 158.221 | 467.891 | 177.208 | 505.323 | 198.472 | 545.748 | 222.289 | 589.408 | 248.964 |
| Buses | 18.923 | 0 | 20.437 | 0 | 22.072 | 0 | 23.837 | 0 | 25.744 | 0 |
| Tourist Coaches | 0 | 26.090 | 0 | 29.221 | 0 | 32.727 | 0 | 36.654 | 0 | 41.053 |
| Freight 1 tonne | 43.352 | 112.120 | 46.820 | 125.574 | 50.566 | 140.643 | 54.611 | 157.520 | 58.980 | 176.423 |
| Trucks 3.5 - 7 tonnes | 19.304 | 49.925 | 20.848 | 55.916 | 22.516 | 62.626 | 24.318 | 70.141 | 26.263 | 78.558 |
| Trucks 10 - 20 tonnes | 49.078 | 126.928 | 53.004 | 142.160 | 57.245 | 159.219 | 61.824 | 178.325 | 66.770 | 199.724 |
| Other | 79.503 | 0 | 85.864 | 0 | 92.733 | 0 | 100.151 | 0 | 108.164 | 0 |

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## Module C: Chardzhev Bridge

### Table 5.3.2 Estimated Growth in Traffic:

### Low Variant

| Avge Annual Volume | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign |
|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | 1996 | | 1997 | | 1998 | | 1999 | | 2000 | |
| **Annual Increase** | | | 6% | 10% | 6% | 10% | 6% | 10% | 6% | 10% |
| Local Passengers | 358.054 | 0 | 379.537 | 0 | 402.309 | 0 | 426.448 | 0 | 452.035 | 0 |
| Passenger Cars | 306.029 | 91.411 | 324.391 | 100.552 | 343.854 | 110.608 | 364.485 | 121.668 | 386.354 | 133.835 |
| Buses | 13.367 | 0 | 14.169 | 0 | 15.019 | 0 | 15.920 | 0 | 16.875 | 0 |
| Tourist Coaches | 0 | 15.073 | 0 | 16.581 | 0 | 18.239 | 0 | 20.062 | 0 | 22.069 |
| Freight 1 tonne | 30.623 | 64.777 | 32.461 | 71.254 | 34.408 | 78.380 | 36.473 | 86.218 | 38.661 | 94.839 |
| Trucks 3.5 - 7 tonnes | 13.636 | 28.844 | 14.454 | 31.728 | 15.321 | 34.901 | 16.241 | 38.391 | 17.215 | 42.230 |
| Trucks 10 - 20 tonnes | 34.668 | 73.332 | 36.748 | 80.665 | 38.953 | 88.732 | 41.290 | 97.605 | 43.768 | 107.365 |
| Other | 56.160 | 0 | 59.530 | 0 | 63.101 | 0 | 66.887 | 0 | 70.901 | 0 |

| Avge Annual Volume | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign |
|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | 2001 | | 2002 | | 2003 | | 2004 | | 2005 | |
| **Annual Increase** | 7% | 10% | 7% | 10% | 7% | 10% | 7% | 10% | 7% | 10% |
| Local Passengers | 483.677 | 0 | 517.534 | 0 | 553.762 | 0 | 592.525 | 0 | 634.002 | 0 |
| Passenger Cars | 413.399 | 147.219 | 442.337 | 161.941 | 473.301 | 178.135 | 506.432 | 195.948 | 541.882 | 215.543 |
| Buses | 18.057 | 0 | 19.321 | 0 | 20.673 | 0 | 22.120 | 0 | 23.668 | 0 |
| Tourist Coaches | 0 | 24.276 | 0 | 26.703 | 0 | 29.373 | 0 | 32.311 | 0 | 35.542 |
| Freight 1 tonne | 41.368 | 104.323 | 44.263 | 114.756 | 47.362 | 126.231 | 50.677 | 138.854 | 54.225 | 152.740 |
| Trucks 3.5 - 7 tonnes | 18.420 | 46.453 | 19.710 | 51.099 | 21.089 | 56.209 | 22.566 | 61.830 | 24.145 | 68.012 |
| Trucks 10 - 20 tonnes | 46.831 | 118.102 | 50.109 | 129.912 | 53.617 | 142.903 | 57.370 | 157.194 | 61.386 | 172.913 |
| Other | 75.864 | 0 | 81.174 | 0 | 86.856 | 0 | 92.936 | 0 | 99.442 | 0 |

## Module C: Chardzhev Bridge

**Table 5.3.3 Estimated Growth in Traffic Revenues (in USD):**

### High Variant

| | Unit Price (Avge) in USD | | Unit Price from 1997 (+ 5%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Local Users | Foreign Users | Local Users | Foreign Users | 1996 | 1997 | 1998 | 1999 |
| Local Passengers | 0,005 | | 0,005 | | 1.790 | 2.011 | 2.152 | 2.303 |
| Passenger Cars | 0,050 | 4,500 | 0,053 | 4,725 | 426.652 | 500.939 | 560.192 | 615.660 |
| Buses | 1,025 | | 1,076 | | 13.701 | 15.393 | 16.471 | 17.623 |
| Tourist Coaches | | 25,000 | | 26,250 | 376.830 | 443.152 | 496.330 | 545.963 |
| Freight 1 tonne | | 1,750 | | 1,838 | 113.359 | 133.310 | 149.307 | 164.238 |
| Trucks 3.5 - 7 tonnes | | 11,000 | | 11,550 | 317.283 | 373.125 | 417.900 | 459.690 |
| Trucks 10 - 20 tonnes | | 25,000 | | 26,250 | 1.833.300 | 2.155.961 | 2.414.676 | 2.656.144 |
| Other | | | | | 2.808 | 3.155 | 3.376 | 3.612 |
| Total Income: Local & Foreign | | | | | 3.085.723 | 3.627.047 | 4.060.405 | 4.465.233 |

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|---|---|
| Local Passengers | 2.464 | 2.661 | 2.874 | 3.104 | 3.352 | 3.620 | 26.332 |
| Passenger Cars | 688.555 | 770.339 | 861.870 | 964.312 | 1.078.968 | 1.207.298 | 7.674.785 |
| Buses | 18.857 | 20.366 | 21.995 | 23.755 | 25.655 | 27.707 | 201.523 |
| Tourist Coaches | 611.479 | 684.856 | 767.039 | 859.084 | 962.174 | 1.077.635 | 6.824.543 |
| Freight 1 tonne | 183.947 | 206.020 | 230.743 | 258.432 | 289.444 | 324.177 | 2.052.978 |
| Trucks 3.5 - 7 tonnes | 514.853 | 576.635 | 645.831 | 723.331 | 810.131 | 907.346 | 5.746.125 |
| Trucks 10 - 20 tonnes | 2.974.881 | 3.331.867 | 3.731.691 | 4.179.494 | 4.681.033 | 5.242.757 | 33.201.802 |
| Other | 3.865 | 4.174 | 4.508 | 4.868 | 5.258 | 5.679 | 41.302 |
| Total Income: Local & Foreign | 4.998.900 | 5.596.918 | 6.266.551 | 7.016.379 | 7.856.014 | 8.796.220 | 55.769.390 |

## Module C: Chardzhev Bridge

**Table 5.3.3 Estimated Growth in Traffic Revenues (in USD):**

### Low Variant:

| | Unit Price (Avge) in USD | | Unit Price from 1997 (+ 5%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Local Users | Foreign Users | Local Users | Foreign Users | 1996 | 1997 | 1998 | 1999 |
| Local Passengers | 0,005 | | 0,005 | | 1.790 | 1.993 | 2.112 | 2.239 |
| Passenger Cars | 0,050 | 4,500 | 0,053 | 4,725 | 426.652 | 492.140 | 540.673 | 594.018 |
| Buses | 1,025 | | 1,076 | | 13.701 | 15.249 | 16.164 | 17.134 |
| Tourist Coaches | | 25,000 | | 26,250 | 376.830 | 435.239 | 478.763 | 526.639 |
| Freight 1 tonne | | 1,750 | | 1,838 | 113.359 | 130.930 | 144.023 | 158.425 |
| Trucks 3.5 - 7 tonnes | | 11,000 | | 11,550 | 317.283 | 366.462 | 403.108 | 443.419 |
| Trucks 10 - 20 tonnes | | 25,000 | | 26,250 | 1.833.300 | 2.117.462 | 2.329.208 | 2.562.128 |
| Other | | | | | 2.808 | 3.125 | 3.313 | 3.512 |
| Total Income: Local & Foreign | | | | | 3.085.723 | 3.562.599 | 3.917.363 | 4.307.514 |

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|---|---|
| Local Passengers | 2.373 | 2.539 | 2.717 | 2.907 | 3.111 | 3.329 | 25.110 |
| Passenger Cars | 652.655 | 717.312 | 788.392 | 866.534 | 952.442 | 1.046.889 | 7.077.706 |
| Buses | 18.162 | 19.433 | 20.794 | 22.249 | 23.807 | 25.473 | 192.166 |
| Tourist Coaches | 579.303 | 637.233 | 700.956 | 771.052 | 848.157 | 932.973 | 6.287.143 |
| Freight 1 tonne | 174.267 | 191.694 | 210.864 | 231.950 | 255.145 | 280.659 | 1.891.316 |
| Trucks 3.5 - 7 tonnes | 487.761 | 536.537 | 590.191 | 649.210 | 714.131 | 785.544 | 5.293.645 |
| Trucks 10 - 20 tonnes | 2.818.341 | 3.100.175 | 3.410.193 | 3.751.212 | 4.126.333 | 4.538.967 | 30.587.320 |
| Other | 3.722 | 3.983 | 4.262 | 4.560 | 4.879 | 5.221 | 39.384 |
| Total Income: Local & Foreign | 4.736.584 | 5.208.907 | 5.728.367 | 6.299.674 | 6.928.005 | 7.619.054 | 51.393.791 |

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## Module C: Chardzhev Bridge

**Table 5.3.4 Estimated Revenues and Expenses: (USD'000s)**

**Option N2 High Variant**

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Refurbishment of Bridge | | | 2.691 | 2.691 | 2.691 | | | | | | | | | | | | | 8.073 |
| Access Roads & Installations | | | | | | | | | | | | 640 | 1.280 | 1.280 | 480 | 480 | 240 | 4.400 |
| Design and Consulting | | | | | | | | | | 2.834 | | | | | | | | 2.834 |
| Construction of New Bridge | | | | | | | | | | | 14.316 | 14.316 | 14.317 | 14.317 | 14.317 | 14.717 | | 86.300 |
| Total Investment | 0 | 0 | 2.691 | 2.691 | 2.691 | 0 | 0 | 0 | 0 | 2.834 | 14.316 | 14.956 | 15.597 | 15.597 | 14.797 | 15.197 | 240 | 101.607 |
| Maintenance Costs | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 215 | 439 | 673 | 907 | 1.129 | 1.357 | 1.361 | 6.080 |
| Depreciation | | | | | | | | | | | 286 | 585 | 897 | 1.209 | 1.505 | 1.809 | 1.814 | 8.107 |
| Amortisation of Refurbishment Expenses | | 0 | 269 | 538 | 807 | 807 | 807 | 807 | 807 | 807 | 807 | 807 | 538 | 269 | 0 | | | 8.073 |
| Amortisation of Design & Consulting | | | | | | | | | | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 2.267 |
| Total Operating Costs | | 0 | 269 | 538 | 807 | 807 | 807 | 807 | 807 | 1.091 | 1.592 | 2.115 | 2.392 | 2.669 | 2.918 | 3.450 | 3.458 | 24.527 |
| Offset By: | | | | | | | | | | | | | | | | | | |
| Toll Revenues | 3.086 | 3.627 | 4.060 | 4.465 | 4.999 | 5.597 | 6.267 | 7.016 | 7.856 | 8.796 | 8.796 | 8.796 | 8.796 | 8.796 | 8.796 | 8.796 | 8.796 | 117.343 |
| Net Revenues | 0 | 0 | -269 | -538 | -807 | -807 | -807 | -807 | -807 | -1.091 | -1.592 | -2.115 | -2.392 | 6.127 | 5.879 | 5.347 | 5.338 | 10.657 |
| Net Revenues without Depreciation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -215 | -439 | -673 | 7.889 | 7.667 | 7.439 | 7.436 | 29.105 |

☐ = Period in which toll revenues accrue to pontoon bridge.

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## Module C: Chardzhev Bridge

**Table 5.3.5 Estimated Revenues and Expenses: (USD'000s)**

**Option N2 Low Variant**

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Refurbishment of Bridge | | | 2.691 | 2.691 | 2.691 | | | | | | | | | | | | | 8.073 |
| Access Roads & Installations | | | | | | | | | | | | 640 | 1.280 | 1.280 | 480 | 480 | 240 | 4.400 |
| Design and Consulting | | | | | | | | | | 2.834 | | | | | | | | 2.834 |
| Construction of New Bridge | | | | | | | | | | | 14.316 | 14.316 | 14.317 | 14.317 | 14.317 | 14.717 | | 86.300 |
| Total Investment | 0 | 0 | 2.691 | 2.691 | 2.691 | 0 | 0 | 0 | 0 | 2.834 | 14.316 | 14.956 | 15.597 | 15.597 | 14.797 | 15.197 | 240 | 101.607 |
| Maintenance Costs | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 215 | 439 | 673 | 907 | 1.129 | 1.357 | 1.361 | 6.080 |
| Depreciation | | | | | | | | | | | 286 | 585 | 897 | 1.209 | 1.505 | 1.809 | 1.814 | 8.107 |
| Amortisation of Refurbishment Expenses | | 0 | 269 | 538 | 807 | 807 | 807 | 807 | 807 | 807 | 807 | 807 | 538 | 269 | 0 | | | 8.073 |
| Amortisation of Design & Consulting | | | | | | | | | | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 2.267 |
| Total Operating Costs | | 0 | 269 | 538 | 807 | 807 | 807 | 807 | 807 | 1.091 | 1.592 | 2.115 | 2.392 | 2.669 | 2.918 | 3.450 | 3.458 | 24.527 |
| Offset By: | | | | | | | | | | | | | | | | | | |
| Toll Revenues | 3.086 | 3.563 | 3.917 | 4.308 | 4.737 | 5.209 | 5.728 | 6.300 | 6.928 | 7.619 | 7.619 | 7.619 | 7.619 | 7.619 | 7.619 | 7.619 | 7.619 | 104.727 |
| Net Revenues | 0 | 0 | -269 | -538 | -807 | -807 | -807 | -807 | -807 | -1.091 | -1.592 | -2.115 | -2.392 | 4.950 | 4.701 | 4.170 | 4.161 | 5.949 |
| Net Revenues without Depreciation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -215 | -439 | -673 | 6.712 | 6.490 | 6.262 | 6.259 | 24.396 |

= Period in which toll revenues accrue to pontoon bridge

Table 5.3.6 Internal Rate of Return Road and Rail Bridge: 30 Year Payback:

USD'000s

| Year | Investmts | High Variant Revenues | High Variant Op'tng Costs | High Variant Net Outlays /Revenues | Low Variant Revenues | Low Variant Op'tng Costs | Low Variant Net Outlays /Revenues |
|---|---|---|---|---|---|---|---|
| 2005 | 2.834 | 0 | 0 | -2.834 | 0 | 0 | -2.834 |
| 2006 | 14.316 | 0 | 215 | -14.531 | 0 | 215 | -14.531 |
| 2007 | 14.956 | 0 | 439 | -15.395 | 0 | 439 | -15.395 |
| 2008 | 15.597 | 0 | 673 | -16.270 | 0 | 673 | -16.270 |
| 2009 | 15.597 | 8.796 | 907 | -7.708 | 7.619 | 907 | -8.885 |
| 2010 | 14.797 | 8.796 | 1.129 | -7.130 | 7.619 | 1.129 | -8.307 |
| 2011 | 15.197 | 8.796 | 1.357 | -7.758 | 7.619 | 1.357 | -8.935 |
| 2012 | 240 | 8.796 | 1.361 | 7.196 | 7.619 | 1.361 | 6.019 |
| 2013 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2014 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2015 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2016 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2017 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2018 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2019 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2020 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2021 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2022 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2023 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2024 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2025 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2026 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2027 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2028 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2029 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2030 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2031 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2032 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2033 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2034 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2035 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2036 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2037 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2038 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| Residual Value | | 35.429 | | 35.429 | 35.429 | | 35.429 |
| Total | 93.534 | 299.316 | 41.453 | 164.328 | 264.001 | 41.453 | 129.013 |
| NPV | | | | | | | |
| 5% | 75.661 | | | 24.204 | | | 9.317 |
| 7,50% | 68.489 | | | -487 | | | -10.897 |
| 9% | 64.641 | | | -9.350 | | | -17.917 |
| IRR | | | | 7,43% | | | 5,95% |

Table 5.3.7 Internal Rate of Return Road and Rail Bridge: 40 Year Payback: (USD'000s)

| Year | Investmnts | High Variant | | | Low Variant | | |
|---|---|---|---|---|---|---|---|
| | | Revenues | Op'tng Costs | Net Outlays /Revenues | Revenues | Op'tng Costs | Net Outlays /Revenues |
| 2005 | 2.834 | 0 | 0 | -2.834 | 0 | 0 | -2.834 |
| 2006 | 14.316 | 0 | 215 | -14.531 | 0 | 215 | -14.531 |
| 2007 | 14.956 | 0 | 439 | -15.395 | 0 | 439 | -15.395 |
| 2008 | 15.597 | 0 | 673 | -16.270 | 0 | 673 | -16.270 |
| 2009 | 15.597 | 8.796 | 907 | -7.708 | 7.619 | 907 | -8.885 |
| 2010 | 14.797 | 8.796 | 1.129 | -7.130 | 7.619 | 1.129 | -8.307 |
| 2011 | 15.197 | 8.796 | 1.357 | -7.758 | 7.619 | 1.357 | -8.935 |
| 2012 | 240 | 8.796 | 1.361 | 7.196 | 7.619 | 1.361 | 6.019 |
| 2013 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2014 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2015 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2016 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2017 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2018 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2019 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2020 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2021 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2022 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2023 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2024 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2025 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2026 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2027 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2028 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2029 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2030 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2031 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2032 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2033 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2034 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2035 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2036 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2037 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2038 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2039 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2040 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2041 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2042 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2043 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2044 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2045 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2046 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2047 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| 2048 | | 8.796 | 1.361 | 7.436 | 7.619 | 1.361 | 6.259 |
| Residual Value | | 17.289 | | 17.289 | 17.289 | | 17.289 |
| Total | 93.534 | 369.138 | 55.058 | 220.545 | 322.051 | 55.058 | 173.459 |
| NPV | | | | | | | |
| 5% | 75.661 | | | 30.635 | | | 14.017 |
| 7,50% | 68.489 | | | 1.727 | | | -9.375 |
| 9% | 64.641 | | | -8.179 | | | -17.150 |
| IRR | | | | 7,72% | | | 6,27% |

Table 5.3.8 **Cash Flow Effect: High Variant 30 Years (USD'000s)**

| Year | Net Results before Interest & Repayments | Interest & Loan Repayments: Interest Rates 5% | 7,50% | 9% | Accumulated Cash Flow 5% | 7,50% | 9% |
|---|---|---|---|---|---|---|---|
| 1998 | 0 | 175 | 228 | 262 | -175 | -228 | -262 |
| 1999 | 0 | 350 | 456 | 524 | -525 | -684 | -524 |
| 2000 | 0 | 525 | 684 | 786 | -1.050 | -1.367 | -786 |
| 2001 | 0 | 525 | 684 | 786 | -1.575 | -2.051 | -786 |
| 2002 | 0 | 525 | 684 | 786 | -2.101 | -2.734 | -786 |
| 2003 | 0 | 525 | 684 | 786 | -2.626 | -3.418 | -786 |
| 2004 | 0 | 525 | 684 | 786 | -3.151 | -4.101 | -786 |
| 2005 | 0 | 710 | 924 | 1.062 | -3.860 | -5.025 | -1.062 |
| 2006 | -215 | 1.641 | 2.136 | 2.455 | -5.501 | -7.161 | -2.455 |
| 2007 | -439 | 2.614 | 3.402 | 3.911 | -8.115 | -10.563 | -3.911 |
| 2008 | -673 | 3.628 | 4.723 | 5.429 | -11.743 | -15.285 | -5.429 |
| 2009 | 7.889 | 4.643 | 6.043 | 6.947 | -8.497 | -13.439 | -4.487 |
| 2010 | 7.667 | 5.605 | 7.296 | 8.387 | -6.435 | -13.068 | -5.207 |
| 2011 | 7.439 | 6.594 | 8.583 | 9.867 | -5.590 | -14.212 | -7.635 |
| 2012 | 7.436 | 6.610 | 8.603 | 9.890 | -4.764 | -15.379 | -10.089 |

= Revenues accrue to pontoon bridge

**Cash Flow Effect: High Variant 40 Years (USD'000s)**

| Year | Net Results before interest & Repayments | Interest & Loan Repayments: Interest Rates 5% | 7,50% | 9% | Accumulated Cash Flow 5% | 7,50% | 9% |
|---|---|---|---|---|---|---|---|
| 1998 | 0 | 157 | 214 | 250 | -157 | -214 | -250 |
| 1999 | 0 | 314 | 427 | 500 | -470 | -641 | -500 |
| 2000 | 0 | 470 | 641 | 750 | -941 | -1.282 | -750 |
| 2001 | 0 | 470 | 641 | 750 | -1.411 | -1.923 | -750 |
| 2002 | 0 | 470 | 641 | 750 | -1.882 | -2.564 | -750 |
| 2003 | 0 | 470 | 641 | 750 | -2.352 | -3.205 | -750 |
| 2004 | 0 | 470 | 641 | 750 | -2.823 | -3.846 | -750 |
| 2005 | 0 | 636 | 866 | 1.014 | -3.459 | -4.712 | -1.014 |
| 2006 | -215 | 1.470 | 2.003 | 2.345 | -4.928 | -6.715 | -2.345 |
| 2007 | -439 | 2.342 | 3.190 | 3.735 | -7.270 | -9.905 | -3.735 |
| 2008 | -673 | 3.251 | 4.429 | 5.185 | -10.521 | -14.334 | -5.185 |
| 2009 | 7.889 | 4.159 | 5.667 | 6.635 | -6.791 | -12.111 | -3.931 |
| 2010 | 7.667 | 5.022 | 6.842 | 8.010 | -4.145 | -11.286 | -4.274 |
| 2011 | 7.439 | 5.907 | 8.049 | 9.423 | -2.614 | -11.895 | -6.257 |
| 2012 | 7.436 | 5.921 | 8.068 | 9.445 | -1.099 | -12.527 | -8.267 |

= Revenues accrue to pontoon bridge

Table 5.3.9 **Cash Flow Effect: Low Variant 30 Years (USD'000s)**

| Year | Net Results before interest & Repayments | Interest & Loan Repayments | | | Accumulated Cash Flow | | |
|---|---|---|---|---|---|---|---|
| | | Interest Rates | | | | | |
| | | 5% | 7,50% | 9% | 5% | 7,50% | 9% |
| 1998 | 0 | 175 | 228 | 262 | -175 | -228 | -262 |
| 1999 | 0 | 350 | 456 | 524 | -525 | -684 | -524 |
| 2000 | 0 | 525 | 684 | 786 | -1.050 | -1.367 | -786 |
| 2001 | 0 | 525 | 684 | 786 | -1.575 | -2.051 | -786 |
| 2002 | 0 | 525 | 684 | 786 | -2.101 | -2.734 | -786 |
| 2003 | 0 | 525 | 684 | 786 | -2.626 | -3.418 | -786 |
| 2004 | 0 | 525 | 684 | 786 | -3.151 | -4.101 | -786 |
| 2005 | 0 | 710 | 924 | 1.062 | -3.860 | -5.025 | -1.062 |
| 2006 | -215 | 1.641 | 2.136 | 2.455 | -5.501 | -7.161 | -2.455 |
| 2007 | -439 | 2.614 | 3.402 | 3.911 | -8.115 | -10.563 | -3.911 |
| 2008 | -673 | 3.628 | 4.723 | 5.429 | -11.743 | -15.285 | -5.429 |
| 2009 | 6.712 | 4.643 | 6.043 | 6.947 | -9.674 | -14.616 | -5.664 |
| 2010 | 6.490 | 5.605 | 7.296 | 8.387 | -8.790 | -15.422 | -7.562 |
| 2011 | 6.262 | 6.594 | 8.583 | 9.867 | -9.122 | -17.743 | -11.166 |
| 2012 | 6.259 | 6.610 | 8.603 | 9.890 | -9.473 | -20.088 | -14.798 |

= Revenues accrue to pontoon bridge

**Cash Flow Effect: Low Variant 40 Years (USD'000s)**

| Year | Net Results before interest & Repayments | Interest & Loan Repayments | | | Accumulated Cash Flow | | |
|---|---|---|---|---|---|---|---|
| | | Interest Rates | | | | | |
| | | 5% | 7,50% | 9% | 5% | 7,50% | 9% |
| 1998 | 0 | 157 | 214 | 250 | -157 | -214 | -250 |
| 1999 | 0 | 314 | 427 | 500 | -470 | -641 | -500 |
| 2000 | 0 | 470 | 641 | 750 | -941 | -1.282 | -750 |
| 2001 | 0 | 470 | 641 | 750 | -1.411 | -1.923 | -750 |
| 2002 | 0 | 470 | 641 | 750 | -1.882 | -2.564 | -750 |
| 2003 | 0 | 470 | 641 | 750 | -2.352 | -3.205 | -750 |
| 2004 | 0 | 470 | 641 | 750 | -2.823 | -3.846 | -750 |
| 2005 | 0 | 636 | 866 | 1.014 | -3.459 | -4.712 | -1.014 |
| 2006 | -215 | 1.470 | 2.003 | 2.345 | -4.928 | -6.715 | -2.345 |
| 2007 | -439 | 2.342 | 3.190 | 3.735 | -7.270 | -9.905 | -3.735 |
| 2008 | -673 | 3.251 | 4.429 | 5.185 | -10.521 | -14.334 | -5.185 |
| 2009 | 6.712 | 4.159 | 5.667 | 6.635 | -7.968 | -13.289 | -5.108 |
| 2010 | 6.490 | 5.022 | 6.842 | 8.010 | -6.500 | -13.640 | -6.628 |
| 2011 | 6.262 | 5.907 | 8.049 | 9.423 | -6.145 | -15.427 | -9.789 |
| 2012 | 6.259 | 5.921 | 8.068 | 9.445 | -5.808 | -17.236 | -12.976 |

= Revenues accrue to pontoon bridge

Table 5.3.10 Internal Rate of Return Road Bridge Only: 30 Year Payback:

USD'000s

| Year | Investmts | High Variant Revenues | High Variant Op'tng Costs | High Variant Net Outlays /Revenues | Low Variant Revenues | Low Variant Op'tng Costs | Low Variant Net Outlays /Revenues |
|---|---|---|---|---|---|---|---|
| 2005 | 1.481 | 0 | 22 | -1.504 | 0 | 22 | -1.504 |
| 2006 | 7.483 | 0 | 134 | -7.617 | 0 | 134 | -7.617 |
| 2007 | 7.948 | 0 | 254 | -8.202 | 0 | 254 | -8.202 |
| 2008 | 8.414 | 0 | 380 | -8.794 | 0 | 380 | -8.794 |
| 2009 | 8.414 | 8.796 | 506 | -124 | 7.619 | 506 | -1.301 |
| 2010 | 7.833 | 8.796 | 624 | 340 | 7.619 | 624 | -837 |
| 2011 | 8.042 | 8.796 | 744 | 10 | 7.619 | 744 | -1.167 |
| 2012 | 175 | 8.796 | 747 | 7.875 | 7.619 | 747 | 6.698 |
| 2013 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2014 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2015 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2016 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2017 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2018 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2019 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2020 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2021 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2022 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2023 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2024 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2025 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2026 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2027 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2028 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2029 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2030 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2031 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2032 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2033 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2034 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2035 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2036 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2037 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2038 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| Residual Value | | 18.877 | | 18.877 | 18.877 | | 18.877 |
| Total | 49.791 | 282.764 | 22.829 | 210.144 | 247.449 | 22.829 | 174.829 |
| NPV | | | | | | | |
| 5% | 40.258 | | | 64.572 | | | 49.684 |
| 7,50% | 36.434 | | | 35.877 | | | 25.467 |
| 9% | 34.382 | | | 24.760 | | | 16.192 |
| IRR | | | | 16,33% | | | 13,86% |

Table 5.3.11 Internal Rate of Return Road Bridge Only: 40 Year Payback:

USD'000s

| Year | Investmnts | High Variant | | | Low Variant | | |
|---|---|---|---|---|---|---|---|
| | | Revenues | Op'tng Costs | Net Outlays /Revenues | Revenues | Op'tng Costs | Net Outlays /Revenues |
| 2005 | 1.481 | 0 | 22 | -1.504 | 0 | 22 | -1.504 |
| 2006 | 7.483 | 0 | 134 | -7.617 | 0 | 134 | -7.617 |
| 2007 | 7.948 | 0 | 254 | -8.202 | 0 | 254 | -8.202 |
| 2008 | 8.414 | 0 | 380 | -8.794 | 0 | 380 | -8.794 |
| 2009 | 8.414 | 8.796 | 506 | -124 | 7.619 | 506 | -1.301 |
| 2010 | 7.833 | 8.796 | 624 | 340 | 7.619 | 624 | -837 |
| 2011 | 8.042 | 8.796 | 744 | 10 | 7.619 | 744 | -1.167 |
| 2012 | 175 | 8.796 | 747 | 7.875 | 7.619 | 747 | 6.698 |
| 2013 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2014 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2015 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2016 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2017 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2018 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2019 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2020 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2021 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2022 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2023 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2024 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2025 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2026 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2027 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2028 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2029 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2030 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2031 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2032 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2033 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2034 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2035 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2036 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2037 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2038 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2039 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2040 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2041 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2042 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2043 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2044 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2045 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2046 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2047 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| 2048 | | 8.796 | 747 | 8.049 | 7.619 | 747 | 6.872 |
| Residual Value | | 9.215 | | 9.215 | 9.215 | | 9.215 |
| Total | 49.791 | 361.064 | 30.298 | 280.976 | 313.978 | 30.298 | 233.889 |
| NPV | | | | | | | |
| 5% | 40.258 | | | 74.007 | | | 57.389 |
| 7,50% | 36.434 | | | 39.457 | | | 28.355 |
| 9% | 34.382 | | | 26.784 | | | 17.813 |
| IRR | | | | 16,42% | | | 13,99% |

**Table 5.3.12 Cash Flow Effect: High Variant 30 Years (USD'000s)**

**Road Portion of Bridge**

| Year | | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Investment Costs:** | | | | | | | | | | | |
| Road Access Way | | | | 465 | 931 | 931 | 349 | 349 | 175 | | 3.200 |
| Bridge Costs | | 1.481 | 7.483 | 7.483 | 7.484 | 7.484 | 7.484 | 7.693 | | | 46.591 |
| **Total** | | 1.481 | 7.483 | 7.948 | 8.414 | 8.414 | 7.833 | 8.042 | 175 | 0 | 49.791 |
| **Maintenance** | | 22 | 134 | 254 | 380 | 506 | 624 | 744 | 747 | 747 | 4.158 |
| **Toll Revenues** | | 0 | 0 | 0 | 0 | 8.796 | 8.796 | 8.796 | 8.796 | 8.796 | 43.981 |
| **Net Operating Revenues** | | -22 | -134 | -254 | -380 | 8.290 | 8.173 | 8.052 | 8.049 | 8.049 | 39.823 |
| **Interest and Loan Repayments:** | | | | | | | | | | | |
| Rate of Interest: | | | | | | | | | | | |
| | 5% | 96 | 583 | 1.100 | 1.648 | 2.195 | 2.704 | 3.228 | 3.239 | 3.239 | 18.032 |
| | 7,5% | 125 | 759 | 1.432 | 2.144 | 2.857 | 3.520 | 4.201 | 4.216 | 4.216 | 23.471 |
| | 9% | 144 | 873 | 1.646 | 2.465 | 3.284 | 4.047 | 4.829 | 4.846 | 4.846 | 26.982 |
| **Cash Flow** | 5% | -119 | -836 | -2.190 | -4.218 | 1.878 | 7.346 | 12.170 | 16.981 | 21.791 | |
| | 7,5% | -148 | -1.041 | -2.727 | -5.251 | 182 | 4.834 | 8.685 | 12.519 | 16.352 | |
| | 9% | -166 | -1.173 | -3.073 | -5.919 | -913 | 3.213 | 6.436 | 9.639 | 12.842 | |

Table 5.3.13 Cash Flow Effect: High Variant 40 Years (USD'000s)

**Road Portion of Bridge**

| Year | | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Net Operating Revenues** | | -22 | -134 | -254 | -380 | 8.290 | 8.173 | 8.052 | 8.049 | 8.049 | 39.823 |
| **Interest and Loan Repayments:** | | | | | | | | | | | |
| Rate of Interest: | | | | | | | | | | | |
| | 5% | 86 | 522 | 986 | 1.476 | 1.966 | 2.423 | 2.892 | 2.902 | 2.902 | 16.155 |
| | 7,5% | 118 | 712 | 1.343 | 2.011 | 2.679 | 3.301 | 3.940 | 3.953 | 3.953 | 22.010 |
| | 9% | 138 | 833 | 1.572 | 2.354 | 3.137 | 3.865 | 4.612 | 4.629 | 4.629 | 25.768 |
| Cash Flow | 5% | -109 | -765 | -2.005 | -3.861 | 2.463 | 8.213 | 13.373 | 18.521 | 23.668 | |
| | 7,5% | -140 | -986 | -2.583 | -4.974 | 637 | 5.509 | 9.621 | 13.717 | 17.813 | |
| | 9% | -160 | -1.128 | -2.954 | -5.688 | -534 | 3.773 | 7.213 | 10.634 | 14.055 | |

**Table 5.3.14 Cash Flow Effect: Low Variant 30 Years (USD'000s)**

**Road Portion of Bridge**

| Year | | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Maintenance | | | 134 | 254 | 380 | 506 | 624 | 744 | 747 | 747 | 4.136 |
| Toll Revenues | | 0 | 0 | 0 | 0 | 7.619 | 7.619 | 7.619 | 7.619 | 7.619 | 38.095 |
| **Net Operating Revenues** | | 0 | -134 | -254 | -380 | 7.113 | 6.995 | 6.875 | 6.872 | 6.872 | 33.960 |
| **Interest and Loan Repayments:** | | | | | | | | | | | |
| Rate of Interest: | 5% | 96 | 583 | 1.100 | 1.648 | 2.195 | 2.704 | 3.228 | 3.239 | 3.239 | 18.032 |
| | 7,5% | 125 | 759 | 1.432 | 2.144 | 2.857 | 3.520 | 4.201 | 4.216 | 4.216 | 23.471 |
| | 9% | 144 | 873 | 1.646 | 2.465 | 3.284 | 4.047 | 4.829 | 4.846 | 4.846 | 26.982 |
| Cash Flow | 5% | -96 | -814 | -2.168 | -4.195 | 723 | 5.014 | 8.661 | 12.294 | 15.927 | |
| | 7,5% | -125 | -1.019 | -2.705 | -5.229 | -973 | 2.502 | 5.176 | 7.832 | 10.489 | |
| | 9% | -144 | -1.151 | -3.051 | -5.896 | -2.068 | 881 | 2.926 | 4.952 | 6.978 | |

**Table 5.3.15 Cash Flow Effect: Low Variant 40 Years (USD'000s)**

**Road Portion of Bridge**

| Year | | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Net Operating Revenues** | | 0 | -134 | -254 | -380 | 7.113 | 6.995 | 6.875 | 6.872 | 6.872 | 33.960 |
| **Interest and Loan Repayments:** | | | | | | | | | | | |
| Rate of Interest: | | | | | | | | | | | |
| | 5% | 86 | 522 | 986 | 1.476 | 1.966 | 2.423 | 2.892 | 2.902 | 2.902 | 16.155 |
| | 7,5% | 118 | 712 | 1.343 | 2.011 | 2.679 | 3.301 | 3.940 | 3.953 | 3.953 | 22.010 |
| | 9% | 138 | 833 | 1.572 | 2.354 | 3.137 | 3.865 | 4.612 | 4.629 | 4.629 | 25.768 |
| Cash Flow | 5% | -86 | -743 | -1.983 | -3.839 | 1.308 | 5.881 | 9.864 | 13.834 | 17.805 | |
| | 7,5% | -118 | -964 | -2.560 | -4.951 | -518 | 3.177 | 6.112 | 9.031 | 11.950 | |
| | 9% | -138 | -1.106 | -2.931 | -5.666 | -1.689 | 1.441 | 3.704 | 5.948 | 8.191 | |

Table 5.3.16 Costs for Rail Usage

USD'000s

| | | |
|---|---|---|
| Total Investment | 93.534 | |
| Road Portion | 49.791 | |
| Portion applicable to rail | 43.744 | |
| Annual operating costs incl.Depr. | 3.458 | |
| Road Portion | 1.743 | |
| Portion applicable to rail | 1.715 | |
| Forecast Development: | No. of Trains Daily | |
| | High | Low |
| Long-Distance Passenger Traffic | 4 | 3 |
| Long-Distance Freight trains | 19 | 12 |
| | Annual Volume | |
| | High | Low |
| Long-Distance Passenger Traffic | 1.440 | 1.080 |
| Long-Distance Freight trains | 6.795 | 4.345 |
| Cost per train (USD) | 208,29 | 316,18 |
| Long-Distance Passenger Traffic | 36,42 | 62,94 |
| Long-Distance Freight trains | 171,87 | 253,23 |
| Cost per Passenger: Avge= 423 | 0,09 | 0,15 |
| Total Tonnage(' 000s Tonnes) | 11.620 | 7.430 |
| Cost per Tonne (USD) | 0,15 | 0,23 |

Table 5.3.17 Shortfall in Toll Revenues

USD'000s

| | Interest Rates | | |
|---|---|---|---|
| | 5% | 7,50% | 9% |
| **Required Annual Coverage** | 6.610 | 8.603 | 9.890 |
| **Coverage per Present Toll Levels:** | | | |
| High Variant | 7.436 | 7.436 | 7.436 |
| Low Variant | 6.259 | 6.259 | 6.259 |
| **Additional Coverage Required:** | | | |
| High Variant | -826 | 1.167 | 2.454 |
| Low Variant | 351 | 2.345 | 3.632 |
| **Percentage Increase Required in Tolls:** | | | |
| High Variant | 0 | 15,70 | 33,01 |
| Low Variant | 5,61 | 37,46 | 58,02 |

Table 5.3.18 Revised Tolls in Accordance with Various Price Increases:

| | Unit Price (Avge) in USD | | Price Incr.= 5,61% | | Price Incr. = 15,70% | |
|---|---|---|---|---|---|---|
| | Local Users | Foreign User | Local Users | Foreign User | Local Users | Foreign User |
| Local Passengers | 0,005 | | 0,005 | | 0,006 | |
| Passenger Cars | 0,050 | 4,500 | 0,053 | 4,752 | 0,058 | 5,207 |
| Buses | 1,025 | | 1,083 | | 1,186 | |
| Tourist Coaches | | 25,000 | | 26,403 | | 28,925 |
| Freight 1 tonne | | 1,750 | | 1,848 | | 2,025 |
| Trucks 3.5 - 7 tonnes | | 11,000 | | 11,617 | | 12,727 |
| Trucks 10 - 20 tonnes | | 25,000 | | 26,403 | | 28,925 |

| | Price Incr. = 33,01% | | Price Incr.= 37,46% | | Price Incr. = 58,02% | |
|---|---|---|---|---|---|---|
| | Local Users | Foreign User | Local Users | Foreign User | Local Users | Foreign User |
| Local Passengers | 0,007 | | 0,007 | | 0,008 | |
| Passenger Cars | 0,067 | 5,985 | 0,069 | 6,186 | 0,079 | 7,111 |
| Buses | 1,363 | | 1,409 | | 1,620 | |
| Tourist Coaches | | 33,253 | | 34,365 | | 39,505 |
| Freight 1 tonne | | 2,328 | | 2,406 | | 2,765 |
| Trucks 3.5 - 7 tonnes | | 14,631 | | 15,121 | | 17,382 |
| Trucks 10 - 20 tonnes | | 33,253 | | 34,365 | | 39,505 |

Table 5.3.19 Internal Rate of Return Road and Rail Bridge: 30 Year Payback: Assuming Charges for Rail Usage

USD'000s

| Year | Investmts | High Variant | | | Low Variant | | |
|---|---|---|---|---|---|---|---|
| | | Revenues | Op'tng Costs | Net Outlays /Revenues | Revenues | Op'tng Costs | Net Outlays /Revenues |
| 2005 | 2.834 | 0 | 0 | -2.834 | 0 | 0 | -2.834 |
| 2006 | 14.316 | 0 | 215 | -14.531 | 0 | 215 | -14.531 |
| 2007 | 14.956 | 0 | 439 | -15.395 | 0 | 439 | -15.395 |
| 2008 | 15.597 | 0 | 673 | -16.270 | 0 | 673 | -16.270 |
| 2009 | 15.597 | 31.035 | 907 | 14.531 | 21.837 | 907 | 5.333 |
| 2010 | 14.797 | 31.035 | 1.129 | 15.109 | 21.837 | 1.129 | 5.911 |
| 2011 | 15.197 | 31.035 | 1.357 | 14.481 | 21.837 | 1.357 | 5.283 |
| 2012 | 240 | 31.035 | 1.361 | 29.435 | 21.837 | 1.361 | 20.237 |
| 2013 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2014 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2015 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2016 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2017 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2018 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2019 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2020 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2021 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2022 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2023 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2024 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2025 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2026 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2027 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2028 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2029 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2030 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2031 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2032 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2033 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2034 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2035 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2036 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2037 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2038 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| Residual Value | | 35.429 | | 35.429 | 35.429 | | 35.429 |
| Total | 93.534 | 966.479 | 41.453 | 831.492 | 690.539 | 41.453 | 555.552 |
| NPV | | | | | | | |
| 5% | 75.661 | | | 305.457 | | | 189.131 |
| 7,50% | 68.489 | | | 196.184 | | | 114.841 |
| 9% | 64.641 | | | 152.507 | | | 85.563 |
| IRR | | | | **31,32%** | | | **22,09%** |

Table 5.3.20 Internal Rate of Return Road and Rail Bridge: 40 Year Payback: (USD'000s)
Assuming Charges for Rail Usage

| Year | Investmnts | High Variant | | | Low Variant | | |
|---|---|---|---|---|---|---|---|
| | | Revenues | Op'tng Costs | Net Outlays /Revenues | Revenues | Op'tng Costs | Net Outlays /Revenues |
| 2005 | 2.834 | 0 | 0 | -2.834 | 0 | 0 | -2.834 |
| 2006 | 14.316 | 0 | 215 | -14.531 | 0 | 215 | -14.531 |
| 2007 | 14.956 | 0 | 439 | -15.395 | 0 | 439 | -15.395 |
| 2008 | 15.597 | 0 | 673 | -16.270 | 0 | 673 | -16.270 |
| 2009 | 15.597 | 31.035 | 907 | 14.531 | 21.837 | 907 | 5.333 |
| 2010 | 14.797 | 31.035 | 1.129 | 15.109 | 21.837 | 1.129 | 5.911 |
| 2011 | 15.197 | 31.035 | 1.357 | 14.481 | 21.837 | 1.357 | 5.283 |
| 2012 | 240 | 31.035 | 1.361 | 29.435 | 21.837 | 1.361 | 20.237 |
| 2013 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2014 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2015 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2016 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2017 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2018 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2019 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2020 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2021 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2022 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2023 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2024 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2025 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2026 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2027 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2028 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2029 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2030 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2031 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2032 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2033 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2034 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2035 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2036 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2037 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2038 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2039 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2040 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2041 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2042 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2043 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2044 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2045 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2046 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2047 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| 2048 | | 31.035 | 1.361 | 29.675 | 21.837 | 1.361 | 20.477 |
| Residual Value | | 17.289 | | 17.289 | 17.289 | | 17.289 |
| Total | 93.534 | 1.258.689 | 55.058 | 1.110.097 | 890.769 | 55.058 | 742.177 |
| NPV | | | | | | | |
| 5% | 75.661 | | | 344.576 | | | 214.730 |
| 7,50% | 68.489 | | | 211.454 | | | 124.711 |
| 9% | 64.641 | | | 161.298 | | | 91.202 |
| IRR | | | | **31,32%** | | | **22,13%** |

## Table 5.3.1 Estimated Growth in Road Traffic

Traceca Central Asia

Module C: Chardzhev Bridge

Estimated Growth in Traffic

Low Variant

| Avge Annual Volume | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1996 | | 1997 | | 1998 | | 1999 | | 2000 | |
| Annual Increase | | | 6% | 10% | 6% | 10% | 6% | 10% | 6% | 10% |
| Local Passengers | 358 054 | 0 | 379 537 | 0 | 402 309 | 0 | 426 448 | 0 | 452 035 | 0 |
| Passenger Cars | 306 029 | 91 411 | 324 391 | 100 552 | 343 854 | 110 608 | 364 485 | 121 668 | 386 354 | 133 835 |
| Buses | 13 367 | 0 | 14 169 | 0 | 15 019 | 0 | 15 920 | 0 | 16 875 | 0 |
| Tourist Coaches | 0 | 15 073 | 0 | 16 581 | 0 | 18 239 | 0 | 20 062 | 0 | 22 069 |
| Freight 1 tonne | 30 623 | 64 777 | 32 461 | 71 254 | 34 408 | 78 380 | 36 473 | 86 218 | 38 661 | 94 839 |
| Trucks 1.5 - 7 tonnes | 13 636 | 28 814 | 14 454 | 31 728 | 15 321 | 34 901 | 16 241 | 38 391 | 17 215 | 42 230 |
| Trucks 10 - 20 tonnes | 34 668 | 73 132 | 36 748 | 80 665 | 38 953 | 88 732 | 41 290 | 97 605 | 43 768 | 107 365 |
| Other | 56 160 | 0 | 59 530 | 0 | 63 101 | 0 | 66 887 | 0 | 70 901 | 0 |

| Avge Annual Volume | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2001 | | 2002 | | 2003 | | 2004 | | 2005 | |
| Annual Increase | 7% | 10% | 7% | 10% | 7% | 10% | 7% | 10% | 7% | 10% |
| Local Passengers | 483 677 | 0 | 517 534 | 0 | 553 762 | 0 | 592 525 | 0 | 634 002 | 0 |
| Passenger Cars | 413 399 | 147 219 | 442 337 | 161 941 | 473 301 | 178 135 | 506 432 | 195 948 | 541 882 | 215 54[illegible] |
| Buses | 18 057 | 0 | 19 321 | 0 | 20 673 | 0 | 22 120 | 0 | 23 668 | 0 |
| Tourist Coaches | 0 | 24 276 | 0 | 26 703 | 0 | 29 373 | 0 | 32 311 | 0 | 35 54[illegible] |
| Freight 1 tonne | 41 368 | 104 323 | 44 263 | 114 756 | 47 362 | 126 231 | 50 677 | 138 854 | 54 225 | 152 7[illegible] |
| Trucks 1.5 - 7 tonnes | 18 420 | 46 453 | 19 710 | 51 099 | 21 089 | 56 209 | 22 566 | 61 810 | 24 145 | 68 01[illegible] |
| Trucks 10 - 20 tonnes | 46 831 | 118 102 | 50 109 | 129 912 | 53 617 | 142 903 | 57 370 | 157 194 | 61 386 | 172 91[illegible] |
| Other | 75 864 | 0 | 81 174 | 0 | 86 856 | 0 | 92 936 | 0 | 99 442 | 0 |

High Variant

| Avge Annual Volume | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1996 | | 1997 | | 1998 | | 1999 | | 2000 | |
| Annual Increase | | | 7% | 12% | 7% | 12% | 7% | 12% | 7% | 12% |
| Local Passengers | 358 054 | 0 | 383 117 | 0 | 409 936 | 0 | 438 631 | 0 | 469 335 | 0 |
| Passenger Cars | 306 029 | 91 411 | 327 451 | 102 381 | 350 372 | 114 666 | 374 898 | [illegible] | 401 141 | 141 269 |
| Buses | 13 367 | 0 | 14 302 | 0 | 15 304 | 0 | 16 375 | 0 | 17 521 | 0 |
| Tourist Coaches | 0 | 15 073 | 0 | 16 882 | 0 | 18 908 | 0 | 20 799 | 0 | [illegible] |
| Freight 1 tonne | 30 623 | 64 777 | 32 767 | 72 550 | 35 061 | 81 256 | 37 515 | 89 381 | 40 141 | 100 107 |
| Trucks 1.5 - 7 tonnes | 13 636 | 28 814 | 14 591 | 32 305 | 15 612 | 36 182 | 16 705 | 39 800 | 17 874 | 44 576 |
| Trucks 10 - 20 tonnes | 34 668 | 73 132 | 37 095 | 82 132 | 39 691 | 91 988 | 42 470 | 101 186 | 45 443 | 113 329 |
| Other | 56 160 | 0 | 60 091 | 0 | 64 298 | 0 | 68 798 | 0 | 73 614 | 0 |

| Avge Annual Volume | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign | Local | Foreign |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2001 | | 2002 | | 2003 | | 2004 | | 2005 | |
| Annual Increase | 8% | 12% | 8% | 12% | 8% | 12% | 8% | 12% | 8% | 12% |
| Local Passengers | 506 882 | 0 | 547 433 | 0 | 591 227 | 0 | 638 526 | 0 | 689 608 | 0 |
| Passenger Cars | 433 233 | 158 221 | 467 891 | 177 208 | 505 323 | 198 472 | 545 748 | [illegible] | 589 408 | [illegible] |
| Buses | 18 923 | 0 | 20 437 | 0 | 22 072 | 0 | 23 837 | 0 | 25 744 | 0 |
| Tourist Coaches | 0 | [illegible] | 0 | [illegible] | 0 | [illegible] | 0 | [illegible] | 0 | 41 0[illegible] |
| Freight 1 tonne | [illegible] | 112 120 | [illegible] | 125 574 | [illegible] | 140 643 | [illegible] | [illegible] | [illegible] | 176 42[illegible] |
| Trucks 1.5 - 7 tonnes | 19 304 | 49 925 | 20 848 | 55 916 | 22 516 | 62 626 | 24 318 | 70 141 | 26 263 | 78 55[illegible] |
| Trucks 10 - 20 tonnes | 49 078 | 126 928 | 53 004 | 142 160 | 57 245 | 159 219 | 61 824 | 178 325 | 66 770 | 199 72[illegible] |
| Other | 79 503 | 0 | 85 864 | 0 | 92 733 | 0 | 100 151 | 0 | 108 164 | 0 |

## Table 5.3.2 Estimated Growth in Traffic Revenues

**Traceca Central Asia**

**Module C: Chardzhev Bridge**

**Estimated Growth in Traffic Revenues (in USD).**

**High Variant**

| | Unit Price (Avge) in USD | | Unit Price from 1997 (+ 5%) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Local Users | Foreign Users | Local Users | Foreign Users | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total |
| Local Passengers | 0,005 | | 0,005 | | 1 790 | 2 011 | 2.152 | 2 303 | 2.464 | 2 661 | 2.874 | 3 104 | 3.352 | 3 620 | 26 33 |
| Passenger Cars | 0,050 | 4,500 | 0,053 | 4,725 | 426 652 | 500 939 | 560 192 | 615 660 | 688 555 | 770 339 | 861 870 | 964 312 | 1 078 968 | 1 207 298 | 7 674 78 |
| Buses | 1,025 | | 1,076 | | 13 701 | 15 393 | 16 471 | 17 623 | 18 857 | 20 366 | 21 995 | 23 755 | 25 655 | 27 707 | 201 52 |
| Tourist Coaches | | 25 000 | | 26,250 | 376 830 | 443 152 | 496 330 | 545 963 | 611 479 | 684 856 | 767 039 | 859 084 | 962 174 | 1 077 635 | 6 824 54 |
| Freight 1 tonne | | 1 750 | | 1 838 | 113 359 | 133 310 | 149 307 | 164 238 | 183 947 | 206 020 | 230 743 | 258 432 | 289 444 | 324 177 | 2 052 97 |
| Trucks 3.5 - 7 tonnes | | 11,000 | | 11 550 | 317 283 | 373 125 | 417 900 | 459 690 | 514 853 | 576 635 | 645 831 | 723 331 | 810 131 | 907 346 | 5 746 12 |
| Trucks 10 - 20 tonnes | | 25,000 | | 26 250 | 1 833 300 | 2 155 961 | 2 414 676 | 2 656 144 | 2 974 881 | 3 331 867 | 3 731 691 | 4 179 494 | 4 681 033 | 5 242 757 | 3 201 80 |
| Other | | | | | 2 808 | 3 155 | 3 376 | 3 612 | 3 865 | 4 174 | 4 508 | 4 868 | 5 258 | 5 679 | 41 30 |
| Total Income Local & Foreign | | | | | 3 085 723 | 3 627 047 | 4 060 405 | 4 465 233 | 4 998 900 | 5 596 918 | 6 266 551 | 7 016 379 | 7 856 014 | 8 796 220 | 55 769 39 |

**Low Variant:**

| | Unit Price (Avge) in USD | | Unit Price from 1997 (+ 5%) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Local Users | Foreign Users | Local Users | Foreign Users | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total |
| Local Passengers | 0,005 | | 0,005 | | 1 790 | 1.993 | 2.112 | 2 239 | 2.373 | 2 539 | 2.717 | 2.907 | 3.111 | 3 329 | 25 11 |
| Passenger Cars | 0,050 | 4,500 | 0,053 | 4,725 | 426 652 | 492 140 | 540.673 | 594.018 | 652 655 | 717 312 | 788 392 | 866 534 | 952 442 | 1 046 889 | 7 077 70 |
| Buses | 1,025 | | 1,076 | | 13 701 | 15 249 | 16 164 | 17 134 | 18 162 | 19 433 | 20 794 | 22 249 | 23 807 | 25 473 | 192 16 |
| Tourist Coaches | | 25,000 | | 26,250 | 376 830 | 435 239 | 478 763 | 526 639 | 579 303 | 637 233 | 700 956 | 771 052 | 848 157 | 932 973 | 6 287 14 |
| Freight 1 tonne | | 1,750 | | 1,838 | 113 359 | 130 930 | 144 023 | 158 425 | 174 267 | 191 694 | 210 864 | 231 950 | 255 145 | 280 659 | 1 891 31 |
| Trucks 3.5 - 7 tonnes | | 11.000 | | 11,550 | 317 283 | 366 462 | 403 108 | 443 419 | 487 761 | 536 537 | 590 191 | 649 210 | 714 131 | 785 544 | 5 293 64 |
| Trucks 10 - 20 tonnes | | 25.000 | | 26,250 | 1 833 300 | 2 117 462 | 2 329 208 | 2 562 128 | 2 818 341 | 3 100 175 | 3 410 193 | 3 751 212 | 4.126 333 | 4 538 967 | 30 587 320 |
| Other | | | | | 2 808 | 3 125 | 3 313 | 3 512 | 3 722 | 3 983 | 4 262 | 4 560 | 4 879 | 5 221 | 39 384 |
| Total Income Local & Foreign | | | | | 3 085 723 | 3 562 599 | 3 917 363 | 4 307 514 | 4 736 584 | 5 208 907 | 5 728 367 | 6 299 674 | 6 928 005 | 7 619 054 | 51 393 791 |

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## Traceca Central Asia

### Module C: Chardzhev Bridge

**Road Traffic Revenues as of May 1996:**

| | Unit Price (Avge) in USD | | Avge Daily Volume | | Avge Annual Volume | | Avge Annual Revenue | |
|---|---|---|---|---|---|---|---|---|
| | Local Users | Foreign Users | Local | Foreign | Local | Foreign | Local | Foreign |
| Local Passengers | 0,005 | | 995 | | 358.054 | 0 | 1.790 | 0 |
| Passenger Cars | 0,050 | 4,500 | 850 | 254 | 306.029 | 91.411 | 15.301 | 411.350 |
| Buses | 1,025 | | 37 | | 13.367 | 0 | 13.701 | 0 |
| Tourist Coaches | | 25,000 | | 42 | 0 | 15.073 | 0 | 376.830 |
| Freight 1 tonne | | 1,750 | 85 | 180 | 30.623 | 64.777 | 0 | 113.359 |
| Trucks 3.5 - 7 tonnes | | 11,000 | 38 | 80 | 13.636 | 28.844 | 0 | 317.283 |
| Trucks 10 - 20 tonnes | | 25,000 | 96 | 204 | 34.668 | 73.332 | 0 | 1.833.300 |
| Other | | | 156 | | 56.160 | | 2808 | |
| Total Income by Category | | | | | | | 33.601 | 3.052.123 |
| Total Income: Local & Foreign | | | | | | | | 3.085.723 |

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## Table 5.3.3 Estimated Net Revenues: High Variant

**Traceca Central Asia**

**Module C: Chardzhev Bridge**

**Estimated Revenues and Expenses: (USD'000s)**

**Option N2 High Variant**

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Refurbishment of Bridge | | | 2.691 | 2.691 | 2.691 | | | | | | | | | | | | | 8.073 |
| Access Roads & Installations | | | | | | | | | | | | 640 | 1.280 | 1.280 | 480 | 480 | 240 | 4.400 |
| Design and Consulting | | | | | | | | | | 2.834 | | | | | | | | 2.834 |
| Construction of New Bridge | | | | | | | | | | | 14.316 | 14.316 | 14.317 | 14.317 | 14.317 | 14.717 | | 86.300 |
| Total Investment | 0 | 0 | 2.691 | 2.691 | 2.691 | 0 | 0 | 0 | 0 | 2.834 | 14.316 | 14.956 | 15.597 | 15.597 | 14.797 | 15.197 | 240 | 101.607 |
| Maintenance Costs | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 215 | 439 | 673 | 907 | 1.129 | 1.357 | 1.361 | 6.080 |
| Depreciation | | | | | | | | | | | 286 | 585 | 897 | 1.209 | 1.505 | 1.809 | 1.814 | 8.107 |
| Amortisation of Refurbishment Expenses | | 0 | 269 | 538 | 807 | 807 | 807 | 807 | 807 | 807 | 807 | 807 | 538 | 269 | 0 | | | 8.073 |
| Amortisation of Design & Consulting | | | | | | | | | | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 2.267 |
| Total Operating Costs | | 0 | 269 | 538 | 807 | 807 | 807 | 807 | 807 | 1.091 | 1.592 | 2.115 | 2.392 | 2.669 | 2.918 | 3.450 | 3.458 | 24.527 |
| Offset By: | | | | | | | | | | | | | | | | | | |
| Toll Revenues | 3.086 | 3.627 | 4.060 | 4.465 | 4.999 | 5.597 | 6.267 | 7.016 | 7.856 | 8.796 | 8.796 | 8.796 | 8.796 | 8.796 | 8.796 | 8.796 | 8.796 | 117.343 |
| Net Revenues | 3.086 | 3.627 | 3.791 | 3.927 | 4.192 | 4.790 | 5.459 | 6.209 | 7.049 | 7.705 | 7.204 | 6.681 | 6.404 | 6.127 | 5.879 | 5.347 | 5.338 | 92.815 |

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**Table 5.3.4. Estimated Net Revenues: Low Variant**

**Traceca Central Asia**

**Module C: Chardzhev Bridge**

**Estimated Revenues and Expenses: (USD'000s)**

**Option N2 Low Variant**

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Refurbishment of Bridge | | | 2.691 | 2.691 | 2.691 | | | | | | | | | | | | | 8.073 |
| Access Roads & Installations | | | | | | | | | | | | 640 | 1.280 | 1.280 | 480 | 480 | 240 | 4.400 |
| Design and Consulting | | | | | | | | | | 2.834 | | | | | | | | 2.834 |
| Construction of New Bridge | | | | | | | | | | | 14.316 | 14.316 | 14.317 | 14.317 | 14.317 | 14.717 | | 86.300 |
| Total Investment | 0 | 0 | 2.691 | 2.691 | 2.691 | 0 | 0 | 0 | 0 | 2.834 | 14.316 | 14.956 | 15.597 | 15.597 | 14.797 | 15.197 | 240 | 101.607 |
| Maintenance Costs | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 215 | 439 | 673 | 907 | 1.129 | 1.357 | 1.361 | 6.080 |
| Depreciation | | | | | | | | | | | 286 | 585 | 897 | 1.209 | 1.505 | 1.809 | 1.814 | 8.107 |
| Amortisation of Refurbishment Expenses | | 0 | 269 | 538 | 807 | 807 | 807 | 807 | 807 | 807 | 807 | 807 | 538 | 269 | 0 | | | 8.073 |
| Amortisation of Design & Consulting | | | | | | | | | | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 2.267 |
| Total Operating Costs | | 0 | 269 | 538 | 807 | 807 | 807 | 807 | 807 | 1.091 | 1.592 | 2.115 | 2.392 | 2.669 | 2.918 | 3.450 | 3.458 | 24.527 |
| Offset By: | | | | | | | | | | | | | | | | | | |
| Toll Revenues | 3.086 | 3.563 | 3.917 | 4.308 | 4.737 | 5.209 | 5.728 | 6.300 | 6.928 | 7.619 | 7.619 | 7.619 | 7.619 | 7.619 | 7.619 | 7.619 | 7.619 | 104.727 |
| Net Revenues | 3.086 | 3.563 | 3.648 | 3.769 | 3.929 | 4.402 | 4.921 | 5.492 | 6.121 | 6.528 | 6.027 | 5.504 | 5.227 | 4.950 | 4.701 | 4.170 | 4.161 | 80.200 |

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## Table 5.3.5 Investment Planning

**Traceca Central Asia**

**Module C: Chardzhev Bridge**

**Investment Planning: (USD'000s)**

| Years | | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Investment | | | 0 | 0 | 2.691 | 2.691 | 2.691 | 0 | 0 | 0 | 0 | 2.834 | 14.316 | 14.956 | 15.597 | 15.597 | 14.797 | 15.197 | 240 | 101.607 |
| Repayments: | Interest<br>Period(Years) | 5%<br>30 | | | 175 | 350 | 525 | 525 | 525 | 525 | 525 | 710 | 1.641 | 2.614 | 3.628 | 4.643 | 5.605 | 6.594 | 6.610 | 35.196 |
| | Interest<br>Period(Years) | 5%<br>40 | | | 157 | 314 | 470 | 470 | 470 | 470 | 470 | 636 | 1.470 | 2.342 | 3.251 | 4.159 | 5.022 | 5.907 | 5.921 | 31.531 |
| Net Revenues: | Low Variant | | 3.086 | 3.563 | 3.648 | 3.769 | 3.929 | 4.402 | 4.921 | 5.492 | 6.121 | 6.528 | 6.027 | 5.504 | 5.227 | 4.950 | 4.701 | 4.170 | 4.161 | 80.200 |
| | High Variant | | 3.086 | 3.627 | 3.791 | 3.927 | 4.192 | 4.790 | 5.459 | 6.209 | 7.049 | 7.705 | 7.204 | 6.681 | 6.404 | 6.127 | 5.879 | 5.347 | 5.338 | 92.815 |

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### 5.3.3 Recommendations For Implementation

#### 5.3.3.1 Recommendation Of Technical Solution

- Refurbishment can only be a short time solution (for not more than 10 years); if possible the recommendations below should be followed.
- Option N2/2B should be preferred against option N2/1B.
- Option N2/3 should be preferred if the money can be raised; in any case this solution should be undertaken for the appropriate piers.
- Option N2/4 is not recommended at all as confirmed in chapter 4.1.3.

All other options (N1, N3) need longer bridges with more costs and are not recommended unless there are other grounds for a decision.

The first phase should be a construction of a new 2 lane road bridge about 200 to 300m west of the existing Railway Bridge. At the same time the foundation and the piers should be constructed for the new railway bridge (combined railway and road bridge).The framework for the Railway Bridge can be done at the same time or later, depending on the further use of the existing bridge.

#### 5.3.3.2 Recommendation For Evaluation

An invitation to tender should be prepared, for which Tender Documents and a Bill of Quantities must be determined.

The following table shows the contents of the BoQ as an example:

| **Sample - BILL OF QUANTITIES** |
|---|

SCOPE (Some chapters are more detailed for illustration; German and English technical terms are given)

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| MAIN CHAPTERS | |
|---|---|
| 12 | Planning Costs |
| 13 | Site Management Costs |
| 14 | Preparation |
| 15 | Foundation Works |
| 16 | Earth Works |
| 17 | Special Foundation Works |
| 18 | Temporary Bridge Works |
| 19 | Concrete Works |
| 20 | Masonry Works |
| 21 | Steel Superstructure Works |
| 22 | Painting Works |
| 23 | Sealing Works |
| 24 | Drainage Works |
| 25 | Additional Works and Bridge Equipment |
| 26 | Road Works |
| 27 | Hydraulic Structure Works |
| 28 | Cable Duct Works |
| 29 | Dayworks |

Some detailed sub-chapters:

| **12** | **Planning Costs** |
|---|---|
| 12.01 | Plans, Drawings and Static Computations |

| **13** | **Site Management Costs** |
|---|---|
| 13.01 | Site Preparation |
| 13.02 | Time Dependent Site Costs |
| 13.03 | Equipment Costs |
| 13.04 | Extra Costs |
| 13.05 | Removal and Site Clean-up |
| 13.06 | General Costs |
| 13.07 | Traffic Signs |
| 13.08 | Installation of Traffic Lights |
| 13.09 | Operation of Traffic Lights |
| 13.10 | Access Facilities |
| 13.11 | Site Bureau for Authorities |
| 13.12 | Container |
| 13.13 | Transport Facilities |
| 13.14 | Office Facilities |
| 13.15 | Photo Documentation |

| 21 | Steel Superstructure Works |
|---|---|
| 21.01 | Delivery of Steel Structure |
| 21.02 | Delivery of Bearings |
| 21.03 | Delivery of Grids |
| 21.04 | Delivery of Railings |
| 21.05 | Delivery of Cable Duct Troughs |
| 21.06 | Delivery of Water Gullies |
| 21.07 | Delivery of Drainage Piping |
| 21.08 | Delivery of Masts |
| 21.09 | Weld Testing |
| 21.10 | Erection of Steel Structure |
| 21.11 | Erection of Bearings |
| 21.12 | Erection of Grids |
| 21.13 | Erection of Railings |
| 21.14 | Erection of Cable Duct Troughs |
| 21.15 | Erection of Water Gullies |
| 21.16 | Erection of Drainage |
| 21.17 | Erection of Masts |
| 21.18 | Launching of Structure |
| 21.19 | Retraction of Structure |
| 21.20 | Demolishing of Steel Structure |

| 22 | Paint Works |
|---|---|
| 22.01 | Preparation Work |
| 22.02 | Rusting Removal Work |
| 22.03 | Painting of Steel Elements |
| 22.04 | Surface Protection Coat |
| 22.05 | Painting of Concrete Elements |

| 29 | Dayworks |
|---|---|
| 29.01 | Wages |
| 29.02 | Equipment |
| 29.03 | Material |

A time table for implementation for refurbishment and for each of the options N2/1B, N2/2B and N2/3 is provided in Annex H

For the preparation of tender documents (General and Special Specification, Bill of Quantities, General Design Drawings, General Dimensioning) a consulting engineer should be engaged.

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Estimated costs (fees) for consulting are as follows:

| | Refurbish-ment | Option N2 | | |
|---|---|---|---|---|
| | | Variant 1B | Variant 2B | Variant 3 |
| Total costs USD | 8.500.000,- | 41.100.000,- | 41.000.000,- | 85.900.000,- |
| Basis fee (percent) | 3,19 % | 2,84 % | 2,84 % | 2,84 % |
| Basis fee USD | 270.791,- | 1.169.067,- | 1.166.222,- | 2.443.378,- |
| ITEM | | | | |
| Preliminary design | 48.700,- | 210.400,- | 209.900,- | 429.800,- |
| Static computation | 67.700,- | 292.300,- | 291.600,- | 610.800,- |
| Bill of quantities | 27.100,- | 116.900,- | 116.600,- | 244.300,- |
| Workshop drawings | 170.600,- | 736.500,- | 734.700,- | 1.539.300,- |
| TOTAL FEE USD | **314.100,-** | **1.256.100,-** | **1.352.800,-** | **2.834.200,-** |

Some of the work could be carried out by local experts and technicians, in which case the costs could be decreased.

### 5.4 Technical and Economic Evaluation

Cost Estimates

| | | | |
|---|---|---|---|
| Option 1 | | | 188,760,000.-- USD |
| Option 2 | Alternative 1 | 90,700,000.-- USD | |
| | Alternative 2 | 119,370,000.-- USD | |
| Option 3 | | | 148,290,000.-- USD |

The realised technical and economic calculations comparing the variants of possible locations for a combined Railway and Road Bridge show the economic efficiency of the bridge building according to option N°. 2 (either alternative 1 or 2).

The option 2 with both alternatives for the bridge recommended shows a savings in building costs in comparison with the other options by a total up to

| | |
|---|---|
| alternative 1 to option 1 app. | 98 mio. USD |
| alternative 2 to option 1 app. | 70 Mio. USD |
| alternative 1 to option 3 app. | 58 mio. USD |
| alternative 2 to option 3 app. | 29 mio. USD |

and improves the transport connection directly between the towns Farap and Chardzhev, involves less running costs with railway transport, less pollution of the traffic and excludes the use of expensive arable land.