OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

19056

DP/ID/SER.A/1491
16 July 1991
ORIGINAL: ENGLISH

RESTRICTED

ASSISTANCE TO THE ZAMBIA INDUSTRIAL AND MINING CORPORATION LTD. (ZIMCO) RESEARCH, DEVELOPMENT AND INNOVATION (RDI) UNIT

DP/ZAM/90/010
REPUBLIC OF ZAMBIA

Technical report: Transport and systems sector*

Prepared for the Government of Zambia
by the United Nations Industrial Development Organization,
acting as executing agency for the
United Nations Development Programme

Based on the work of J. Dedek,
transport and systems expert

Backstopping officer: J. Pavlik
Institutional Infrastructure Branch

United Nations Industrial Development Organization
Vienna

*This document has not been edited.

V.91-27164

C O N T E N T S

A N N E X E S

0.0 ABSTRACT

This Technical Report is aimed at:

- assessment of the present situation in transport under ZIMCO/INDECO;
- recommendations regarding the improvement of transport based on analysis of the situation;
- implementation of systems analysis to the transport problem;
- systems analytical recommendations for other priority subsectors: agronomy, food technology, and chemical industry.

The report comprises ten major Chapters:

1 Introduction
2 Present situation in transport sector and ZIMCO/INDECO (assessment of the present situation in the transport sector in Zambia based on available information)
3 The general transport problem (brief outline of essential problems of the sector)
4 Links (breakdown of major problems and links)
5 Formulation of RDU in transport and systems sector (job description for the RDU under ZIMCO/INDECO)
6 RDU operation in transport and systems sector (recommended organization and equipment for the RDU)
7 RDI problems to be analyzed (a more detailed analysis of the major problems listed in Chapter 3)
8 Research and development priorities
9 Recommendations in the transport and systems sector (a total of 11 fundamental recommendations)
10 Project implementation up-scaling (schedule for installing the recommended computer facility at the RDU).

The technical Report contains three Annexes.

The general conclusion is to

- launch a Research and Development Unit for ZIMCO/INDECO
- include R & D in transport and systems as one of the Unit's principal activities
- examine a range of R & D and technology upgrading projects.

This Technical Report is an integral part of the Terminal Report "Assistance to ZIMCO RDI".

1.0 INTRODUCTION

In all parts of the world, transportation ranks among the most important sectors of the national economy. The following modes of transport are present in Zambia, with respective facilities, installations, vehicles, equipment, etc.:

Passenger transport, i.e.,
- railway transport
- road transport
- air transport
- water transport;

Transport of cargo, i.e.,
- railway transport
- road transport
- air transport
- water transport;

Transport of crude oil by pipeline[1].

Assessment of the present situation in the transportation sector and any recommendations concerning further development of the sector have to be linked to a comprehensive range of problems which must be solved as they are of prime concern to the entire national economy (multi-sectorial problems).

The one factor highly important to proper operation of the transportation sector is abundant available energy for operating the vehicles, i.e., in the case of Zambia, mainly an adequate supply of liquid fuels (petrol, diesel oil, and aviation fuels). For Zambia to have sufficient supplies of liquid fuels means
- for ZIMOIL to import from Dar-es-Salaam to Ndola enough crude through Tazama Pipelines,
- to adequately process it at Indeni Petroleum Refinery Company in Ndola to liquid fuels of desirable quality, and
- to distribute the fuels throughout Zambia as required.

The other factor essential to the operation of the transportation subsector is the availability of adequate rail and road networks. Various components of the economy (incl. RDI) which effect either of these essential factors are in need of improvement.

---

[1]Formally not belonging to the transport sector according to Zambian classification, at variance with worldwide usage where long-distance pipelines are regarded as primarily transport installations.

2.0 PRESENT SITUATION IN TRANSPORT SECTOR AND ZIMCO/INDECO

Transport is a fundamental pre-requisite to the process of socio-economic and political development. Transport networks and systems foster development by bringing areas and populations which are inaccessible due to hostile terrain, long distances and remoteness into the orbit of development. The availability of an efficient transport stimulates production and productivity by linking production to demand and generating employment and raising the general income levels. However, efficient operations of the transport sector require a well developed infra-structural system, serviceable equipment and effective management.

One of the major constraints to economic recovery program as identified in the **Fourth National Development Plan** (FNDP) and the **Policy Framework Paper** (PFP) is the deteriorating condition of the transport sector. To this trend, the restoration of this sector to a level that would permit the efficient conduct of economic activities was one of the main objectives of both the FNDP and PFP.

The recovery concept as envisaged by the **Public Investment Program** (PIP) was as follows:

- maintenance and rehabilitation of transport infrastructure;
- spare parts supply, through increased allocation of foreign exchange;
- maintenance and rehabilitation of fleets in Zambia Railways and the trucking industry;
- urgent fleet acquisition for Zambia Railways and private truck operations;
- improved planning and policy formulation based on enhanced data collection, processing and systems analysis;
- improved management of transport parastatals to eliminate subsidies;
- encouragement to the private trucking sector;
- improving the financial position of the parastatals e.g. cost cutting, accounting, financial controls, etc.

Resulting from the Persian Gulf crisis the country experienced fuel shortages and escalations in the price of petroleum products. This further called for the upward revision tariffs and has a detrimental effect on the development of the sector as a whole.

2.1 Railway transport

Zambia has a total main line network of 2,708 km with 848 km on **Zambia Railways** and 1,860 km on **Tazara Railway**. During the period under review, railway transport continued to be the dominant mode of transport for movement of domestic and international traffics. Railways handled about 85 per cent of the country's imports and 90 per cent of export traffic. The actual performance of Zambia Railways was less than 50 per cent of its capacity due to the poor condition of the basic infrastructure and low availability of locomotives and rolling stock. Over 40 per cent of the locomotive fleet is more than 18 years old. The average availability is around 55 per cent as compared to the operational requirement estimated at 75 per cent.

The total number of serviceable wagons in revenue earning goods traffic stood at ca. 6400 units of which ca. 2700 belonged to the unitary system and are over 35 years old and are therefore unserviceable.

Zambia Railways freight traffic mainly consisted of copper, coal, maize and limestone which together accounted for 90 per cent of the total traffic. Passenger traffic has been showing a growing trend attributed in part to the fact that tariffs have been increasing at a slower pace than the general prices level. Zambia Railways alone transported a total of ca. 2.5 million tons of cargo and ca. 480 thousand passengers between the period January and September, 1990.

Both Zambia Railways and Tazara Railway embarked on major rehabilitation of equipment and infrastructure and the acquisition of new locomotives and wagons to improve their operational efficiency.

Boliden Conteh, Swedrail, and **Halifab** formed a unique Swedish consortium to rehabilitate the ailing 1,800 km Tazara Railway under a project code named "SEI". With the rehabilitation of Tazara's rail track now underway, many delays which have hampered smooth traffic flows could soon be avoided thanks mainly to the chief sub-contracts (Swedrail and Boliden).

The construction of the **Chipata-Mchinji Railway Line** to link the Malawi railway network onward to Mozambican ports continued but at a slow pace mainly due to problems of funding.

Recent developments in metropolitan transportation include the construction of the **Matero** commuter rail line in Lusaka.

2.2 Road transport

Zambia has a designed road network of ca. 39 thousand kilometers of which ca. 6 thousand kilometers are bitumen, ca. 9 thousand kilometers gravel and ca. 24 thousand kilometers unclassified. The GRZ through the Roads Department maintains about 54 per cent of the network and the Districts councils maintain the remainder of 46 percent.

Lack of maintenance of roads has had severe detrimental effects on collection of crops in recent years. In 1989 alone it was estimated that some 360 thousand tons of maize was not collected from remote areas such as Gwembe in the south because of impassable roads.

The most important objective of the transport sector in future is to continue to rehabilitate and upgrade the existing roads. In 1991, Zambia received road construction equipment worth 7.3 million US$ from Japan. Japan has supplied 95 units of equipment and machinery. The first consignment consisted of 10 bulldozers, 9 wheel front-end loaders, 28 motor graders and spare parts for the equipment and the next batch of 48 units is to include 18 tipper trucks, 9 pick-up vans, 9 water tanker trucks, 9 mobile workshop trucks and 9 road rollers.

Due to the unfavorable economic environment, the activities of road transport operators remained depressed. This is attributable to their inability to carry out an effective replacement program. Most of the vehicles are old and need replacement in order for this subsector to operate at optimal level.

United Bus Company of Zambia Limited (UBZ) had been best with a number of structural and operational problems which culminated into the company being unable to effectively realize the objectives for which it was created. Following the directive, GRZ took a number of measures to reorganize and resuscitate UBZ as follows:

- also, GRZ and ZIMCO took all UBZ's external and domestic liabilities, respectively;
- exempted UBZ's outstanding taxes and fines payable to GRZ;
- injected capital initially to improve the bus fleet position;
- mandated UBZ to gradually reduce its labor force in order to maintain economic manpower levels by offering an acceptable retirement package.

In line with its mandate to offer an economic and effective passenger road transport, during 1991, UBZ embarked on a five year program to procure a total of 150 new buses annually. The

first instalment of 150 buses of Leyland DAF will be ready at the end of 1991.

Contract Haulage Limited (CHL) continued to make a significant contribution of the national economy trough the movement of both domestic and international freight. The restructuring of CHL in 1984 brought new impetus to the company's operations. More recently, the management of CHL was re-organized and manpower levels reduced. Despite having an over aged fleet the performance of CHL in terms of revenue collection and profitability was encouraging. The company made a gross profit and continued to enjoy a higher vehicles availability ratio of 80 per cent compared to the 1989 figure of 70 per cent. Between 1990 and 1991, CHL recorded an improvement in kilometer coverage from an average of 3,500 km to an average 4,500 km per month per vehicle. In addition to CHL in the freight subsector, private operators affiliated to the **Truckers Association of Zambia** played a vital role in the haulage of agro-inputs and outputs. These operators faced immense operational problems due to non-availability and high cost of spare parts and the increased cost of new vehicles. The state of public passenger transport in the country particularly in the urban areas further deteriorated.

Both UBZ and CHL have shown remarkable improvement in the financial performance due to the more economic tariff structure brought about by the liberalization of prices and an improvement in fleet acquisitions. The companies are now engaged in a program to further expand their fleet in order to service the ever increasing demand for passenger and cargo transportation.

On the other hand, the development over the years of the fleet size of UBZ and/or CHL sofar presents a bleak picture:

Year	No. of operational vehicles UBZ [buses]	CHL [trucks]
1979/1980	445	283
1980/1981	434	297
1981/1982	365	325
1982/1983	304	228
1983/1984	260	185
1984/1985	184	180
1985/1986	161	171
1986/1987	143	155
1987/1988	91	166
1988/1989	182	182
1989/1990	278	204

United Transport and Taxis Association (UTTA) played an important role in the movement of passengers both on intra and intercity services. Their market share was in the range of 90 per cent. However, although the private operators played a leading role in the provision of passenger transport services, especially in the urban areas they were not able to effectively play their role due to their inability to replace the buses and acquire spare parts. Realizing the important role the private operators are playing in the provision of passenger services, GRZ encouraged the operators to form a **Transport Cooperative Union.**

Truckers Association of Zambia (TAZA) is estimated that the private sector controls about 70 per cent of the domestic road haulage market. Out to this, TAZA operators control about 60 per cent share. The most serious problem which beset TAZA was its inability to replace their aged fleet and to procure the necessary spare parts from maintenance and repairs. The major commodities handled were agricultural produce and inputs such as fertilizer and implements. The TAZA operators also played a significant role in the international road haulage market.

The **National Tourist Board** (ZNTB) is the main GRZ agency responsible for tourism promotion. ZNTB offices in London, Milan, and New York continue carry out promotional activities. New offices are planned to open in Bonn, Tokyo, Stockholm, and Sydney. Many individual travel agencies such as Capital City Care Hire, Eagle Travel, etc. maintain fleets of passenger cars and vans for taking tourists around the country. These cars are generally in good condition.

2.3 Air transport

Zambia in 1990 had 131 airfields of which 45 are GRZ owned, 26 private licenced and 60 private unlicensed. For the transport subsector budget contained two main items of interest. The first was the GRZ's decision to liberalize access to Zambia air space. Foreign passenger and cargo airlines are to be allowed to fly to Zambia without restriction and anyone wishing to establish and airline business in the country is to be allowed to do so.

The move, in line with liberalization measures in the budget, had already been presaged by GRZ's October 1990 decision to grant an airline permit to **Lupenga Air Charters** (LAC), making it the first local private firm to be licenced. The licence allows LAC to operate international and domestic services.

It seems unlikely in the short term that **Zambia Airways** Corporation Limited (ZA) will face a significant increase in

competition. In fact services to Zambia look set to contract rather than expand as a result of the huge rise in local fuel costs since Iraq's invasion of Kuwait. Concern over this trend underlies another point of note in the budget - the decision by GRZ to allow foreign airlines to pay for fuel in Kwacha as well as in foreign exchange. GRZ also pledged to fix prices at a level competitive with fuel costs in neighboring countries.

Despite its pledge, GRZ subsequently announced that it was prevented from cutting prices by high interest charges on the money borrowed to pay for oil. Most airlines responded by refusing to purchase fuel locally, instead refuelling either in adjacent states or in West Africa. ZA announced in late December 1990 that, with local aviation fuel costing 170 per cent more than anywhere else, it would be following suit.

The problems created by high fuel costs have not prevented ZA pursuing its plans to expand and modernize its fleet. In October 1990 the company acquired a new Boeing 757 freighter aircraft. It is operated by ZA's cargo subsidiary, National Air Charters (NAC), and has been leased from Australia's Ansett Worldwide Aviation.

ZA has received a US$ 14 mln loan from Greyhound Leasing Corporation AG of Switzerland. A large part of the money would be used to refurbish the DC 8-71 aircraft and a smaller part of the money would be used to buy a spare engine and other requisites for this plane. The loan is repayable over six years in 72 monthly installments.

The Boeing 757 and DC 8-71, which are more fuel efficient and quieter than older planes, have combined maximum payloads and are be used on routes to Europe and the Middle East.

2.4 Water transport

Inland water transport continues to play an important role in providing transport services to areas which are inaccessible by transport. Low cost is the inherent advantage of water transport. It is the cheapest mode in energy terms and it can still be a useful supplementary mode providing relief to surface transport.

Zambia has a good potential for developing water transport in some parts of the country, particularly along the stretches of Zambezi, Luapula, Kafue and Luangwa rivers. The same applies to the waters of Kariba, Bangweulu, Mweru, Mweru-Wantipa and Tanganyika lakes and Lukanga swamps. The only significant development with regard to inland water transport of note during

1990 is the rehabilitation of Mpulungu port and the establishment of Mulamba Harbor (construction of staff houses and offices on the upper Zambezi river). The Mpulungu port continued to play an important role in the export of cement, sugar and bitumen to Burundi and Rwanda.

The development of inland water transport is inhibited not only by lack of handling equipment at the inland ports but also by the inadequacy of dredging facilities to keep canals and channels free of weeds, mud and sand banks. The vessels and their spare parts to maintain the existing services are also lacking.

2.5 Transport of crude oil by pipeline

Tazama Pipelines Limited owns and operates a crude oil pipeline from Dar-es-Salaam to Ndola. The pipeline comprises 1,710 km of 8" line together with 769 km of 12" loop lines and has an annual transportation capacity of 1.1 mln tons. The company also operates a tank farm facility and 7 intermediate pumping stations. The pipeline is owned by Zambia (2/3 of the share capital) and Tanzania (1/3 of the share capital).

Zambia, as expected, proved to be one of the countries worst affected by the higher oil prices caused by the Persian Gulf crisis. During 1990 developments in the energy sector were dominated by events in the petroleum and petroleum products subsector. The beginning of the 1991 saw a slowly but steadily rising price for crude oil on the international markets. However, in August, 1990 events in the Persian Gulf led to the disruption of established lines of supply of the nation's energy fuel imports and, consequently, the domestic fuel prices were allowed to rise substantially to reflect the higher world prices. Initially the Persian Gulf crisis resulted in shortages of oil and queues for fuel on the Zambian market. Improvement can be expected to go hand in hand with stabilization of the post-war situation in the Gulf.

The age and the deteriorated state of certain sections of the Tazama pipeline due to excessive corrosion make its rehabilitation imperative. The Indeni Petroleum Refinery, built some 15 years ago needs equipment, some plant replacement as well as some engineering works.

Both Tazama and Indeni are also paid attention in a parallel report on the Chemical Industry subsector (cf. Technical Report "C").

2.6 ZIMCO and INDECO

Each and every company and institution must cope with issues of passenger as well as freight transport. These issues differ case to case. However, companies exist within the ZIMCO/INDECO group which have transport as a substantial part of their commercial or supporting activities:

- passenger transport or freight haulage for other companies;
- assembly of vehicles;
- manufacture of vehicles or their parts;
- manufacture of vehicle accessories;
- vehicle maintenance and repair;
- maintenance and/or construction of rail tracks, roads, airports, ports, pipelines;
- production and distribution of liquid fuels for vehicles.

The list shown as Annex T-1 gives a total of 30 ZIMCO or INDECO subsidiaries active at least in part in some of the aforementioned activities thus contributing to the over-all transportation system of Zambia. It is one of the aims of the present report to analyze both the ZIMCO/INDECO subsidiaries' contribution to the nationwide as well as international transport system and to address their problems in this regard, rather than to dwell on the functionality of their in-house transport.

2.7 Review of the results of technology audits

During a previous mission to Zambia by the present UNIDO team (cf. DP/ZAM/88/028, April/May 1989) the following subsidiaries which can be ranked as belonging to the transport sector were visited:

- Zambia Railways Limited
- Zambia Concrete Limited
- United Bus Company of Zambia Limited
- Contract Haulage Limited
- Zambia Airways Corporation Limited
- National Airports Corporation Limited
- Tazama Pipelines Limited.

During the present mission to Zambia (April/May 1991), the following subsidiaries of the transport sector were covered:

- Lusaka Engineering Company Limited
- Consolidated Tyre Services Limited.

Each of above subsidiaries was tapped according to a scenario including, as a rule, an interview of several executives, answers to specific questions, writing a file describing the visit,

recording essential data, and a visit of the company operations. A recommendation focusing on R & D issues and on the way of handling constraints of immediate concern was formulated for each subsidiary. Essential conclusions for these subsidiaries are reproduced below in the briefest outline.

Zambia Railways Limited (ZR) urgently needs tracks rehabilitation, spare parts for available cars and locomotives, and gradual replacement of locomotives, passenger wagons, and freight cars. Basic information on ZR can be found in Chapter 2.1.

Zambia Concrete Limited produces concrete railway sleepers. In connection with the imperative rehabilitation program of the Zambian Railways, the only producer of railway sleepers should be given ZIMCO's support in his endeavor to expanded production not only for the domestic market but also to cover the potential exports. The residual life of major manufacturing equipment is expiring, so an innovation of the factory is necessary.

United Bus Company of Zambia Limited (UBZ) is involved in city and intercity passenger transport. The number of buses is too low, spares are in short supply, service life is adversely affected by poor roads. Basic information on UBZ can be found in Chapter 2.2.

Contract Haulage Limited (CHL) operates intra-state as well as inter-state freight transport. The park of trucks is in need of expansion, spare parts are hard to come by, service life suffers from poor condition of roads (also cf. Chapter 2.2).

Zambia Airways Corporation Limited (ZA) transports passengers and freight on domestic and international lines. Regular airline services connect the following airports:

- Domestic airports: Lusaka, Ndola, Kasama, Kasaba Bay, Mfuwe, Chipata, Livingstone;
- Foreign airports (from Lusaka international airport): Nairobi, Bombay, Frankfurt, London, Rome, Harare, Entebbe, Dar-es-Salaam, Francistown, Gaborone, Johannesburg, Lilongwe, Lubumbashi, Manzini, Mauritius, Windhoek.

More information can be found in Chapter 2.3.

National Airports Corporation Limited is structurally divided into the following departments:

- air traffic control and services;
- engineering;
- rescue services;
- AFTN (Aeronautical Fixed Telecoms Network);
- fire rescue services.

Air traffic navigation at Lusaka international airport urgently requires a range of additional navaids to be installed, to bring it up to the standard regarded as minimum acceptable for truly international airports.

Tazama Pipelines Limited transports crude from Dar-es-Salaam to Indeni Petroleum Refinery Company Limited at Ndola where petrochemical processing takes place, yielding mainly the liquid fuels. The pipeline built in 1968-1973 holds a key position in Zambia's power and energy sector, and rehabilitation is in progress. Zambia's Public Investment Program (PIP, annex of April, 1990) lists the project called "TAZAMA Pipeline Rehabilitation Phase II" as the sector's first priority for 1990-1993, of a total worth of US$ 15 mln plus ZMK 20 mln (also cf. Chapter 2.5).

Lusaka Engineering Company Limited (LENCO) is a company with a share holding of 60 per cent Intersomer SPA and Umberto Piacenza (Italy), each with 20 per cent of the shares. At its inception in 1972 the company manufactured light engineering products, viz., door frames, window frames, flyscreens, metal and tubular furniture. Soon after the commissioning of the new factory, the heavy engineering department was established to manufacture heavy transport equipment, i.e. trailers, truck bodies, new products within these existing product lines have since been introduced in the recent past years. These are the galvanized roofing screws and ox-drawn ploughs. The various products are manufactured to service the construction, consumer, mining and transport sectors for commercial, institutional and domestic requirements on a large scale.

LENCO has an annual rated capacity of 830 trailers, 100 bus bodies and 5000 ox-drawn ploughs. However, the production of these is far below their rated capacities. The output of trailers in 1990 was 204 against the budgeted production of 519. However, production increased by 34.2 per cent compared to 1989. Production of bus bodies increased only from 5 in 1989 to 7 in 1990. The output of buses in 1990 was 96 buses named AVM (with DAF engines from Zimbabwe).

Other components of LENCO's program (door frames, flyscreens, furniture, ploughs, etc.) are outside the scope of this report.

Consolidated Tyre Services Limited (CTS) has four plants (2 in Kitwe, 1 in Lusaka and 1 in Chingola). Business activities include

- retreading and relugging of tires;
- rubber lining;
- sales of new tires;
- sales of new batteries.

The full capacity of CTS is 100 thousand retreaded tires per year. Present production is 26 thousand tires. Potential market demand is about 2 mln tires. Detailed information about its production profile and R & D activities can be found in the report on the Chemical Industry subsector (Technical Report "C").

Livingstone Motor Assemblers Limited (LMA) assembles passenger cars (Fiat UNO, about 10 cars per month). 70 per cent of shares is owned by Livingstone Motor Assemblers Limited, 20 per cent belongs to Fiat (Italy), and 10 per cent to Intersomer SPA (Italy).

3.0 THE GENERAL TRANSPORT PROBLEM

The general transport problem encompasses a number of individual problems (discussed below) of which hardly any single one can be handled by ZIMCO/INDECO alone, however important the contribution by ZIMCO/INDECO may be. The general transport problem is, of course, a nationwide issue and should be handled as such by the RDU, to the benefit of ZIMCO/INDECO as well as of Zambia at large.

The individual problems outlined below must be tackled at an increased intensity by Zambia if transportation is to be upgraded and make more effective, and the new RDU of ZIMCO/INDECO can be of valuable assistance here. The problems listed as 3.1 through 3.5 are then dealt with in more detail in the Chapters 7.1 through 7.5.

3.1 Systems analysis of transport problems

This analysis involves in the first place

- gathering of data on transport (rail, road, air, water, other)
- recording the data in a computer based data bank system which of course has first to be defined and initialized
- application of the data banks to the solution of specific transport problems (which involves data screening and analysis).

These projects are of the greatest importance to Zambia's transport sector and their success or failure will influence the methodology, quantification, and actual handling of future transport problems. It is important that the problems facing the various modes of transport (i.e., rail, road, air, and water) be coped with simultaneously as they are not independent of one another.

Such applications should benefit from yet another data bank (not directly concerned with transport themselves) which will contain data on

- raw materials
- products
- intermediates/byproducts
- wastes

(cf. Chapter 7.1.3) and also from a data bank of literature information (cf. Chapter 7.1.4) as well as from the various lists to be compiled by the RDU (cf. Chapter 5.3.5.1).

For all such analyses to be meaningful in the practical context of ZIMCO/INDECO, an economic evaluation is indispensable. The

Economic Evaluation Unit (EEU) of INDECO should be used extensively in this context[2].

3.2 Construction, innovation, rehabilitation, and maintenance of transport routes

The results of systems analysis of the transport problems as defined in Chapter 3.1 will provide an opportunity for a well-founded assessment of which transport routes must be

- re-built;
- innovated;
- rehabilitated;
- maintained at a higher or lower periodicity.

Systems analysis of this kind will also assist decision-making by work schedules depending on available funding.

3.3 Construction, innovation, rehabilitation, and maintenance of vehicles

This is a task which converts to recommendations regarding

- the handling of the problem of routine vehicle maintenance;
- manufacture of specific accessories and spares;
- assembly of vehicles and accessories (from manufactured or imported components);
- innovation of specific conveyances, and innovative techniques;
- rehabilitation of vehicles and transport systems, including a spare parts management system.

---

[2]Yet another important aspect of all systems analyses is adequate systems support. The systems support to serve the comprehensive activities of the RDU is defined in detail in Chapters 5.2 and 7.1. The existing systems support of the EEU (comprising 5 IBM PCs and the software packages COMFAR, DBASE III+, LOTUS 1-2-3, PFS WRITE - WORD PROCESSOR, SUPER PROJECT+, WRITING ASSISTANT, HARVARD GRAFIX, NORTON UTILITIES, and FRAMEWORK II operated under MS-DOS) should be expanded and, for maximum coordination and effectiveness, the whole EEU should be made part of the RDU. The scope of activities of the EEU should be expanded by general systems analysis as outlined in Chapter 6.6.

In order to successfully tackle above problems, an analysis of the transport situation making use of data bases outlined in Chapter 3.1 is a prerequisite.

3.4 Diversity of liquid fuels sources and reconnaissance of replaceable liquid fuels for transport

This task involves searching for alternative sources of liquid fuels for Zambia, including e.g., periodic reassessments of the second oil pipeline project and its linkage to petrochemical processing.

Further, this task entails techno-economic balances of the production of substitute fuels. For Zambia, several approaches to the production of substitute liquid fuels are worth analyzing:

- fermentation of agricultural and lignocellulosic feedstocks to produce ethanol;
- vegetable oils as diesel extenders/substitutes;
- production of synthetic ethanol from coal.

The importance of solving the problem 3.4 relates to the fact that all engine fuels derive from imported crude (Tazama Pipelines Limited) subjected to petrochemical processing (Indeni Petroleum Refinery Company Limited).

3.5 Waste recovery from scrapping of vehicles

Operation of vehicles of all kind eventually ends by a scrapping process generating scrap and wastes. The following problems have to be faced:

- collection and refining of spent engine oils;
- collection and retreading/disposal of worn tires;
- scrapping of the vehicles, i.e.,
  - dismantling
  - hand-picking parts which can be re-used as spares
  - screening the remainder to separate iron & steel, aluminum, copper, glass, textiles, and plastics scrap and wastes returnable for reprocessing.

Coping successfully with these problems would make an important contribution to the environmental balance of Zambia.

4.0 LINKS

One way of regarding the possible links and liaisons in the transport and systems sector is as belonging to one of five groups:

- in-house links;
- company to company links;
- links between subsectors;
- links to other sectors of national economy;
- links to GRZ and non-ZIMCO/non-INDECO institutions.

The individual transport and systems sector problems as listed in Chapter 7.0 can be allocated according to the link groups shown above. Some problems can be classified as belonging to several groups. Referring again to individual Sections of Chapter 7.0, individual problems are allocated to link groups as follows:

In-house links:
7.1.4, 7.1.5, 7.3.1, 7.5.1, 7.5.2, and 7.5.3.

Company to company links:
7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1.5, 7.3.1, 7.3.2, 7.3.3, 7.3.4, 7.3.5, 7.4.1, 7.4.2, 7.4.3, 7.4.4, 7.5.1, 7.5.2, and 7.5.3.

Links between subsectors:
7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1.5, 7.2, 7.3.2, 7.3.3, 7.3.4, 7.3.5, 7.4.1, 7.4.2, 7.4.3, 7.4.4, 7.5.1, 7.5.2, and 7.5.3.

Links to other sectors of national economy:
7.1.1, 7.1.2, 7.1.3, 7.2, 7.3.2, 7.3.3, 7.3.4, 7.3.5, 7.4.1, 7.4.2, 7.4.3, 7.4.4, 7.5.1, and 7.5.3.

Links to GRZ and non-ZIMCO/non-INDECO institutions:
7.2, 7.4.1, (7.4.2), (7.4.3), and (7.4.4).

5.0 FORMULATION OF RDU IN TRANSPORT AND SYSTEMS SECTOR

Discussed in this Chapter are all the major aspects of the transport and systems sector, followed by a description of the activities of the Transport & systems sector specialist for the new RDU. The problems of the sector proper were already dealt with briefly in Chapter 3.0 and were analyzed in more detail in Chapter 7.0.

The definition of the entire RDU, encompassing RDI in all the priority subsectors and, eventually, in all sectors of ZIMCO and INDECO, is not dealt with in this report; it can be found in the Terminal Report of which this Technical Report is an annexure.

5.1 RDU objectives

The general objectives to be pursued by the RDU in the transport and systems sector include following:

- improvement of transport;
- utilization of wastes from transport conveyances;
- diversification of sources for utilizable the production of liquid fuels for transport conveyances;
- reconnaissance of substitute liquid fuels for transport conveyances;
- collection and sharing of information about raw materials, products, intermediates/byproducts and wastes;
- collection and sharing of literature information.

5.2 RDU activities

The general scope of RDU's activities in the transport and systems sector is as follows:

- RDI consulting on transport problems;
- mediation of intra-sectoral and inter-sectoral contacts and links in transport problems;
- collection and dissemination of transport data and information;
- collection and dissemination of scientific and RDI information;
- technology auditing within the transport sector;
- solution of transport problems;
- preparation and startup of RDU data banks;
- acquisition, validation, recording, and updating of data for data banks;
- organization of training, meetings, and ad hoc teams addressing transport problems.

5.3 RDU outputs

The RDU objectives and activities enumerated in Sections 5.1 and 5.2 above are formally appurtenant to RDU outputs for the transport and systems sector. The individual outputs are outlined below, in Sections 5.3.1 through 5.3.5.

5.3.1 RDI promotion

The transport and systems specialist will be appointed and given responsibility for RDI in the sector. Information on the RDU and its staff will be circulated to all ZIMCO/INDECO subsidiaries, including the main features of the staff members' job descriptions.

The information concerning the RDU and the Transport & systems specialist will also be sent to the Ministry of Power, Transport and Communications.

5.3.2 RDI coordination within the RDU group

RDU Head controls, supervises, and coordinates the work of the RDU staff. Depending on the nature of the problem faced he always charges on of the RDU specialists with responsibility for the project or problem. The specialist himself is then responsible for the project in all its stages.

Because of the combined nature of the "transport and systems" post in the RDU, the transport and systems specialist should assist the RDU Head in coping with the coordinating and liaising tasks.

5.3.3 RDI cooperation and planning at nationwide level

In the first place, RDU should take part in the solution of the RDI problems of ZIMCO/INDECO. It is recommended though that the RDU operate at a nationwide level. The RDU must be informed of ongoing RDI projects outside ZIMCO/INDECO.

The project supervisor takes care of cooperation with other institutions and with companies, depending on the nature of the problem to be solved and regardless of whether the cooperating organization is a ZIMCO/INDECO subsidiary or belongs to GRZ or the private sector. He is responsible for cooperation planning

with a view to the deadline agreed for that particular project. Should the cooperating organization require ZIMCO/INDECO financing, it is the RDU Head's responsibility to locate the funds and provide all necessary background regarding the financing decision. Funding from a variety of sources can be considered (ZIMCO/INDECO, ZIMCO/INDECO subsidiary or associate company, GRZ Ministries, another parastatal, private sector, donor agencies).

5.3.4 RDI conducted by the RDU

As a rule, a new RDI problem is to be tackled as follows:

- defining the objective, profit or benefit, and deadline for the proposed project;
- proposing a method to be used to solve the problem;
- detailing methodology;
- preliminary contacts to ensure cooperation if necessary;
- defining project stages (internal breakdown);
- solution proper of the problem, including the organization of stage evaluation reviews;
- finalizing the solution (as a rule, by organizing a review meeting);
- handing over the results for implementation;
- training if this is required by the nature of implementation of the project.

5.3.5 RDU information services

5.3.5.1 Data acquisition

The solution to any problem requires data logging and the gathering of information. When tackling a problem in the transport and systems sector, the following activities must be undertaken in the area of data collection:

- gathering data on transport links and routes using questionnaires and aiming at the generation of DRW type data bank (Chapter 7.1.1);
- questionnaires on public passenger transport aiming at the DBP data bank (Chapter 7.1.2);
- questionnaires on raw materials, products, intermediates/byproducts, and wastes aiming at the DBRPIW (Chapter 7.1.3);

- the DBL data bank (Chapter 7.1.4) of literature information (each RDU specialist collects information relating to his particular profession/subsector as a brief annotation including an accurate identification of the information source);
- general information on transport from a variety of sources and angles (monographs, articles, prospectuses, reports, etc.) - the DBL must include annotation and identification of the information source);
- list of projects to be launched;
- list of contact persons;
- connection to or, respectively, liaising with MCI, NCDP, and NCSR data banks.

5.3.5.2 RDI surveying

Within the transport and system sector, the RDU specialist has to monitor and systematically support the following activities:

- serious questionnaire type data logging to provide inputs to the DBW, DBP, DBRPIW, and DBL data banks;
- efforts to thoroughly populate, update, and extend the data in all above data banks;
- distribution of possible results arising from the application of above data banks with their outputs oriented toward potential clients;
- consideration and acceptance of comments and criticisms on the part of the clients or interested parties using the results generated by the data banks (introduction of feedback)
- serious efforts to solve the transport problems, including steps to convert RDI results into tangible outputs.

5.3.5.3 Data dissemination

When tackling problems at the RDU, three cases can occur, in principle, as concerns the professional leaning of the problem to be solved:

- the problem requires only one of the RDU specialists;
- the problem requires at least two specialists of the RDU (an interdisciplinary problem);
- the problem requires one or more RDU specialists but also some other specialist not on the RDU staff (interdisciplinary problem again).

It can be demonstrated that out of the three cases, the interdisciplinary problems occur most frequently in practice. It is exactly in solving such problems that disseminated information and data are needed. The generation of the data banks mentioned above, i.e., DBW, DBP, DBRPIW a DBL (described in v Chap. 7.1) prevent "loss" of data and information being disseminated.

6.0 RDU OPERATION IN TRANSPORT AND SYSTEMS SECTOR

6.1 Schedule of operations

For RDU operations, three time horizons are recommended:

- Phase I (start-up);
- Phase II (routine);
- Phase III (up-scaling and integration).

These are described in more detail in the Terminal Report, inasmuch as the schedules are the same for all the RDU specialists in the priority subsectors.

6.2 RDU staff

Guidelines for national staff for Phase I and Phase II can be deduced from the methodology proposed.

Job description for the Transport & systems specialist is given in the Annex T-2 of this report.

6.3 RDU methodology

RDU methodology reflects the character of work encountered at a research and development facility. In the transport and systems sector, the following general methodical activities occur:

- working with literature (gathering, classification, and study of information on transport and systems analysis);
- collection and classification of data obtained in Zambia in the transport sector;
- consultations and problem-oriented meetings;
- working with computers (especially, in mass data processing and informatics);
- in-depth study of the general RDI problem;
- developing systematic attitudes to RDI.

6.4 RDU premises

As a rule, ordinary offices would be quite satisfactory for the work of the RDU, as mentioned in the Terminal Report. With a view to transport and systems, the computer facility common to the whole RDU should also be housed in these premises. This is no longer any problem, since the computer rooms no longer need be air conditioned.

6.5 RDU facilities

6.5.1 Computing facilities (Hardware & Software)

The RDU must be equipped with adequate hardware and software. The following equipment is recommended, after careful study:

- Multiusing minicomputer system microVAX 3100 including:
  - CPU (32 bits) with 16 Mbytes memory;
  - hard disks (2 x RZ56 disk drive, i.e. 2 x 665 Mbytes formatted capacity);
  - floppy disk drive 5.25" (1.2 Mbytes);
  - TZ30 streaming cartridge tape drive (95 Mbytes) with an embedded SCSI ccntroller (effective back-up and software distribution unit);
  - ca. 5 color terminals VT340 (resolution 800 pixels x 414 lines);
  - laser printer DEClaser 2200;
  - software: operating system VMS (licence for 6-10 users), RDB (data bank system), compilers (COBOL, C, FORTRAN 77), DECnet EndNode software and PCSA (net software for connection IBM PC with VMS).

- 3 pcs of IBM PC/286 (or compatible) connected with system microVAX 3100 (working off line and/or under the operating system VMS in net) and in the same configuration, i.e.:
  - CPU/286 with 1 Mbyte memory and co-processor 287;
  - hard disk (60 - 80 Mbytes);
  - floppy disks (3.5" and 5.25");
  - VGA card;
  - color monitor (14", 800 x 500);
  - US standard keyboard (102 buttons);
  - matrix lineprinter A4;
  - software: operating system MS-DOS, data bank software DBASE III+, C compiler, LOTUS 1-2-3, NORTON UTILITIES, WORD PERFECT.

The recommended hardware a software will have to be re-assessed immediately prior to placing the order, owing to the soaring developments in computing. Hardware and software development is so rapid nowadays that it is useful to revise all items before the purchase is made.

6.5.2 Transportation facilities

It is recommended that an automobile be secured for the RDU. This should best be a landrover or station wagon type capable of carrying loads such as instruments and apparatus. The RDU will of necessity be required to travel in Zambia rather extensively, in connection with the problems being handled.

6.6 RDU management

The recommendation is to have the RDU established under the R & D Directorate of ZIMCO/INDECO. Within the INDECO there exists an **Economic Evaluation Unit** (EEU), as already mentioned in Chap. 3.1. It is recommended that the EEU closely cooperate with the RDU. The EEU activities would continue focusing mainly on the economic issues whereas the RDU would focus on technology. EEU should have full access to RDU's computing facility.

On a more remote time horizon, it is recommended that

- NCDP and NCSR each be equipped with one terminal which would be connected to the RDU computing facility;
- an interface with NCDP data banks be provided.

Until this is done, information can be shared on diskettes. It should be realized that diskettes can store certain files or tabulations but not extensive data bases.

6.7 RDU financing

RDU financing should be taken care of by ZIMCO/INDECO. Clearly, projects made for clients outside ZIMCO/INDECO should be made on contract. State subsidies are also possible, i.e., individual Ministries of GRZ interested in specific information should also be interested in supporting the information processing financially, with a view to the problems faced by individual sectors and subsectors of the national economy.

The costs of purchasing the items of equipment listed in Chap. 6.5 have been estimated as follows:

	Equipment	Price [US$]
1.	Hardware & software minicomputer microVAX 3100 system with accessories[3]	64,000
2.	Hardware & software three IBM/286 PCs (or compatible) with accessories[3]	10,000
3.	Automobile[4]	17,000
	Total	91,000

It is expected that these costs would be covered by the upscaling budget, recommended to the attention of UNIDO, for an upscaled institution building project.

[3]Including shipping, re-shipping, and handling.

[4]Preferably, landrover or station wagon type capable of carrying loads (instruments & apparatus).

7.0 RDI PROBLEMS TO BE ANALYZED

This Chapter presents a more detailed analysis of the problems outlined in Chapter 3.0, that is, a detailed breakdown of the subchapters 3.1 through 3.5 in the subchapters 7.1 through 7.5. To successfully solve the four problems outlined in 7.1 it is indispensable that the RDU be equipped with computing facility as outlined in 5.5.1.

The recommendation below represent a very specific job for the RDU specialist in transport and systems analysis. The job description for the Transport & systems sector specialist is given in Annex T-2 of this report.

7.1 Systems analysis of transport problems (in detail)

Chapter 3.1 gave a brief outline of the application of systems analysis to the solution of transport problems. The problem 7.1.1 (data base DBW) and the problem 7.1.2 (data base DBP) closely relate to the problems of transport. The problem 7.1.5 concerns in-house transport of cargo, such as gathering of harvest at the agricultural subsidiaries of ZIMCO/INDECO.

The problem 7.1.3 (data base DBRPIW) is first of all extremely useful in studies of intra-sectorial as well as inter-sectorial relations from the points of view of raw materials, products, intermediates/byproducts, and wastes. Also, it can aid the solution of cargo transport problems. The problem 7.1.4 (data base DBL) concerns professional literature and abstracts useful for all RDU specialists as well as for ZIMCO/INDECO subsidiaries.

For the problems 7.1.1 through 7.1.4, one record of the data bank is always described in detail, to clearly indicate what data and to what extent should be logged and stored.

All five recommendations given below require cooperation by all RDU specialists, mainly in logging the data for the data bases, and also require cooperation on the part of the subsidiaries.

7.1.1 Data acquisition and data bank of transport routes (DBW)

For the purpose of evaluating the passenger and cargo transport, a data bank containing data on the transport routes must be available, with only the rudimentary information.

The recommendation for DBW is as follows: (description of a single record):

- identification of the route (1 character: T for railways, resp. tracks, R for roads, A for airways, W for waterways, and P for pipelines);
- names of the two end points of the route (max. about 30 characters each);
- distance of the end points, in kilometers (incl. air routes);
- quality of the route, as a two-digit parameter (2 digits from the interval <0,99>; in fact, five sets of indicators are needed, for five kinds of transport).

Such data are sufficient indication of the transport distances when tackling a transport problem. The data must be logged step by step, on the basis of geographical information, thus gradually populating the data bank of routes with data useful for ZIMCO/INDECO. It is also possible that the data bank of routes can be more broadly based, to suit GRZ needs.

City streets can also be assigned and defined, with a view to the future needs of urban transport. The DBW data bank communicates with the data base administrator in a dialogue mode (on the basis of a menu).

Within this data bank there must be a program (for example, named **WAYS**), making it possible to

- find the distance of user-defined points, along routes of the type of **T/R/A/W**, or using combination routes;
- find the minimum distance of two points (again, allowing for two possibilities such as road/rail, etc.).

7.1.2 Data acquisition and data bank of passengers (DBP)

For evaluation of weekly mass transport of passengers, a data bank is needed containing basic demands on the weekly, periodic transport of a mass of passengers from one location to another. It is enough to work out a single transportation schedule, unless mass passenger transport which is seasonal (work in agriculture) should also be covered. This however is mostly taken care of by company organized transport.

The following recommendation is given for the DBP data bank (one data bank record):

- names of the two end points of travel (about 30

characters each, with indication of the direction of travel; both end points must already be contained in the DBW);
- the day of the week (1 character: 1/2/3/4/5/6/7);
- departure time (hour & minutes);
- duration of travel (minutes);
- number of passengers within a time limit along the route specified.

This data is sufficient for a weekly schedule of mass passenger transport. A survey of the transportation requirement is a necessity. This data bank would be of considerable importance to UBZ, mainly for inter-city transport where in case of greater distances, the time of departure is not important; what matters is the number of passengers (in the morning and at night). Mapping weekly mass transport in urban areas in very laborious, inasmuch as a number of accessory facts must be taken into account: company organized mass transport, location of the passengers' homes, etc.

The DBP data bank communicates with the data bank administrator in a dialogue mode (menu).

The data bank must comprise a program (named e.g., TPASS), which would make it possible to generate weekly schedules of mass transport. The TPASS program makes use of the DBP but also of the DBW. Simple analysis yields the optimum number of conveyances to suit the passenger demand.

7.1.3 Data acquisition and data bank of raw materials, products, intermediates/byproducts and wastes (DBRPIW)

The DBRPIW data bank is destined in the first place for important inter-sectorial information on raw materials, products, byproducts, and wastes, but also serves the transport sector.

The following recommendation applies to the DBRPIW (one record):

- material type identification (1 character: R for raw material, P for product, I for intermediate/byproduct, and W for waste);
- text description of material (max. 80 characters);
- identification of material by ISIC code (International Standard Industrial Classification);
- identification of material by SITC code (Standard International Trade Classification);
- annual consumption (for R) or annual production (for P/I/W), in tpy;

- contractor of raw material (only for R):
  - domestic/import (D/I);
  - identification of Zambian supplier of the material, or of the country of origin (60 characters);
- name of company where the material is consumed/produced (max. about 60 characters);
- three-digit sector/subsector designator (3 digits from the interval <0,999>);
- company location (max. about 30 characters).

This is a scope of data sufficient to generate surveys of consumed or produced materials involving more than one sector of the national economy. It can also be distinguished whether the material is local, imported, or exported.

The DBRPIW data bank would make it possible to generate various tabulations for more detailed analysis. It would be of advantage if the DBRPIW could gradually also encompass important non-ZIMCO companies. Menu communication.

DBRPIW can later be expanded so as to also include the following data:

- prices of raw materials;
- production prices of products and intermediates/ byproducts;
- waste disposal costs;
- optional data.

7.1.4 Data acquisition and data bank of literature information (DBL)

DBL is a data bank recommended for handling professional literature and sector-oriented information. The DBL data bank would keep on file brief abstracts of all kinds of literature (monographs, articles, prospectuses, etc. in a synoptical form.

The recommendation for DBL is as follows (one record):

- accurate pointer to original literature (max. about 80 characters);
- author/document name and affiliation (max. about 80 characters);
- full title of document (max. about 90 characters);
- abstract/annotation (max. about 240 characters);
- optional, up to 12 keywords, together with numeric code (international decimal classification).

The arrangement of the documents in the DBL provides speedy access to professional documentation, allowing for a variety of users' requirements as to data search and data presentation. The DBL data bank would again communicated by means of a menu.

7.1.5 Systems analysis of transport problems in ZIMCO/INDECO subsidiaries

In-house haulage of transport is a pressing problem in many companies. Haulage of agricultural produce is one example, harvesting is another. This is a classical transport problem, i.e., optimized utilization of existing conveyances over a defined territory. The data must include description of the route network, dislocation of loading/unloading points, and loading as well as unloading times.

Network analysis is then applied to optimize the schedules for each of the conveyances.

7.2 Construction, innovation, rehabilitation and maintenance of transport routes (in detail)

Transport routes must be built, innovated, rehabilitated, and maintained.

As for railroads, this will mostly be a case of sidings and yards, rather than new lines in Zambia.

The road network needs incessant maintenance, particularly after the rainy season. The road surface should be able to withstand all traffic, including heavy truck haulage and interstate transports. The condition of the grid of roads should be periodically analyzed. The DBW data base, cf. Chapter 7.1.1, would assist this task. The major cause of breakdowns and poor service life of road vehicles in Zambia is the poor condition of roads, especially the trunk roads.

Air transport depends on the number of available aircraft. Hence, the funds available for investment is the decisive factor, with the actual demand on air transport playing only a secondary role.

It is of prime importance however for the air transport in Zambia that the Lusaka airport should receive adequate navaids and communication links, to keep abreast of other international airports and to cope with a higher transport frequency.

Under the conditions of Zambia, the demand on inland water transport will grow. Again, the problem is lack of funding.

The crude oil pipeline between Dar es Salaam and Ndola operates under marginal conditions, its useful service life having been exhausted, as already mentioned. For Zambia however this is the only inflow of liquid fuel. Rehabilitation of the line is a matter of utmost priority. Funding is available, as described in Chapter 2.6. A technical description of techniques which can find application in pipeline rehabilitation is given in Annex T-3. The underlying principles make it possible to

- extend the pipeline service life by another 10-15 years;
- effect the rehabilitation at a cost no higher than 30% of the cost of a new pipeline.

The suggestions presented in this Chapter require a wide cooperation of various sectors of manufacturing, including GRZ Ministries.

7.3 Construction, innovation, rehabilitation and maintenance of transport vehicles (in detail)

Chapter 3.3 outlined five problems which were then treated in more detail in the sections 7.3.1 through 7.3.5.

All five recommendations made below would require the cooperation on the part of all ZIMCO/INDECO subsidiaries, especially at the surveying stage.

7.3.1 Daily maintenance of road transport vehicles

Daily maintenance of road vehicles is not good. As a rule, the drivers possess inadequate technical knowledge of their vehicles, lack spares and even the most basic tools needed for repairs in the field. There being relatively few repair workshops in Zambia, this is a situation worth looking into, because on the bad roads it is up to the drivers to take care of routine repairs.

In this context, the recommendation is

- to organize technical training for drivers on maintenance and routine repairs;
- to pay attention to the lack of tooling;

- to motivate drivers so that they pay more attention to the condition of their vehicles.

7.3.2 Production of automotive accessories

Based on the results of a survey, local production of selected automobile accessories could be launched. LENCO would already have a tradition in this line of business so ZIMCO/INDECO should consider an expansion.

7.3.3 Conveyances assembling and automotive accessories assembling

Under Zambian conditions, it would be useful to assemble vehicles or vehicle subassemblies using imported components. This certainly is a way to keep the vehicle costs lower. The absence of downstream metallurgical industries makes it impracticable to launch an extensive program though. A survey of practical options would be useful, and could be done by the RDU.

Of course, Livingstone Motor Assemblers Limited assemble Fiat UNO cars from imported components.

7.3.4 Vehicles innovation

Innovation of production equipment and installations probably is contingent upon a joint venture involving a foreign partner to start a new assembly line. The situation should be monitored and ZIMCO/INDECO should be kept informed on which foreign automobile manufacturers come into consideration.

7.3.5 Vehicles rehabilitation and spare parts problems

Vehicle rehabilitation must be linked with a network of repair shops. Large companies active in transport, such as UBZ or CHL of ZIMCO/INDECO, can sell repair services to other companies as well. Another possibility would be to establish yet another company within ZIMCO/INDECO which would specialize in vehicle repairs.

The problem of spare parts is crucial in Zambia, and this applies

to vehicles perhaps more than to any other industrial or commercial equipment. At the first glance, the case is simple: purchase spare parts in advance and keep a stock of spare parts as required. Hence, with every finished vehicle purchased there must be a definite scope of spare parts, larger in a country with bad roads. Of course, the spare parts problem also is a financial problem: spare parts do no work until used. Only large companies can afford to keep extensive stocks of spares.

No doubt, an investment in spare parts is better than to have vehicles which cannot move.

7.4 Diversity of liquid fuels sources and reconnaissance of replaceable liquid fuels for transport (in detail)

In Zambia, there is practically just a single source of crude for the production of fuels. Alternative sources should be sought, however remote their actual exploitation may seem from today's perspective. This would involve the building of a new pipeline, and its connection to the Ndola Refinery.

Basically there are three alternatives for producing liquid fuels under Zambian conditions, cf. Chapter 3.4. The recommendations listed below as 7.4.2 through 7.4.4 concern the production of ethanol as a substitute fuel, an alternative diesel fuel, and processing of coal to fuels. The last mentioned alternative is most expensive but would yield a range of inputs to the chemical industry.

Three of the recommendations (given below as 7.4.2, 7.4.3, and 7.4.4) would require the collaboration of agronomists, biochemists, and chemists. Also, they would involve links tying together agriculture, manufacturing, energy, transport & communications, building & construction, trading & services, banking and finances.

7.4.1 Diversity of liquid fuels sources

In view of the one single source of oil for Zambia, the problems to be dealt with include:

- problems of rehabilitation of the standing pipeline (Tazama pipeline);
- search of alternative sources of crude oil including a preliminary assessment of the feasibility of transport to Zambia, e.g., from Angola.

7.4.2 Fermentation of agricultural and lignocellulosic feedstocks to produce ethanol

Ethanol is produced from the fermentation of simple sugars by micro-organisms, principally yeasts. Almost any form of biomass containing carbo hydrates can be utilized for ethanol production but the scale of fuel markets limits the choice to sugar crops such as beet or cane; starch crops such as cereal grains; and lignocellulose, the principal constituent of wood, grasses and cereal straws. The actual process of ethanol fermentation is the same regardless of the source of fermentable sugars. Given the high cost of agricultural feedstocks for ethanol production, attention has more recently turned to lignocellulose which appears to have greater long term potential in terms of both costs and availability.

Raw materials for fuel ethanol production may be ranked on the basis of the following attributes:

- low cost of fermentable material made possible by high yields and low requirements for agricultural inputs;
- year round availability via length of harvesting season and/or low costs of storage;
- low waste treatment costs ideally with co-products valuable for sale or as process fuel.

Sugar cane is the dominant feedstock for ethanol production worldwide - for the large scale program in Brazil as well as a number of smaller scale endeavors elsewhere in South America, Central America and Africa.

7.4.3 Vegetable oils as diesel extenders/substitutes

Interest in the use of vegetable oils as fuels for diesel engines has a history almost as long as the diesel engine itself.

A superficial comparison can be made of some of the more important fuel properties of vegetable oils against conventional diesel oil as follows:

- density of vegetable oils is around 10 per cent higher;

- viscosity is much higher by a factor 10 - 20;
- the high viscosity of vegetable oils can give rise to poor fuel atomization with a consequent increase in smoke and some gaseous emissions;
- cetane number comparable with low cetane diesel oil;
- cold flow properties are variable but generally poorer than diesel oil;
- volumetric calorific value is lower by about 5 per cent.

These shortcomings can be overcome either by blending vegetable oils with diesel oil or by chemical conversion of vegetable oil to esters. Blending makes more sense in economic terms provided diesel oil is available. Most vegetable oils are completely miscible with hydrocarbon diesel fuels and blending is the simplest way to minimize property differences, particularly the viscosity.

7.4.4 Production of synthetic ethanol from coal

The production of ethanol from coal involves the following major processing steps:

- heating of coal in absence of oxygen (carbonization) yielding coke and raw gas (using e.g., coal from Maamba Collieries);
- raw gas purification (yielding ammonia, sulfur compounds, nitrogen compounds, tar);
- catalytic conversion of carbon monoxide to carbon dioxide (using water vapor);
- catalytic synthesis of ethylene;
- purification of ethylene-rich gas;
- catalytic hydration of ethylene to ethanol;
- treatment of the synthetic ethanol to liquid fuel.

In addition to ethanol, other important products are obtained: coke, ammonia, sulfur, nitrogen compounds, and tar (all of them are feedstocks for the chemical industry, metallurgy, and power engineering).

7.5 Waste recovery from transport conveyances (in detail)

Chapter 3.5 indicated three possibilities of reusing wastes obtained from vehicles -- during vehicle operation and also when scrapping the vehicle. The problems 7.5.1 through 7.5.3 give details.

All three recommendations as given in Chapter 7.5 require the cooperation of chemists/technologists with mechanical engineers.

7.5.1 Collection and recovery of spent engine oils

It is damaging to economy and ecology if spent motor oil are not regenerated. It is recommended that a system of collection of spent oils and their regeneration be worked out.

To have a properly operating system, there must be motivation, e.g., through

- setting a price on spent motor oils;
- allowing for a discount when replacing oil at workshop.

7.5.2 Collection, innovation and scrapping of worn-out tires

Tires used only once are an economic loss. Retreading is necessary. This is done at CTS, see Chapter 2.6. However, for a tire to lend itself to retreading, drivers and operators must display a certain discipline. Damaged tires cannot (should not!) be retreaded. New tires must be used before the old tires wear off completely. This again requires a stock of tires.

Tires once retreaded are no longer acceptable for retreading in most countries, because of the fatigue of the steel reinforcement. Such tires are difficult to dispose of.

Special technologies exist where crushed tire rubber is added to solid fuels and burnt at high temperatures, to minimize damage to the environment, or where finely crushed rubber is added as fillers to various industrial mixes (putties, rubber pre-forms before curing, etc.).

CTS will retread tires up to three times! Relugging is also done. Tires no longer considered acceptable are disposed of as follows at the CTS: the rubber is added to the mix used for rubber shoe soles.

The recommendation is to avoid the practice of multiple retreading, on safety grounds; to study the disposal problem; and to look for new ideas on how to reuse the rubber.

7.5.3 Scrapping of old vehicles

In industrial countries, scrapping is done by crushing and automatic classification, to separate iron, aluminum, copper, plastic, glass, and textiles. Hydraulic processes are used at an advantage. Magnetic separation is another classical technique. Hand screening is possible.

Under Zambian conditions, the recommendation is to dismantle the vehicle and first to salvage whatever can be regarded as spare parts. The remaining waste can then be sorted manually, and return to the manufacturing cycle.

Old rails are another type of scrap, providing high-quality input of iron material.

8.0 RESEARCH AND DEVELOPMENT PRIORITIES

It is very difficult to set priorities in the transport and systems sector. The problem is that a whole range of factors intervene, such as project funding and project design involving the solution of interdisciplinary issues.

However, out of all priorities the one which must be given highest priority is the rehabilitation of Tazama Pipeline, seeing how crucial this single source of oil is to Zambian economy.

Other two problems ranking high on the list include

- stepwise rehabilitation and innovation of trunk railroads; and
- stepwise, continuous rehabilitation, maintenance, and innovation of the road network.

This goes beyond the scope of ZIMCO/INDECO but of course, ZIMCO/INDECO should be involved.

The priorities in the sphere of computing and systems include

- hardware and software for the RDU (cf. 6.5.1);
- software for the applications described under 7.1;
- training of RDU staff.

The computer facility as recommended in this Technical Report should in fact be very much a turnkey delivery assisted by UNIDO. RDU would mainly be involved in training and in implementation and possibly development/modification of the application software. This is how cases like this one are commonly handled worldwide in the sphere of computer technology.

9.0 RECOMMENDATIONS IN THE TRANSPORT AND SYSTEMS SECTOR

The recommendations given below are based on a previous analysis of the situation in the transport and systems sector:

(R1) It is recommended that ZIMCO/INDECO takes organizational steps to assure the closest possible cooperation between the standing EEU and the new RDU, their activities being complementary.

(R2) It is recommended that the RDU be equipped with computing facilities (hardware & software) as per specification by the UNIDO mission. This can be financed by UNDP if the follow-up project is approved (cf. Chapter 6.5.1).

(R3) Software for the RDU, i.e., the data bases proposed (DBW, DBP, DBRPIW, DBL), the corporate modeling package, possibly also the FORECASTER strategic planning package badly needed to complement the EEU's (and, therefore, also the RDU's) project evaluation capability, as well as utility programs for data analysis and the base lists defined in the Technical Report is to be acquired or generated ahead of the main mission of the up-scaling project. Only the training of RDU staff and possibly some debugging should be done at the RDU. Data base population should then be taken care of by RDU in cooperation with UNIDO specialists (cf. Chapters 7.1.1, 7.1.2, 7.1.3 and 7.1.4).

(R4) One of the early tasks of the RDU should be to assist the optimization of the transport problem when hauling in the harvest to the processing plants. This could be done in cooperation with growers on a step-by-step basis. It can be assumed that the results of this analysis would bring about an increased capacity utilization of the growers' conveyances during harvest time (cf. Chapter 7.1.5).

(R5) The RDU should become involved with Lusaka municipal transport projects and should provide data for the city council. The general municipal transport project should be reopened in cooperation with UBZ, the city, and pertinent GRZ Ministries. The problem should be broken down into accountable stages.

(R6) RDU ought to take part in studies concerning construction, innovation, rehabilitation, and maintenance of transport routes (cf. Chapter 7.2).

(R7) RDU should be among the coordinating bodies for construction, innovation, rehabilitation, and maintenance of transport vehicles (cf. Chapter 7.3).

(R8) RDU together with EEU, should engage in techno-economic and pre-feasibility studies concerning

- further rehabilitation of Tazama pipeline;
- seeking alternative sources of oil and access to oil by pipeline transport, up to Indeni refinery.

Such studies should be participated in by Tazama Pipelines Ltd., Indeni Petroleum Refinery Co. Ltd., NCDP, and the Ministries (cf. Chapter 7.4.1).

(R9) RDU together with EEU, should launch a study into substitute liquid fuels for the transport sector, in cooperation with NCSR, NCDP, and pertinent Ministries on the basis of a thorough study of literature sources (cf. Chapters 7.4.2, 7.4.3 and 7.4.4).

(R10) RDU should work out and present proposals concerning the recovery of wastes and rejects (scrap) from transport vehicles (cf. Chapter 7.5).

(R11) There should be a passenger car available for the RDU, in view of the persistent transport problems of the country and the need of extensive travel in liaising the subsidiaries (cf. Chapter 6.5.2).

10.0 Project implementation up-scaling

This Chapter focuses on the schedule and content of implementation of the RDU's intended computer facility. The job required involves four months' work by UNIDO's Transport & systems specialist in his home country, plus one month on site in Zambia. Turnkey delivery of both hardware & software for the RDU.

The recommended work plan is as follows:

Stage 1
Finalize the purchase of the computer (cf. 6.5.1). Break down delivery into two parts:

- part 1: the core of the system microVAX 3100 (CPU, hard disks, floppy disk, streamer, 2 terminals, printer, software for microVAX) and 1 pc IBM PC/286 (or compatible) incl. hardware & software for IBM PC to be supplied to the home base of UNIDO's Transport & systems specialist, for him to develop and test the software proposed for the RDU.

- part 2: the remainder of the installation, cf. 6.5.1, to be delivered to the RDU directly.

Stage 2
Debugging of software to be followed by presentation of the facility, and introductory training of two RDU specialists, most probably the RDU Head and the Transport & systems specialist, in the UNIDO expert's country (2 weeks).

Stage 3
Field mission by the Transport & systems expert to the RDU, incorporating

- commissioning of the facility
- further training of the RDU staff
- work on the software
- methodology of data logging to populate the data bases
- final hand-over of hardware & software to the RDU.

ANNEX T-1

ZIMCO subsidiaries and associate companies involved in the transport sector

Company	Sector	Principal products/services
Africa Bound Ltd.		travel services
Agip (Zambia) Ltd.	C	gasoline & petroleum products (retail)
Auto Care Ltd.		automobile care
BP (Zambia) Ltd.	C	gasoline & petroleum products (retail)
Circuit Safaris Ltd.		travel services
Consolidated Tyre Services Ltd.	A,C	tire retreading
Contract Haulage Ltd.		transport of cargo
Dunlop Zambia Ltd.		tires
Eagle Travel Ltd.		travel services
Engineering Services Corp. Ltd. (ESCO; former MSD)		engrg. & transport services
Industrial Development Corp. Ltd.	A,C,F	mixed
Livingstone Motor Assemblers Ltd.		motor vehicles
Luangwa Industries Ltd.		bicycles, motorcycles & three-wheelers
Lusaka Engineering Co. Ltd.	A	metal products (window & door frames, bus bodies, nails & bolts, furniture, agricultural implements)
Mpulungu Harbour Corp. Ltd.		transport of cargo
National Air Charters Zambia Ltd.		air transport of cargo
National Airports Corp. Ltd.		air transport services
National Import and Export Corp. Ltd.	F	international trading
Roan Air Services Ltd. (formerly Mines Air Services)		air transport
Tazama Pipelines Ltd.	C	transport of crude petroleum

United Bus Co. of Zambia Ltd.		passenger transport
ZAL Holdings Ltd.		travel, transport &
(Zambia Appointments Ltd.)		technical services (lifts, laundry, ...)
Zambia Airways Corp. Ltd.		air transport
Zambia Concrete Ltd.		railway slippers
Zambia National Shipping Co. Ltd.		transport
Zambia Railways Ltd.		railroad transport
Zamcargo Ltd.		transport of cargo
Zimco Institute of Management	A,C,F	training
ZIMOIL	C	import of crude

Note: A = agronomy sub-sector
C = chemical technology sub-sector
F = food technology sub-sector

ANNEX T-2

Job description for the Transport & systems sector specialist

Post title: Transport & systems sector specialist

Qualifications: Mechanical Engineer (university graduate). Experience in transport problems, systems analysis, application of computers and/or transport research is desirable.

Duties:

- To participate, under the general direction of the RDU Head and in close cooperation with the other staff members, in the startup and routine work of the RDU.
- To closely monitor all RDI activities in the transport & systems sector.
- To assist the RDU Head in the execution of liaising & coordinating activities.

The specialist will be expected to perform the following activities:

- review the results of the "ZIMCO Technology Audit" in given professional area
- introduce a methodical approach to evaluation of existing and future transport requirements in the country
- relevant input data are to be extracted from the ongoing technology audit activity carried out by the RDU's team
- generate and update a list of all inputs, outputs (incl. wastes) of all subsidiaries and associate companies within the transport & systems analysis sector
- generate and update a list of all transport problems in all other sectors, mainly in agronomy, food processing, and the chemical industry sub-sector
- convert above list to data banks input formats

- assist companies in accelerating existing R & D projects
- identify RDI problems to be analyzed and potential new RDI projects to be launched
- make efforts to initiate the utilization of wastes from the transport conveyances and look for economical, effective, and environmentally harmless waste disposal methods
- advise companies on transport problems
- take an active part in the dissemination of information on transport R & D problems
- write a list of R & D contact persons at the companies who can maintain links in the area of R & D to other sectors
- mediate company-to-company links in transport and/or systems analysis problems
- establish a system of information in RDU on computer data banks
- advise RDU Head on participation by professionals from his sector in the work of ad hoc teams on cross-sectoral or multi-sectoral RDI projects
- provide help to subsidiaries in their efforts to establish, expand, or re-orient their R & D departments
- establish and maintain linkage between NCSR, UNZA, Copperbelt University, and the RDU in the area of transport and systems analysis
- look for natural species which can be used for the solution of transport problems
- advise on the rehabilitation of existing transport systems and suggest alternative efficient systems for study with regard to their potential in Zambian long-distance and local transport
- advise on development of disciplines related to the general distribution problem and passenger transport, e.g. packaging, storage, information handling, freight manipulation, maintenance planning, and traffic control

- train companies' RDI staff in methods of effective work with professional transport literature and in literature to related branches.

ANNEX T-3

Reconstruction and Rehabilitation of Steel Pipelines Technical and Economic Opportunities

A number of long-distance pipelines in the world are presently operated at the limit of their effective service life. At a time when the investment costs of laying new pipelines are soaring while the available resources are dwindling, it becomes ever more important to deal with the issue of how to ascertain the residual technical service life as accurately as possible. If this is done properly, it not only allows to avoid emergencies but also affords an opportunity to actually improve the technical condition of the standing pipeline thus extending its residual life and postponing investment in a new pipeline.

The cardinal issue is to what extent the continued operation of worn pipelines is justified and safe. Some of the accidents already witnessed with such old pipelines involved little physical injury and loss of life but entailed substantial losses due to cuts in deliveries to customers and a blemish on the repute of the pipeline operators.

This problem can best be tackled by a specialized oil/gas pipeline designers company intimately involved in issues of residual service life as well as of operational and technical safety of pipelines, with R & D as well as practical experience are being applied with in the area of advanced systems of international high-pressure, long-distance gas and oil pipelines.

The commercial applications include testing, technical assessment, and the so-called small scale rehabilitation (not including a general overhaul of the insulation system) but also a special stress test which not only checks the integrity of the pipeline but also ameliorates its technical condition. This is done so that the wall of the pipeline is loaded by stressing it to the yield point range. This generates plastic zones at subcritical crack roots within the metal whereby the propagation of such cracks is temporarily halted. Pipe surface damaged by corrosion is also favorably affected by the stress test. What happens is that supercritical cracks open up during the test under controlled condition, thereby avoiding accidents. The stress test conditions are established on the basis of in-depth analysis of material and layout.

The rehabilitation activities which offer themselves for potential implementation on the Tazama as well as on other

existing or planned pipelines include

(i) assessment of the present condition of pipeline sections with suspected service life exhaustion
(ii) rehabilitation of pipeline and repair/overhaul of defective locations
(iii) upgrading pipeline throughput and extending its useful service life by 15-20 years

Pipeline assessment includes
- verification of the present hydraulic parameters of the pipeline
- comprehensive evaluation of corrosion damage (incl. the effectiveness of active and passive protection), plus detection/identification of points of serious corrosion attack
- assessment of the effect of prolonged operation on the mechanical and fracture characteristics of the steel used under conditions of static loading and low-cycle fatigue
- proposal of pipeline rehabilitation technology.

Pipeline rehabilitation includes
- hydraulic stress test of the pipeline aimed at
  - defect detection and repair
  - blocking the propagation of subcritical cracks in the wall of the piping for safe operation
- repair of defective insulation, and reconstruction of active protection system if required.

Extension of useful service life of the pipeline is documented by
- the upgraded hydraulic parameters of the rehabilitated pipeline
- a technical report defining the extended service life
- a data bank oriented toward operational monitoring of the rehabilitated pipeline.

All above activities require the support and cooperation of the respective Departments of the pipeline operator.

Price of the pipeline assessment/rehabilitation/upgrading package is determined by individual calculation taking into account the individual operations involved. As a rule, the sum total is less than 30 per cent of the cost of a new pipeline.