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I. T. Transport Ltd

Consulting Engineers

STUDY OF THE POTENTIAL FOR A LOW COST VEHICLES ASSEMBLY/ MANUFACTURING PLANT IN ETHIOPIA

Report of the consultant on low cost vehicle manufacturing technology.

VOLUME 1 MAIN REPORT

by
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for
Industrial Projects Service
of the Ministry of Industry,
Government of Socialist Ethiopia,
on behalf of
Feasibility Study Section
United Nations Industrial Development Organisation.

January 1986

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CONTENTS

Volume 2 - Annexes

1. SUMMARY

1. This report presents the findings of a consultancy input to a feasibility study being carried out by the Industrial Projects Service on behalf of the National Metal Works Corporation of the Government of Socialist Ethiopia. The study is of the feasibility of establishing a plant to manufacture low cost vehicles. Low cost vehicles are currently used to only a limited extent in Ethiopia, but are perceived as being appropriate to conditions in the country and as having significant potential to improve rural and urban transport facilities and promote economic and social development. The proposed plant is therefore intended both to create, and respond to, demand for low cost vehicles.

2. Because the project is concerned with creation of demand, precise market data is not available. However, demand estimates have been made based on available supply data, information on rural and urban transport requirements, physical and economic conditions in Ethiopia, and comparisons with vehicle usage in other developing countries. Based on these estimates a plant is proposed with a capacity to produce 12,500 bicycles, 5,000 motor cycles, 4,000 animal carts, 1,000 bicycle trailers, and 1,250 load carrying motor cycle attachments per annum. It is unusual to manufacture such a range of vehicles in a single plant, but it has advantages in the Ethiopian situation in creating demand for low cost vehicles, in making efficient use of production facilities at the output levels proposed, and in providing flexibility to meet changing demands. This flexibility is considered important, as is provision for longer term expansion of the plant to increase both the range and quantity of vehicles produced as the market develops. It is also recommended that the production of Basic Transport Vehicles, in a separate plant, be investigated further.

3. The standard heavy-duty roadster bicycle, of the type common in developing countries, is identified as being most appropriate to Ethiopia. Manufacture of this bicycle will require technical collaboration with an overseas source of technology. The most suitable collaborators, in terms of product design, production technology and cost, are Indian and Chinese manufacturers. At the proposed level of output, about 50% by value of the bicycle components can be produced locally, the remainder being imported. Motor cycle production will focus initially on 125 cc models - a trail bike for rural and off-road use, and a general purpose motor cycle for urban and on-road use, and for load-carrying adaptations. A collaboration agreement with an overseas manufacturer, most probably Japanese, will be required. Initially only about 11% by value of components will be produced locally, but

this can increase subsequently as the market grows, and the automotive components industry in Ethiopia develops.

4. It is proposed that the plant should concentrate on the manufacture of a range of wheel/axle assemblies for animal carts. These will be distributed to small-scale industries in different parts of the country to build into complete carts. Both pneumatic-tyred and steel-wheeled models will be produced, the former using a tyre developed specifically for animal-drawn carts. Two-wheeled trailers are identified as the most suitable cargo-carrying adaptation of the bicycle. The demand for low cost motorised load-carrying vehicles is best met, in the early years, by the supply of attachments to standard motor cycles. Two attachments are proposed, a sidecar and a pick-up/van, based on the extensive and effective use of these devices in the Philippines to provide rural and urban goods and passenger carrying services. The cart wheel/axle assemblies, the trailer and the motor cycle attachments can be produced with a high local content, and do not require collaboration with an overseas source of technology, except for the production of cart tyres. However, short-term technical assistance will be required to establish production.

5. In order to make the range of vehicles available quickly, and so meet the national economic objectives of the project, the development of production will be phased as follows:

Year 1	- assembly of bicycles and motor cycles from imported SKD kits;
Year 2	- production of carts, trailers and motor cycle attachments;
Years 3 and 4	- local production of bicycle and motor cycle components.

6. The proposed plant will have manufacturing facilities for pressforming, tube manipulation, machining and fabrication of steel raw materials, for painting and plating, and for upholstery work, which will be used to produce components for the different vehicles. It will also have facilities for brazing of bicycle frames and forks, for the welding of motor cycle frames and for the final assembly of all products.

7. The plant will consume about 510 tonnes of steel per annum, of which 360 tonnes of tube and sheet will be supplied by an Ethiopian manufacturer. The total cost of raw materials, components and process materials used per annum is 11.5 million Birr, of which 6.7 million Birr is imported. The plant will use the services of existing Ethiopian industries for the supply of bicycle, animal cart, and subsequently motor cycle, tyres and tubes, for the manufacture of plastic-

moulded, forged and cast components, for body building and heat treatment, and for the supply of packaging materials.

8. The plant will require an investment of about 3.15 million Birr in production equipment and tooling, storage and material handling facilities. Much of the equipment is standard manufacturing machinery which can be purchased on the world market. Special-purpose machinery and tooling for bicycle and motor cycle production will be supplied through the overseas collaborators. Some tooling, and many of the storage and material handling items, can be supplied from within Ethiopia.

9. The plant will require a building of 3,850 m^2, of which 1,200 m^2 is for manufacturing, 2,350 m^2 for storage and 300 m^2 for offices. It is recommended that the plant be located in the corridor connecting Addis Ababa and Nazareth to provide good access for inputs, and efficient distribution of products to different parts of the country.

10. The plant will employ 122 production and ancillary workers and supervisors, and 4 technical management staff, at a cost of 425,000 Birr per annum. This does not include non-technical staff and management requirements. An amount of 700,000 Birr is allocated to overseas training of senior technical staff, in-plant training and technical assistance provided by the overseas collaborators, and technical assistance to establish production of carts, trailers and motor cycle attachments.

11. Based on the technical analysis, preliminary estimates have been made of the prices of vehicles produced by the plant. These show that, including allowances for import duties and taxes, bicycles and motor cycles can be made available at substantially lower prices than current imports, and that the other products can be supplied at price levels expected to generate the predicted demand.

2. INTRODUCTION

2.1 Background to the Study

By contract Reference No. 85/51/HQ I.T. Transport Ltd. was commissioned by UNIDO to provide the services of a consultant on low cost vehicles, Mr. I. Barwell, to assist the Ethiopian Industrial Projects Service (IPS) in preparing a study of the potential of a low cost vehicles assembly plant in Ethiopia.

IPS is a consultancy house established under the Ministry of Industry of the Government of Socialist Ethiopia to carry out industrial project studies. IPS has been commissioned by the National Metal Works Corporation to carry out a study of the feasibility of establishing a plant for the assembly and manufacture of low cost vehicles. The range of low cost vehicles identified for inclusion in the study were:

- animal-drawn carts and carriages;
- bicycles and tricycles;
- motor cycles and motor scooters;
- motor cycles and sidecars;
- three wheeled vehicles and vans.

This range of vehicles was envisaged as being suitable for transporting people and products in urban and rural areas. The study was perceived by the Ministry of Industry, of which the National Metal Works Corporation is a part, in the context of creating a demand for vehicles which are either unknown, or used only to a limited extent in Ethiopia at present (bicycles and motor cycles are imported in limited quantities, and horse-drawn carriages are used to provide passenger transport services in some urban areas). Low cost vehicles are perceived as being appropriate means to make a significant contribution to improving transport facilities in Ethiopia, a country which has low income levels, a limited road network, and scarce foreign exchange resources to import conventional motor vehicles and petroleum fuel.

Only limited work on the subject has been undertaken in Ethiopia prior to the feasibility study, although a study on bicycle production was carried out by a consultant in 1982 but was considered unsatisfactory for implementation. The Chinese have recently made an outline proposal for the establishment of a bicycle assembly plant. IPS commenced work on the feasibility study in July 1985 and the final report is due to be submitted to the National Metal Works Corporation in March 1986.

2.2 Consultant's Terms of Reference

Detailed Terms of Reference for the consultant's assignment are presented in Annex 1. The consultant's visit to Ethiopia was made in the early stages of the study and essentially his role was to make inputs into technical aspects of the study. In summary, the consultant's tasks were as follows:

Market and Capacity Study

i) based on projected demand levels, identify the types of low cost vehicle appropriate for Ethiopia, and the economic scale of production or assembly that would be justified;

ii) select the suitable technology for the type and scale of production envisaged;

iii) assess the possibility of fabricating some of the components for low cost vehicles in existing industries, and indicate the costs involved;

Materials and Inputs

iv) evaluate the use of locally available materials and processing technology to develop locally manufactured content;

v) select the appropriate materials and processing technology to develop locally manufactured content;

vi) estimate the annual cost and requirement of components, materials and inputs, prepare a chart showing the flow and balance of these items, and determine the types and sizes of facilities required for handling and storing them;

Location and Site

vii) identify and evaluate alternative options for the most appropriate location and site;

Technology

viii) survey the evolutionary development of low cost vehicle manufacturing technologies, drawing on experience of other developing countries;

ix) identify and define the stages in developing local manufacture, set criteria for gradual localisation of component supplies, select the appropriate technology for such growth, and indicate alternative commercially available sources of such technology that would enhance this process;

x) describe the assembly process at initial and subsequent stages by type of low cost vehicle;

xi) draw up guidelines for designing a plant and process layout;

xii) work out quality requirements, standards and specifications for each type of low cost vehicle and design adequate quality control systems and procedures;

Manpower

xiii) determine the total direct and indirect manpower requirements by function;

xiv) recommend the type, number and duration of expatriate assistance required for the transfer of technology and know-how;

xv) specify suitable training programmes for the production personnel.

In order to carry out the assignment, Mr. Barwell visited Ethiopia from 20th August to 4th October 1985. A list of persons met is attached as Annex 2.

2.3 Approach to the work

The approach to the work in Ethiopia was conditioned by three factors;

i) the subject of low cost vehicles is new to Ethiopia;

ii) the input was made in the early stages of the feasibility study;

iii) although IPS had prepared in advance a review of relevant market data (population, road network, vehicle stock, urban transport in Addis Ababa, rural crop production and access to markets), no detailed projections of demand for low cost vehicles were available.

It was considered important to improve the familiarity with, and understanding of, low cost vehicles and the range of means of transport encompassed by the term, among the IPS project team. A slide presentation was therefore given to the project team early in the visit, and subsequently repeated for the Vice-Minister of Industry[1]. A list of general references that provide background information on low cost vehicles relevant to the study was prepared, and IPS have now obtained most of these. (These references are detailed in Annex 3, which also lists references specific to Ethiopia used in the work). A briefing note was prepared at the start of the visit summarising the whole range of low cost vehicle options and their transport characteristics, to provide a framework for the more detailed investigations during the study. This note is attached as Annex 4.

1. A copy set of the slides has been forwarded to IPS.

For this study, which is concerned with the creation of demand for products new to Ethiopia, the realistic estimation of demand is more difficult than for an import substitution project, or for one concerned with the processing of local raw materials for export. However it was considered essential to devote some time and effort to making demand estimates, based on assessment of the types of low cost vehicles most immediately relevant to Ethiopia. These were necessary in order to define the most appropriate design and production technologies, to determine the level of local content that can be achieved, and to define the characteristics of a plant for the production of low cost vehicles. One source of information used in making the demand estimates was comparative data on the use of low cost vehicles in other developing countries of Africa and Asia. However, it is important to recognise that the demand estimates presented in this report involve a number of assumptions, and it is desirable that the IPS project team put some effort into refining these estimates during the remainder of the study. It is also important to understand that, because low cost vehicles are to a large extent new to Ethiopia, demand will develop over a period of time, particularly if supported by policy measures to encourage such means of transport. Account has therefore been taken of the need to provide flexibility for the plant to expand output, to increase the range of vehicles produced, and to vary the mix of products.

Having prepared preliminary demand estimates, the major part of the consultant's time in Ethiopia was devoted to analysis of the various technical aspects of vehicle design and manufacture. Because of the need to focus on the demand issue, and the importance of making the maximum input on technical aspects, it was agreed with the IPS project leader that the subject of plant location and site should be covered in less depth than envisaged in the consultant's Terms of Reference. It was agreed that the consultant should define the key considerations, but that final recommendations on choice of location and site will be made by the IPS project team.

The draft report was submitted to UNIDO in Vienna and IPS in Addis Ababa at the beginning of November 1985. This final version of the report, which incorporates a number of minor modifications and corrections to the text, has been prepared following acceptance of the draft report by UNIDO.

2.4 Structure of the Report

The main body of the report is divided into five Chapters (3-7) while the more detailed technical and production data is presented in a series of Annexes. Since this report represents one input into the feasibility study, with the main focus on technical aspects, it is not appropriate to use the standard UNIDO report format for such studies. However elements of this format have been used wherever feasible to facilitate the preparation by IPS the final report.

Chapter 3 reviews the present transport situation in Ethiopia and discusses the role of low cost vehicles in improving transport facilities. It identifies the low cost vehicles most relevant to Ethiopia and presents a preliminary estimate of the demand for such vehicles. It discusses the issue of the capacity of the plant and defines the output figures used in the detailed engineering analysis. It also summarises the marketing and policy measures that might be applied to maximise the demand for low cost vehicles.

Chapter 4 discusses the various design options for the low cost vehicles defined as being most relevant to Ethiopia, identifies the most appropriate designs, and summarises the evolution of these technologies in other countries. It reviews the alternative production technologies for the vehicles, identifies those most suitable for Ethiopia, and discusses the sources and mechanisms for technology transfer. The last section indicates guidelines for developing the locally manufactured content.

Chapter 5 presents, with the aid of technical annexes, the detailed production engineering analysis of the vehicles. It starts with a review of the present capability of relevant industries in Ethiopia, of local and imported sources of materials, and of labour costs. It then details the proposed manufacturing methods for the vehicles, giving information on equipment, tooling, materials and labour requirements.

Chapter 6 draws together the information from the analysis in Chapter 5 to present a review of the proposed low cost vehicles industry. It summarises the role of the proposed plant and ancillary industries, and discusses the options for phasing the introduction of vehicle assembly and the local manufacture of components. It presents an analysis of the physical facilities, plant and equipment, materials and inputs, quality control procedures, staffing, training and technical assistance required. Finally it presents a preliminary financial analysis of the proposed plant.

Chapter 7 presents recommendations on various issues that require further attention by the IPS project team during the remainder of the feasibility study.

2.5 Note on Units

All costs have been expressed in Ethiopian Birr. However, it has been necessary to convert a number of costs and prices from foreign currencies and the following exchange rates, prevailing at the time of the visit, have been used:

2.07 Birr = 1 US Dollar
2.8 Birr = 1 Pound Sterling
0.73 Birr = 1 German Deutschmark

All dates are expressed according to the international calendar rather than the Ethiopian calendar (E.C.).

3. MARKET DEMAND AND PLANT CAPACITY

3.1 Background

This Chapter presents an estimate of the demand in Ethiopia for the various types of low cost vehicle under consideration in the feasibility study. A realistic estimate of demand is the necessary starting point for defining:

i) the types of low cost vehicle which are most appropriate for Ethiopia;

ii) the technologies for their assembly and manufacture;

iii) a viable industrial project.

The figures presented here are initial working estimates of demand, involving a number of assumptions, used as the basis for the detailed analysis of vehicle options and technologies. It is desirable that further, more detailed demand analysis be carried out during the course of the feasibility study to refine these estimates.

It is useful to review the reasons for examining the feasibility of a low cost vehicles plant. The present availability of transport facilities in Ethiopia is limited, in terms both of the extent of the road network and the number of motor vehicles. The shortage of foreign exchange means that the import of motor vehicles, and petroleum fuels for their operation, is restricted. Import of private motor vehicles is currently severely restricted, and fuel is rationed. Given the experience of other developing countries in Asia and Africa in the use of low cost motorised, animal drawn and pedalled vehicles, it is considered that the development of the use of such vehicles could offer national economic benefits in Ethiopia by:

i) improving the transport facilities available in the country and hence assisting agriculture, service and other industries while limiting the foreign exchange cost of such facilities. In particular, low cost vehicles can:

* provide means of personal goods and passenger transport which, because of their low capital cost are available to a greater number of people than conventional vehicles;

* be used to provide transport services in urban and rural areas for the movement of people and goods;

* because of the ability of certain types of vehicle to operate on low quality roads and tracks, provide a means of improving transport facilities for rural farmers despite the limitations of the rural road network;

ii) providing the basis for an economically viable industrial project.

It should be noted that, to the extent to which the efficient use of low cost vehicles can be encouraged as a substitute for more expensive conventional motor vehicles, there is a direct benefit in foreign exchange cost of vehicles and fuel. However, another role of low cost vehicles will be to complement the services that can realistically be provided by conventional motor vehicles, and therefore, to improve the overall facilities available for the transport of people and goods.

It is important to understand that, since most of the low cost vehicle options considered are at present unknown, or used only to a limited extent, in Ethiopia, precise estimates of demand are difficult. One would expect the demand for low cost vehicles to evolve and develop as they become more easily available, as people become more aware of their potential, and as measures to encourage their use are applied. However, it is necessary to identify those particular types of low cost vehicle which provide the most appropriate basis for a local industry, and to make realistic estimates of demand, in order to prepare a viable industrial project.

3.2 The Transport Situation in Ethiopia

Table 3.1 presents data on road and motor vehicle densities for selected developing countries in Africa and Asia. One must be careful in drawing comparisons between different countries because definitions of what constitutes a road vary, population estimates are often approximate, and registration categories differ from country to country. However, the figures illustrate the limited transport facilities available in Ethiopia at present. The road network consists of about 17,000 km of all weather routes and 23,000 km of dry weather routes. This is low in relation to population and land area. However, it is comparable with Egypt which is of similar population and land size, but has significantly higher per capita GNP. The vehicle population is also very low, with a total of about 60,000 vehicles in a country of 40 million people. However, the table does not include some countries, for example China and Laos, where conventional motor vehicle densities are low, but for which precise figures are not available. These countries make extensive use of low cost vehicles, including motor cycles. Table 3.2 presents data on vehicle registrations for the period 1971/72 to 1983/84. This gives a breakdown by category of the stock of motor vehicles, and illustrates that its growth has been fairly slow (about 20% in the last five years). For several years there have been no imports of private motor vehicles which involve the flow of foreign exchange out of the country. Since early 1985 imports of private motor vehicles have been banned, and government imports are restricted by availability of foreign exchange. Restrictions on fuel use have been tightened with nationwide rationing for private and business use. Restriction on government fuel use is imposed by control of vehicle usage. In these circumstances, rapid growth of the vehicle stock is unlikely in the short term.

TABLE 3.1: COMPARATIVE TRANSPORTATION DATA FOR DEVELOPING COUNTRIES IN AFRICA AND ASIA

	Population (Million)	GDP/ Capita US $	Population Density Per sq/km	Road Network '000 km	Motor Vehicles '000	Motor Cycles '000	Road Density km/sq km	Vehicle Density Per '000 Population	Motor Cycle Density Per '000 Population
Ethiopia	40.8	125	33.4	37.50	58.28	1.29	0.03	1.43	0.03
C.A.R.	2.2	796	4.0	22.56	125.53	80.35	0.04	57.06	36.52
Cameroon	8.4	851	18.0	63.78	118.50	43.00	0.13	14.11	5.12
Egypt	42.0	464	42.0	30.09	878.70	177.30	0.03	20.92	4.22
Kenya	16.4	426	28.0	64.58	171.07	16.78	0.11	10.43	1.02
Mauritius	1.0	1002	535.0	1.79	71.45	27.44	0.96	71.45	27.44
Morocco	20.3	876	45.0	57.53	730.67	18.46	0.13	35.99	0.91
Nigeria	77.1	1392	83.0	107.99	633.27	287.12	0.12	8.21	3.72
Tanzania	17.9	275	19.0	53.61	105.68	25.00	0.06	5.90	1.40
Zimbabwe	7.4	744	19.0	170.40	286.70	19.94	0.44	36.31	2.69
India	693.9	230	211.0	1604.10	3551.30	1678.10	0.49	5.12	2.42
Indonesia	151.9	460	80.0	154.34	5879.75	4135.68	0.09	38.71	27.23
Korea	38.0	1534	386.0	54.60	1313.94	528.80	0.55	34.58	13.92
Pakistan	82.4	339	103.0	94.99	605.95	325.61	0.21	7.35	3.95
Philippines	51.0	696	170.0	154.42	990.74	186.99	0.51	19.43	3.67
Thailand	47.7	702	93.0	72.15	2127.44	1140.70	0.14	44.60	23.91

TABLE 3.2: MOTOR VEHICLE REGISTRATIONS IN ETHIOPIA 1971/72 - 1983/84

	Motor Cycles	Private Cars	Taxis	Govt.	Aid and UN Agencies	Small Buses	Small Trucks	Large Buses Trucks Trailers Etc.	Total
1971/72	954	26158	1572	3435	768	1123	2165	5543	41718
1972/73	1020	29165	2027	4337	1078	1261	2465	6122	47475
1973/74	1083	30577	1973	4554	1221	1248	2666	7038	50360
1974/75	982	33014	1721	4616	1462	961	2415	6971	52142
1975/76	546	34012	2004	5470	1750	974	1957	7569	54282
1976/77	599	29728	1988	5668	1206	1048	2026	5161	47424
1977/78	300	29410	1404	5923	1148	786	2630	3686	45287
1978/79	325	26697	3091	6701	1052	2031	4247	6720	50864
1979/80	336	29560	2715	8224	1119	1588	4412	7873	55827
1980/81	650	28459	2883	8668	1217	2146	3863	7412	55298
1981/82	1349	28537	3302	8762	1825	1782	3660	7675	56892
1982/83	1291	27279	3260	11602	2566	3591	3480	7256	60325
1983/84	1292	27047	3410	12945	2745	3136	3328	7813	61716

Table 3.3 gives data on the private use of motor vehicles in Addis Ababa. It is drawn from an urban passenger transport survey carried out in the city in 1984, and is not directly comparable with the registration data since the figure for cars includes taxis and minibuses, and vehicles owned by firms or public bodies but used by employees for their personal transport. However, it does indicate that a high proportion of passenger vehicles are concentrated in Addis Ababa, so that availability in other parts of the country is lower than the overall figures indicate. Another implication is that, even in the capital city, less than 10% of the estimated 300,000 households own any means of wheeled transport. It is understood that public urban bus services operate only in Addis Ababa, Asmara and Jimma and, while blue taxis have become a significant means of urban transport in Addis Ababa, similar services operate in very few other cities. Of total urban trips in Addis Ababa, most of these under 20 minutes duration, and 56% of those over, are by walking. Of total trips 12% are by bus, and nearly 10% by taxi. A major reason for the predominance of walking is low income levels. However other reasons are poor infrastructure in some areas and, for higher income groups, the discomfort of public transport.

TABLE 3.3: OWNERSHIP OF TRANSPORT MEANS IN ADDIS ABABA

Means of Transport	Number of Owners
Car	23,686[1]
Motor Cycle	390
Other	2,496[2]
Nothing	916,942
Total	943,514[3]

1. Includes taxis and minibuses, and cars owned by firms and public bodies but available for the employee's personal use.

2. Mostly bicycles.

3. This total figure is the population over 10 years of age. Note that of these, 396,350 are between 10 and 20 years of age.

Inter-urban transport is provided primarily by privately operated, but nationally regulated and licenced, services using buses of different types and sizes. Small towns are often connected by "blue taxi" type vehicles, including some with four wheel drive, for distances up to 80-100 km.

The availability of low cost vehicles in Ethiopia is also low. International data is limited for non-motorised vehicles because they are not normally required to be registered. However, Table 3.1 suggests that the stock of motor cycles is small, and there are very few low cost motorised passenger or goods carriers in the country. As subsequent discussions show, use of bicycles and animal carts, the two low cost vehicles most widely found in developing countries, is also low. The rural use of animal carts for goods carrying is very rare.

Two characteristics of Ethiopia contribute to the limited availability of transport facilities. First, GNP per capita is amongst the lowest in the world, and is lower than in other developing countries with which comparisons can most usefully be made. Second, the terrain in Ethiopia is difficult in many rural and urban areas, making the construction of roads more expensive, and the operation of any type of vehicle more difficult, than in many other countries. There are certain positive features to the present transport situation which are relevant to analysis of the demand for low cost vehicles:

i) the fares charged for public passenger transport servies are relatively low. The standard fare for any urban bus journey in Addis Ababa is only 15 cents. The blue taxis, which provide a more convenient and flexible service, charge only 50 cents for journeys up to 5 km. Similarly, long distance bus fares are low;

ii) one means of low cost transport that is common in Ethiopia is the horse-drawn carriage, the ´gari´. These are widely used in the smaller cities and towns, where public buses do not operate, to provide passenger services.

iii) a particular feature of Ethiopia is the extensive use of pack animals (donkeys, mules, horses and camels) by farmers for rural transport.

Table 3.4 gives a breakdown of work animal ownership by region. The Table is based on data from about 15 years ago but gives a reasonable indication of the level of ownership. Note that draught cattle are used primarily for cultivation (ploughing etc.) while donkeys, mules and horses are used primarily as pack animals for transport. While rural people still have to walk, these pack animals eliminate, for those who own them, much of the physical burden of fetching water and firewood, bringing crops to market and carrying purchases back to the home. Part of the incentive in some other countries to develop the rural use of animal carts, bicycles etc., has been that, in the absence of pack animals, rural people have to carry these loads themselves. However, there is a limit to the transport capacity that can be provided by pack animals before it becomes worthwhile, except in steep terrain, to use a more efficient method.

TABLE 3.4 OWNERSHIP OF WORK ANIMALS IN RURAL AREAS

% Of Households Owning

Region	Draught Cattle	Donkeys	Mules	Horses	Camels
Arsi	61	30	9	35	0.20
Bale	50	30	7	25	0.20
Gamo Gofa	25	3	4	3	0
Gojjam	57	16	1	6	0
Gondar	67	28	3	5	0.20
Harerge	39	23	3	1	0.50
Illubabor	41	2	4	5	0.10
Keffa	48	2	6	6	0
Shoa	54	23	6	17	0.05
Sidamo	17	5	5	10	0.05
Tigrae	57	24	3	1	1.00
Wellega	43	10	4	3	0.05
Wello	59	25	5	5	0.05
Average (Excluding Eritrea)	49	18	5	9	0.15

Data not available for Eritrea and Nomadic Areas.

3.3 Low Cost Vehicle Options

Detailed below is the range of low cost vehicles selected for demand analysis. It is convenient to divide the vehicles into three categories:

i) personal transport - those vehicles which will primarily be used by individuals, firms or government agencies to provide personal transport, or to move limited quantities of goods, in rural or urban areas;

ii) rural farmer transport - those vehicles which will primarily be used by farmers for the movement of themselves, their families and their goods;

iii) service vehicies - those vehicles whose primary role is to offer passenger or goods services in urban or rural areas. Some might also be used by firms or public agencies to provide goods or passenger transport.

Personal Transport

Bicycle

Commonly regarded as the basic means of personal transport in urban and rural areas of developing countries. It provides mobility at low cost, requires no petroleum fuel, and is frequently used as a load carrier as well.

Bicycle and Trailer

The use of a detachable trailer increases load carrying capacity while retaining the convenience of the bicycle alone for personal transport. It has both urban and rural applications for personal use, for collection and delivery of goods, and in some types of institution.

Motor Cycle

The cheapest means of motorised personal transport, it offers a high degree of accessibility in urban and rural areas but has limited load carrying capacity. It is available in a wide variety of specifications, of which those most relevant to Ethiopia are:

* The moped, which is the cheapest form of motor cycle, suitable for personal transport in urban areas;

* The 'general purpose', typically 125 cc, motor cycle able to carry one or more passengers, or a cargo load. It is suitable for use on reasonable roads in urban or rual areas, and for longer journeys than a moped;

* The 'trail bike' suitable for use both on and off road. Often used by firms and public agencies for staff transport in rural areas.

Rural Farmer Transport

Animal Cart

A common means of transport for small farmers in many developing countries where draught animals are used in agriculture. Two wheeled carts, drawn by a donkey or a pair of oxen, are relevant to Ethiopia.

Single-Axle Tractor and Trailer

The single axle tractor is a low cost tractor capable of on field operations in soft soils, and of powering stationary agricultural equipment. Fitted with a trailer it also provides a means of transport for the farmer.

Service Vehicles

Tricycle

Based on bicycle technology, these pedalled three wheelers are widely used in parts of Asia to provide urban passenger services and, with a different type of body, for short distance urban or rural goods transport. However, passenger use is considered socially unacceptable in many countries, and the more likely application in Ethiopia is for goods movement.

Animal Drawn Carriage (gari) — A horse-drawn two wheeled cart with seating for three people. Already commonly used in Ethiopia to provide passenger services in smaller urban centres, and in the peripheral areas of large cities.

Motor Cycle and Sidecar — Extensively used in the Philippines, based on a 125 cc general-purpose motor cycle. It has the flexibility to provide a variety of different services:

* Urban passenger movement, either as a short distance feeder service to large capacity vehicles on main routes in a large city, or as the main passenger transport service in smaller urban centres;

* For urban goods collections and deliveries;

* For general goods and passenger transport in rural areas, able to provide an extensive service linking villages to markets, even where road conditions are very poor.

Motor Cycle Van/Pick Up — Again a vehicle developed in the Philippines, consisting of a two wheeled attachment mounted over the rear of a general-purpose 125 cc motor cycle. Used primarily as a low cost urban van or pick-up, depending on the type of body fitted.

Motor Cycle Based Three Wheeler — A variety of designs used in different countries in Asia and Latin America. They are purpose built vehicles, but using motor cycle driveline components. Used for passenger transport services and, to a lesser extent, for goods, primarily in urban areas.

Basic Transport Vehicle (BTV) — Developed by major automotive companies, using standard driveline assemblies (engine, transmission, rear axle) but simple chassis and bodywork, to provide a low cost four-wheeled motor vehicle that can be produced with significant local content in relatively low volumes. Essentially they provide a cheaper alternative to conventional one tonne pick-ups. They have made some impact on the market in Asia, most successfully in the Philippines, and are also used to a limited extent in parts of Africa. They can provide public and private passenger and goods services on sealed roads, and in the Philippines are also used as government vehicles.

Table 3.5 presents an analysis of relevant characteristics of the range of vehicles under consideration. It covers both cargo and passenger carrying applications and details:

Column 1 — The load carrying capacity of the vehicle, expressed either as weight of goods or number of passengers, including the rider for personal means of transport, but only fare paying passengers for service vehicles;

Column 2 — Typical fuel consumption (for those vehicles which consume fuel);

Column 3 — The operating speed of the vehicle, expressed as the average speed that the vehicle should be able to maintain over a typical journey, in non-congested conditions;

Column 4 — The estimated sales price of the vehicle, assuming efficient assembly/manufacture in Ethiopia;

Column 5 — A measure of the capital cost efficiency of the vehicle, expressed as the cost of the vehicle divided by the "quantity" of useful transport that can be accomplished per hour of operation. "Quantity" is measured either as tonne km or passenger km;

Column 6 — A measure of fuel efficiency, expressed as the fuel consumed per "unit" of useful transport. A "unit" is one tonne km or one passenger km.

For both measures of efficiency, the lower the figure the more efficient the vehicle.

Two vehicles, the motor cycle and sidecar and the basic transport vehicle, have different characteristics depending on whether the application is urban, inter-urban (on surfaced roads) or rural (assuming poor road conditions). Three sets of figures are therefore given for these vehicles.

The figures in the table must be interpreted with some care. Obviously some characteristics (payload, fuel consumption and operating speed) will vary according to the conditions of use, attitude of the operator etc., but every attempt has been made to make the figures for different vehicles comparable. The measures of capital cost and fuel efficiency assume the maximum utilisation of the vehicle. Thus the comparison between different vehicles is only valid when each is carrying its maximum payload and operating at the speed of which it is capable. In crowded urban conditions any vehicle is reduced to the speed of the

TABLE 3.5: CHARACTERISTICS OF LOW COST VEHICLES

		1		2	3	4	5		6	
		Carrying Capacity		Fuel Con-sumption	Operating Speed km/hr	Price	Capital Cost Efficiency		Fuel Efficiency	
		kg	pass.	km/litre	km/hr	Birr	Birr/ tkm/hr	Birr/ pass. km/hr	litres per tkm	litres per pass.km
Personal	Bicycle	-	1	*	15	250	-	16.7	-	*
	Bicycle and Trailer	150	-	*	12	400	222.0	-	*	-
	Moped	-	1	45	30	2200	-	73.3	-	0.022
	125 cc Motor Cycle	-	2	30	50	2700	-	27.0	-	0.016
	Trial Bike	-	2	25	50	3200	-	32.0	-	0.020
Rural	Animal Cart: 1 Donkey	250	-	*	5	500+	400.0	-	*	-
	Animal Cart: 2 Oxen	700	-	*	5	600+	171.0	-	*	-
	Single Axle Tractor and Trailer	750	-	10	15	4500	400.0	-	0.13	-
Service	Tricycle	200	-	*	12	560	233.0	-	*	-
	Animal Drawn Carriage	-	2	*	7	800	-	57.1	-	*
	M/Cycle + Sidecar: Urban	300	4	25	30	3500	388.9	29.2	0.13	0.010
	Interurban	300	4	25	40	3500	291.7	21.9	0.13	0.010
	Rural	450	6	18	20	3750	416.7	31.2	0.12	0.009
	M/Cycle Van/Pick-Up	400	-	22	30	4000	333.3	-	0.11	-
	Three Wheeler	500	3	20	30	5500	366.7	61.1	0.10	0.017
	BTV: Urban	1000	14	11	50	16000	320.0	22.9	0.09	0.006
	Interurban	1000	14	11	70	16000	228.6	16.3	0.09	0.006
	Rural	1000	14	8	30	16000	533.3	38.1	0.125	0.009

* Uses no petroleum fuel
\+ Excludes cost of animal

traffic flow, and in this circumstance the figures will be biased against slow moving vehicles. Similarly if the vehicle is moving loads smaller than it is capable of, it is operating at lower efficiency and under this circumstance the figures are biased against low capacity vehicles. Finally the figures for capital cost are only comparable if similar utilisation rates are assumed for the different vehicles.

3.4 Population Data

Data on the distribution of population is needed to make estimates of vehicle demand. Table 3.6 gives a breakdown by region of the numbers of people living in towns, categorised as large urban centres (population greater than 30,000), medium sized centres (population between 2,000 and 30,000) and small population centres of less than 2,000 people. Most of the last are rural markets. For the purposes of demand analysis it is appropriate to consider the urban population as those living in centres with more than 2,000 people. The small market centres of less than 2,000 people are considered to be part of the rural population. This gives an urban population of about 4,295,000 of which 33% lives in Addis Ababa. The rural population is about 37,275,000. The seventeen major urban centres, with populations greater than 30,000 are:

Addis Ababa	1,412,575
Asmara	275,385
Dire Dawa	98,104
Nazareth	76,284
Gondar	68,956
Dessie	68,848
Harar	62,160
Mekele	61,583
Jimma	60,992
Bahir Dar	54,800
Beseka	54,146
Debre Zeit	51,143
Debre Markos	39,808
Assela	36,720
Wonji Gefersa	35,420
Shashemene	31,531

Note: To refine the analysis of the potential for low cost vehicles to meet rural transport requirements, IPS are preparing detailed data on the numbers of people within the influence area of different sizes of market.

Over 50% of the population of Ethiopia is under 20 years of age. Since this will influence the future demand for transport the age distribution of the population is given in Table 3.7.

TABLE 3.6: POPULATION LIVING IN TOWNS

Administrative Region	Population <2,000		Population 2,000 - 30,000		Population >30,000	
	No. Of Towns	Population	No. Of Towns	Population	No. Of Towns	Population
Arsi	13	15,758	19	80,657	1	36,720
Bale	10	8,152	9	69,055	-	-
Eritrea	2	2,648	10	97,865	1	275,385
Gamo Gofa	16	13,538	9	62,968	-	-
Gojjam	25	28,608	28	138,628	2	94,606
Gondar	20	23,488	18	118,904	1	68,958
Harerge	25	38,618	31	114,217	2	160,264
Illubabor	23	15,097	11	50,720	-	-
Keffa	30	29,600	13	63,894	1	60,992
Shewa	78	77,397	74	422,028	6*	1,661,039
Sidamo	17	19,168	30	179,915	1	36,169
Tigrai	2	3,352	17	125,621	1	61,583
Wellega	33	35,792	16	105,278	-	-
Wollo	17	17,732	20	142,207	1	68,848
Total	311	329,148	305	1,771,957	17	2,524,626

* Includes Addis Ababa, population 1,412,575

TABLE 3.7: AGE DISTRIBUTION OF ETHIOPIAN POPULATION

Percentage of Total Population

Age Group (year)	National	Rural	Urban
0-4	17.4	17.7	15.6
5-9	15.8	16.2	14.3
10-14	12.2	12.1	12.8
15-19	9.2	8.9	11.3
20-24	7.9	7.7	9.6
25-29	7.3	7.1	8.1
30-34	6.4	6.3	6.7
35-39	5.6	5.4	5.7
40-44	4.5	4.5	4.4
45-49	3.5	3.6	3.1
50-54	2.8	2.9	2.2
55-59	2.1	2.2	1.7
60-64	1.8	1.8	1.7
65+	3.5	3.6	2.8

Source: National Sample Survey Second Round, in Statistical Abstract 1982

3.5 Demand Estimate for Personal Means of Transport

3.5.1 Bicycles

Imported bicycles are currently used in Ethiopia. Import statistics for bicycles and associated spare parts are detailed in Table 3.8 and major sources of supply in Tables 3.9 and 3.10.

The data has to be interpreted with some care:

i) the figure of imports for 1977 is exceptionally high, and is accounted for, as Table 3.9 shows, by import of 13,273 bicycles from Italy at the very low value of 29,246 Birr (2.2 Birr per bicycle). There are two possible explanations for this:

- a mistake in the trade statistics;

- supply of the bicycles under a grant aid arrangement, so that the value shown does not represent the true cost of the bicycles.

ii) there is some indication that the statistics underestimate the supply of bicycles, since for five of the years 1976-82 the value of imports of spare parts is very high in relation to that of complete machines. This may be accounted for partly by the fact that, in a period of declining sales for new bicycles, a greater emphasis on imports of spares for those already on the road would be expected. However, for 1981 in particular the figure is excessive, and it is noteworthy that:

* imports of spares from India are very high, while imports of complete bicycles are low;

* Chinese imports of spares are high in 1980 and 1981, while imports of complete bicyles have stopped completely.

This suggests that some bicyles have been imported from these sources partly disassembled and classified as spare parts.

iii) the trade statistics do not differentiate between adult and children's bicycles. The units imported must include a proportion of child or juvenile models, but inspection of the unit import values from particular countries suggests the proportion is fairly small.

TABLE 3.8: IMPORTS OF BICYCLES, TRICYCLES AND SPARE PARTS

	Bicycles and Tricycles Value (Birr)			Spares Value (Birr)
	No.	Total	Per Unit	
1971	9,331	308,619	33.1	136,867
1972	4,989	302,572	60.6	137,103
1973	*	*	*	*
1974	4,122	272,530	66.1	225,117
1975	2,928	291,905	99.7	211,778
1976	4,941	396,764	80.3	89,952
1977	17,527	380,813	21.7	216,536
1978	5,323	346,060	65.0	267,787
1979	1,165	99,370	85.3	89,876
1980	99	21,403	216.3	196,942
1981	715	158,433	221.6	743,485
1982	572	135,882	237.6	291,078
1983	2,903	502,242	173.0	554,329
1984	1,204	174,437	144.9	112,658
Total	55,819	3,391,030	-	3,273,508

* No data available.

TABLE 3.9: IMPORTS OF BICYCLES BY MAJOR SOURCE (QUANTITY)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
China (PR of)	1700	500	2911	3065	3415	600				
Czechoslovakia	140	1239	1289	52		50				
Denmark					150			40		
France	200	100			100					
India	830	161	50	210	120	120				
Italy	472	443	414	13273			54	36	98	775
Japan	454	436	72	111	50			11		
Saudi Arabia								65	169	161
Taiwan			100	200				400		
UK	87			151				92	78	243
USA		36							157	
USSR	200			440	1458	364				1627
FRG								18		

TABLE 3.10: IMPORTS OF BICYCLE SPARES BY MAJOR SOURCE (VALUE BIRR)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
China (PR of)	83034	37535	61162	142122	164589		82010	558799	6480	121348	21360
Czechoslovakia		20540									
India	24077	6281		7377	65054		26678		163838		
Italy	68145	78250				67185			88940	38140	28775
Japan	37521	50430	18187	30071	21779	17240	61780		31270	355825	26138
Taiwan				14363				103680			32655
UK	8520	8562									
Total	225117	211778	89952	216536	267787	89876	196342	743485	291078	554329	112658

It is also conceivable that some bicycles have been brought over the border illegally without payment of duties.

Whatever assumptions are made in interpreting the statistics, the general trend is that supply of bicycles dropped substantially after 1978 but has recovered somewhat since 1982.

Assuming a 10 year life, the stock of bicycles in the country is 35,000 - 40,000. Assuming a 15 year life the stock is 55,000 - 65,000. Based on the trade statistics, the average annual imports are as follows:

Over the past ten years:	3700 units/year
Over the past five years:	1100 units/year
Over the past two years:	2000 units/year

The supply data from trade statistics is not an adequate indication of the potential demand for bicycles produced in Ethiopia. First, the supply of bicycles in recent years has been limited by restrictions on the availability of foreign exchange. Evidence of this is the high price being charged by private traders - prices as high as Birr 850 have been quoted for a Chinese bicycle, which would have a landed price of about Birr 200.

Second, the price of any bicycle in Ethiopia at present is higher than that at which a model produced by a local industry could be sold. The cheapest price quoted is 360 - 380 Birr, whereas a realistic target sales price for a locally produced model is about 250 Birr. Given the low level of incomes in the country, demand will be very sensitive to price.

Comparative international data on bicycle demand is difficult to obtain since bicycles are not normally registered. Table 3.11 presents the national level data that does exist and compares per capita income with the stock of bicycles and the current level of demand, measured in terms of domestic sales. The data for different countries is for different years, but to make the comparison as realistic as possible, per capita income is expressed as a ratio to the cost of a bicycle at the time of the data was current. Although some of the data is approximate, a rough pattern can be interpreted;

i) demand level (units per 1000 population) is between 50 - 200% of the ratio of per capita income to the cost of a bicycle;

ii) demand levels tend to be lower in Africa than Asia, particularly in rural areas (and other evidence bears this out), because population densities are lower and travel distances typically longer;

iii) when a country reaches a certain level of affluence, demand in relation to income level will tend to diminish (see Malaysia 1981), as a significant proportion of the population becomes able to afford a motor vehicle. However, absolute demand levels can remain high as more affluent households become owners of a motor vehicle and one or more bicycles;

iv) China has been able to develop a high level of bicycle ownership at low per capita income levels by a deliberate policy of encouraging their use. Ownership was encouraged by producing bicycles on a mass scale and making them available at a very low price. At the same time private motor vehicle (and particularly private car) ownership was severely restricted.

Tanzania made an ambitious attempt, in the late 1970's, to stimulate bicycle use and established a plant to produce at an initial rate of 100,000 units per annum with a planned increase to 150,000. The attempt failed because of major problems in operating the plant and maintaining production, particularly with a programme of rapid development of high local content. However, attempts continue to encourage use of bicycles there through supply by bilateral donors. If this level of supply were to be maintained and absorbed, it would represent a demand similar to that in Table 3.11.

Examining the figures for Ethiopia, and discounting the limitations on bicycle supply, it is clear that the relationship proposed above between demand and income level does not apply. Two reasons can be offered which partly explain this:

i) the nature of the terrain in Ethiopia will tend to reduce demand relative to other countries;

ii) income level in relation to the cost of a bicycle (under present supply conditions) is signficantly lower than for the other countries in the table. It is reasonable to expect that the relationship between demand and income levels will not hold true at very low incomes. There is a threshold of income which must be reached before a household becomes able to afford a bicycle.

It is therefore useful to examine bicycle ownership at different income levels. Table 3.12 presents national level data from India and Malaysia. It is based on household rather than per capita income since this is the more relevant indicator of ability to purchase a bicycle. Ownership of bicycles for households in the 0 - 13.5 income range in Malaysia is much higher than in India. However, examination of the percentage of households in different ranges indicates that income levels in Malaysia are higher than in India. Therefore, in Malaysia a larger proportion of households in the lowest income range would be at the top end of that range. The implication is that bicycle ownership becomes substantial (40% or more of households owning a bicycle) when income levels reach about ten times the cost of a bicycle.

TABLE 3.11: INTERNATIONAL DATA ON BICYCLE USAGE

		Per Capita Income / Cost Of Bicycle	Bicycle Stock Per '000 Population	Current Demand Level Per '000 Population
India	1968	3.2	39.3	3.3
India	1984	4.2	43.0	3.3
Malaysia	1968	6.0	92.3	10.0
Malaysia	1981	26.0	130.0	16.0
Nigeria	1981	8.0	40 - 45[1]	5.5
Kenya	1984[2]	2.5		1.25
China	1984[3]	4 - 6	200 - 300	8 - 10
Tanzania	1980[4]	3 - 4		5 - 6
Ethiopia (at current cycle prices)		0.65	1.35[5]	0.06

Notes:

1. Estimate, precise stock not known.

2. The current demand is an estimate based on information about the cycle industry in Kenya.

3. The Chinese data is based on analysis of quoted estimates. Since the data is not very precise, ranges of figures are given.

4. Note that the Tanzanian demand estimate is based on the output planned for the national bicycle factory, not on sales achieved.

5. Based on a stock of 55,000 bicycles.

Local level data from a study in Northern Nigeria offers some support for this hypothesis, while again indicating that rural bicycle demand tends to be somewhat lower in Africa than Asia. Rural households owning no vehicle had an average income ten times the cost of a bicycle. Households owning only a bicycle had an average income nineteen times its cost.

Based on the above analysis two alternative methods are presented for estimating demand for bicyles produced by a local industry in Ethiopia. It is assumed that the development of the local industry would make bicycles more freely available and would reduce the price to the customer to about Birr 250 compared with the current minimum of Birr 360 - 380.

Approach 1: Based On Per Capita Income And Comparative Demand Levels:

The locally produced bicycle brings the ratio of per capita income to bicycle cost to unity. Using the relationship derived from Table 3.11, and making the most conservative assumption (demand per 1000 population is 50% of ratio of per capita income to bicycle cost) suggests a demand level of 20,000 units per annum. However, the effect of terrain and low absolute income levels would reduce this. If we assume a reduction of 50% this gives a demand of 10,000 units per annum. It is important not to overemphasise the effect of terrain. While riding a bicycle is more difficult in hilly terrain than on the flat, it does not preclude its use. Much of the demand for bicycles will be from urban areas or for short rural journeys and many places in Ethiopia will be suitable for their use. Even though Addis Ababa has some steep hills, bicycle riding is feasible in many parts of the city. It should also be noted that there are other African cities (eg. Nairobi) where, although the terrain is by no means flat, bicycles are quite common.

Approach 2: Based On Population And Income Distribution, And Bicycle Stock:

In round figures the urban population is about 4,250,000 and the rural population 37,250,000. Assuming average urban household size to be five persons (Addis Ababa is 4.78) and rural to be six persons (most recent survey gives 5.61) then there are:

850,000 Urban Households
6,208,000 Rural Households

Based on the data from Table 3.12 and, making allowance for lower utilisation for cycles in Africa, assume that there is the potential for 50% of households with an income fifteen times the price of a bicycle above to own one. Detailed data on income distribution is not available, but it is probably a conservative estimate to say that the average urban household has an income of this level (3,750 Birr) and above, and that therefore, about 40% of urban households fall into the category of potential bicycle ownership. This gives a potential urban stock of 170,000 bicycles. Halving this to allow for terrain conditions leaves a potential stock of 85,000 urban bicycles. Given low rural income levels most households will not be able to afford a bicycle. However, it is not unreasonable to expect rural ownerhip level of 0.5%, given that the overall definition of rural includes small towns on under 2,000 people and that there is likely to be some demand for bicycles from small businesses and co-operatives as well as individuals. this implies a potential rural stock of 30,000, giving a total of 115,000. Taking the estimate of existing stock as 55,000 and assuming that this is brought up to its potential level over a ten year period, the demand for bicycles is:

TABLE 3.12: INTERNATIONAL DATA ON BICYCLE OWNERSHIP AT DIFFERENT INCOME LEVELS

	Household Income / Cost Of Bicycle	National % Of Households	National % Owning Bicycle	Rural % Of Households	Rural % Owning Bicycle	Urban % Of Households	Urban % Owning Bicycle
India 1968	0 - 13.5	72.2	14.7	74.4	12.4	63.4	25.1
	13.5 - 22.7	14.6	46.4	13.3	41.8	19.9	58.8
	22.7 - 45.5	10.1	59.4	9.7	62.9	11.5	48.2
	45.5 - 68.2	2.2	73.2	1.9	73.4	3.1	68.1
	68.2 +	0.9	61.9	0.6	75.8	2.1	51.2
Malaysia 1968	0 - 13.5	55.3	47.1				
	13.5 - 40.5	35.7	72.3				
	40.5 - 101.5	7.1	59.7				
	101.5 +	1.9	37.8				

Replacement Of Stock	3,500 per annum (15 year life)
Build Up Of Stock	6,000 per annum
Total	9,500 per annum

These estimates are based on existing economic conditions. There is a real sense in which it can be said that Ethiopia is just at the start of its bicycle age, and one would expect demand levels to increase:

i) increases in gross domestic product, and in population size, will bring a larger number of households to the level where a bicycle is affordable;

ii) over half of the population of Ethiopia is under 20. In India the main purchasers of bicycles are males between the ages of 16 and 30. Ethiopia will therefore have an increasing number of potential cyclists reaching adulthood and bicycle purchasing age in the next few years. For example, in five years time there will be 11.7 million peopple in the age group 15 - 29, compared with 9.7 million today (Table 3.7).

It should be noted that there is also a substantial demand for bicycle spare parts, some of which could be suppied by a local industry as the locally manufactured content is developed.

3.5.2 **Bicycle Trailer**

The bicycle trailer can be sold to existing users of bicycles as well as new purchasers. Its main applications will be for individuals who need to move a larger quantity of goods than can be transported conveniently on a bicycle, and for people who can use it in connection with small businesses and trading. It should be noted that in India the bicycle and trailer is finding some institutional applications, e.g. for moving seedlings and water in community forestry nurseries. For initial analysis it has been assumed that the potential market for cycle trailers is about 5% of bicycle owners. Using the figures in the estimate for bicycle demand this leads to a trailer demand of:

2,750 from existing bicycle owners:
300 per annum from new bicycle purchasers.

Assuming that the demand from existing owners is met over five years gives a total demand of 850 units per annum.

3.5.3 **Motor Cycle**

Imported motor cycles are currently used in Ethiopia. Import statistics for motor cycles and associated spare parts are detailed in Table 3.13 and major sources of supply in Tables 3.14 and 3.15.

The statistics give a more reliable guide to supply than those for bicycles since:

i) there is no evidence of machines being imported as spare parts;

ii) illegal import is less likely than for bicycles;

iii) the statistical category is more specific.

While there have been year by year fluctuations, imports have been reasonably consistent over the past ten years;

Annual average:	Last ten years	535/annum
	Last five years	645/annum
	Last two years	550/annum

TABLE 3.13 IMPORTS OF MOTOR CYCLES AND SPARE PARTS

	Motor Cycles Value (Birr)			Spares Value (Birr)
	No.	Total	Per Unit	
1971	350	206,586	590.2	52,885
1972	303	263,286	868.9	79,129
1973	*	*	*	*
1974	1,864	376,538	202.0	61,053
1975	230	215,236	935.8	70,948
1976	407	391,494	961.9	58.055
1977	154	213,917	1389.1	90,962
1978	777	676,368	870.5	72,660
1979	521	791,868	1519.0	176,876
1980	1,021	905,182	886.6	327,831
1981	729	1,487,901	2041.0	202,229
1982	373	479,431	1285.3	281.130
1983	717	866,166	1208.0	204,236
1984	443	748,576	1689.8	189,676
Total	7,889	7,622,548		1,367,670

* No Data Available

The major source of supply is Japan, which accounts for 70% of the quantity, and nearly 76% of the value imported in the period 1975-84. Given the evidence that motor cars are repaired and maintained to keep them on the road for many years in Ethiopia, it is reasonable to expect that motor cycles would have a relatively long working life here compared with other countries. Based on the import data, a seven year working life gives a stock in the country of about 4,500 units and a ten year life about 5,400 units. However, Table 3.2 shows only 1,292 registered units. While it is possible that some motor cycles are operated on the road unregistered, this could account for only a small part of the difference. The most likely explanations are:

TABLE 3.14: IMPORTS OF MOTOR CYCLES BY MAJOR SOURCE (QUANTITY)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
China (PR of)	1200										
Germany West					172						
Germany East							174				
Netherlands	104										
Italy	26	21			43						
Japan	487	192	330	150	456	517	272	427	332	333	307
Korea									24		
UK								101		300	26
USSR					90		539	168			50
Total	1864	230	407	154	777	521	1021	729	373	717	383

TABLE 3.15: IMPORTS OF MOTOR CYCLE SPARES BY MAJOR SOURCE (VALUE BIRR)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
China (PR of)	44758										
France				15185							
Germany East								110444	42222	13442	44504
Germany West		9789			23041						
Italy						79905					
Japan	9763	21290	38219	43555	28896	82867	81973		234880	161153	132633
Netherlands	6194		12002	30124							
Switzerland								42745			
UK		15013					72415				11008
USSR		9833									
Total	61053	70948	58055	90962	72660	196876	327831	202229	281130	174595	188145

i) motor cycles legitimately unregistered, because they are used only on private roads, for example on state farms;

ii) motor cycles used by government departments, for example by extension officers, and therefore subsumed in the government vehicle category of the registration statistics;

iii) motor cycles used by the military forces.

There are three elements to the total demand for motor cycles. Adaptations of motor cycles as service vehicles are discussed in a later section. The two applications for personal transport are by government, and in the private sector.

The present supply of motor cycles underestimates the demand since the supply has been restricted by the availability of foreign exchange. This is likely to have been a greater constraint on the private sector than on government, though it will affect both. Further, retail prices in the market are higher than would be expected from a locally assembled product, and this will reduce demand. A final consideration is that the tight restrictions that have been imposed on vehicle imports and fuel supplies should be expected to generate an increased demand for motor cycles (if these are made easily available), as a substitute for four wheeled vehicles, for those uses where the ability to transport one or two people and a limited quantity of goods meets requirements.

Table 3.16 compares motor cycle stock and per capita income for lower income countries of Africa and Asia, using data from Table 3.1. Since government use of motor cycles represents a very high proportion of total use, two sets of figures are given for Ethiopia, for privately registered motor cycles and for total stock. Table 3.17 presents similar data for India and Malaysia, using the ratio of per capita income to the cost of a motor cycle, and gives figures for demand as well as stock. The implications are similar to those for bicycles. Again, the use of motor cycles in Ethiopia is very low, but the income level is lower than for the other countries. The two nearest equivalents in Table 3.16 are Tanzania and India. Tanzania has a per capita income 2.2 times that of Ethiopia, but over eleven times as many motor cycles per head of population. Taking only privately registered motor cycles in Ethiopia, Tanzania has thirty five times as many units per head of population. India has a per capita income 1.85 times that of Ethiopia, and nearly twenty times as many motor cycles per head of population, or more than sixty times as many in comparison with private ownership.

TABLE 3.16 COMPARATIVE DATA ON MOTOR CYCLE STOCK FOR SELECTED LOW INCOME COUNTRIES IN AFRICA AND ASIA

Country		GNP/Capita US $	Motor Cycles Per ´000 Population
Egypt		464	4.22
Kenya		426	1.02
Tanzania		275	1.40
India		230	2.42
Indonesia		460	27.23
Pakistan		339	3.95
Ethiopia	Total Stock	125	0.125
	Private Stock		0.04

Taking the cost of motor cycles into account (Table 3.17) the picture is more favourable, with the Indian situation in 1968 being the nearest equivalent to Ethiopia today. The income ratio in this comparison is 1.94, but the motor cycle stock in India was about six times that of Ethiopia. However, in India at that time the local motor cycle industry was unable to satisfy the demand and there were waiting lists of several years for machines. It is worth noting that in the (approximate) period 1960 - 1980 there was a policy of developing the use of motor cycles in India and stimulating their manufacture, while that of motor cars was restricted. This is one reason for the rapid increase in both motor cycle stock and demand between 1968 and 1984.

TABLE 3.17 COMPARATIVE DATA ON MOTOR CYCLE STOCK AND DEMAND FOR INDIA, MALAYSIA AND ETHIOPIA

		GNP/Capita / Cost Of Motor Cycle	Motor Cycles Per ´000 Population	Demand Per ´000 Population
1968	India	0.24	0.65	0.17
1974	India	0.28	1.34	0.29
1984	India	0.38	2.42	1.30
1968	Malaysia	0.69	16.00	10 - 15
1981	Malaysia	2.70	99.00	
Ethiopia	Total	0.125	0.125	0.014
	Private		0.040	0.0045

The terrain in Ethiopia imposes a much less severe constraint on the use of motor cycles than bicycles and indeed should serve to generate some demand for trail bikes given their off-road capability, but the low income level is a major factor in determining demand. It is therefore useful to look at the effect of income distribution on demand. Table 3.18 gives some figures for India and Malaysia. For India the implication is that

TABLE 3.18: INTERNATIONAL DATA ON MOTOR CYCLE OWNERSHIP AT DIFFERENT INCOME LEVELS

		National		Rural		Urban	
	Household Income / Cost of Motor Cycle	% Of Households	% Owning Motor Cycle	% Of Households	% Owning Motor Cycle	% Of Households	% Owning Motor Cycle
India 1968	0 - 1.2	72.2	-	74.4	-	63.4	-
	1.2 - 2.0	14.6	0.18	13.3	-	19.9	0.63
	2.0 - 4.0	10.1	1.2	9.7	0.5	11.5	3.30
	4.0 - 6.0	2.2	5.4	1.9	2.1	3.1	12.90
	6.0 +	0.9	16.2	0.6	11.5	2.1	22.90
Malaysia 1968	0 - 1.35	55.3	2.8				
	1.35 - 4.05	35.7	17.8				
	4.05 - 10	7.1	24.8				
	10 +	1.9	78.9				

ownership becomes significant at household incomes above about four times the cost of a motor cycle, and in Malaysia at a somewhat lower figure. The lower figure for Malaysia probably reflects a more mature market, with much easier availability of machines and signficant second-hand sales.

Tanzania is in the same part of the world, and has similar characteristics to Ethiopia in terms of economic conditions and population data. The number of motor cycles in Tanzania implies a potential stock in Ethiopia, taking account of differences in per capita income, of about 20,000 units. The figures for India in 1968 (Table 3.17) where government use of motor cycles would be insignificant compared with private use, again allowing for difference in income levels, suggest a potential stock in Ethiopia of 13,500 units and a demand for 3,500 units per annum. The equivalent figures, based on India 1974 data, are a stock of 24,000 units and a demand of 5,000 units per annum. The lowest of these figures suggests a potential stock of privately owned motor cycles in Ethiopia of 13,500 units and a demand of 3,500 units per annum.

A second method of analysis is to consider the different markets for motor cycles in Ethiopia.

i) Private
Assuming that 7.5% of the households in Ethiopia have income levels where motor cycle ownership becomes significant, purchase of machines by 20% of these households would result in a private stock of 12,000 machines;

ii) Co-Operatives
It seems likely that motor cycles, and particularly trail bikes with their ability to operate off-road, would be a useful means of transport for officers of service co-operatives. The purchase of one machine each by 50% of the co-operatives would result in a stock of 2,000 motor cycles;

iii) Government
The figures on imports and registration imply that the various branches of government have a stock of about 3,500 motor cycles. It would make sense in terms of expenditure for the government to maximise its use of motor cycles in preference to four wheeled vehicles (two or four wheel drive) wherever this is feasible for personal transport. It is understood that the government has already started to apply this approach, for example by providing motor cycles for agricultural extension officers. It is assumed that it is feasible to increase the government stock to 6,000 units.

The above analysis gives a potential total stock of 20,000 motor cycles and, assuming this level is reached over a five year period, an annual demand of 3,500 units, calculated as follows:

	Replacement Of Existing Machines On A 10 Year Life Cycle	New Purchases	Total
Urban	150	2,100	2,250
Co-Operatives		400	400
Government	350	500	850
Total Units/Annum			3,500

As noted earlier, continued restrictions on the private use of four wheeled motor vehicles should encourage the greater use of motor cycles, particularly if the products are available from a local industry. It is therefore, likely that demand would increase above 3,500 units per annum as the industry becomes established, particularly taking into account the low average age of the population and the expectation of increasing income levels.

3.6 Demand Estimate For Rural Farmer Transport

3.6.1 **Animal Cart**

This section estimates the demand for goods-carrying animal carts from rural farmers. Animal drawn carriages (´gari´) are discussed in Section 3.7.

The only data available on the supply of animal carts are the production statistics from the Assela Rural Technology Centre. Table 3.19 gives planned and actual production over a four year period. The planned output is based on returns from extension officers of the demand for carts. However, output has not reached planned levels, mainly because of difficulties in the supply of raw materials. While the carts produced at Assela are cheap (prices range from 200 - 405 Birr and are subsidised) the quality is fairly poor. They use wooden bearings and fabricated steel wheels, with the result that draught efficiency is quite low, and they vibrate badly on rough roads. While low cost is very important in making carts available to rural people, it is not the only consideration in defining the specification. Many people will be familiar with the ´gari´ that operate in the towns, which travel smoothly and easily with their pneumatic tyres, roller bearings and leaf springs. This will tend to result in prejudice against a design which is noisy, inefficient and uncomfortable.

Demand

There is significant potential to improve transport facilities in rural areas of Ethiopia by the use of animal-drawn carts, given that:

i) work animals suitable for hauling carts are already widely owned in rural areas;

ii) carts do not consume any petroleum fuel;

TABLE 3.19: PRODUCTION OF ANIMAL CARTS FROM ASSELA RURAL TECHNOLOGY CENTRE

	1982/3		1983/84		1984/85		1985/86	
	Planned	Actual	Planned	Actual	Planned	Actual	Planned	Actual
Donkey Cart	-	15	60	-	60	24	101	-
Ox Cart	-	125	180	103	452	54	300	-
Total	-	140	240	103	512	78	401	-

iii) the farmer can ride on a cart with his goods, whereas he must walk with his pack animals. The cart can also be used to transport the farmer and his family.

While the steep terrain in some areas is a constraint on the operation of animal-drawn carts, this does not preclude them from making a significant contribution to rural transport. Cart operation is not restricted only to flat areas and they can be used on hills as long as gradients are not too steep. Carrying capacity will of course decrease with increasing gradient until the point is reached where the animal can carry a greater load on its back than it can haul. A second constraint is the limited extent of the rural road network. However, while it is true that the better the quality of the road surface the easier it is to operate the cart, it is feasible to use carts away from the engineered road network on earth tracks. In India over 70% of the total use of carts, measured in terms of tonne kilometres, is off the road network. The low speed of carts limits their use to journeys up to about 15 km, typically to and from market, and in and around the area of the dwellings and the farmland.

Table 3.20 presents an initial attempt to assess the potential level of use of animal drawn carts in Ethiopia. Column 1 lists the regions of Ethiopia and Column 2 the number of households in those regions excluding Nomadics. Column 3 details the proportion of households within the influence area of a market since these are the most likely users of animal carts. Column 4 estimates the proportion of households which have access to suitable draught animals, and Column 5 the proportion of households in terrain, and with road/track access, likely to be suitable for use of carts. A higher figure has been assumed for Arssi than the other regions because of its high agricultural potential. The product of Columns 2, 3, 4, and 5 is given in the Column 6 as the number of potential users of animal carts in each region. This estimate indicates that about 380,000 households are potential users. However, 150,000 of these are in Shoa Province. Because Shoa is the central region in the country and encompasses the capital city, it will have better transportation facilities than other regions, in terms both of the number of vehicles and the extent of the road network. This may tend to reduce the demand for animal carts, and it is therefore prudent to work on the more conservative assumption that about 300,000 rural households are potential users of animal-drawn carts.

Two key factors will determine the proportion of potential users that will actually buy carts:

i) the need for the increased transport capacity offered by a cart compared with a pack animal;

ii) the ability to pay the price of the cart.

In India ownership of carts becomes significant at income levels between five and six times the price of a cart. In Ethiopia it is estimated that rural household income levels are between 1.5 and 2.5 times the price of the cart. Thus only higher income rural households will be able to afford a cart. It is also these households that will have the greatest need for the increased

TABLE 3.20: ESTIMATE OF NUMBER OF POTENTIAL USERS OF ANIMAL CARTS

Regions	Number Of Rural Households (excluding nomadics)	Proportion Of Households Within Influence Area of Market	Proportion Of Households Owning Draught Animals	Proportion Of Households With Terrain/ Road Access Suitable For Animal Carts	Potential Users Of Animal Carts (2 x 3 x 4 x 5)
1	2	3	4	5	6
Arussi	250,000	0.68	0.75	0.33	42,000
Bale	122,000	0.12	0.65	0.12	1,100
Eritrea	250,000	0.13	?	0.12	-
Gamo Gofa	196,000	0.63	0.25	0.25	7,700
Gojjam	420,000	0.58	0.65	0.25	39,500
Gondar	420,000	0.35	0.80	0.25	29,400
Harerge	390,000	0.34	0.50	0.12	7,900
Illubabor	135,000	0.58	0.40	0.25	7,800
Keffa	360,000	0.46	0.50	0.25	21,800
Shoa	1,100,000	0.84	0.65	0.25	150,100
Sidamo	580,000	0.72	0.20	0.25	20,900
Tigrai	370,000	0.26	0.70	0.12	8,000
Wellega	330,000	0.31	0.45	0.25	11,500
Wollo	495,000	0.44	0.70	0.25	38,000
Total					385,000

capacity that a cart offers. In the absence of detailed rural income distribution data, an estimate of the actual demand for animal carts can be obtained by extrapolating the data for Arussi to other regions. Actual production at Assela has averaged 107 carts per annum for the years for which data is available. Analysing the planned output, and assuming that orders unfulfilled in one year are carried forward to the next, implies a demand of about 200 units per annum. However, this is likely to be an underestimate since there will be dissatisfaction with unfulfilled orders. It was suggested by the manager of the Technology Centre that many extension officers do not attach much priority to encouraging the use of carts. Therefore assume that the actual demand for carts in Arussi with 42,000 potential users is about 250 units per annum. For a total of 300,000 potential rural users, this equates to a demand for about 1,785 carts per annum purchased by individual households.

Another form of purchase is through peasants´ associations. Through the accumulation of capital from individual members, these have the financial ability to purchase carts, reinforced by the fact that they have access to credit. A further consideration is that, while many individual farmers would have only limited use for carts, common ownership would be a more worthwhile investment, and result in more intensive use.

Based on an average membership size of 250 farmers, the 200,000 households who are potential users of carts equate to 800 peasant associations. The purchase of one cart per annum by 50% of associations would generate an additional demand of 400 units. The total demand for animal drawn carts is therefore estimated at 2,200 units per annum.

3.6.2 **Single-Axle Tractors and Trailers**

There is no real evidence available of the potential demand for single-axle tractors and trailers in Ethiopia. As the data in Table 3.5 shows the vehicle does not have very favourable characteristics if assessed as a means of transport, and its use only makes economic sense if the tractor is also used for agricultural operations. The addition of a trailer then extends the usefulness of the tractor, allows it to be used more intensively, and its transportation role can be assessed in terms of the marginal investment involved. Thus the demand for single axle tractors and trailers is dependent on the applicability of the tractor in Ethiopian agriculture. The Ministry of Agriculture has recently obtained a batch of 50 single-axle tractors, complete with a range of implements including trailers. These are now being evaluated on an experimental basis on various projects. Low cost mechanisation is a logical next stage of development to animal-draught based agriculture and the formation of farmers´ associations and co-operatives provides the financial base to make small tractors affordable. Initial trials with the single-axle tractor suggests tht it is suitable for cultivating certain types of Ethiopian soil but, as far as is known, insufficient work has been done to demonstrate that it is a suitable technology for Ethiopia. The process of agricultural mechanisation is a complex one, normally involving a variety of inputs, including improved cultivation practices and seed varieties, fertiliser supplies, credit, etc., as well as tractors. The single-axle tractor has made a major impact in certain parts of Asia (in some cases only in certain areas of a particular country), usually for rice cultivation, while in others it has failed to take off. Taking into account the failure of a number of low cost agricultural mechanisation attempts in Africa it is considered imprudent and premature to predict the demand for single-axle tractors and trailers. Logically the lead should come from the Ministry of Agriculture when sufficient investigative work has been done to demonstrate the suitability of the single-axle tractor, and a policy decision has been made to promote its use. If and when that stage is reached there is a good prospect that local manufacture of the tractor, trailer and other implements would be a viable industrial project, as has proved to be the case in several Asian countries.

3.7 Demand Estimate For Service Vehicles

Section 3.3 lists a range of possible low cost service vehicles that might suit requirements in Ethiopia. Of these the two which are least attractive in the establishment of a low cost vehicle industry are the pedal tricycle, and the motor cycle based three wheeler. A pedal tricycle has significant advantages over a bicycle and trailer for carrying passengers. However, the more likely application in Ethiopia is for goods transport. For such use the cycle trailer has very similar operating characteristics to the tricycle, but has the advantages of being somewhat cheaper to produce, and suitable for use with existing bicycles. It is therefore preferable to concentrate initially on developing the use of trailers as a load-carrying adaptation of the bicycle.

As Table 3.5 shows, the two attachments to a standard motor cycle, the sidecar and the van/pick-up, offer similar operating characteristics to the motor cycle based three wheeler. The motor cycle and sidecar has the advantage over other motor cycle based load carrying vehicles of being able to operate effectively in difficult rural conditions. It is therefore proposed, initially at least, to concentrate on the manufacture of attachments to the standard motor cycle to adapt it to a range of service uses. This will serve to increase the demand for motor cycles and is preferable to introducing an additional vehicle, the motor cycle based three wheeler, with a separate manufacturing technology.

The two most likely roles of the motor cycle and sidecar are for the urban movement of passengers, and to provide a goods and passenger service linking rural areas to markets and small towns. In the former role, it would operate in a similar way to the 'gari', but provide a faster service, and have a greater range of travel from the urban centre. Detailed figures of the numbers of 'gari' in use are being obtained by IPS, but in the interim an estimated stock of 10,000 units has been assumed. Vehicles similar to 'gari' have been used to provide passenger services in several countries in Asia. The pattern that typically has occurred is that, as a motorised substitute has been introduced it has replaced the traditional, animal-drawn mode first in the larger urban centres. However, it has generally taken a long time for the traditional mode to be replaced completely. Thus it is assumed that the motor cycle and sidecar would tend to replace the ´gari´ in the peri-urban areas around Addis Ababa, and in the larger towns. In terms of speed and payload, the motor cycle and sidecar has three to four times the transportation capacity of the ´gari´. Thus, replacing half the fleet of ´gari´ over a five year period would generate a demand for about 300 motor cycles and sidecar attachments per annum. The other role for this vehicle is to operate in the rural areas around the small towns. There are about 300 small towns/markets of less than 2,000 people, and the same number with population of 2,000 - 30,000 people. The use of motor cycles and sidecars in this application is likely to take time to develop, and the demand is difficult to predict. An initial estimate has been made as follows:

One vehicle per annum in the larger small towns	300 units/annum
One vehicle per annum in 50% of the smaller towns	150 units/annum

Thus the total initial demand for motor cycles and sidecars is estimated at 750 units per annum. Since ´garis´ will continue in use for some years, it is feasible for the proposed low cost vehicles industry to supply the wheel/axle assemblies for these, while production of the rest of the vehicle remains with the existing small workshops. Manufacture of wheel/axle assemblies fits in well with the production of the same items for animal-drawn carts. Based on the continued useage of about 5,000 gari, and a working life of ten years, there is an annual demand for about 500 wheel/axle assemblies per annum.

The van/pick-up attachment to the standard motor cycle is only suitable for urban and peri-urban use, but provides a low cost commercial vehicle suitable for a range of cargo carrying needs in the private sector, and in government agencies. Demand is very difficult to predict, but a figure of 250 units per annum has been assumed.

The Basic Transport Vehicle (BTV) is different from the other options considered here in that it is a direct substitute for conventional motor vehicles. It has the same operating characteristics as a conventional light commercial vehicle, but offers some saving in cost (20 - 25%). Thus, its role in Ethiopia would be as a direct substitute for conventional light commercial vehicles, with the potential for assembly with some local content. Table 3.21 details motor vehicle imports for the period 1971 - 1983. These show that the vehicles for which the BTV could substitute (lorries of less than 1500 kg payload and buses with less than 15 seats), have only been imported in small quantities in recent years. However, analysis on the basis of its most likely uses indicate a higher potential demand.

i) the fleet of about 4,000 blue taxis in Addis Ababa is very old. The BTV is used to provide similar services in cities in other countries. Replacement of the existing fleet of blue taxis by BTV over a five year period would yield an annual demand of 800 units.

TABLE 3.21: MOTOR VEHICLE IMPORTS

	Passenger Cars	Four Wheel Drives	Lorries < 1500 kg Pay Load	Lorries > 1500 kg Pay Load	Buses < 15 Passengers	Buses > 15 Passengers	Total
1971	2,762	586	129	517	25	160	4,179
1972	1.929	525	142	591	127	66	3,380
1973	*	*	*	*	*	*	*
1974	2,500	565	138	673	26	100	4,002
1975	1,732	627	273	691	106	96	3,525
1976	1,706	583	247	472	22	74	3,104
1977	1,175	1,142	452	514	2	55	3,340
1978	688	1,198	407	1,512	20	173	3,998
1979	507	1,035	165	628	14	21	2,370
1980	487	1,067	212	688	4	62	2,520
1981	590	691	79	1,247	+	65	2,672
1982	1,156	1,321	59	832	*+	57	3,425
1983	1,152	959	182	942	+	99	3,334

* No Data Available
+ Included With Larger Buses

The more conservative assumption of replacement over ten years gives an annual demand of 400 units;

ii) a second likely role for the BTV is to provide inter-urban bus services. There are currently just over 3,000 registered small buses (Table 3.2). Assuming a ten year life gives an annual replacement demand of 300 units.

Given the other possible uses of BTV as light commercial vehicles in the private sector, and by government agencies, the figures suggest there is a total potential demand of 1,500 - 2,000 units per annum.

3.8 Capacity of Plant

The present study is in some respects unusual. The proposed project is not an attempt to substitute imports by locally manufactured products, nor is it intended to generate foreign exchange by the export of processed raw materials. Rather the study has been perceived in the context of creating a demand for vehicles which are unknown, or are used only to a limited extent at present, because of their potential to improve the transportation system in Ethiopia. Consequently the study has broader implications than simply an industrial project. It is also concerned with the definiton of, and changes in, government policies and strategies for the development of a transportation system appropriate to the economic and social conditions in Ethiopia. This has important implications for the execution of the study:

i) the selection and specification of the products to be made in the factory is a key issue;

ii) estimates of demand are imprecise because they have to be based on a number of assumptions, rather than relying primarily on import statistics or present consumption data;

iii) demand is sensitive to actions that might be taken by government to encourage the use of the vehicles.

It is also unusual to establish a single plant to manufacture the range of vehicles, although the approach is sensible given the objectives of the project. As will be shown, there are several good reasons for proposing a single plant to manufacture different types of low cost vehicle.

The role of low cost vehicles in a country such as Ethiopia is primarily to provide transport over relatively short distances, and for the movement of relatively small loads (compared, for example, with a truck). They fit into the total transport system of the country in two ways:

i) to provide improved transport capability in circumstances where conventional motor vehicles cannot, or realistically will not, for reasons of poor terrain, high cost or non-availability, meet peoples´ needs;

ii) in situations where the use of low cost vehicles is more cost effective, or more economically efficient, than using a conventional motor vehicle.

Both elements are particularly relevant to Ethiopia where the availability of conventional motor transport is limited (in terms both of vehicles and infrastructure), and where the need to conserve, and make the most efficient use of, foreign exchange is of crucial importance. In selecting those low cost vehicles to be made in a local industry, consideration has been given both to the conditions in Ethiopia (and in rural areas to the process of villagisation, and the development of peasants' associations and co-operatives) and to the different transport requirements. Eliminating long distance movement needs for which low cost vehicles are not suitable, the range of products proposed for local manufacture can meet the following needs:

i) movement of rural people, agricultural and household goods, and of extension and other government personnel, in rural areas;

ii) the linking of rural areas to local markets and small towns, both for the movement of goods and people;

iii) the movement of people in and around small and large urban centres;

iv) the movement of goods in and around urban areas.

The range of vehicles proposed offers the potential to make more use of indigenous energy resources for transport by encouraging bicycles and animal-drawn carts. The range proposed is also intended to develop the use of low capital cost, low fuel consumption, motor vehicles where these can meet movement needs more efficiently (in terms of national resources) than larger vehicles. Finally, in identifying low cost vehicles for rural areas, particular attention has been given to those that can be used away from the engineered road network on earth tracks, footpaths etc. The use of such vehicles would mean that the development of the rural transport system in Ethiopia is not totally dependent on the extension of the engineered road network and the maintenance of the existing roads.

Although it is difficult to make precise estimates of demand it is necessary, in order to identify the appropriate design and production technologies, and to determine the level of local content that can be achieved, to define a capacity for the plant. Based on the demand estimate, the detailed engineering analysis has been carried out on the basis of an annual capacity, on a single shift basis, of:

Bicycles	12,500 Units
Motor Cycles	5,000 Units

Animal Carts	4,000 Units[1]
Bicycle Trailers	1,000 Units
Motorcycle Attachments	1,250 Units

These figures allow, for each of the vehicle categories, some excess of plant capacity above the estimated demand. The output of motor cycles includes those to be used with attachments. The output of animal carts includes ´gari´.

Although a key objective of the project is to create demand for means of transport appropriate to Ethiopian requirements it is considered desirable that:

i) the plant should commence production with a limited range of vehicles rather than including a wide range of different technologies. This is important to ensure that the integrated plant is manageable, and that reasonable economics of scale are reached in production. It is for this reason that emphasis is placed on the manufacture of attachments to bicycles and motor cycles, to adapt them to different uses, rather than widening the range of "special purpose" technologies;

ii) the plant capacity should not be set at an unrealistically high level in the hope that, simply by producing large numbers of low cost vehicles, their widespread use will be ensured.

However, as low cost vehicles become more easily available, as measures to encourage their use are applied, and as people become more aware of the potential of those means of transport which are new to Ethiopia, demand will increase and new requirements will emerge. In particular one can expect a significant increase in demand for the innovative, passenger and cargo carrying vehicles as they become established. It is therefore important that the proposed plant should be planned so that it has the capability to:

i) increase production in response to demand;

ii) alter the mix of products manufactured to meet changing requirements;

iii) introduce new types of low cost vehicle as specific needs are identified;

iv) develop local design innovations, rather than simply introduce vehicles used in other countries.

1. For reasons discussed in Chapter 4, it is proposed that the plant should concentrate on the manufacture of the wheel/axle assemblies of carts.

In other words the proposed plant capacity is perceived as providing the basis for the long term development of the use of low cost vehicles as a major, integral part of the transport system in Ethiopia. Three factors are particularly important in ensuring that the plant has the capability defined above:

i) the capacity level is based on single shift operation. Capacity can be nearly doubled by expanding to two shift operation;

ii) the bicycle and the motor cycle are the two most complex technologies, and those which require the greatest capital investment. The production technologies proposed for these vehicles will remain economically efficient for substantial increases in output. For example, if demand for motor cycles doubled from 5,000 to 10,000 units per year, there would, in general, be no advantage in changing the production methods used. Rather at the higher level of output the priority would be to invest in additional equipment to increase the local content;

iii) the manufacture of the different vehicles in an integrated plant is important in maximising the local content that is viable at the output levels proposed, since many of the production facilities will be shared by different products. However, it also has other advantages. First, it means that the focus will be on the supply of low cost vehicles as a entity, rather than on a single product. Second it provides the flexibility to change the mix of production, to increase output of one vehicle, reduce output of another, or introduce an additional design, as demand dictates. An important contributor to this flexibility is that many of the production operations use standard manufacturing equipment rather than high output special purpose machinery. Thus it is easy to alter the mix of products, and it is possible to increase output by incremental stages (eg. by the purchase of additional items of equipment or the employment of extra staff), rather than by the installation of a second production line to double capacity. This flexibility is greatest for cargo and passenger carrying vehicles which are new to Ethiopia and for which the demand levels are least certain, but are most likely to grow as the vehicles become more familiar. Finally an integrated plant provides the basis for developing expertise in the technology of low cost vehicles and thus the capability to adopt or design vehicles to suit local requirements.

Reference was made earlier to the sensitivity of demand for low cost vehicles to measures to encourage their use. There are several aspects to this.

i) it is important that the plant is established with a marketing capability and strategy to maximise the sales of the low cost vehicles, and a distribution system to ensure that they are made available throughout the country. Since some of the proposed vehicles are new to Ethiopia it will be necessary to generate awareness of their availability, their capability, and their applications;

ii) a major factor in the acceptance, and longer term expansion, of the use of low cost vehicles will be the development of spare parts distribution network and of the capability to repair and maintain the vehicles. One of the factors taken into account in selecting the range of vehicles to be produced is the ease with which maintenance capability can be developed;

iii) in implementing a policy that develops the role of low cost vehicles in the transport system, there are a variety of specific measures which the government can take to stimulate their use. There are precedents in other countries for government to take an active role in stimulating the use of low cost vehicles. For example, in both China and Vietnam, in order to encourage the use of non-motorised means of rural transport, industries were established to produce cheaply and in large number, and to distribute to rural workshops, standard engineered components (wheels/ bearings/axles) for animal carts, handcarts and wheelbarrows. In India, between 1960 and 1975 rapid growth in the use of motor cycles and motorised three wheelers was achieved while the stock of conventional motor vehicles grew only slowly. This was accomplished by measures to stimulate manufacture of the former, while restricting output of the latter.

The establishment of a low cost vehicles plant is a key element in developing their use, but there are other measures that Government can take:

* the demand for low cost vehicles in a low wage economy is very sensitive to price. The production of these vehicles in a public sector plant can result in a significant reduction in sales price. However the final price will depend on the level of profit margin determined for the plant, and whether it is considered worthwhile to subsidise the cost of certain vehicles as is done with the small number of carts currently produced at Assela Technology Centre. In estimating sales prices, full allowance has been made for import duties on bicycle (15%), motor cycle (40%) parts and imported raw materials and for municipal, transaction and excise taxes. A reduction in duties on imported parts for locally produced vehicles would lower sales prices, particularly for the motor cycle and load carrying adaptations based on it;

* given the low income levels in Ethiopia, the demand for any type of low cost vehicle will be

sensitive to the availability of credit for its purchase. The development of a credit facility that makes loans available to individuals, farmers associations and co-operatives for the purchase of load carrying low cost vehicles would stimulate demand. For the basic personal means of transport, the bicycle, credit schemes could be developed through factories and labour unions;

* the government can stimulate demand, and set the pattern for encouraging low cost vehicles by making the maximum use of them for its own operations;

* in the short term, use of low cost vehicles must be based on existing infrastructure. However, as use of low cost vehicles increases, and their roles are clearly defined, infrastructure can be developed to suit their requirements, rather than focussing solely on the construction of roads engineered for conventional motor vehicles. For example, in rural areas where the use of animal carts to link villages to markets is appropriate, low specification but well engineered cart tracks can be developed in preference to more expensive motorable roads;

* it is important to ensure that the use of low cost motor vehicles is not constrained by legislation (e.g. licencing, operating restrictions etc.) introduced before such vehicles become available, which does not take their use into consideration.

It should be noted that the capacity of the proposed low cost vehicles plant has been determined on the basis of domestic consumption. While there is some potential for exporting some of the products for the plant:

i) it is likely to be a long term development;

ii) at this stage it is difficult to predict a realistic level of exports;

iii) a number of other countries in the region which are potential markets already have, or have the capacity to develop, local assembly/manufacturing industries for bicycles, and for motor cycles and carts.

3.9 Basic Transport Vehicles

In the discussion of demand, reference was made to the potential for Basic Transport Vehicles (BTV). They have not however, been included in the capacity of the proposed plant, for two reasons:

i) in the terms in which the study is perceived, it is questionable whether BTV's are 'low cost' vehicles. The focus of the study is on means of transport which are much cheaper than conventional motor vehicles (25% of the cost or less) and have quite different operating capabilities. The reasons for examining the potential of low cost vehicles are largely related to these distinctive characteristics. The BTV on the other hand is a somewhat cheaper version of, but has essentially the same operating capabilities as, a conventional light commercial vehicle.

ii) the manufacturing technology of the BTV does not fit with the other vehicles selected. It is a much larger, and heavier vehicle, and has different requirements in terms of manufacturing plant, material handling equipment, assembly methods and painting facilities. It would fit more easily into a facility such as the AMCE factory, or the bus assembly plant in Asmara rather than the proposed low cost vehicles industry.

However, the BTV is worthy of further consideration in Ethiopia. There is clearly a role for light commercial vehicles which could be fulfilled by the BTV. It could be made available more cheaply than a conventional vehicle, and could be produced with a significant level of local content. The automotive sector in Ethiopia at present consists of truck, bus and tractor assembly, all of which are in the process of expansion, and a very limited ancillary components industry. In this study the production of motor cycles and other low cost motor vehicles is being examined. The gap that remains, in terms of the development of a coherent automotive sector, is light commercial vehicles. The production of BTV's would fill this gap and, in conjunction with the other initiatives, stimulate the development of the ancillary components industry.

4. DESIGN AND PRODUCTION TECHNOLOGY

4.1 Bicycle

4.1.1 Design Technology

There are a range of types of bicycle in different parts of the world, for a variety of different applications. The characteristics of the main types of adult bicycle are summarised below[1].

Roadster Bicycle

This is the conventional general purpose bicycle used for personal transport and, in developing countries, for load carrying. The bicycle has an upright riding position with horizontal handlebars, and 26 or 28 inch diameter spoked wheels with 1 3/8 or 1 1/2 inch tyre section. Male models have a diamond frame, female models a double down tube frame. The frame is made from steel tube and is normally of lugged and brazed, but through sometimes welded, construction. The bicycle is fitted with rod or cable operated rim brakes, though in some countries hub brakes or back pedalling rear brakes are used. The chain drive transmission is either single speed, or has a three speed hub gearbox. The bicycle is fitted with full mudguards.

Sports/Racing Bicycle

This bicycle is designed for recreational and competition use and the emphasis is on light weight and high efficiency. It has drop handlebars, allowing a crouched riding position. Wheels are normally 27 inch diameter, with 1 1/4 inch tyre section, on aluminium alloy rims. Male models have a diamond frame, female models either a double down tube or a cantilever frame. The frame is made up of high strength alloy steel tubes, usually butted at the joint ends, and is of lugged and brazed construction.

The bicycle is fitted with cable operated rim brakes. Multi-speed derailleur type transmission is used with 5 - 12 speeds. Lightweight alloy transmission components are common.

Small-Wheeled Bicycle

This type of bicycle has become increasingly common in industrialised countries in recent years, for general purpose personal transport. It has an upright riding position with horizontal handlebars and the wheels are 16 - 20 inch diameter with 1 3/8 inch tyre section. The frame is of H or step-through configuration and is suitable for both male and female riders. The main frame is made from

1. Note: It remains standard practice to specify many features of bicycles in inch rather than metric dimensions. Inch dimensions are therefore used in these descriptions where appropriate.

relatively large section tube and is usually of welded construction. Cable operated rim, drum or coaster brakes are fitted and the transmission is either single speed, or incorporates a three speed hub gearbox. The bicycle is fitted with full mudguards. There are various adaptations of this category of bicycle, including folding versions.

All-Terrain Bicycle (ATB)

This type of bicycle is a relatively recent development, and evolved originally in America, for "off-road" recreational use on tracks and trails. It has a fairly upright riding position with horizontal, but very wide, handlebars. The wheels are 26 inch diameter, but with wide 2 1/4 inch section tyres. The frame is a diamond type, but of heavy duty specification using high quality steel tube. The bicycle has cable operated rim brakes, and a derailleur gear transmission system with up to 18 speeds, including low ratios for difficult or steep terrain.

In addition to these adult bicycles, childrens and juvenile models are produced most of which are simpler and lower specification versions of the adult types. However, a juvenile bicycle that has become popular in recent years is the BMX. It is intended for play and sporting use, and is of heavy-duty construction. It has a lozenge (essentially a squashed diamond) frame and has generated several innovations, most notably:

* reinforced thermoplastic moulded wheels;
* use of oval, rather than round, section main frame tubes;
* constant, circular cross section front fork blades, with leading fork ends.

The pace of development of product technology in the cycle sectors is much slower than in the automotive or motor cycle industries. Much of the development has focussed on new, specialised products such as BMX and ATB bicycles and on the refinement of the sports bicycle for the enthusiast. The evolution of roadster and small-wheeled bicycles, which in world terms constitute the major part of the total market, and which provide practical transport, has been relatively slow. The most significant innovation in the last thirty years has been the emergence of the small-wheeled category. There have been many other attempts at innovation which have either failed, or found only a very limited market. Examples of such unsuccessful modifications include:

* the use of suspension on front and rear wheels;
* transmission systems which avoid the use of pedals and chain;
* continuously variable chain drive transmissions (as an alternative to hub or derailleur gears);
* disc brake;

* plastic and aluminium as alternatives to steel tubes for frames;

* puncture proof or puncture resistant tyres.

In Ethiopia the primary demand for bicycles is as a basic, durable means of transport, often on poorly surfaced or rough roads. A bicycle is an expensive purchase for most Ethiopians, and therefore the specification selected must be robust and have a long useful life of ten years or more. However it is important to keep the price low in order to bring the bicycle within the means of as many Ethiopians as possible. Thus the specification selected should provide the optimum mix of low initial cost and high durability.

The most suitable type of bicycle to be manufactured in Ethiopia is the roadster model. Sports bicycles are expensive and specialised, and are not intended for general purpose personal transport or for goods carrying. The small-wheeled bicycle, while well suited to urban personal transport in developed countries, is not a particularly robust model, and the small wheels are a disadvantage on rough or pot-holed roads. The specification of the all-terrain bicycle has certain attractions for use in rural areas, but this type of bicycle is very expensive (250 - 300% of the cost of a typical roadster or small wheeler) and would have only a limited market in Ethiopia.

The roadster category of bicycle encompasses a range of specification options. The major technical issues in defining the appropriate specification for Ethiopia are as follows:

i) Frame Construction

Most roadster bicycles use lugged and brazed frame construction. High quality diamond frames, as typically used on sports bicycles, use butted tubes where the thickness of the tube, (but not the outside diameter) is increased at the ends where joints are to be made. This gives the most efficient brazed joint but is expensive since it requires special tubing. Typical roadster frames are made from standard, welded mild steel tube but with liners inserted at the jointed ends. This gives a similar effect to using butted tube, but is cheaper, and allows the frame to be built from standard steel sections. Some roadster frames are of welded construction. These dispence with the lugs altogether, and the joints are made simply by welding the adjoining tubes. Welded frames have the advantage of reducing the number of components, but the joints are less strong than the lugged type, and the quality of welding is critical. Given the requirement for a durable, robust bicycle in Ethiopia, lugged and brazed joints are preferable.

ii) Brakes, Wheels and Handlebars

The choice of brakes used on the bicycle determines the specification of the wheels and handlebars fitted.

With **rod** actuated rim brakes, the movement of the brake blocks when the brakes are engaged is radially outwards towards the rim. This requires the use of a "Westwood" section rim which has the braking surfaces on its underside. Rod brakes require a handlebar which curves to the rear, so that the handgrips are parallel to the plane of the frame, to provide the necessary mechanical advantage on the lever when the brakes are applied.

With **cable** actuated rim brakes, the movement of the brake blocks when the brakes are engaged is laterally inwards toward the rim. This requires the use of an "Endrick" section rim which has the braking surfaces on the sides. With cable brakes the handlebars can be of any shape. For a roadster it is normal to use "straight" handlebars where the grips are angled only slightly back from a plane perpendicular to the frame.

Drum brakes have the advantage that they are protected from rain and therefore maintain their efficiency in the wet. However they are too expensive to suit the main market for bicycles in Ethiopia.

The back pedalled brake (also known as a coaster brake), is fitted only on the rear wheel. It is operated, as its name suggests, by pedalling backwards. Its advantages are that it is protected from rain, and it eliminates the need for a lever and linkage to operate the rear brake. However, its efficiency depends on the position of the pedals when the brake is applied.

Of the two major options, rod or cable, cable-braked bicycles have the more 'modern' image. However it is proposed that rod brakes be used for the basic specification of Ethiopian bicycle. The main reason is that the Westwood rim is stronger than the Endrick, and takes a wider tyre. (1 1/2 inch rather than 1 3/8 inch section). It is therefore better suited to road conditions in Ethiopia. Based on observation in towns such as Nazareth where bicycles are quite popular, it is also the most common type of bicycle in the country. However it is feasible to produce both rod and cable braked models using identical frames and many common components, in the same factory.

iii) Gearing

Given the terrain in Ethiopia, the use of three speed hub gearbox on bicycles would appear to be advantageous. However, while the three speed hub has been used in some parts of the world for many years, it remains rare in the developing countries of Africa and Asia. Apart from the fact that it increases the cost of the bicycle, the main reason for this is that it is a complex device (based on the epicyclic principle), requires careful adjustment to operate effectively and is difficult to repair.

It is recommended that the basic specification of bicycle to be used in planning the development of an industry in Ethiopia, is a heavy duty roadster bicycle with single speed chain drive, rod brakes, and 28 inch x 1 1/2 inch spoked wheels. This continues to be the most popular type of bicycle in the developing countries of Asia and Africa, and is therefore appropriate to conditions in Ethiopia. There is another reason for selecting this specification. Two of the major sources of product and manufacturing technology for this type of bicycle are India, and the Peoples´ Republic of China, both of which have major cycle industries. Both countries are low cost sources of complete bicycles and components and the use of this type of technology will be a major factor in keeping production costs and sales prices low in Ethiopia. There are several variations on the basic specification:

i) Frame Size

Bicycles are normally offered in a range of frame sizes. Frame size is conventionally measured in inches, along the centre line of the seat tube, from the centre of the bottom bracket axle to the top of the seat lug. Changes in frame size affect only the height, not the length, of the bicycle and are achieved by altering the length of the seat and head tubes.

ii) Ladies´ Frame

The conventional diamond frame is not suitable for use by women wearing skirts. A ladies´ frame has no top tube, but two down tubes.

iii) Double Top Tube Model

A common variation of the standard roadster diamond frame is the fitt.ng of a second top tube, and this model appears to be quite popular in Ethiopia. The second tube improves the strength of the frame, and in particular increases the capacity for carrying loads supported on the cross-bar.

iv) Accessories

There are a range of accessories that can be added to the basic bicycle specification defined above, according to the user´s requirements:

Pump	For inflating tyres.
Bell	For warning pedestrians or other vehicles.
Chain Cover	A chain cover fitted over the upper side of the chain and chainwheel prevents clothes being dirtied or trapped in the chain. A fully enclosed chain case performs this function, and also protects the chain drive from dust. The chain

case can be designed to hold a reservoir of oil to keep the chain lubricated.

Luggage Carrier	A carrier fitted over the rear wheel, and attached to the rear axle, provides a platform for carrying loads.
Stand	A pivotting stand allows the bicycle to be parked easily. The simpler type is clamped to the chain stays and pivots sideways, so that the bicycle is parked at an angle. A second type pivots around the line of rear wheel axle and allows the bicycle to be parked vertically, with the rear wheel clear of the ground.
Lighting Set	The fitting of lights front and rear improves visibility at night and, more important, allows the bicycle to be seen by other vehicles. Lamps can be of the dry battery type, or powered from a dynamo driven by the bicycle wheel. The latter type consumes some of the rider's effort and, unless an accumulator is built into the system, ceases to illuminate when the rider stops (e.g. at a junction).
Mud Flap	Flexible mud flaps fitted at the base of the front and rear mudguards provide additional protection from road spray in wet weather.
Lock	A lock provides security from theft. The most common type is the ring lock, attached to the seat stay, which clamps around the rear wheel rim.
Tool Kit	The provision of a simple tool kit facilitates repair and maintenance of the bicycle.

v) Pedals

The pedal specified is the type most commonly used in developing countries. It consists of two rubber blocks, one each side of the pedal axle. It is durable, but quite complicated to manufacture because of the number of components. For local manufacture, a simpler alternative is a single rubber block with the pedal axle passing through it.

vi) Mudguard

The mudguard specified is typical of Indian practice and again is relatively complicated. The stay assembly consists of a bridge, spot-welded to the mudguard, and two stays each threaded at one end for attachment to the bridge, with pressed tabs at the other end for attachment to the wheel axle. This arrangement allows the set of the mudguard to be adjusted. However, for local manufacture an alternative is to make the stay assembly from a single piece of bent wire.

vii) Colours

Traditionally, the developing country roadster bicycle is painted black. Using only a single colour simplifies control of the painting process, but there is no practial reason why the bicycles should not be offered in a range of brighter colours.

viii)Brake Blocks

The standard rubber brake block, operating on the chrome plated wheel rim, provides effective braking in dry weather. However in wet conditions braking efficiency is greatly reduced. a recent innovation is leather-faced brake blocks, which offer improved wet-weather braking efficiency.

Because of its usefulness as a load carrier, adaptations of the bicycle have evolved in certain countries to increase its carrying capacity. In countries such as Laos and Vietnam it is common practice to carry passengers on a bicycle. To facilitate this, a padded cushion is attached to the rear carrier as a seat, and footrests are provided by extending the length of the rear axle. In Indonesia and Vietnam the strength of the bicycle is increased, to allow a greater weight of cargo to be moved, by reinforcing the front fork, using a double top tube frame, fitting a heavy duty rear wheel rim and tyre, and by increasing the thickness and/or the number of rear spokes. In addition to the rear carrier, another convenient location for placing loads is over the front wheel. Front carriers are available as an accessory, but are attached so that they turn with the front fork when steering.This makes steering control difficult if a heavy load is carried. An adaptation of the roadster model, known as a carrier bicycle, has the front carrier attached to the front of the bicycle frame. A refinement of this is the low gravity carrier which has a smaller (20 inch diameter) front wheel, providing a larger load carrying area.

In summary it is proposed that the development of the bicycle industry in Ethiopia should be based around a standard heavy duty roadster model, produced in a range of frame sizes, with a double top tube frame as an option, a female frame if there is sufficient demand for this, and with a range of accessories available to suit customer requirements. As local manufacturing content is increased there are likely to be design modifications to facilitate production. This basic bicycle can be adapted in the ways described above to increase its load carrying capacity either by offering such options from the factory, or leaving these adaptions to small-scale industries.

While the heavy-duty roadster bicycle will meet the main potential demand - for cheap, basic transport - there is also likely to be some demand for other specifications. It is quite feasible to build these alternatives into the activities of the bicycle industry, both in terms of assembly, and of local manufacture. For example, a cable braked roadster bicycle could be offered alongside the rod-braked model, with most of the components and sub-assemblies common. Similarly coaster brake or three speed rear hubs could be offered as options, though the hubs would have to be imported. As the industry becomes established, the product range can be expanded to include juvenile and sports bicycles if the demand make it economically worthwhile. However, initially it is sensible to concentrate on the heavy duty roadster bicycle, and it is on this model that the production engineering analysis is based. Table 4.1 gives an outline specification.

4.1.2 Production Technology

The bicycle industry is international, with large, medium and small-scale manufacturers in many countries in Eastern and Western Europe, Asia, Latin America, North America and in Africa. The large-scale manufacturers have outputs of up to 3 million units per annum. In developing countries, large-scale cycle industries have evolved in China, India and Taiwan, and they are now significant exporters of both complete products and components to countries in Africa and elsewhere. They have been able to penetrate these markets because of the suitability of their products in other developing countries, and the low cost of their components. The nature of smaller scale manufacturers varies. In developed countries they tend to concentrate on specialist bicycles, buying in most of the components but making the frames in-house. In less populous developing countries of Africa and Asia where small-scale industries have been set up to meet domestic demand (eg. Kenya) as much of the bicycle as is economically viable is manufactured locally, and the remaining components are either puchased from a variety of sources, or supplied by an overseas collaborator. In India a significant small-scale sector has developed, which includes some bicycle manufacturers, and many suppliers of components to the major companies.

The design of the roadster bicycle that will form the basis of the industry in Ethiopia is international. It is produced by several companies in different countries, with only minor, detail design differences.

TABLE 4.1 ROADSTER BICYCLE SPECIFICATION

Frame:	Diamond male roadster, with lugged and brazed joints and detachable seat stays. 19 inch, 21 inch and 23 inch frame sizes. Options: - double top tube frame; - double down tube female frame.
Front Wheel:	28 inch x 1 1/2 inch tyre and Westwood rim; 32 x 14 gauge spokes; 5/16 inch diameter axle; Ball bearing hub with adjustable cone.
Rear Wheel:	28 inch x 1 1/2 inch tyre and Westwood rim; 40 x 14 gauge spokes; 3/8 inch diameter axle; Ball bearing hub with adjustable cone.
Transmission:	Single speed, with 46 tooth chainwheel, 18 tooth freewheel and 1/2 inch pitch by 1/8 inch wide chain; 7 inch cranks with double rubber block pedals.
Handlebar and Brakes:	Roadster handlebar with roller brake levers; Pull-up rod-actuated rim brakes on front and rear wheels; Rubber brake blocks.
Mudguards:	Full length steel rolled mudguards with adjustable stays.
Saddle:	Fully sprung leather saddle.

Accessories to be offered:

chain cover
pump
bell
lighting set
carrier
stand
lock
tool kit
mud flaps

The three most likely sources of technology for Ethiopia are China, India and Taiwan, simply because their costs are significantly lower than other countries. Of the three Taiwan should be discounted because the quality of its products is generally poorer than the other two. The production technology of bicycle manufacture is to a large extent international although in high wage developed economies it is more capital-intensive than in, for example, many of the Asian industries. However, there is one signficant difference in the production technologies available from China and India. The Indian industry has a substantial small-scale sector within which production methods, special-purpose machinery and tooling have been evolved to allow efficient manufacture at relatively low outputs. The Chinese industry, on the other hand, is primarily large scale. Given that the two design technologies are identical, India therefore offers the more appropriate source of production technology for conditions in Ethiopia[1]. However, it is prudent to investigate both options before making a final decision.

It would be possible to develop a bicycle industry in Ethiopia without a formal collaboration agreement with an overseas source of technology. Components could be purchased from the world market and assembled locally and, over a period of years, local manufacture could be developed. However, collaboration with an overseas source of technology has significant advantages:

i) it ensures the supply of components to consistent dimensional standards, which can be assembled into complete bicycles without problems, and which will be compatible with locally manufactured parts;

ii) it provides the "know-how", the training capability and the source of special-purpose machinery and tooling, to develop the local content of the bicycles as rapidly as possible.

Thus a technical collaboration agreement with an overseas manufacturer need not involve the production of their product, using their brand name. Rather the agreement would cover the following elements:

i) the supply of imported components, to an agreed pricing structure, for a fixed period of time;

ii) the provision of "know-how" and the supply of special-purpose machinery and tooling to an agreed programme for developing local content;

iii) the provision of training in production methods and quality control.

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1. The Chinese have made a preliminary proposal to establish a bicycle assembly plant in Ethiopia. However, the proposed output is high (50,000 units per annum) and there is no indication that it would develop from assembly to local manufacture.

The programme for development of local content should include provision for adapting technology, or using alternative technologes for specific processes, where appropriate. Also the items of **standard** manufacturing equipment required need not be sourced from India but can be purchased on the world market.

Once the planned level of local content is achieved and technical expertise has been developed in the Ethiopian industry, the need for overseas technical collaboration will cease, and components can then be sourced from the world market on the basis of competitive bidding. The collaboration agreement should therefore be for a fixed period of time. However it may prove appropriate to extend the collaboration, and increase the level of local content further, as demand increases to justify this.

4.2 Motor Cycle

4.2.1 Design Technology

The term motor cycle embraces a range of products which can be classified in broad terms (though there is a degree of overlap between categories) as follows:

Power Assisted Bicycles

Such devices have a long history in I.. ›pe, though thier use is now rare. Two Indian manufacturers have developed 35 cc petrol engine and transmission assemblies which can be attached to a standard bicycle. The resulting machine is "power assisted" in that the rider pedals to build up speed, which in turns starts the engine. Similarly under high load conditions (eg. travelling uphill), the rider must pedal tc assist the motor. This device constitutes the cheapest form of "motor cycle" but involves a considerable degree of compromise. The higher travel speed allowed by the engine, and its vibration, tend to cause damage to other parts of the bicycle, particularly front wheel and forks. A variation on this approach is the bicycle assisted by an electric motor, which is finding a minority market in Europe and the USA.

Velo-Solex

Velo-Solex is a French trade name which describes a vehicle similar in configuration, through different and stronger in form of construction, to a bicycle. Mounted on a frame above the front wheel is a small petrol engine driving a friction roller which in turn drives the front wheel. The rider starts the vehicle by pedalling. He then engages a lever which lowers the drive roller on to the front wheel. This starts the engine which then propels the vehicle. Thus the Velo-Solex is motor assisted. Velo-Solex motor cycles are very common in France, in part because they are exempt from many of the age and safety restrictions on the riding of conventional motor cycles. They have also become quite popular in Francophone areas of Africa and Asia.

Moped

The name moped derives from the fact that it is a **motor** and **pedal** driven vehicle. Over the past thirty years it has become a popular means of transport in many parts of the world and there has been substantial evolution in design. The basic moped, from which recent developments have evolved, has the following characteristics:

i) semi "step-though" frame, of pressed steel construction;

ii) spoked wheels, about 500 mm diameter;

iii) leading arm front suspension and no, or simple swinging arm, rear suspension;

iv) 49 cc single cylinder two-stoke engine, with single speed chain drive transmission to the rear wheel;

v) auxiliary pedal drive for starting, and for assistance to the motor on steep hills.

The basic moped is less dependent on the pedal drive than the two categories decribed above, and became popular as the cheapest, convenient means of motorised personal urban transport. The limitation on engine size of less than 50 cc was the result of vehicle licencing regulations in some countries, though some of the more recent evolutions in design have engines of 70 or 80 cc. The most important recent evolutions of this basic moped specification are as follows:

i) with increasing power output from small engines (and in countries where the regulations allow it) the deletion of the pedals and the introduction of a kick starter, with a centrifugal clutch to engage the drive to the wheels;

ii) the use of more complex suspension systems, front and rear, including telescopic front forks;

iii) the introduction of two or three speed, usually automatic, transmission systems;

iv) the use of smaller wheels, usually made as aluminium die castings;

v) tubular, rather than pressed steel, frame construction, some of the latest designs being based on a single, large diameter backbone tube;

vi) most recently, the use of belt or shaft drive transmissions, and changes in configuration so that, from the user's point of view, some of the latest designs have many of the characteristics of a motor scooter (see below).

Motor Scooter

The motor scooter was originally developed by the Piaggio Company in Italy in the late 1940's. Usually powered by a 125 cc - 200 cc single cylinder engine, it differs from the configuration of a conventional motor cycle in that it has small wheels, and the engine is in unit with the rear wheel with, in the case of the Piaggio designs, a direct drive. This allows the use of a "step through" frame, witn the riding position closer to that of a car than a motor cycle, and the foot controls on the floor-board, rather than at the sides of the machine. Thus the motor scooter provides a more comfortable, cleaner riding position than a conventional motor cycle.

General Purpose Motor Cycle (100 - 250 cc)

This category includes the basic, low cost, cheap to operate, low capacity conventional motor cycles used to provide convenient transport for one or two people and, in developing councries, with various adaptations, as load carriers. The main characteristics are:

i) conventional layout with the engine behind the front wheel and the fuel tank above it, two seater saddle, straight handlebars and close fitting front mudguard;

ii) air cooled engine, usually single cylinder two-stroke, (though some 250 cc models are twin cylinder);

iii) tubular steel or, for some of the cheaper models, pressed steel frame;

iv) telescopic front forks and swinging arm rear suspension;

v) four or five speed chain drive transmission with manual clutch;

vi) wire spoked wheels and drum brakes, though some of the more "up-market" versions have cast wheels and front disc brakes.

Trail Bike

Most commonly using 100 - 175 cc engines, but with specialist models having capacities over 500 cc, trail bikes are designed for off-road use. The mainstream models are also suitable for on-road use. The main differences from a general purpose motor cycle are:

i) greater ground clearance, achieved by higher mounting position of the engine;

ii) always at least five speed, sometimes six speed transmission with lower overall gear ratios;

iii) different steering geometry (greater rake on front fork) for impoved manoevrability on rough ground;

iv) large clearance between front wheel and mudguard;

v) high mounted exhaust for protection from water;

vi) larger diameter front wheel and wider rear tyre;

vii) "knobbly" tread tyres;

viii) always fitted with drum brakes;

ix) more upright riding position.

The more specialised versions of these trail bikes are intended primarily for sporting rather than practical use, and exaggerate the characteristics of the mainstream models. Some developments from these specialist models are now being introduced on the mainstream models, most notably in rear suspension design with the use of a single, remote-mounted shock absorber unit.

Large Capacity Motor Cycle

This broad category of motor cycles with an engine capacity of greater than 250 cc is aimed primarily at enthusiastic and specialist markets. There are a variety of different designs to suit differnt tastes (traditionalist, sporting, touring). The machines become more powerful and heavier with increasing engine size, and it is in this category that the more sophisticated design features are most commonly applied (eg. cast wheels, single and double disc brakes, liquid cooling, electric starting, shaft drive etc.).

In the developing countries of Africa and Asia, the demand is predominantly for the lower cost, more economical, motor cycles of under 250 cc capacity. It is on such motor cycles that this analysis focusses, though it is recognised that there is a limited demand for more specialist machines. For example, the Ethopian traffic police use large capacity, shaft-driven BMW motor cycles.

Whether viewing the motor cycle market as a whole, or focussing only on those sectors of particular relevance to Ethiopia, there have been major advances in design technology in the past fifteen years. The first, and most important, development is the increase in both performance and fuel efficiency of a typical motor cycle of a given engine size. This has happened for two reasons:

i) reduction in weight resulting from greater use of light alloys in engines, and industrial plastics and high strength steels in the frame and body;

ii) developments in engine and carburettor design, resulting in higher specific power outputs and fuel efficiency.

Other developments have made motor cycles more convenient, safer to use, or easier to maintain:

* variable or automatic transmission for moped;
* electric starting;
* separate oil tank and pump for two-stroke engines;
* high wattage magneto which gives high output at low speed;
* directional flashers, and sealed beam headlights;
* easily readable instrumentation;
* electronic ignition;
* chrome plated cylinder walls for low wear;
* non-corroding petrol tanks.

4.2.2 Evolution of Motor Cycle Manufacture

Until the mid 1950´s the manufacture of motor cycles was dominated by European makers with a significant, but more specialised, industry in the United States of America. Motor cycle industries continue, in some cases on a reduced scale, in many European counties (including Italy, Austria, West Germany, East Germany, Holland, France, Russia and Czeckoslovakia) but the market has come to be dominated by the four major Japanese manufacturers - Honda, Kawasaki, Suzuki and Yamaha - who are now responsible for 70% of the world´s total production of motor cycles. Between 1945 and 1960 there were significant design innovations in Europe, including the introduction of new types of motor cycle such as the scooter and moped. While technical innovation in Europe has continued, it has become more specialised as the companies have focussed on particular market areas. It is now only the Japanese manufacturers who produce popular, reasonably priced motor cycles in all the market segments. Further, the lead in technical innovation has in many respects passed to the Japanese particularly in terms of production technology, and the evolution of more efficient, higher performance, competitively priced machines in the popular market sectors.

Motor cycle industries have evolved in a number of developing countries. In India, where domestic production has grown from 7,500 units in 1960 to 163,000 in 1974 and an estimated 900,000 in 1984, it is possible to identify three distinct phases of development:

i) India established its motor cycle industry by the purchase of technology from Europe (scooters from Italy, motor cycles from Poland and UK). The technology purchased included manufacturing equipment and tooling for obsolete models no longer produced in their country of origin. Production rapidly moved to 100% local content;

ii) from the base established in Phase I, the market for mopeds (as a lower priced option for urban transport) was developed in the 1970's, either by the copying of designs or design features from foreign products;

iii) Phases 1 and 2 were both implemented during a period when the Indian government imposed strict limits on foreign financial involvement in domestic industry, and on the import of components and raw materials. The government controlled production of motor cycles through the issuing of manufacturing licences to various companies which specified maximum output. However, by the end of 1970's it was apparent that the models being produced were very out-dated, and that this had significant economic disadvantages. As a result of the loosening of Government controls on the import of technology and components, and on foreign collaboration, a number of projects have now been established in India to manufacture contemporary, overseas designs of motor cycle. The companies now manufacturing, or about to start production, in collaboration with Indian industries, include:

Honda	- Japan	- Motor Cycles and Scooters
Kawasaki	- Japan	- Motor Cycles
Suzuki	- Japan	- Motor Cycles
Yamaha	- Japan	- Motor Cycles
Zundapp	- West Germany	- Mopeds and Motor Cycles
Piaggio	- Italy	- Scooters
Garelli	- Italy	- Mopeds
Peugeot	- France	- Mopeds
Motobecane	- France	- Mopeds

Two significant features of this third phase of development are:

* whereas the old models had Indian brand names, the new products incorporate the name of the overseas collaborator eg. the Suzuki model is known as the Ind-Suzuki;

* the new products will rely on a proportion of imported components, at least for the first few years of manufacture.

The Philippines has developed a motor cycle industry with an output, prior to the financial crisis of late 1983, of about 50,000 units per annum. The industry was initiated by means of private joint ventures between Filipino companies and the four major Japanese manufacturers, with motor cycles being imported in knocked down form for local assembly. From 1973 the Government took more control over the industry by establishing the Progressive Motor Cycle Manufacturing Programme. The objectives of this were to rationalise the range of models and to increase the local value added. All four companies decided to remain in the market by accepting the restrictions imposed, of which the main ones were:

i) model range restricted to motor cycles of 80 cc - 125 cc capacity;

ii) local content to be increased to 50% over five years, with intermediate targets also specified. The Government to have the power to enforce the deletion of certain components from the imported kit of parts.

The targets of the programme were generally achieved, although 50% local content was only reached after six years. However, it is important to understand the definition used for the percentage of local content, which was defined as:

$$\frac{\text{FOB imported spare part value of components made locally}}{\text{FOB value of complete imported motor cycle}} \times 100\%$$

Since the spare part price of a component is always significantly higher than its original equipment cost, this definition over-estimates the real proportion of local manufacture in the motor cycle. Further it takes no account of imported raw materials used in local production of components. Initially the total licensed capacity of the four manufacturers was restricted to 33,000 units, with the smallest having an output of 6,000 units. It should be noted that the restrictions on types of motor cycle produced has been relaxed recently to include mopeds and trail bikes, because of an increasing demand for these products in the Philippines.

A motor cycle industry has been developed in Nigeria by commercial agreements between local and overseas companies. The main overseas companies involved are Peugeot (mopeds) and Suzuki and Yamaha (motor cycles in the 80 cc - 200 cc range). Kits of parts are imported and assembled, with a degree of local manufacture, though the development of local content has been arrested by the difficult economic situation which has reduced demand so that the plants are operating well below capacity.

4.2.3 Appropriate Motor Cycle Technology For Ethiopia

Although it is reasonable to expect that the market for motor cycles will grow over a period of time, initially the output will be low with a planned capacity for the proposed plant of 5,000 units. It is therefore desirable to minimise the number of different models produced, and maximise the commonality of components between them. This will maximise the local content that is economically viable, and facilitate maintenance and the supply of spare parts. The choice of design technology is more complex than for the bicycle since:

i) no single type of motor cycle will cover market requirements;

ii) the specifications of motor cycles vary significantly between manufacturers, between categories of machine, and with engine size (for example, a 175 cc motor cycle, though similar in overall design to a 125 cc model, will be bigger in size and weight, have larger wheels, etc.).

The preliminary market estimate is based on the assumption that the largest demand would be for general purpose motor cycles, trail bikes, and mopeds. Even this limited range of models means that, with a total output of 4,000 - 5,000 units, production of any individual model will be low. In Ethiopia the trail bike must form part of the product range given the demand, from Government and from other sources, for a motor cycle that can be used off-road in rural areas. The general purpose motor cycle is the most suitable to form the basis for load carrying adaptations, and is more appropriate for urban and on road use than the trail bike. It can perform the same urban, personal transport functions as the moped, but at somewhat higher price. It is therefore proposed that initial production in the plant should concentrate on the trail bike and the general purpose motor cycle, but with the moped being introduced into the range as demand increases to justify a third model. Ethiopia, because of its terrain and road conditions is unusual in that trail bikes will form a major part of the initial demand. However, the pattern proposed above is similar to that adopted in both India and the Philippines where in the initial years production focussed on general purpose motor cycles, with the moped introduced subsequently.

In identifying product specifications suitable for Ethiopia, it is desirable to focus on contemporary designs rather than pursuing the option of purchasing redundant technology as was done in India in the first phase of local manufacture. The reason for recommending this is the rapid developments in motor cycle design in recent years, particularly in respect of engine performance and fuel efficiency. In general terms it is desirable that a local motor cycle industry should operate on a long product replacement period except where there is significant benefit from introducing technical improvements, but this makes it more important to initiate the industry with contemporary technology. However, from within the choice of recent motor cycle designs available, the focus should be on simple, robust models, avoiding those new features or accessories whose main function is either cosmetic or to generate increased sales in competitive developed country markets, rather than of offering significant operating benefits in Ethiopia. Thus, for example, machines to be made in Ethiopia should have spoked rather than cast wheels, drum rather than disc brakes, conventional suspension systems (telescopic forks at the front and swinging arm shock absorbers at the rear), kick starters and magneto ignition.

Engine size and type is a major consideration given the high altitude in many parts of Ethiopia. As an approximation the power output of a petrol engine decreases by 1% for each 100m increase in altitude above sea level. This equates to a 25% loss in power output in Addis Ababa though, with a petrol engine the loss can be mitigated by tuning to suit the operating altitude. This implies that, to maintain the operating performance that the particular machine enjoys in other countries, its engine size should be increased in Ethiopia. However, motor cycles generally are produced in specific engine sizes - 100 cc, 125 cc, 175 cc, 250 cc, etc. To jump from 125 to 175 cc is more than is necessary to compensate for altitude power losses and will significantly increase cost (for example, in Ethiopia a 175 cc trail bike is 25% more expensive than a 125 cc model). This is an issue which can only finally be resolved with the overseas collaborator selected for project implementation. At this stage it is proposed that the analysis should focus on a 125 cc trial bike and a 125 cc general purpose motor cycle, but with the engines tuned for operation at altitude. However the moped, with its small engine, has a limited power output and a 50 cc model would have difficulty coping with the combined effects of altitude and steep hills in Addis Ababa. It is therefore preferable to specify a moped of 70 cc or 80 cc engine capacity.

Most motor cycles use two-stroke engines although Honda still produces primarily four-stroke models. A two-stroke engine will give a higher specific power output than an equivalent four-stroke, and is easier to maintain. A four-stroke engine should have longer life, but in developing countries this is compensated for by the lower spares cost and easier maintenance of a two-stroke. Further, on two-stroke engines the fitting of an autolube system simplifies operation, precluding the need to mix petrol and oil. It is therefore recommended that two-stroke engines be specified for Ethiopia. All trail bikes, most motor cycles over 100 cc, and some mopeds, have tubular frames. However, many mopeds and some smaller motor cycles have pressed steel frames and, in the case of the mopeds, pressed steel suspension members. It is recommended that the focus in Ethiopia be on machines with tubular steel frames which are more robust, and offer better prospects of local manufacture.

Table 4.2 gives recommended outline specifications for a trail bike and general purpose motor cycle for manufacture in Ethiopia, based on the products of likely sources of technical collaboration. The motor cycles must be supplied fitted with a lighting system to meet the requirements of traffic regulations, including front and rear lights, rear brake light and front and rear indicators. They will also be fitted with a small rear carrier since, unlike the bicycle, this is not an accessory but is usually an integral part of the design and provides the mounting for the rear lights and number plate. However the specification should be kept as simple as possible, with items such as windshield and rear view mirrors being offered as optional extras at the choice of the individual customer.

It is unrealistic to expect Ethiopia to establish an indigenous motor cycle industry without some form of technical collaboration with an existing overseas manufacturer. The form of collaboration will be rather different from that for bicycle production since the details of motor cycle design are specific to a particular manufacturer. The arrangement would therefore be for the local industry to assemble/part manufacture the product of the overseas collaborator in Ethiopia. This has certain implications:

i) the collaborator will wish to impose certain restrictions on export of the machines, to avoid conflict with agreements with agents, or local industries, in other countries. However, the collaborator might perceive Ethiopia as a base from which to penetrate certain overseas markets;

ii) the collaborator will wish to have its name on the machines produced in Ethiopia, possibly in conjunction with a local name (cf. Ind-Suzuki in India). It will also wish to exercise some control over the quality of the machines produced in Ethiopia, and particularly of the locally manufactured components. Ideally this should be achieved through training and technical assistance in quality control and in the introduction of local manufacture of components.

While a joint venture arrangement would provide part of the financing for the proposed plant, it is not essential for the collaboration to take this form, and in fact it is likely to be difficult to set up the industry in this way given that it will be producing other products apart from motor cycles. The collaboration agreement would have to cover the following aspects:

i) the licensing to the Ethiopian industry of the rights to assemble/part manufacture the motor cycles, and market them in Ethiopia and other agreed locations;

ii) the long term arrangements for setting the price of imported parts. This is important to avoid unjustified price increases once the industry is tied to a particular source of technology;

iii) the provision of training and technical assistance in production, quality control and the development of local content;

iv) an agreed programme on the level of local content to be achieved, the means by which it will be reached and the time-scale.

The details of such an agreement must obviously be negotiated as part of the project implementation process. Although the present size of the market is small, the incentive for the overseas collaborator is the opportunity to hold the leading position in the market as it develops.

While the local industry will be based on standard products from the collaborator, there is scope for adaptation of these designs to suit conditions in Ethiopia. The issue of engine tuning for altitude has already been discussed but other possibilities include:

i) reinforcement of the chassis frame and modifications of suspension settings; (as is done in the Philippines to suit use with sidecars);

ii) modifications to the design of some components to suit locally appropriate manufacturing methods and locally produced raw materials (as has happened in India as part of recent technical collaboration projects).

The possible sources of technical collaboration are motor cycle manufacturers in Western and Eastern Europe, and in Japan. Other, emerging industries such as that in India are not direct possibilities since they are themselves linked with overseas collaborators and would not make any input without approval. Western

TABLE 4.2 OUTLINE MOTOR CYCLE SPECIFICATIONS

	General Purpose	Trail
Engine:	-single-cylinder air-cooled 2 stroke -125cc capacity -rotary valve -flywheel magneto ignition -kick start -autolube lubrication system	-single cylinder air cooled 2 stroke -125cc capacity -rotary valve power output > 9kw -flywheel magneto ignition -kick start -autolube lubrication system
Transmission:	-4 speed constant mesh gearbox -wet multi-disc clutch -chain drive	-5 speed constant mesh gearbox -wet multi-disc clutch -chain drive
Chassis:	-tubular single cradle frame -telescopic front fork -swing arm rear suspension with oil dampers -cast drum brakes front and rear -spoked wheels each with 36 butted spokes -identical size tyres front and rear, either 3.00x16 or 2.75x18	-tubular single cradle frame -telescopic sprung front fork -swing arm rear suspension with coil springs over oil dampers -pressed drum brakes front and rear -spoked wheels each with 36 butted spokes -front tyre to be larger and narrower than rear
Features:	-steel, close fitting mudguards -headlight, rear light, brake light and turn indicators -rear carrier -2 person saddle	-plastic, high rise mudguards -high mounted exhaust -headlight, rear light brake light and turn indicators -rear carrier -2 person saddle

European and Japanese motor cycle design technology is in advance of that of Eastern Europe, but the deciding factor in the selection of collaborator is the key role of trail bikes in Ethiopia. While some European manufacturers produce trail bikes, most notably the Italians, they tend to be specialised, high priced models. The market for "mainstream", reasonably priced trail bikes is dominated by the four Japanese companies. While it is worth investigating the prospects of collaboration with an Italian company it is most likely that the source of technology will be Japanese, particularly since at this stage it is sensible to collaborate with a single company on the range of models to be produced.

4.3 Animal Cart

4.3.1 Evolution of the Technology

The animal-drawn cart is different from the other vehicles in this study in that it has been in use in some parts of the world for hundreds or even thousands of years. It is also the only low cost vehicle currently made in Ethiopia. Animal-drawn two-wheeled carts and four-wheeled wagons were the mahor means of road transport in Europe and America for several centuries until the introduction of the internal combustion engine and the widespread use of motor vehicles in the early years of the 20th century. However animal drawn carts remain in everyday use in some low-income areas of Europe. European carts and wagons were constructed largely from wood with large diameter spoked wheels made by skilled wheelwrights.

In parts of Asia the animal cart, drawn be a pair of bullocks, has been in use for thousands of years. In a country such as India, which has over 15 million carts, the traditional wooden cart, made by village carpenters with large diameter, spoked wooden wheels that very in design in different parts of the country, remains most popular. However in the 1930's the Dunlop company in India introduced the ADV (animal-drawn vehicle) wheel/axle assembly. This is fitted with pneumatic tyres, similar in appearance to those used on motor vehicles, but designed specifically for animal carts. Because carts move only slowly, and the wheels transmit no torque, the tyre can be of a lower specification than for a motor vehicle, with different tread, ply material and rubber compounds. Consequently the ADV tyre is about half the price of a comparable motor vehicle tyre. The ADV tyre fits on a steel wheel rim, which turns on tapered roller bearings mounted on a square section steel axle. An Indian cart built using an ADV wheel/axle assembly typically costs about twice as much as the traditional wooden type but, with a given pair of animals can move two to two and a half times the load and travel at a somewhat higher speed, except on very muddy tracks. The market for the ADV cart has developed only slowly, primarily in places where there is substantial commercial carting (e.g. sugar growing areas) so that the owner obtains a direct return from its higher efficiency, and in the most progressive farming areas. In areas where the small farmer wants the cheapest possible cart, to move limited quantities of goods, the traditional wooden cart remains most common. However the ADV cart continues to expand its share of the market, a process assisted by the fact that timber is becoming increasingly expensive in some parts of India, so that the cost advantage of the traditional cart is diminishing.

In China wooden carts have also been used traditionally for many years. However as part of its policy of encouraging the use of non-motorised means for short distance rural transport (up to 20km), the government established the centralised manufacture of pneumatic-tyred wheel/axle assemblies in the 1960's. These assemblies were distributed to small workshops for building into complete carts.

In Africa, the traditional use of animal-drawn carts is much less extensive than in Asia. In recent years there have been several efforts to develop the use of animal-drawn carts for rural transport, usually in conjunction with programmes to expand the use of draught animals in agriculture. Four different approaches can be discerned:

i) the import of complete wheel/axle assemblies, usually through aid or development projects,and the building of these into complete carts, either directly by the project or through local small-scale industries assisted by the project;

ii) the development of cart designs suitable for manufacture by local small-scale industries, and the provision of technical and/or financial assistance to these industries to establish production;

iii) the centralised, medium or large scale manufacture of animal-drawn carts, usually in conjunction with agricultural equipment, for distribution to different parts of the country. A good example of this approach is the Sismar factory, established initially with the assistance of UNIDO, in Senegal;

iv) the commercial development, usually by small private industries and workshops, of cart manufacture, often relying on scrap materials or components (wheels, tyres, hubs or rear axles) from old motor vehicles.

In Ethiopia the horse-drawn carriages used in many urban areas have been made locally for some years. There are detail design variations but typically they are made by small workshops who obtain wheels and bearings from a scrap motor car or motor cycle, adapting these where necessary to fit onto axles produced by private industries in Addis Ababa from reinforcing bar. A simple wooden body consisting of draught poles, seat and floor is built up by the workshop and attached to the axle by means of leaf springs, again obtained from old motor vehicles. Metal brackets for the body are obtained from small metalworking industries.

The Rural Technology Centre at Assela, which comes under the Ministry of Agriculture, has established the small-scale manufacture of ox and donkey-drawn carts (see production figures in Chapter 3). These use fabricated steel wheels made by the Ethiopian Metal Tools Factory, which run in wooden bearings mounted on the frame. Each wheel is mounted independently, its axle running in two bearings, one on each side of the wheel.

Originally the complete frame and body was made in wood, but more recently a steel frame has been introduced. It is clear that the technology of these carts is not yet fully developed, the draught efficiency is low, the bearings wear rapidly, and the wheels are prone to breakage. Recently a small number of wooden carts, with large diameter spoked wooden wheels, have been made at the Centre as a demonstration by Korean artisans.

4.3.2 Appropriate Cart Technology for Ethiopia

The market in Ethiopia includes the continued supply of horse-drawn carriages to urban areas and, more important, the use of animal carts for rural transport, drawn by a donkey or a pair of oxen. Draught oxen are widely owned in Ethiopia but at present are used only for agricultural operations. However there is no reason why the same animals should not be used to pull carts, as is done in many other countries. Work donkeys are used only as pack animals but again there is no reason why they should not be trained to pull carts. At Assela there is more demand for ox than for donkey carts. In Ethiopia the demand will be for two-wheeled carts rather than four-wheeled wagons, the latter being much less common worldwide, expensive, limited to use on reasonable quality roads and only suitable for the commercial hauling of large loads.

It is proposed that the role of a low cost vehicles industry under the National Metal Works Corporation should be the centralised manufacture of wheel/axle assemblies which would be distributed to different parts of the country for building into complete carts, either by technology centres, such as that at Assela, or by small-scale industries. There are several reasons for proposing this:

i) the wheel/axle assembly is the most complex engineered element of the complete cart. The availability of good quality, well designed wheel/axle assemblies is the key factor in the supply of efficient carts appropriate to local conditions. An industry under the NMWC would be well placed to produce such assemblies at reasonable cost, and to make them available in different parts of the country;

ii) to manufacture the complete carts in one centralised industry would tend to increase total costs. A complete cart is a bulky, but relatively low value item, and the transport cost of distribution to different areas of a large country such as Ethiopia would be high;

iii) an industry such as that proposed to manufacture low cost vehicles is best suited to the production of a limited range of products in relatively large numbers. The industry would produce wheel/axle assemblies to a limited range of specifications, which could then be built into a wide variety of different types of cart (including urban carriages) depending on the type of body and draught arrangement fitted, to suit different uses and local conditions.

There are a variety of designs of wheel/axle assembly used in different parts of the world. The key factor in determining the specification appropriate to Ethiopia is the type of wheel. Three proven types of wheel are in common use:

i) Fabricated, Spoked Steel Wheel.
This is of relatively small diameter (up to about 700mm), has no tyre, a flat section steel rim, and a series of bar or tubular steel spokes welded to the hub and the rim. It is quite widely used in parts of Southern Africa (e.g. in Zimbabwe) and would be the cheapest type to produce in Ethiopia. The wheels used on the Assela carts are of this type, though the detailed design is not very satisfactory. Its disadvantages are that on rough roads or tracks it is noisy, uncomfortable and has low rolling efficiency;

ii) Wooden Spoked Wheel
This is the traditional type of wheel used in Asia. It is of large diameter (typically 1 - 1.5m) and consists of a hub, and a series of spokes and rim sections, all made of wood, which are assembled and usually held together by a thin strip of metal "tyre" around the perimeter. It has better rolling efficiency and is less uncomfortable, than a metal spoked wheel, because of its large diameter. However it is relatively heavy, its construction uses a lot of timber and is a very skilied process. In Asia the skill of wheel making is usually handed down from one generation to the next. It would be a difficult technology to introduce in Ethiopia because of the problems of developing the manufacturing skills, and because of the increasing scarcity and cost of timber. Further, it would not be a suitable technology for an industry under the National Metal Works Corporation;

iii) Pneumatic-Tyred Wheel.
This is essentially similar to the wheel of a motor vehicle though the detail specification of the tyre and rim may vary. It has a high rolling efficiency, though it is somewhat less effective than a large diameter wooden wheel in deep mud, is comfortable, quiet, and relatively light. However it is also more expensive, than the steel spoked type.

The steel spoked wheel is the cheapest option, and therefore has the advantage of making carts available at least cost. However there is likely to be a degree of customer resistance, because of its noise and discomfort, particularly from people who have had experience of travelling in the pneumatic-tyred and sprung horse-drawn carriages. These objectives can be overcome by the use of pneumatic-tyred wheels, but at higher cost.

It is therefore proposed that the industry be established to supply both types of wheel, but specified so that each will fit onto the same design of axle. There are options for the supply of pneumatic tyres (and tubes) and for the design of wheel to suit. There are several choices of tyre supply:

i) use scrap motor vehicle tyres. This is acceptable for small scale production, but would not be suitable for the output of the proposed industry, since the availability of scrap tyres would rapidly diminish, and it would be necessary to produce wheels in a range of sizes to suit the variety of scrap tyres;

ii) use new tyres in a standard size produced by the Addis Tyre Company. This is technically acceptable but will be relatively expensive. A pair of tyres and tubes of a suitable size (7.00 x 14) would cost 220 Birr. One option considered was to use reject tyres from the Addis Tyre production line, since many of these would be adequate for the requirements of an animal cart, and would be cheaper. However the problem would be to prevent such tyres being transferred to motor vehicles where they would be a safety hazard.

iii) obtain ADV tyres from the Dunlop Company in India, with the option of subsequently transferring the production technology to the Addis Tyre Company. A pair of ADV tyres and tubes of suitable capacity currently sells from the factory in India for about 90 Birr. Allowing for shipping costs, but assuming they could be imported free of duty as agricultural equipment, it should be possible to make them available for substantially less than the cost of automotive tyres from the Addis Tyre Company. It whould be relatively easy to transfer the technology to the Addis Tyre Company since existing moulds can be used, as the tread pattern is not critical. The know-how to be transferred would be the specifications for the materials (rubber, ply and bead) and for the construction of the tyre.

It is recommended that the feasibility of using Dunlop ADV technology be investigated further when the IPS project team makes its study tour visit to India. However the remainder of the design and production technology for pneumatic-tyred wheel/axle assemblies is independent of the source of tyres.

The manufacture of a conventional automotive steel rim to accept a pneumatic tyre is quite complex, and requires heavy investment in capital equipment. The rim has a complex cross section to allow fitting and removal of the tyre and is made using special-purpose rolling plant, which is of heavy-duty design because of the thickness of the rim material. Investment in such equipment is not justified at the level of output proposed, though it may become worthwhile in the future to meet the requirements of expanded production of trucks and buses at AMCE, and of tractors and trailers, in addition to animal carts. For the present an alternative technology is proposed which allows pneumatic-tyred wheel rims for animal carts to be produced with much lower investment. This technology uses a rim made in two halves, bolted together. The tyre is fitted and removed by splitting the rim. Consequently, the rim can be of flat rather than profiled cross section, and can be rolled on standard metal fabrication equipment. The tyre is retained by a length of bar or tube welded to the edges of the rim. This would not be acceptable for a motor vehicle but is adequate at the low speeds of which a cart is capable. A further advantage of this split rim wheel is that the hub is fabricated in one piece with the wheel. With a conventional automotive wheel the hub is a separate assembly to which the wheel is bolted, and this increases cost.

There are two other considerations in the design of the wheel/axle assembly - the bearings and the axle. The ADV design uses tapered roller beaings which are expensive, and have an unnecessarily high specification for a cart. Wooden bearings of the type used at Assela wear quickly, though life can be improved by impregnating the wood with oil prior to machining. However the preferred option is to use machined cast iron bushes, pressed into the hub and turning on the steel axle. These will give high efficiency and long life, and can be produced in Ethiopia.

It is proposed to use a full width dead axle made of square section steel bar, with the wheels fitted at each end. The ends of the axle will be turned to fit the bushes, and threaded so that the wheels are retained by locknuts. Different types of frame and body can be attached to the axle, either directly or by means of leaf springs if suspension is appropriate. The axle will be made to a standard track width, but in two different cross sections, depending on the capacity requirements.

Thus in summary the proposed specification for the animal cart wheel/axle assemblies is as follows:

Axle:
- Standard 1.4m track width.
- Made in two different cross sections:
  40mm x 40mm square steel bar for carts drawn by two oxen, with payload capacity up to 1 tonne;
  30mm x 30mm square steel bar for animal drawn carriage or cart drawn by one donkey, with payload capacity up to 500kg.
- Axle ends machined and threaded to accept wheels running on cast iron bushes retained by locknuts.

Wheels:
- Split rim wheel to accept 7.00 x 14 tyre from Addis Tyre Company or ADV tyre for use on ox or donkey drawn carts.
- Split rim wheel to accept standard motor cycle tyre for use on horse drawn carriage (this wheel will be sufficiently strong for the lightly loaded carriages, and the use of motor cycle tyres reduces cost).
- Steel spoked wheel, 600mm diameter, for use on ox or donkey drawn carts.
- All wheels to have integral tubular hubs to accept cast iron bushes fitting on to the standard axles.

This limited range of wheels and axles will be suitable for manufacture in the proposed industry, but will provide the basis for constructing a wide range of carts for different applications, with or without springs as appropriate. Marketing of these assemblies will require close co-ordination with the Ministry of Agriculture, probably extending to the provision of standard designs of cart frames and bodies which can be made by rural technology centres or small-scale industries.

Long term technical collaboration is not necessary to establish local manufacture of cart wheel/axle assemblies, nor is an interim phase of assembly form imported parts. Manufacture can commence with a high level of local content, based on short-term technical assistance to prepare detailed product specifications, design and oversee construction of production tooling, and define detailed manufacturing procedures. A technology transfer agreement would be needed to acquire the ADV tyre technology, but this should not involve long-term collaboration.

4.4 Bicycle Trailer

The bicycle and trailer has been identified as the load carrying adaptation of the bicycle most suitable for Ethiopia. Bicycles are adapted in a variety of ways in different parts of the world to carry loads:

Bicycle and Sidecar

This vehicle has been used in some parts of Asia as a passenger carrier, and finds occasional use elsewhere as a load carrier. The sidecar consists of a single wheeled attachment to one side of a standard bicycle. The sidecar wheel is on the same axis as the rear bicycle wheel and the load carrying space is between them. The main disadvantage of the bicycle and sidecar is its instability. The vehicle itself is light in comparison to the rider, whose centre of gravity is located high on, and to one side of, the vehicle. The bicycle and sidecar is therefore prone to tipping over, particularly when empty, becoming more stable as the pay load is increased.

Pedal Tricycle

The pedal tricycle has three wheels and is a "three track" vehicle. There are two configurations. The first type has two wheels at the front and one at the rear. It is based on the rear half of the standard bicycle with a standard pedal drive to the rear wheel. The front half is modified to provide a vertical steering pivot in the plane of the bicycle frame. The load carrying area is between the front wheels, and the vehicle has centre-point steering, i.e. the two front wheels can be thought of as being connected by a rigid axle which pivots about its centre. This type of tricycle is found in Indonesia as a passenger carrier and to a lesser extent in other Asian countries as a cargo carrier, or for the vending of food on the streets. It is also used in small numbers in parts of Europe for vending of products such as ice cream. It is easy to manufacture because it retains the transmission and rear braking system of a standard bicycle. However, the centre-point steering system used causes some instability, particularly when the vehicle is heavily loaded and is travelling downhill, or on rough or cambered roads.

The second type of tricycle has a single wheel at the front, and two wheels at the rear. It is more stable than the type with two wheels at the front. In terms of numbers worldwide it is the most popular adaptation of the bicycle, and is used most extensively in India and Bangladesh, primarily as a passenger carrier. The normal design retains the standard front half of a bicycle, including the pedal axle assembly. The rear half of the bicycle is replaced by a fabricated frame which carries a rear axle fitted with two wheels. The wheelbase is longer than the bicycle, the chain drive of which is extended to a sprocket mounted centrally on the rear axle. Normally only one of the rear wheels is driven, the other free-wheeling on the axle. The load carrying area is between the rear wheels. This tricycle normally has braking only on the front wheel. The manufacture of this type of tricycle evolved in South Asia in the 1940's by the adaptation of standard roadster bicycles for passenger-carrying, as an improvement over the traditional hand pulled "Rickshaw". The adaptations were, and continue to be, carried out by small blacksmithing workshops who purchase the standard cycle components, and make the rear frame, axle and fittings by hand forging. The passenger-carrying bodywork is made by local carpenters and finished by the tricycle makers. The cycle industry in India now manufactures heavy-duty "Rickshaw" type spoked wheels (with thicker gauge spokes and thicker section rims) and tyres (of 6 or 8 ply construction rather than the 4 ply normally used on a bicycle) for these vehicles. Because of the heavy loads carried, standard bicycle wheels and tyres are not strong enough.

An evolution of this configuration of tricycle is the Oxtrike. Its major difference is that it is purpose-built as a tricycle, rather than adapted from a bicycle, and is specifically designed for manufacture by metalworking industries. It has a backbone chassis made from steel tube, drive to both rear wheels, and braking on all three wheels The Oxtrike is now in production in the U.K. and Kenya.

Bicycle and Trailer

The attachment of a two-wheeled trailer to a bicycle provides a substantial increase in load carrying capacity but, unlike the other adaptations, also allows use of the bicycle, with the trailer detached, as personal transport. Cycle trailers are used in limited numbers in parts of Europe, most commonly in France. They are also found in some parts of Francophone Africa, South-East Asia, China and Korea. They are rarely used for passenger transport, for which they are much less covenient than tricycles. However, there is unlikely to be a significant demand for adaptations of bicycles for this application in Ethiopia. The more likely application is for goods transport and here the characteristics of the trailer are very similar to those of tricycles and of bicycles and sidecars. The weight that can be carried is slightly lower than for a tricycle, and a tricycle with two rear wheels is better for carrying very bulky loads. However, for most applications a cycle trailer is equally as useful as a tricycle a. :, in the Ethiopian context, has the following advantages:

i) it attaches to a standard bicycle and its market in Ethiopia therefore includes existing bicycle owners, as well as new customers;

ii) its flexibility allows the bicycle owner to use one vehicle for both personal and goods transport;

iii) the total cost of a bicycle and trailer will be less than that of a tricycle;

iv) the demand for trailers as goods carriers will serve to increase the total demand for bicycles;

v) it is possible to supply the trailer with different types of body for specialist applications (eg. transport of liquids).

It is therefore proposed that the cycle trailer is the most suitable load carrying adaptation of the bicycle for Ethiopia.

The design selected for analysis is one that has recently been introduced in India. The strength and durability of the design have been proven by field tests, production has commenced in a metalworking industry in central India, and it is now planned to expand manufacture to other parts of the country. The specified payload of the trailer is 150 kg but, since it is known that this type of vehicle is habitually overloaded, this figure includes a substantial safety factor. Loads of over 300 kg have been carried without problems.

The trailer suits the type of bicycle which is already common in Ethiopia and which it is proposed will form the basis of a local cycle industry. The trailer design proposed has a frame made from 25mm diameter x 1.5mm wall thickness mild steel tube. This welded tubular structure includes the tow bar, and the mountings for the two wheels, which are fitted in exactly the same way as on a bicycle. The wheels are of the same construction, size (28 inch x 1 1/2 inch) and appearance as those on a bicycle but are of the "rickshaw" type referred to earlier with heavy-duty spokes, rims and tyres. An open-topped box load-container, fabricated from mild steel sheet, fits into the tubular frame. Other special-purpose bodies can be fitted instead of this box. The hitch consists of a steel ball mounted on the front of the towbar which fits into a simple, fabricated bracket clamped to the bicycle seat stays immediately below the saddle. The ball is retained in the socket by means of a single bolt.

Long term technical collaboration is not required to establish the local production of the cycle trailer, nor is there any need for an initial phase of assembly from imported parts before commencing local manufacture. Rather production can commence with the trailer being manufactured with a high local content, but using some imported materials and parts (primarily the wheel components). However, introduction of the cycle trailer will require short term technical assistance to evaluate the design under Ethiopian conditions, prepare the final product specification, design and oversee the construction of the production tooling, and define the detailed manufacturing procedures.

4.5 Motor Cycle Attachments

Sidecar and pick-up van attachments to motor cycles have been identified as the low cost "three-wheeled" motorised load carrying vehicles most appropriate to Ethiopia. However a variety of motor cycle based, load carrying three wheelers are used in different parts of the world. They fall into three categories:

Purpose Built Three Wheelers

These are designed specifically as load carrying vehicles, usually by manufacturers who also produce two wheeled motor cycles or scooters. They share components with the other products of the manufacturer, but are integrated designs which constitute quite separate products from the two wheeled machines. They normally have the same riding positions as a motor cycle or motor scooter. The most common type has a single front wheel (with suspension and steering based on motor cycle technology) and two rear wheels both driven by a purpose-designed transmission system incorporating a differential. The most widely used examples are the Piaggio range of three wheelers produced in Italy, of 175 - 250 cc engine capacity and using components from the same company's motor scooters. These three wheelers have been a common form of goods transport in Italy, and particularly the southern part of the country, since the early 1950's. A more recent development from this company uses a rear-mounted engine driving directly to the rear axle, rather than a standard motor scooter engine and gearbox.

The Bajaj Company in India produces a range of three wheelers based on technology licenced from the Piaggio Company, but now of 100% Indian manufacture, and incorporating indigenous design developments. The main demand is for passenger carrying versions which are extensively used in India (and exported to other Asian countries including Sri Lanka and Bangladesh) to provide low cost taxi services, carrying two or three people. Van and pick-up versions which carry up to 440 kg, and an articulated "truck" with a capacity of 750 kg, are also produced. Bajaj three wheelers of the cargo carrying type have been exported to a number of African countries. Piaggio three wheelers are also manufactured in Pakistan.

In Thailand there is a vehicle called the "Tuk Tuk", produced locally but based on Daihatsu technology, and used primarily, like the Bajaj, as a low cost taxi. It is a slightly larger vehicle than the Bajaj, and its distinctive feature is that most run on liquid petroleum gas rather than petrol. This reduces operating costs, and also causes less pollution in a crowded city such as Bangkok. Other three wheeled vehicles are manufactured in Greece, Indonesia and Latin America.

The less common configuration of this category of three wheeler has two front wheels with the load carying space between. Steering is usually of the Ackermann type rather than the centre point system used on the equivalent pedal tricycle, for greater stability on the faster vehicle. Examples of this type of vehicle are produced in Holland, Italy and Sweden, but are not known to be used to any significant extent in developing countries. The vehicles are usually based on moped technology and have limited carrying capacity, the pay load being typically about 150 kg.

Adaptations of Motor Cycles

This category is different from the first in that the vehicles are based on a standard motor cycle which is modified to convert it into a three wheeler. The modification is normally done independently of, or at most with technical advice from, the source of the motor cycle technology.

Typically these vehicles retain the front fork and steering assembly, the engine and gearbox, and the seating position of the standard motor cycle. The frame is modified and extended to provide the mounting for a two-wheeled rear axle. The transmission is adapted to this configuration and braking for the rear wheels is added. Conversions of this type can be observed in several countries in Asia and Latin America, but usually in limited numbers and constructed by small-scale industries.

Attachments to Motor Cycles

Three types of load carrying attachment can be fitted to a standard motor cycle:

i) Trailer

This is a two wheeled trailer hitched to the rear of the motor cycle operating on the same principle as a cycle trailer. They are quite commonly used in parts of South-East Asia, the trailer often being simply a handcart tied to the rear of a motor cycle or moped with a piece of rubber tubing. More sophisticated trailers, with a ball joint hitch, suspension, and fibre-glass bodywork, are used in Zimbabwe, primarily for goods deliveries in urban areas. The maximum carrying capacity of the trailer is about 200 kg and is limited by the fact that, at the speeds of which a motor cycle is capable, the machine can become unstable if the trailer weight is excessive in relation to that of the motor cycle (this is not a problem with the slower moving bicycle and trailer).

ii) Sidecar

A motor cycle with a passenger carrying sidecar attached was at one time a common means of family transport in Western Europe. Although limited numbers are still in use its popularity has declined with increasing car ownership levels. However, the vehicle remains in use in parts of Eastern Europe, and there are a few motor cycles and sidecars of this type in use in Addis Ababa. The concept has been applied in several countries in Asia where cargo carrying sidecars are used, the body usually being a simple, open topped box. However, the concept has been developed to the greatest extent in the Philippines where motor cycles and sidecars constitute about 20% of the total motor vehicle stock, and account for about 80% of all motor cycle sales. The use of this type of vehicle began with development of the market for Japanese 100 - 125 cc motor cycles in the 1960's. Small workshops began fitting sidecars to these machines and their initial use was as low cost taxis in the capital city, Manila. With the increasing traffic congestion they are now restricted to operating away from the main roads in that city, providing feeder services to the larger capacity vehicles that are the major means of urban passenger transport. However, their use developed rapidly in other parts of the country and they now perform the following functions:

* in major cities, providing feeder services in suburbs and away from main routes;

* in small cities, operating freely and providing a service which complements other passenger transport modes, and also links to areas immediately surrounding the cities;

* in small towns providing the only public means of passenger transport;

* in rural areas, providing the main means of linking villages to markets, and to the secondary highway system where more conventional motor vehicle services operate. In this rural application they carry both people and goods, and their key characteristics are the ability to operate economically in areas where transport demand is relatively low and insufficient to justify the use of larger vehicles, and on poor quality roads or earth tracks where conventional motor vehicle operators will not venture.

The type of sidecar used in the Philippines is different from that found in Europe. It normally has seating for two or four people and space for some goods. In larger urban areas the payload is limited to two or three passengers, but in rural situations it is quite usual to see the vehicles carrying seven passengers, 450 kg of cargo or, most commonly, a combination of the two. To cope with such loads on poor rural roads, the machine is fitted with additional spring/shock absorber units at the rear, a reinforced sidecar wheel, and places for additional passengers to sit or stand. In rural areas the motor cycles are of 125 cc capacity, though some urban operators use 100 cc machines. Although sidecars are produced separately from motor cycles, usually by small-scale manufacturers, there is close colaboration between the two industries. Because use with sidecars constitutes the major part of the demand, the marketing of motor cycles is oriented towards this application. The dealers recommend certain makes of sidecar to their customers and arrange financing for the purchase of the complete vehicle. The motor cycle manufacturers in the Philippines have introduced certain detailed design modifications to suit the sidecar application.

iii) Motor Cycle Based Pick-Up or Van

This is another vehicle that has evolved in the Philippines, but is a more recent development. It is in fact a four, rather than three, wheeled vehicle. The attachment consists of a frame to which is fitted, by means of leaf springs, a full width axle with a wheel mounted at each end. A cargo carrying body, usually an open-bed pick-up or a closed van, is built up on the frame. This attachment is mounted so that the load carrying area is on either side of and behind the motor cycle. Viewed from the front the motor cycle is positioned on the centre line of the attachment. Viewed from the side, the attachment axle is positioned behind the centre line of the rear motor cycle wheel. Despite the unusual configuration, the vehicle operates efficiently on reasonably surfaced roads, but is not suitable for use on poor rural roads. It is therefore essentially an urban vehicle which offers a much lower cost alternative (in terms of both purchase and running costs) to a conventional light commercial vehicle. It has a pay load of 400 kg and is suitable for many carrying applications, both for private businesses and government departments, in and around urban areas. The attachments are manufactured in the Philippines by vehicle body builders but, like the sidecars, are marketed in close collaboration with the motor cycle manufacturers and dealers.

As is discussed briefly in Chapter 3, it is proposed that, of the various low cost motor vehicle options, the sidecar and pick-up/van attachments to the motor cycle are most appropriate to Ethiopia. Since, unlike the other vehicles in the proposed product range, the use of these devices is largely limited to one country at present, it is worth explaining in more detail why they are recommended for Ethiopia. First it is important to understand that, although they are only used in signficant numbers in the Philippines, they are by no means a 'novelty', but form an integral and major part of the transport system there. They are approved and licensed by the Government vehicle registration authority for use on the road and for the carriage of passengers and goods. They are insured in the same way as conventiona motor vehicles by the major insurance companies. Perhaps most important, they have the approval and support of the local motor cycle manufacturers, each of whom is associated with one of the major Japanese companies. These companies would not lend their name to the vehicles - to the extent of including them as an integral part of their advertising material - unless they considered the attachments safe, soundly engineered and worthy to be associated with their brand names. It should also be noted that the motor cycle and sidecar does not suffer from the same stability problems as the bicycle and sidecar because it is heavier and has a lower centre of gravity.

For use in Ethiopia the sidecar and pick-up/van attachments to a standard motor cycle offer the following advantages over other low cost motor vehicle options.

i) they can be manufactured at a lower cost than the other options, yet their performance capabilities are comparable in terms of carrying capacity, speed of operation, fuel consumption, and the road conditions in which they can operate. In the case of the motor cycle and sidecar, its flexibility gives it superior characteristics to other options, in particular because of its capability to operate economically under difficult rural conditions. It therefore offers the realistic prospect of providing motor transport services for rural people and goods, linking in to market centres, in circumstances where it is unlikely that conventional motor vehicles will provide such services;

ii) with the level of output proposed for the low cost vehicle industry in Ethiopia, it is sensible to maximise the demand for motor cycles by producing attachments to adapt them to a range of different applications, rather than manufacturing a specialised three wheeled motorised vehicle. The latter course would require a separate production technology and additional collaboration agreement with an overseas supplier for a vehicle that would be produced only in limited quantities and for which it would therefore be difficult to develop significant local content.

The detailed design of the sidecars produced in the Philippines varies, but the basic specification is as follows:

i) a welded frame made up of mild steel tube of 38 mm and 25 mm diameter by 1.5 mm wall thickness. Welded to this frame are three brackets for attaching the sidecar to the motor cycle (at the front of the motor cycle frame, at the base of the frame near the footrest, and at the top rear shock absorber mounting);

ii) a suspension arm, also of tubular construction which is attached to the chassis by a pivot at the front, and a leaf spring at the rear, into which is fitted the sidecar wheel. This is usually of the same size and type as the motor cycle wheels but can be reinforced for use on rough roads;

iii) steel sheet panelling for the tubular frame to form the body sides and floor, and a roof for the passengers. This roof sometimes extends to cover the motor cycle rider;

iv) an upholstered seat, attached to the tubular frame, for two or four passengers;

v) for rough road conditions, brackets to allow additional shock absorbers or coil springs to be fitted at the rear of the motor cycle;

vi) a simple lighting system to provide front and rear sidelights for the sidecar.

Similarly, the pick-up/van attachment consists of a tubular steel frame with sheet steel panelling to provide the body. The frame and body extends over the front of the motor cycle to provide an open sided cab for the rider, with a small passenger seat on either side of him, and a perspex windscreen. A rear axle is attached to the frame by means of a leaf spring on each side. Wheels of the attachment are either of the motor cycle spoked type, with adapted hubs to attach to the full width axle, or are of cast and machined aluminium. In each case standard motor cycle tyres are used The attachment is fitted to the motor cycle as follows:

i) at the front, a clamp is attached to a bracket on the motor cycle frame, and bolted to the attachment from either side;

ii) at the rear the arrangement is more complex. Since the attachment and the motor cycle both have suspension there must be allowance for relative vertical movement between them. Two rollers are fitted to the attachment, which move up and down on vertical guides mounted on either side of the motor cycle. This allows relative vertical movement between the two, but locates the attachment laterally.

Local manufacture of the sidecar and pick-up/van attachments can be established in a single phase with high local content, and no requirement for long-term technical collaboration. However, short-term technical assistance will be needed to evaluate the designs under Ethiopian conditions, finalise the product specifications, design and oversee construction of the production tooling, and define the detailed manufacturing procedures. The small-scale industries that produce these devices in the Philippines do not offer an appropriate source of technical assistance. The options are to utilise an independent source as for the animal cart and cycle trailer, or to obtain assistance from the overseas collaborators on motor cycle production. The latter approach is possible if a Japanese collaborator is selected since each of the Japanese companies is involved with industries in the Philippines.

4.6 Guidelines For The Localisation Of Component Supplies

As is shown in the previous sections, of the range of low cost vehicles to be produced in the proposed industry, the two which have the most complex technology are the bicycle and the motor cycle. For the remaining items - animal cart, bicycle trailer and motor cycle attachments, the technologies selected as being most appropriate for Ethiopia are such that:

i) long-term collaboration with a commercial overseas source of technology is not necessary, though some short term technical assistance will be required to finalise product specifications, specify the details of the manufacturing processes and prepare the production tooling;

ii) it is not necessary to develop local production in a series of stages, commencing with assembly and then progressively increasing locally manufactured content. Rather, production can commence with a high local content. The import content will consist of those raw materials and specialised components which cannot be supplied locally. In general it will be necessary to import these items on a longo-erm basis, unless the capacity in other sectors of Ethiopian industry is developed to supply them locally.

For the bicycle and motor cycle it is necessary to determine by more detailed analysis the level of local content that is appropriate to the conditions and to the proposed scale of production in Ethiopia, and the stages by which that level should be reached. As a starting point, it is assumed that local assembly from semi-knocked down kits (SKD)[1] has advantages over the import of built-up units since:

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1. The term SKD is used when a product is supplied as a kit of sub-assemblies and individual components. The term CKD is used when the product is ´completed knocked down´ into individual components. SKD is not a precise definition and the form in which it is proposed that bicycle and motor cycle kits should be imported is detailed in Chapter 5.

i) initial purchase price and shipping cost, and hence foreign exchange requirement and import duty, will be lower;

ii) some employment will be created locally, and the assembly operation will provide the basis from which to develop local content.

It is technically feasible to manufacture all parts of a bicycle or motor cycle in Ethiopia, but the capital investment would be enormous and, given the low planned level of output, would never be recovered, while the cost of the finished products would be very high in comparison with equivalent imported items. Pragmatically, the focus of local production should be on those items which have relatively low capital investment compared with their output value, and which reach reasonable economies of scale at relatively low levels of production. In order to apply a more rigorous approach to determining the appropriate level of local content the following issues have been considered:

i) Adaptation of Technology

While the production of bicycles and motor cycles will involve collaboration with an overseas source of technology, it does not follow that the manufacturing processes adopted should be exactly the same as those used in the parent factory. Where appropriate, the manufacturing processes and production technology used should be changed or adapted in order to maximise the local content that can be achieved under the conditions prevailing in Ethiopia, and in particular:

* the relatively low planned output levels;

* the scarcity of capital;

* the availability of labour at low cost.

In adapting the manufacturing technology it may be necessary to modify or change the detailed design of some components to suit the process selected as being most appropriate. It is important to ensure that an adequate level of quality is maintained in the finished product. In establishing a new bicycle and motor cycle industry in Ethiopia it may be appropriate to exploit the advantages of recent developments in manufacturing technologies, even if these are not utilised in the well established parent industries.

ii) Locally Produced Materials

It is desirable to make maximum use of locally produced materials. The availability of such materials is discussed in Chapter 5.

iii) Existing Manufacturing Resources

It is desirable to exploit, wherever appropriate, the existing manufacturing resources in Ethiopia, particularly where these are at present under-utilised. However, it is prudent to make this analysis in terms of manufacturing processes which are the 'core' of the proposed industry and those which are 'peripheral' to it. For 'core' processes, if capital equipment can be used efficiently (ie. with high capacity utilisation) solely for the production of low cost vehicles, then there are advantages in housing it within the factory, to control supply and quality of components. This does not preclude the possibility of utilising existing resources for 'core' processes if there is **substantial** under-utilisation of capacity at present **and for the foreseeable future.** For 'peripheral' processes, where utilisation of equipment for the production only of low cost vehicle components would be low, it is sensible to use existing manufacturing resources wherever possible. The existing industries which are of most relevance are discussed in Chapter 5.

iv Integrated Low Cost Vehicles Plant

One of the major reasons for proposing to manufacture a range of low cost vehicles in a single factory, rather than making each product in a separate plant, is to increase the efficiency with which some items of capital equipment are used. Several of the main manufacturing processes are required by two or more of the range of vehicles to be made. The common use of manufacturing equipment for these processes will increase its utilisation, and hence increase the overall level of local content that is economically viable.

v) Economic Viability

For some of the products included in the project it is clearly cheaper to manufacture locally rather than to import (the frame of the cycle trailer is a good example). Where local manufacture of a component is cheaper (measured at full cost, including return on capital) than importation then the decision is clear cut. However, for some elements of a bicycle or motor cycle, local production is likely to be more expensive than importation, but may offer other benefits which make it worthwhile. For such elements, three criteria are proposed for determining whether local production is worthwhile:

* the foreign exchange cost of the raw material for a locally produced component should be less than the foreign exchange cost of importing it complete. It may seem surprising that this should ever be an issue, but there are two reasons why the imported raw materials to make a component may cost more than the imported part;

    - many bicycle and motor cycle parts are produced on a large scale. The producer can therefore buy his materials very cheaply by bulk purchase and can benefit from the economics of scale in converting these to finished components. The cost of these finished components may be less than the cost of the raw materials purchased in relatively small quantities for small scale production;

- in the motor cycle industry many component suppliers are under the control of the major manufacturers. The control can be such that the manufacturer dictates the level of profit of the supplier in return for assuring a captive market and financial support. In this manner the cost of components is brought to an irreducible minimum;

* when assessed on the basis of "shadow" pricing, ie. at economic rather than financial costs, the locally produced component should be cheaper than the imported item. This criterion is intended to take account of the economic benefits of local manufacture, primarily savings in foreign exhange and utilisation of local resources;

* where components are made in existing industries which have under utilised capacity, the depreciation of the existing capital equipment used should not be included in determining whether local production is worthwhile.

In practice it is not necessary to apply these criteria to every individual component under consideration. Rather they can be applied to groups of components which use common production processes.

5. DETAILED ENGINEERING ANALYSIS

5.1 Background

This Chapter provides the detailed engineering analysis of the manufacture of the five product groups proposed for the low cost vehicles plant:

* Bicycles
* Motor Cycles
* Animal Carts
* Bicycle Trailers
* Motor Cycle Attachments

The bicycle and the motor cycle are the two most important products, in terms of contribution to the turnover of the industries, the complexity of the manufacturing processes, the level of capital investment required, and the issues associated with determining the appropriate level of local content. Although the bicycle is less complex than the motor cycle, and its contribution to turnover is lower, it is dealt with first, and in the most detail since;

i) given its higher output (measured in units) it has significantly greater potential for local content;

ii) it is therefore the product from the range which will to a large extent determine the manufacturing operations to be carried out in the plant, and its organisation;

iii) much of the detailed description and analysis of the manufacturing and assembly processes is also applicable to the motor cycle.

A section is then devoted to the motor cycle, analysing the assembly process, the potential for local content and how it fits in with bicycle production, and the components that can be made in ancillary industries in Ethiopia.

The third section is concerned with animal carts, bicycle trailers and motor cycle attachments which, in terms of how they fit in with the manufacture of bicycles and motor cycles, and of the additional plant required, can be analysed as a group.

The critical technical and cost information is in the main text, while more detailed data is contained in a series of Annexes. For each of the stages of assembly, or local manufacture analysed, a summary of direct labour requirements, direct material costs and equipment costs is presented. This covers only the items directly attributable to that assembly or manufacturing stage. Indirect costs, and those which must be spread over the range of products to be made, are discussed in Chapter 6.

In the review of the proposed low cost vehicles industry in Chapter 6, more detailed information is given on the numbers and grades of direct labour required, and the method of calculating their costs. Similarly, Chapter 6 gives more detailed information on the items of equipment required and the method of estimating their costs. For each stage of assembly or local manufacture analysed, the quality control requirements are discussed. Overall quality control procedures are reviewed in Chapter 6.

Before proceeding to the detailed analysis of particular products, it is necessary to review the availability of raw materials in Ethiopia, and the ancillary industries which have the capability to manufacture components for low cost vehicles.

5.1.1 Materials Supply

There are three local raw materials industries which are relevant to the manufacture of low cost vehicles:

i) Kalliti Steel Industries

Kalliti Steel Industries manufacture a range of electric resistance welded mild steel tubes from imported hot and cold rolled coil. The range of tube sizes produced are sufficient to cover all mild steel tube requirements of the low cost vehicles industry. The range of sizes produced are summarised below:

Round Tube:	From 18 mm diameter x 0.8 mm wall thickness to 127 mm diameter x 3.5 mm wall thickness
Square Tube:	From 15 mm square x 1.0 mm wall thickness to 100 mm square x 3.5 mm wall thickness
Rectangular Tube:	From 20 mm x 10 mm x 1.0 mm wall thickness to 120 mm x 80 mm x 3.5 mm wall thickness

Kalliti imports the material in wide coil form (4.5 tonnes/coil), slits it to the correct width, then rolls and welds the material to form the tube. The only slight concern about their tube is that some of the forming rolls are worn, so that the tolerance on outside diameter may be less tight than is ideal. This will not matter for most applications, but is important for bicycle frame tubes, whose outside diameters have to suit the lugs into which they fit. If necessary Kalliti will have to obtain new forming rolls for 25 mm and 28 mm diameter tubing.

Kalliti also produce a range of angle sections cold rolled from mild steel strip, and mild steel sheet slit and cut from imported coil in thicknesses from 0.8 mm - 6.0 mm. They can supply all the mild steel sheet requirements for the low cost vehicles industry. Some of this must be supplied annealed for components which are press formed by drawing. Since Kalliti have slitting facilities, mild steel strip for press formed components can be supplied by them in continuous coils slit to the correct width for forming.

Kalliti also produce cold rolled sections for building construction - door and window frames - and supply aluminium sheet. Their total product output at present is 5,000 tonnes/annum, mostly tube and sheet.

ii) Akaki Iron and Steel Works

The main product from Akaki at present is corrugated galvanised roofing sheet, made from imported cold rolled sheet in four thicknesses - 0.2, 0.25, 0.32 and 0.4 mm. They can supply the galvanised sheet uncorrugated, and go up to 0.6 mm thickness if there is sufficient demand. Current capacity is 21,000 tonne per annum on three shifts.

Early next year they plan to recommence production of welded steel tube and galvanised wat r pipe, using equipment which has been unused for several years. The welded steel tube, which is of most relevance, will be to the same specification as Kalliti, except that it is induction rather than resistance welded. However, the range of sizes will be limited:

Round Tube:	From 20 mm diameter x 1.2mm wall thickness to 32 mm diameter x 1.2 mm wall thickness
Square Tube:	25 mm x 25 mm square - 1.2 and 1.5 mm wall thickness
Rectangular Tube:	50 mm x 30 mm x 1.5 mm wall thickness.

While electric resistance welded mild steel tube is acceptable for low cost vehicle applications, induction welded tube is of better quality. Akaki products should therefore be used in preference to Kalliti when suitable sizes are available. Planned output of steel tube is 3,500 tonne/annum.

iii) Ethio-Foam

Ethio-Foam produces a range of flexible thermoplastic foams which can be used for any upholstery work on low cost vehicles.

There is another public sector industry producing steel sections, Akaki Foundry. They process a combination of scrap and imported material to produce reinforcing bar, but this is only of a quality suitable for building construction work.

In the engineering analysis of low cost vehicles, prices for locally available raw materials have been obtained from the Sales Division of NMWC. Prices of imported materials are based on latest comparable quotes available from the Purchasing Department of NMWC. Annex 5 details the calculation of material prices used in the analysis.

5.1.2 **Ancillary Industries**

There are a limited number of industries in Ethiopia currently producing ancillary components for the automotive industry. Of these the most important is the Addis Tyre Company which manufactures cross ply tyres and inner tubes for heavy and light commercial vehicles and private cars, using imported raw materials - rubber, chemicals, ply, and bead wire. Its current capacity is about 110,000 tyres and tubes per annum, though actual output is dependent on the mix of different sizes of tyre. It has an agreement with the Yokahama Company of Japan whereby they advise on technical matters by correspondence, and by regular visits to the plant in Addis Ababa. Addis Tyre also produces limited numbers of compression moulded rubber components using equipment primarily intended to make laboratory samples. Addis Tyre has an agreed four year expansion programme to double its output of tyres and tubes, and to expand its capacity to make other moulded rubber components.

Ethio-Springs manufactures a range of leaf springs from imported raw materials, and already supplies springs as original equipment for the trucks and buses assembled at the AMCE plant in Addis Ababa. The Addis Ababa Battery Factory fills and assembles Ebonite-cased batteries using imported parts and materials, and supplies these as original equipment to the AMCE Factory. A private company in Asmara produces a range of oil, air and fuel filters for internal combustion engines.

There are three public sector industries which have manufacturing capabilities relevant to the production of low cost vehicles. The Ethiopian Metal Tools Factory produces a range of hand tools, and therefore has substantial forging and heat treatment capacity. To complement its own product range it produces forged components for other industries under contract. It also has some facilities for cold press forming. A feasibility study on the factory has recently been completed which proposes the purchase of new equipment to rehabilitate the existing facilities and allow a degree of expansion.

Ethio Plastics and Ethio Gas and Plastic Crates both have under utilised capacity for injection moulding of thermoplastics, the former up to a shot weight of about 110 gm, the latter about 300 gm. Ethio-Plastics also has under-utilised capacity for extrusion moulding of plastics, and the production of plastic sheathed copper wire. This includes facilities for drawing and winding the wire as well as extrusion moulding of th. plastic sheath.

Two planned initiatives are relevant to the low cost vehicles industry. Implementation has commenced of a project (known as the FATA Project) to establish a factory to make spare parts for processing equipment used in existing industries in Ethiopia (eg. sugar, textiles, etc.). The factory, which is planned to start producing spare parts at the beginning of 1988, will have forging, foundry, machining and heat treatment facilities.

Initially the focus will be on supply of spare parts for existing processing equipment, but if the factory proves to have spare capacity this could be used in the future to make components for low cost vehicles. The factory will have the facilities to make new forming rolls for Kalliti.

A project currently being studied is the establishment of an engineering design centre and pilot toolroom. If this goes ahead to an appropriate time schedule it could provide facilities to make production tooling for the low cost vehicle industry.

5.2 Bicycle Manufacture

The analysis of bicycle production is based on the standard roadster model. Annex 6 presents a detailed component breakdown of this model, noting the variations for double top tube and ladies' frames. The Annex also lists the items that can be supplied as accessories to the basic specification.

The planned capacity for bicycles of 12,500 units per annum is insufficient to justify the local manufacture of those components for which the available technologies are capital-intensive, requiring specialised, high output equipment. Listed below are those items which are precluded from local manufacture for this reason. For each item the minimum level of economic production, based on Indian experience, is given together with the output required in Ethiopia.

Item	Minimum Economic Production Level/ Annum	Output Required In Ethiopia/ Annum
Spoke	10,000,000	1,000,000
Nipple (and Washer)	10,000,000	1,000,000
Chain	150,000	12,500
Pedal	200,000	25,000
Freewheel	100,000	12,500
Bottom Bracket Shell	100,000	12,500
Mudguard	150,000	25,000
Rim	100,000	25,000
Hub	100,000	25,000
Saddle	40,000	12,500

Components such as ball bearings, nuts, bolts and washers are normally produced in vast quantities by specialist manufacturers and supplied to the bicycle industry.

The analysis of bicycle production in Ethiopia is therefore based on those elements of the process which are relatively efficient at lower levels of production, specifically:

i) assembly from imported SKD Kit;

ii) manufacture and painting of frame and front fork;

iii) manufacture and plating of press formed and tubular components;

iv) manufacture and plating or hardening of machined components;

v) manufacture of components by existing industries in Ethiopia.

In addition to exploiting existing resources in the country for component manufacture, the system of production proposed makes maximum use of the facilities at Kalliti Steel Industries for the initial processing of imported raw material. Thus the proposed system utilises steel tube, sheet and slit coil supplied by Kalliti.

The system proposed requires the continuing import of bicycle parts to the value of about 49% of that of a complete SKD Kit. In other words about 51% of the value of the complete kit is replaced by locally manufactured parts. However, these parts do use imported raw materials.

There is a significant demand for bicycle spare parts in Ethiopia, and this will increase as the stock of bicycles rises. The proposed industry will be able to produce certain components for the spare parts market, as well as complete bicycles.

It is worth noting that, if the market for bicycles increases substantially to, say, 25,000 units per annum, there is potential for increasing local content to include saddles, pedals (using a plastic moulded pedal insert), hubs (for which some of the required processes will already be available), and mudguards (possibly by the development of rolling facilities at Kalliti Steel Industries).

In the analysis of bicycle production, labour and equipment requirements have been calculated on the basis of a capacity of 12,500 units per annum, on a single shift basis, operating at 80% efficiency, assuming 2,000 working hours per annum.

5.2.1 Assembly Of Bicycles From SKD Kits

The estimated cost breakdown for a complete kit of bicycle parts (CIF Assab) is given in Table 5.1. The total cost, based on supplies from India[1] is 125.2 Birr.

Annex 7 presents a detailed analysis of the proposed organisation of bicycle assembly, including equipment and direct labour requirements. The Annex details the form in which the kit is supplied. It is semi rather than completely knocked down since those components which are permanently joined (by welding, brazing or rivetting) to form sub-assemblies are supplied assembled and finished (by painting or plating). However, within

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1. For comparison, the Chinese summary of the costs for a plant to assemble 50,000 bicycles a year used a CIF cost of US $55 (114 Birr) for a kit. The average CIF cost of an imported bicycle in 1984 was 144.9 Birr.

TABLE 5.1: COST OF COMPLETE KIT OF BICYCLE PARTS SOURCED FROM INDIA

	Price CIF Assab (Birr)
Frame Assembly	22.5
Front Fork	9.0
Handlebar	6.75
Hub (Front and Rear)	5.0
Freewheel	3.3
Brake Set	4.0
Transmission Set	11.7
Spokes and Nipples	7.0
Rims and Tape	13.65
Tyres and Tubes	10.5
Saddle and Seat Pillar	12.0
Mudguard Set	7.8
Accessories	12.0
Pump	
Sidestand	
Lamp Bracket	
Carrier	
Toolset	
	125.2 Birr

this constraint the kit is as disaggregated as possible except that the hubs are supplied assembled since this must be done prior to plating. The system of assembly is as follows:

i) incoming kits are checked and put into the component store;

ii) batched sets of parts are despatched, on purpose-built trolleys to the appropriate sub-assembly or final assembly line stations;

iii) the complete bicycles are checked as they leave the final assembly line, packed, and despatched to the final store.

The quality control procedures for assembly are as follows:

i) imported parts to be to specification and standard agreed with the supplier;

ii) visual inspection of parts when unpacking crates and delivering items to store. Damaged or reject items to be replaced by supplier;

iii) further identification of reject or damaged items during assembly;

iv) detailed final inspection (defined in Annex 7) to control quality of assembly.

These procedures will form part of the total quality control system as locally manufactured parts replace some components in the imported kit.

Table 5.2 lists the equipment required solely for assembly of bicycles. Table 5.3 details the labour requirement and estimate of cost elements directly associated with the assembly of bicycles. Both the investment in assembly equipment and the labour content are low.

5.2.2 Manufacture Of Frame And Fork

Almost all parts of a bicycle are either plated or painted. Therefore the development of component manufacture is linked to the provision of these finishing facilities. The major painted items are the frame and the front fork. Most of the components for these items can be manufactured locally, but one critical part, the bottom bracket, must be imported. This part is made either as a complex pressing or as a malleable iron casting. The press forming method involves an expensive set of tooling which can only be justified by large scale production. Many manufacturers therefore continue to use cast bottom brackets which are normally supplied by specialist foundries.

Allowing for the continued import of this item and other major components, the value of the imported items replaced by a locally manufactured frame and fork is 27.5 Birr, or about 26% of the value of the complete kit of parts.

TABLE 5.2: EQUIPMENT REQUIRED FOR ASSEMBLY OF BICYCLES

2	Hand Presses
5	Vices
10	Sets Hand Tools
1	Wheel Stand
6	Pneumatic Screwdrivers (with tools)
1	Truing Stand
1	Tyre Roller
1	Tyre Inflator
1	Eye Nut Inserter
6	Benches
27	Mobile Racks
4	Fixed Racks
3	Bicycle Stands
1	Ground Level Track

Total Estimated Cost 100,500 Birr

TABLE 5.3: DIRECTLY ATTRIBUTABLE COSTS OF BICYCLE ASSEMBLY

	Cost/ Bicycle Birr	Cost/ Annum Birr
1. Materials		
Imported kit CIF Assab	125.2	1,565,000
Import Duty[1]	18.75	234,500
Transport[2]	5.6	70,000
Packing Material	5.0	62,500
Total Material Cost	154.55	1,932,000
2. Labour		
14 Workers	3.48	43,500
3. Equipment For Assembly		
(Depreciated at 10%/Annum)	0.84	10,500

1 15% Duty

2 All transport costs Assab - Addis Ababa Calculated at 0.125 Birr/Tonne km.

Materials for the manufacture of the frame and fork will be supplied primarily from Kalliti, as follows:

i) welded steel tube in various standard sizes - 40 tonnes/ annum (note the tube must be formed from cold rolled strip);

ii) mild steel cold rolled strip supplied in slit coil form from Kalliti - 22 tonnes/annum. Imported materials would be supplied to Kalliti in standard 1m width, 4.5 tonne coils. Using their existing facilities they can slit this into coils of precise widths for the press forming of different components. Some of the steel strip will be supplied annealed (7.5 tonne), the remainder as rolled (14.5 tonne).

In addition a small amount of imported wire is required, together with painting, brazing and welding materials.

Annex 8 describes the frame and fork manufacturing process and details the equipment and labour requirements. However, it is worth commenting on some of the features of the process. A lugged and brazed bicycle frame gains its strength from the fact that the tubes are joined by lugs, each one formed from a single piece of steel. Each lug is formed by a series of pressing operations:

i) blanking from steel strip or coil;

ii) shallow drawing to form the curve of the ports;

iii) bending and closing to the final shape.

The lug is then welded along the open seam that remains, and the ports are reamed to diameter for the tubes to fit inside and leave the correct gap to achieve good brazing quality. Manufacture of the tubular components involves tube cutting and press forming operations. A special-purpose tube cutting lathe is recommended, since this gives accurate control over tube length. The most complex part of the fork is the blade, which is of tapered oval cross section. For large scale production the shape can be formed from steel tube, but at lower levels of output it is press formed from sheet by blanking, bending, closing and welding along the seam.

Some of the press forming tools detailed in Annex 8 are progression tools. On these tools two operations (usually piercing and blanking) are carried out in one stroke of the press. For the various welding operations, MIG welders are proposed. These are faster, and require less skill, than gas welding and, for the material thicknesses used give a good quality joint.

To make the frame the various components are assembled in a fixture, and held together temporarily by drilling holes through the joints and fitting pegs. The joints are then brazed. There are various methods of brazing a bicycle frame but the one proposed is dip brazing. Each frame joint is dipped into a bath of molten brass which runs up into the gap between tube and lug by capillary action. The brass solidifies on cooling. Any excess brass is then removed electrolytically. This method of brazing is less efficient in its use of brass than others, but it is easier to achieve good quality, and it suits the planned level of production. After brazing any distortion in the frame is removed by setting it manually in a fixture. The head and seat tubes are reamed to the correct diameter for their fittings, and the bottom bracket threads are tapped on a special-purpose machine.

To make the fork the various components are assembled in a fixture and held together by tack welding. The fork crown joint is then dip brazed. The fork blades are bent to the correct shape in a special fixture after brazing.

Annex 8 does not detail the painting operation since it is recommended that two methods be evaluated. The traditional way of painting a frame or fork in small-scale industries is by stove enamelling. The sequence is as follows:

- i) degreasing, to clean the frame;
- ii) bonderising (phosphating) to provide a rust protective layer;
- iii) painting, by spray or dipping;
- iv) stove baking.

Three coats of paint are usually applied, a primer and two finishing coats, with baking after each stage.

A process which has recently become common in small-scale cycle industries in Europe and America is powder coating. The process is as follows:

- i) the frame is shot blasted to clean it and prepare the surface for painting;
- ii) an epoxy paint is applied electrostatically in powder form;
- iii) the frame is passed through a low temperature oven where the particles of paint soften, coalesce, and cure to a high quality finish.

Two layers of paint are normally applied, a primer and a final layer. Epoxy powder paint is more expensive than enamel, but the process has the following advantages;

- i) the degreasing and phosphating processes are replaced by a single shot blasting operation requiring only one piece of equipment;
- ii) the amount of paint used is minimised. Only two layers are required, and with powder coating they can be very thin. The electrostatic method of application minimises wastage;
- iii) it is very easy to change colours with minimum downtime;

iv) it produces a high quality finish which is resistant to damage since the cured paint retains some flexibility and deforms rather than cracks when knocked.

Subject to a comparison of relative costs, powder coating is recommended as a more modern, more efficient and better quality painting method. Furthermore, the process is suitable for other products to be made in the low cost vehicle plant.

In summary, four manufacturing sections are required for the production of frames and forks:

Press Forming Section	Which will make the pressed components, including welding, grinding and reaming of lugs.
Tube Manipulation	For cutting and deburring of tubes.
Frame and Fork Assembly and Brazing	Including post-brazing operations prior to painting.
Painting and Finishing	Self explanatory.

The Press Forming, Tube Manipulation and Painting and Finishing Sections will also be used in the manufacture of other products. Frame and fork production will involve the introduction of certain quality control procedures;

i) the use of fixtures for assembling frames and forks provides an in-process check on tube lengths;

ii) for good brazing it is important to maintain the correct gap between tube and lug. It will therefore be necessary to:

- check that the diameter of tube supplied from Kalliti is within tolerance limits;

- check the diameter of the ports of all lugs using "go-no go" gauges:

iii) visual checks of frame and fork joints after brazing for unfilled gaps;

iv) testing of selected frames and forks using standard non-destructive procedures.

Table 5.4 lists the equipment requirements for frame and fork production, by section. Although it is proposed to have the steel strip for press forming supplied in slit coil form, it is desirable to have a guillotine shearing machine to prepare steel strip for those press formed components where the quantity of material used is not sufficient to justify using coil. Such a machine is included in the facilities provided for manufacture of carts, trailers and motor cycle attachment. It has sufficient spare capacity to prepare sheet for press forming.

TABLE 5.4: MANUFACTURING EQUIPMENT FOR THE PRODUCTION OF FRAMES AND FORKS

Press Forming Section - Estimated Cost 322,500 Birr

4 Mechanical Presses with Coil Feeds
2 MIG Welders
1 Pedestal Drill
1 Pedestal Grinder
1 Spot Welder
1 Wire Straightening and Cutting Machine
58 Press Tools (Including those for double top tube model)
1 Chainstay Welding Fixture
1 Seatstay Welding Fixture

Tube Manipulation Section - Estimated Cost 42,500 Birr

1 Special Purpose Tube Cutting Lathe
1 Deburring Machine
1 Slotting Machine

Frame And Fork Assembly And Brazing - Estimated Cost 154,000 Birr

1 Dip Brazing Furnace - Frames
1 Dip Brazing Furnace - Forks
1 Electrolytic De-Brassing Tank
3 Frame Assembly Fixtures
1 Fork Assembly Fixture
1 Frame Setting Jig
1 Pedestal Drill
1 Special Purpose Tapping Machine
1 Fork Bending Fixture
10 Frame Brazing Jigs
1 Gas Welder
1 Portable Drill

Painting Section - Estimated Cost 100,000 Birr

Complete Painting Plant

TOTAL 619,000 Birr

Table 5.5 makes an estimate of the direct materials and labour cost for frame production, and of the depreciation of manufacturing equipment and tooling. The value of the imported components replaced is 27.5 Birr/bicycle, while the cost of direct materials, labour and equipment depreciation for local production is 27.03 Birr/bicycle. Given the saving on foreign exchange this implies that local production is worthwhile.

With the facilities required for frame and fork production it is feasible to import the mudguards unpainted, make wire hairpin stays, and build up the mudguard assemblies in the factory. They would also be painted in the factory, which ensures that they match other painted items.

5.2.3 Manufacture Of Tubular And Press Formed Plated Components

There are several parts on a bicycle which require the same press forming or tube manipulation processes as the frame components but which are plated rather than painted. Thus, by the installation of a plating plant, and certain other additional equipment, these components can be manufactured locally, sharing some of the plant used for frame and fork production.

Annex 9 details the components that come into this category, and the production operations, equipment and labour requirements. In summary, the components consist of the handlebar assembly, the pressed steering assembly fittings, the seat pillar, and press formed or tubular brake components. The estimated CIF value of the imported components replaced by the local manufacture of these items is 12 Birr, or about 9.5% of the value of a complete imported kit. The 12 Birr is made up as follows:

Handlebar Assembly	6.0
Brakes	3.5
Seat Pillar and Fork Fittings	2.5

The production of most of these items is straightforward but it is worth explaining certain features briefly. The handlebar lug is made in the same way as the frame lugs, and the bar and stem are cut to length from tube. The three items are assembled and the joint is dip brazed. The handlebar is bent to shape, and the holes drilled for the brake lever fittings, after brazing and prior to plating. The seat pillar is cut to length from tube, and one end is closed down to the correct diameter to fit the saddle by a press forming operation. The various braking system components are made by press forming from sheet, cutting from tube or cutting from wire. They are built up into sub-assemblies by hand brazing prior to plating. Some of the materials for the manufacture of these components can be supplied from Kalliti:

i) welded steel tube in two standard sizes - 15 tonne per annum (the tube to be formed from cold rolled strip);

ii) cold rolled steel strip supplied in slit coil form 17.5 tonne per annum, of which 6.5 tonne will be supplied annealed.

TABLE 5.5: DIRECT ATTRIBUTABLE COST OF BICYCLE FRAME AND FORK PRODUCTION

	Cost/Bicycle Birr	Cost/Annum Birr
Materials		
Tube Purchased From Kalliti 40 Tonne @ [illegible],500 Birr/Tonne	8.0	100,000
Annealed Sheet Purchased From Kalliti In Slit Coils 7.5 Tonne @ 2,300 Birr/Tonne	1.38	17,250
Sheet Purchased From Kalliti In Slit Coils 14.5 Tonne @ 2,200 Birr/Tonne	2.55	31,900
Steel Wire 0.4 Tonne/Annum @ 2,000 Birr/Tonne	0.07	800
Process Materials (For Welding, Brazing and Painting)	6.84	85,500
Total Materials	18.84	235,450
Labour		
15 Workers	3.24	40,500
Equipment		
(Depreciated at 10%/Annum)	4.95	61,900

The remaining materials will be imported:

i) mild steel rod 10 tonne/annum;

ii) hard bright wire 0.9 tonne/annum;

iii) small diameter tube for brake parts (sizes not available from Kalliti) 0.9 tonne/annum;

iv) process materials for plating.

The manufacture of these components will utilise the same facilities as for frame production:

i) press forming - the mechanical presses, welding, grinding and reaming facilities, and the wire straightening machine;

ii) tube manipulation - the tube cutting lathe, and slotting machine;

iii) frame and fork assembly - for dip brazing.

The additional facilities required in these sections will be:

i) an additional, small capacity mechanical press for making the small brake parts, together with 43 press tools;

ii) handlebar bending fixture and drilling jig, and a hand brazing set.

The major additional equipment needed is a complete plating facility for nickel and bright chromium plating. This will include polishing machines for finishing the components after plating. The facility will be used to plate components of all products manufactured in the factory.

Quality control of these components involves the following inputs:

i) use of "go-no go" gauges to check bores of handlebar lug prior to brazing;

ii) a test rig for carrying out non-destructive testing of selected handlebars taken from the production line after brazing and bending;

iii) laboratory facilities for control of plating process.

Table 5.6 summarises the equipment requirement for manufacture of press formed and tubular plated components. Table 5.7 details direct material and labour costs for these operations, together with an estimate of equipment depreciation costs. The sum of these costs is slightly higher than the import value of the components (12.92 Birr compared with 12 Birr). However, taking into account the saving in import duty (15% of 12 Birr) and in foreign exchange, and the fact that the plating plant can be

TABLE 5.6: ADDITIONAL MANUFACTURING EQUIPMENT FOR PRESS FORMED AND TUBULAR PLATED COMPONENTS

Press Forming Section - Estimated Cost 115,000 Birr

1 Mechanical Press
43 Press Tools

Frame/Fork Assembly and Brazing Section - Estimated Cost 9,500 Birr

1 Handlebar Bending Fixture
1 Hand Brazing Set
1 Bench and Vice

Plating Section - Estimated Csot 112,000 Birr

1 Nickel and Chromium Plating Plant with Material Handling Equipment
2 Double Ended Polishing Machines

Total 236,500 Birr

TABLE 5.7: DIRECT ATTRIBUTABLE COST OF PRESS FORMED AND TUBULAR PLATED COMPONENTS

	Cost/Bicycle Birr	Cost/Annum Birr
Materials		
Tube Purchased From Kalliti		
15 Tonne @ 2,500 Birr/Tonne	3.0	37,500
Annealed Sheet From Kalliti		
6.5 Tonne @ 2,300 Birr/Tonne	1.2	14,950
Sheet From Kalliti		
11 Tonne @ 2,200 Birr/Tonne	1.94	24,200
Imported Rod		
10 Tonne @ 1,375 Birr/Tonne	1.1	13,750
Imported Wire		
0.9 Tonne @ 3,000 Birr/Tonne	0.22	2,700
Imported Small Tube		
0.9 Tonne @ 3,000 Birr/Tonne	0.22	2,700
Process Materials	2.2	27,500
Materials Total	9.88	123,300
Labour		
6 Workers	1.15	14,400
Equipment		
(Depreciated @ 10%/Annum)	1.89	23,650

used for other operations, investment in the local manufacture of these components appears worthwhile.

5.2.4 **Manufacture Of Machined Bicycle Components**

There are a series of machined components on a bicycle which are either plated or case hardened. The total value of the machined components as part of an imported kit is about 3 Birr. This is only a small part of the total value of the kit, but;

- i) manufacture of these components will use existing plating facilities;
- ii) the Ethiopian Metal Tools Factory has the necessary heat treatment facilities; and
- iii) a machining section is necessary for other products of the industry.

Materials for the manufacture of these components will be imported:

- i) round mild steel bar, black finish, in various sizes, and hexagonal mild steel bar (40 mm across flats) - 15.65 tonne/annum;
- ii) process materials for plating.

The availability of plating facilities in-plant, and the forging capacity at EMTF, also allow consideration of the manufacture of the cranks and chainwheel. The total value of these components as part of an imported kit is estimated at 6 Birr. Material requirements for EMTF are as follows:

- i) to be supplied by Kalliti, cold rolled mild steel sheet - 11.75 tonne/annum;
- ii) to be imported, mild steel black bar 32 mm diameter - 23.65 tonne/annum.

The local manufacture of these components will require the establishment of a machining section in the factory.

Annex 10 describes the manufacturing processes for all the above components, and details the equipment and labour requirements. The machined components require a series of turning operations, most of which are best carried out using a capstan lathe, working from bar stock. Some require additional turning or drilling operations after parting off. The axle has two flats milled on it, and the two ends are ground after hardening. The quality control procedures are as follows:

- i) use of a capstan lathe provides the first stage of control since the correct setting of the tooling is primarily responsible for the correct dimensions of the final components;
- ii) this will be complemented by dimensional checking of selected components from the production line, using

go-no go gauges, to monitor any changes in the setting of machines during the processing. The ground diameter of the axle ends will be checked in the same way;

iii) hardness checks will be carried out on batches of heat treated components returned from the Metal Tools Factory.

The two cranks are made by forging from bar stock, and are machined to face the critical surfaces, and to drill the bottom bracket axle, pedal axle ard cotter pin holes. The pedal axle hole is then tapped. These machining operations will be carried out in the factory. The chainwheel is made by a series of pressing operations. However, these require a larger capacity press than is needed for other operations in the factory. It is therefore proposed that this component is made using existing facilities at the Ethiopia Metal Tools Factory. The R.H. crank and chainwheel are assembled by fitting the wheel over a boss on the crank, and then rolling the boss. This assembly operation would be carried out in the machining section of the factory.

Table 5.8 details the equipment requirements for manufacture of machined components and the cranks and chainwheel. It is assumed that the press forming and forging dies for the latter would be purchased by the low cost vehicle industry and supplied to the Metal Tools Factory to make the components under contract.

Table 5.9 makes an estimate of the direct materials and direct labour costs for production of these components, and of the depreciation of manufacturing equipment and tooling.

5.2.5 Manufacture Of Bicycle Components By Ancillary Industries

In addition to the processing of materials by Kalliti, there are three other possibilities for local manufacture of cycle components by ancillary industries.

*	Tyres and inner tubes	Addis Tyre
*	Plastic components	Ethio-Plastic
*	Accessories	Small-Scale Industries

The estimated reduction in CIF value of the imported kit of parts from local manufacture of these items is about 15 Birr, accounted for primarily by the tyres and tubes.

Tyres and Tubes

The Addis Tyre Company has the "up-stream" equipment for rubber compounding and preparation, ply cutting, and bead making needed for manufacture of cycle tyres and tubes. The additional equipment required to make bicycle tyres and tubes would be for the down-stream operations of tyre construction and moulding, and inner tube making. An output of 12,500 bicycles per year gives a requirement of 25,000 each of one size of tyre and tube. Since tyres and tubes usually constitute the largest maintenance cost for bicycles, there is also a substantial spare parts market,

TABLE 5.8: MANUFACTURING EQUIPMENT FOR THE PRODUCTION OF MACHINED COMPONENTS, CRANKS AND CHAIN WHEEL

Machining Section - Estimated Cost 203,000 Birr

1 Capstan Lathe
2 Chucking Lathes
1 Milling Machine
1 Centreless Grinding Machine
1 Pedestal Drill
1 Tapping Machine
4 Drilling Jigs
1 Milling Jig
1 Chainwheel Rolling Machine

Plating Section - Estimated Cost 6,000 Birr

1 Polishing Lathe

Tools For EMTF - Estimated Cost 45,000 Birr

5 Press Tools
2 Forging Dies

Total 254,000 Birr

TABLE 5.9: DIRECT ATTRIBUTABLE COST OF BICYCLE MACHINED COMPONENTS, CRANKS AND CHAINWHEEL

	Cost/Bicycle Birr	Cost/Annum Birr
Materials		
Sheet Purchased From Kalliti 11.75 Tonne @ 2,200 Birr/Tonne	2.07	25,850
Imported Mild Steel Bar 39.3 Tonne @ 1,375 Birr/Tonne	4.32	54,040
Process Materials	0.88	11,000
	7.27	90,890
Labour		
5 Workers	1.15	14,400
Equipment		
(Depreciated @ 10%/Annum)	2.03	25,400

both for existing bicycles (though not all of these will use the same tyre size) and for those produced by the proposed industry.

The company could also produce heavy duty tyres for the bicycle trailer, using the same equipment but a different construction specification. Given the demand for tyres and tubes as spare parts, in addition to the original equipment requirement, the local manufacture of these items by Addis Tyre in parallel with the establishment of the bicycle industry would seem worthwhile.

The investment in production equipment, and the purchase of raw materials, would be by the Addis Tyre Company who would supply to the proposed industry as original equipment, and distribute through the spare parts market for replacements. The existing technical agreement between Addis Tyre and Yokahama provides the expertise needed to ensure correct specification and satisfactory quality, in conjunction with the quality control procedures already used by the company.

Plastics Components

Ethio-Plastics has underutilised moulding capacity. This facility could be used to make handlebar grips and plastic rim tapes. The handlebar grip is a simple slush moulding and with a requirement of 25,000 units per annum the investment in a moulding tool (2,000 Birr) would be well worthwhile. The estimated material consumption of plastic PVC is 1.5 tonne/annum at 2,025 Birr/tonne - 3,040 Birr/annum.

The traditional type of rim tape is woven from natural fibre and held together by a simple clip. A more recent design is made as a plastic band, which is fitted by stretching it over the rim. It is made as a continuous extrusion moulding which is cut to length, the ends are heat welded to form a tape of the correct diameter, and a hole is punched for the tyre valve. The investment would be in an extrusion die (10,000 Birr) and ancillary equipment for heat welding and hole punching (5,000 Birr). The estimated material consumption of thermoplastic polyurethane is 1.25 tonne/year at 3,525 Birr/tonne - 4,400 Birr/annum. The commercial arrangement for these plastic moulded items would be for the low cost vehicle industry to provide the equipment and tooling to Ethio-Plastics who would produce under contract.

Accessories

Two accessories, the carrier and a parking stand, could be produced by private small-scale metal working industries. They can be made by labour intensive methods with very limited capital investment. The low cost vehicle industry would simply contract with a suitable private company to supply these items in quantities according to customer requirements.

5.3 Motor Cycle Manufacture

Except at much higher levels of production than are envisaged for Ethiopia, one would expect that the local content of a bicycle would be higher than for a motor cycle at the same level of output (measured in units per annum). This is because in comparison with the bicycle, the motor cycle is a more complex technology, using high specification raw materials, and a significant part of the total value of the machine is accounted for by the engine/clutch/gearbox assembly. This is designed for large-scale, capital intensive manufacture. Thus, since the planned output of motor cycles is only 40% of that of bicycles and will be split between two models, the viable level of local content will be substantially lower.

Of the examples of developing country motor cycle industries given earlier the nearest equivalent, in terms of scale of production, to that envisaged in Ethiopia is the Philippines industry immediately after the establishment of the progressive manufacturing programme. There were then four manufacturers with a total capacity of 33,000 units. The smallest of these had an output of 6,000 units per annum, which is comparable with the capacity proposed for Ethiopia. This manufacturer, like the others, gave a commitment to achieve 50% local content over a five year period. However, this level of local content is not realistic for Ethiopia at this stage for the following reasons:

i) as noted earlier, the measure of local content used in the Philippines is optimistic. Measured in terms of the true value of the components of a complete motor cycle kit replaced by locally manufactured items, a more realistic figure is 30 - 35%;

ii) it is the nature of the motor cycle industry that many of the specialised components are manufactured by ancillary industries. The collaborators in the Philippines programme were able to assist the development of ancillary industries, to serve all four motor cycle manufacturers, on the basis of a combined output of 33,000 units per annum.

A further feature of the situation in the Philippines is that an automotive industry had already been established. Thus a number of component manufacturers were already in existence who were able to serve both automotive and motor cycle industries. At present, although Fiat trucks have been assembled in Ethiopia for a number of years, there are very few ancillary automotive industries. The proposed expansion of AMCE´s activities to increase both the output and the level of local content, and the development of the tractor industry in Ethiopia would, together with the manufacture of motor cycles, provide a basis for the development and expansion of ancillary industries.

For the purposes of detailed engineering analysis of motor cycle manufacture, the following approach has been adopted:

i) a single model of general purpose motor cycle forms the basis of the analysis, but with allowance made for those different, or additional operations involved in the production of a trail bike;

ii) the assembly of motor cycles is analysed at both the SKD level, and with major items such as the engine and transmission imported unassembled;

iii) the components which it is feasible to manufacture in the proposed plant are identified and analysed;

iv) the manufacture of components by existing ancillary industries in Ethiopia is analysed;

v) an assessment is made of the potential for future increases in local content with expansion of the demand for motor cycles, and the development of ancillary industries.

The analysis is based on a plant capacity of 5,000 units per annum on a single shift, operating at 80% capacity (equivalent to 19.2 minutes input per worker per motor cycle). The value of a complete kit of parts for a motor cycle, CIF Assab, is estimated at 1,200 Birr, based on a general purpose motor cycle. A trail bike would be more expensive at about 1,350 Birr. This compares with an average CIF price of built-up units in 1984 of just under 1,700 Birr. The reduction in import value takes account of the saving by supplying in SKD form, and the potential to negotiate a more attractive price for a larger volume of imports.

The estimated CIF import value of components that can be replaced by locally manufactured parts is 134.5 Birr or just over 11% of the value of the complete kit. The replacement values of locally produced items are calculated using local content percentages applied in the Philippines, but converting from spare parts to original equipment values. There is potential for increasing the local content of the motor cycle in three ways:

i) development of ancillary industries in Ethiopia;

ii) use of ´redundant´ production tooling from overseas collaborator;

iii) expansion in demand for motor cycles.

5.3.1 **Motor Cycle Specification**

Annex 11 gives a breakdown of the component parts of a typical 125 cc general purpose motor cycle. It is not broken down to the individual component level (ie. every part, including nuts, bolts, washers etc. identified separately). Rather the major individual elements are itemised, and groups of minor parts are identified. Some major elements - the frame and the main engine/clutch/transmission assembly are identified as single assemblies at this stage, but are analysed in more detail subsequently. The specification is presented in this way for three reasons:

i) unlike the bicycle, the detailed specification of a motor cycle varies significantly between different manufacturers, particularly in terms of details of component design, and the methods of attaching the components to the main assembly. The specification presented here is based on a 125 cc model produced in the Philippines. The breakdown of components is disaggregated sufficiently to analyse the process of assembly, even though the details of some of the operations will vary from model to model;

ii) in the form presented the component breakdown is, with only minor variations, applicable to a trail bike as well as a general purpose motor cycle. However, the design of many of the individual components will be different for the two models including:

* the frame configuration and the suspension systems;

* the wheel hubs, since those for a trail bike are usually pressed while for other models they are cast;

* the wheel sizes;

* the fuel tank, handlebars, saddle and mudguards.

Some of the fittings, including controls, lights, switches etc., will be common, and it should be possible to use essentially the same engine/clutch transmission assembly, though details of carburation and gear ratios will vary and the exhaust systems will be different;

iii) the level of disaggregation of the component breakdown is sufficient to focus on those elements for which there is potential for developing localcontent.

5.3.2 **Assembly Of Motor Cycles From SKD Kits**

Annex 12 presents an analysis of the proposed organisation of motor cycle assembly, including equipment and labour requirements. The system of assembly is very similar to that proposed for bicycle assembly, namely:

i) incoming kits are checked and put into the component store;

ii) batched sets of parts are despatched on purpose-built trolleys to the appropriate sub-assembly or final assembly stations;

iii) the complete motor cycles are checked as they leave the final assembly line, packed and put into the despatch store.

The final quality control check is more comprehensive than for the bicycle. It will include the adding of engine and transmission fluids, running the engine, and taking the motor cycle on a short test ride to check operation of clutch, gearbox and brakes. It will also include a test of all electric systems. To avoid damage during assembly the bulbs, lenses and battery are fitted as part of the checking operation.

Again, the quality control procedures are the same as for the bicycle:

i) imported parts to be to specification agreed with supplier;

ii) visual inspection of parts when unpacking crates and delivering items to store. Damaged or reject items to be replaced by supplier;

iii) further identification of reject or damaged items during assembly;

iv) detailed final inspection (defined in Annex 12).

These procedures will form part of the total quality control system as locally manufactured parts replace some components in the imported kit.

Table 5.10 lists the equipment required solely for assembly of motor cycles. As can be seen both the labour content and the direct investment in assembly equipment are low. Table 5.11 details the labour content and estimate of cost elements directly associated with the assembly of motor cycles.

One option to increase local content is to import the kit in a more disaggregated form and introduce a higher degree of local assembly. The main potential for this is in the engine/clutch/ transmission assembly which could be imported in component form. This would result in only a marginal saving in import cost. The additional labour cost would be low - 100 minutes assembly time per unit is equivalent to six extra skilled workers at 300 Birr per month, a cost of 21,600 Birr per annum or 4.3 Birr/motor cycle. The additional investment cost would also be small - assembly benches, high quality hand tools, and mobile racks - about 50,000 Birr investment. Given the small cost implications, local assembly of the engine/transmission unit would be worthwhile in order to develop capability within the industry.

5.3.3 Manufacture Of Motor Cycle Components In-Factory

In addition to constraints on local manufacture of motor cycles imposed by the low output level, a further consideration is the nature of the agreement with the overseas collaborator. The collaborator will wish to maintain quality levels, particularly for components that are critical to performance or safety, and will want to ensure that the local facilities developed for component manfuacture meet this criterion. However, given that the strategy for development of local content will be defined as part of the collaboration agreement, the collaborator will then provide the technical expertise to develop local production methods and facilities of a suitable standard. There are two

TABLE 5.10: EQUIPMENT REQUIRED FOR ASSEMBLY OF MOTOR CYCLES

Equipment - Estimated Cost 95,000

1 Wheelstand

8 Pneumatic Screwdrivers (with tools)

1 Truing Stand

1 Tyre Roller

1 Tyre Inflator

1 Fluid Filling Stand

4 Complete Tool Sets

3 Benches

21 Mobile Racks

3 Fixed Racks

1 Ground Level Track System

TABLE 5.11: DIRECTLY ATTRIBUTABLE COSTS OF MOTOR CYCLE ASSEMBLY

	Cost/Motor Cycle Birr	Cost/Annum Birr
Materials		
Imported Kit CIF Assab	1,200	6,000,000
Import Duty @ 40%	480	2,400,000
Transport	56.25	281,250
Packing Material	15	75,000
Total Materials Cost	1,751.25	8,756,250
Labour		
11 Workers	7.02	35,100
Equipment For Assembly		
(Depreciated @ 10%/Annum)	1.9	9.500

other relevant aspects of the technical support from the collaborator;

i) they can draw on their experience from ventures in other developing countries in adapting production technologies to suit the much lower level of output than in the parent factory;

ii) it is quite possible that they will be able to provide ´redundant´ tooling from the parent factory, at a substantially lower investment cost than new tooling, for the manufacture of some components. It was stated earlier that it is undesirable to establish an industry based on redundant motor cycle designs, since Ethiopia would then not benefit from recent developments in efficiency and safety. This remains true as far as the overall design and specification of the motor cycle is concerned. However, in developed country industries, such as Japan, component designs are often changed at frequent intervals for styling or marketing reasons, rather than because of technical innovations. For such components, the use of ´redundant´ tooling would be quite acceptable in Ethiopia, as long as it is in good condition and has a resonable working life. Since it is not possible to predict what ´redundant´ tooling will be available, the analysis is based on the use of new production tooling.

In identifying components for manufacture within the factory, the focus is on items which can be made economically at low output levels, and which can utilise the same manufacturing processes as other products to be made in the plant.

The components identified for local manufacture are the following assemblies;

* Main Frame

* Parking Stand

* Rear Foot Rests

* Rear Carrier

* Saddle

* Individual press formed and tubular components.

Annex 13 gives detailed information on manufacture of these items but the main features are summarised below:

Assemblies

The most important assembly is the main frame. One component of the frame, the head tube, is quite complex, being of stepped diameter, and it is proposed that this should be imported. The remainder of the frame consists of tubular and pressed parts which are welded together to form the complete assembly, prior to painting. The CIF import value of the element of the parts kit to be replaced by local manufacture of the frame is estimated at 50 Birr.

Motor cycle frames are made from carbon steel, rather than mild steel, tube. To ensure quality it is assumed that this material would be imported, not supplied by Kalliti. High quality welding is essential in ensuring the strength, integrity and safety of the completed frame, and it is therefore proposed:

i) to carry out motor cycle frame welding in a separate section from other welding operations;

ii) to test the strength of selected frames from the production line on a non-destructive test rig;

iii) to use magnetic crack detection equipment for testing welds on selected frames from the production line;

iv) to use only skilled welders for this operation, and to train them in the procedures for welding frames.

Frame manufacture will use common facilities in the plant for:

i) press forming of components;

ii) tube cutting and deburring;

iii) painting.

At the planned level of output, the bent tubular components of the frame can be made using a hydraulic tube bender, rather than using more capital-intensive methods. Two complete sets of press tools and welding jigs will be needed since the frames for the general purpose motor cycle and the trail bike are of different specifications.

Parking stands come in a variety of different designs. A simple one consists of two separate legs, each attached to a pivot on the motor cycle frame, with a spring to hold it in the closed position. The stand can be made using facilities in the press forming section to form the components of the leg and weld them together. The assembly is then painted. A set of press tools is required to form the components. Materials for the parking stand can be supplied by Kalliti. The estimated CIF import value of the parking stand is 7 Birr.

The two rear footrests each consist of a tube with two circular plates welded to it, and a pivot which passes through a hole in the tube to attach it to a bracket welded on the suspension arm. The assembly is plated. The footrest can be manufactured using facilities in the press forming and tube manipulation sections, and the pivot in the machining section. Press tools will be required for blanking and piercing the plates. Materials can be supplied by Kalliti, except rod for the pivot. The estimated CIF import value of the rear footrest (excluding the rubbers) is 5 Birr. The same footrest design can be used on different motor cycle models.

Many different designs of rear carrier are used on motor cycles. The basic design is a bent outer frame made from mild steel rod, with the ends flattened to form brackets for attachment to the motor cycle. Straight lengths of rod are welded across the frame and the assembly is plated. The carrier can be manufactured using faciliites in the press forming section. Press tools will be required for flattening and piercing the frame ends. The estimated CIF import value of the carrier is 4 Birr.

The saddle consists of a tubular steel frame, a series of bent wire springs welded across it, and a hinge and clip for attachment to the main frame. The saddle is upholstered with foam covered by an outer layer of vinyl leather. The frame, springs, hitch and clip can be made and assembled using facilities in the press forming and tube manipulation sections, and painted prior to upholstering. Press tools will be required to make the hinge and clip. Tube and sheet for the saddle can be supplied by Kalliti. A small upholstery section is required ,which can also be used for work on motor cycle attachments. The foam can be supplied, cut to size and shape, by Ethio-Foam. The estimated CIF import value of the saddle is 22 Birr.

Press Formed Components

The simple press formed components of the motor cycle (i.e. those for which the tooling investment is relatively low) can be made in the factory:

* footrest clamp
* brake torque arm
* instrument panel box
* battery box
* front and rear number plate brackets.

All items are painted, except the brake arm which is plated. Press tools will be required for the different forming operations, and the battery box is assembled using the spot welder. Steel sheet for the various comonents can be supplied from Kalliti. The estimated CIF import value of these components is 15 Birr.

Tubular components

Two tubular components can be made in the factory:

* handlebar
* front footrest

The handlebar consists of the main bar, and a stretcher bar, made from smaller diameter tube, welded to it. The assembly is plated. The front footrest is a single length of tube, bent to shape and painted. Both components can be made in the tube manipulation section, with the handlebar welding done in the press forming section. A jig will be required for welding the handlebar. A test rig should be provided for non-destructive testing of handlebars selected from the assembly line after welding. The estimated CIF value of these components is 9 Birr.

Summary

In summary components to a CIF import value of 112 Birr can be made in the plant. Their manufacture will use many of the facilities required for bicycle production, but the following additional items of equipment will be required in existing sections:

1 mechanical press (to increase the capacity of the press forming section)

1 hydraulic tube bender

1 tube profiling machine

Two new manufacturing sections will be needed: motor cycle frame welding, and upholstery. Table 5.12 details the direct equipment and tooling requirements for motor cycle production. Table 5.13 presents a summary of the direct materials, labour and equipment depreciation costs associated with motor cycle production. This indicates that the local manufacture of these components is worthwhile, and demonstrates the benefits of combining bicycle and motor cycle production since the Table shows only the additional investment for the latter. However production of these motor cycle components also uses manufacturing facilities required for bicycles. The investment in these facilities is used more efficiently when both products are manufactured in the same plant.

The availability of redundant tooling from the collaborator would increase the potential for locally manufactured content, particularly for the larger or more complex pressed components such as the suspension arm, lamp bodies, fuel tank and autolube tank. It would be worth investing in the plant to make these items if the tooling was available cheaply.

5.3.4 Component Manufacture by Ancillary Industries

Table 5.14 lists those components for which it is worth assessing the feasibility of local manufacture by existing ancillary industries in Ethiopia. The list is broken down by industry into:

tyres and tubes;
other rubber components;
plastic components;
forged components;
filters;
battery.

TABLE 5.12: M[illegible]ACTURING EQUIPMENT FOR PRODUCTION OF MOTOR CYCLE COMPONENTS

Press Forming Section - Estimated Cost 519,000 Birr

1 Mechanical Press
40 Press Tools For Frame Components
8 Press Tools For Parking Stand
1 Welding Jig For Parking Stand
1 Welding Jig For Footrest
2 Press Tools For Carrier
1 Bending Jig For Carrier
1 Welding Jig For Carrier
6 Press Tools For Saddle
1 Wire Bending Jig For Saddle
20 Press Tools For Press Formed Components
1 Handlebar Welding Fixture

Tube Manipulation Section - Estimated Cost 50,000 Birr

1 Profiling Machine
1 Hydraulic Tube Bender

Machining Section - Estimated Cost 6,000 Birr

2 Drill Jigs For Footrest

Motor Cycle Frame Welding Section - Estimated Cost 120,000 Birr

4 Welding Sets
6 Welding Jigs

Upholstery Section - Estimated Cost 8,500 Birr

1 Industrial Sewing Machine
1 Cutting Table
1 Set Of Cutting Templates

TOTAL 703,500 Birr

TABLE 5.13: DIRECT ATTRIBUTABLE COSTS OF PRODUCTION OF MOTOR CYCLE COMPONENTS

	Cost/Motor Cycle Birr	Cost/Annum Birr
Materials - Local		
Mild Steel Tube From Kalliti 16.85 Tonne @ 2,500 Birr/Tonne	8.425	42,125
Mild Steel Sheet From Kalliti 44 Tonne @ 2,200 Birr/Tonne	19.36	96,800
Foam From Ethio-Foam	3.0	15,000
Materials - Imported		
Carbon Steel Tube 45 Tonne @ 2,750 Birr/Tonne	24.75	123,750
Mild Steel Rod 37.5 Tonne @ 1,375 Birr/Tonne	1.03	5,160
Wire 2.5 Tonne @ 3,000 Birr/Tonne	1.5	7,500
Vinyl Leather Cloth	5.0	25,000
Process Materials	12.52	61,000
Materials Total	75.60	376,335
Labour		
10 Workers	6.6	33,000
Equipment		
(Depreciated @ 10%/Annum)	14.07	70,350

TABLE 5.14: MOTOR CYCLE COMPONENTS CONSIDERED FOR MANUFACTURE BY ANCILLARY INDUSTRIES

1. Tyres and Tubes

4015 Rear Inner Tube
4016 Rear Tyre
8013 Front Inner Tube
8014 Front Tyre

2. Other Rubber Components

1003 Front Footrest Rubber
3008 Rear Footrest Rubber
2002 Engine Mounting Grommets
2012 Kick Start Rubber
2026 Air Cleaner Pipe
2029 Autolube Pipe
2037 Fuel Pipe

3. Plastic Components

Injection Mouldings

2034 Fuel Filter Body
2035 Fuel Filter Cap
5003 Rear Light Lens
5007 Indicator Lens
5011 Headlight Lens
7004 Hand Grip
7005 Twist Grip Moulding
9014 Trim Panel
6010 Front Mudguard (Trail Bike Only)
9001 Rear Mudguard (Trail Bike Only)

Extrusion Mouldings

4014 Front Rim Tape
8012 Rear Rim Tape
5026 Wiring Loom

4. Forged Components

2009 Kick Start Lever
2015 Gear Change Pedal

5. Filters

2016 Air Filter
2036 Fuel Filter
Oil Filter (part of 2000 - engine assembly)

6. Battery

5023 Battery

Tyres and tubes

The Addis Tyre Company has the "upstream" facilities for making motor cycle tyres and tubes, including the equipment for rubber compounding and preparation, ply cutting bead making and inner tube manufacturing. The additional equipment required would be for the "downstream" operations of tyre construction and moulding, and inner tube moulding. An output of 5,000 motor cycles per annum gives a demand for 10,000 tyres and tubes. The additional requirement for sidecars and pick up/van attachments increases demand to about 11,500 of each.

The present replacement market for tyres and tubes is low, given the small stock of motor cycles in the country. However, it will expand significantly as the number of motor cycles increases. For example, assume that after 5 years local production there are 20,000 motor cycles on the road and at least 4,000 sidecars and 1,000 pick up/van attachments, and that tyres have a 3 year, and tubes a 2 year, life (conservative estimates of wear or damage given the road conditions). In the sixth year the market demand would be:

	tyres	tubes
original equipment	11,500	11,500
replacements	18,500	28,000
Total	30,000	39,500

It is normal practice for motor cycles to have different sizes of tyre front and rear. For the general purpose motor cycle it is possible to standardise on a single tyre size, and this is already done in some countries. However, it is inherent in the design of a trail bike that the front tyre is larger in diameter but narrower than the rear. The tyres also have a different tread pattern from those of a general purpose motor cycle. It will therefore be necessary to produce three sizes of tyre and tube to meet the requirements for locally manufactured motor cycles and attachments. Each size of tyre will require separate tooling for construction and moulding. Each size of tube will require separate tooling for moulding.

Motor cycle tyres and tubes will have a low value added compared to the large, commercial vehicle tyres and tubes which form the major part of Addis Tyre output at present. Therefore it would not be worthwhile to invest in six sets of manufacturing equipment (one for each size of tyre and tube) at the initial demand level of 11,500 units per annum. However as the stock increases and the replacement market grows, it would be worthwhile to make tyres and tubes locally. The capital investment in tooling and equipment would be made by Addis Tyre, who would supply both to the low cost vehicle industry as original equipment and to the replacement market as spare parts.

The existing technical cooperation agreement between Addis Tyre and Yokahama will provide the expertise needed to ensure correct specification and satisfactory quality of tyres and tubes, in conjunction with the quality control procedures already employed by Addis Tyre.

The estimated saving in CIF value of the imported motor cycle kit by making tyres and tubes locally is 40 Birr (3.3%).

Other Rubber Components

There is only limited capacity at present in Ethiopia to make high quality rubber compression moulded components. The Addis Tyre Company produces some items using equipment that is primarily intended for the preparation of laboratory samples. However in the second phase of its agreed expansion plan it will establish a rubber moulding section to produce components for other industries in Ethiopia. When this capacity is available it will be feasible to manufacture the footrest rubbers, kick-start rubber and engine mounting grommets. The range of motor cycles can be specified so that these items are identical for the different models produced. All of these items are small components and are easy to mould, which minimises tooling costs. Each motor cycle will use four grommets giving an annual requirement of 20,000 units and two each of front and rear footrest and kick-start rubbers, or 10,000 each per annum. At these levels, local manufacture is worthwhile as compression moulding capacity becomes available. The case for making the various rubber pipes locally is not as strong. No existing local manfacturer of rubber pipe has been identified and the quantities required are small. Local production would only be worthwhile if the same cross sections and specifications of pipe were also required by other industries in Ethiopia.

Plastic Components - Injection Mouldings

There is substantial underutilised injection moulding capacity at Ethio-Plastics and at Ethio Gas and Plastic Crates. Thus the capital investment to make injection moulded components locally will be in the purchase of moulding tools. However the cost of injection moulding tools is high, and increases with the size and complexity of the component to be made. Of the items listed in the Table:

i) the fuel filter and cap both require complex tooling (to mould the clasp arrangement that holds them together);

ii) the front and rear mudguards require large tools, and output is low because they are used only on trail bikes;

iii) the trim panel requires separate, relatively large tools for the general purpose motor cycle and the trail bike;

iv) the three lamp lenses require tooling of similar complexity, but four indicator lens are required per motor cycle so that the output from this tool would be higher;

v) the hand grip and twist grip can be made by slush moulding with a relatively simple tool.

The relevant details for the hand and twist grip are:

Material:	Plastisol PVC
Material Cost:	2025 Birr/tonne
Material Consumption:	1 tonne/annum
Moulding Tools:	12,000 birr

The estimated CIF import value of the grips is 2.5 Birr, so local manufacture of these items is well worthwhile.

The relevant details for the indicator lens are:

Material:	Acrylic
Material Cost:	3525 Birr/tonne
Material Consumption:	2.5 tonne/annum
Moulding Tool:	80,000 Birr

The estimated CIF import value of four lenses per motor cycle is 6.5 Birr. This suggests that investment in tooling for moulding of the indicator lens is worthwhile. However it would not be worthwhile for the other lenses because the tooling cost is spread over a much smaller output of components. However moulding of other components would be worthwhile if redundant tooling is available from the overseas collaborator.

Plastic Components-Extrusion Moulding

The rim tapes for all motor cycle wheels can be made in the same way as for bicycles. A standard extrusion moulding is cut to the appropriate length for different sizes of wheel, heat welded and punched to form the valve hole. There is underutilised capacity for extrusion moulding at Ethio-Plastics so that the major capital investment is in the extrusion tool. The relevant data for the production of rim tapes at Ethio-Plastics is detailed below:

Material:	Thermoplastic polyurethane
Material Cost:	3100 Birr/tonne
Material Consumption:	1 tonne/annum
Extrusion Tool:	12,000 Birr
Ancillary tooling:	As for bicycle rim tape

The commercial arrangement for the manufacture of rim tapes would be for the low cost vehicle industry to provide the necessary tooling for Ethio-Plastics who would supply complete tapes under contract.

The estimated CIF value of the tapes is 1.5 Birr.

The wiring loom of a motor cycle consists of a series of lengths of plastic coated copper wire of different lengths, with appropriate fittings at the ends. which are bundled together and clipped to the motor cycle frame. Individual connections to different electrical items are then made during the assembly process. Ethio-Plastics already have facilities for drawing copper to different wire diameters, for winding, and for extruding the plastic sheathing around the wire. It would seem sensible to develop the capacity at Ethio-Plastics to make wiring looms, by acquiring the downstream facilities to cut the coated wire to length, attach fittings and assemble the looms. With this capacity Ethio-Plastics could supply the requirements for the AMCE truck assembly plant, and the Nazareth tractor assembly plant, as well as for motor cycle manufacture. Thus the investment would be made by Ethio-Plastics who would then supply the various industries.

The estimated CIF value of the motor cycle wiring loom is 12 Birr.

Forged Components

Table 5.4 lists two forged components which could be made at E.M.T.F.. The components can be common to different models of motor cycle, but an output of 5,000 units per annum is low. However if redundant tooling were available from the collaborator, local production would be worthwhile.

Filters

A private company in Asmara produces a range of engine filters. However the AMCE assembly plant continues to import all filters for its trucks and buses. The local manufacture of filters is an ancillary industry that would be expected to develop as automotive production of all types grows in Ethiopia. The decision to use locally manufactured filters is one that should be made, once the low cost vehicle industry is established, on the following basis:

i) that the local manufacturer is able to provide a regular supply of filters, of a suitable quality at an acceptable price;

ii) that the local manufacturer makes any captial investment required.

Battery

The existing battery factory makes only traditional Ebonite case batteries. The type used on all motor cycles has an injection moulded thermoplastic case. This is a quite complex moulding and an output of 5,000 units per annum is not sufficient to justify the tooling investment.

Thus initially, the only role of the battery factory could be to assemble and fill the batteries, using imported cases, plates and chemicals. However as the automotive industry develops it is likely that the battery factory will be upgraded to make thermoplastic batteries, both for original equipment and replacement markets. At this stage, motor cycle batteries could be included in the product range.

5.4 Manufacture Of Animal Cart, Cycle Trailer, And Motor Cycle Attachments

As discussed earlier these are technically the simplest products to manufacture and it is not necessary to proceed in phases from assembly to local production of components. Rather, manufacture can commence with a high proportion of locally manufactured components, but with some parts being imported on a continuing basis. The specification of the products has already been discussed, but for the purpose of analysis, the following annual output of cart wheel/axle assemblies has been assumed:

2,000	1 tonne capacity axles fitted with ADV pneumatic tyres;
500	1/2 tonne capacity axles fitted with ADV pneumatic tyres;
500	1/2 tonne capacity axles fitted with motor cycle tyres;
1,000	1/2 tonne capacity axles fitted with steel spoked wheels.

Manufacture of the vehicles utilises the following raw materials:

i) 87.9 tonne of mild steel tube (made from hot rolled strip) in various round and square sections, supplied by Kalliti;

ii) 116 tonne of hot rolled mild steel strip, in various thicknesses, supplied by Kalliti;

iii) foam from Ethio-Foam for upholstery of sidecar seats;

iv) 77.75 tonne of mild steel black finish bar, imported;

v) vinyl leathercloth for upholstery of sidecar seats, imported.

A number of components are supplied from local industries:

i) leaf springs for the sidecar and motor cycle attachments, from Ethio-Springs;

ii) Bushes for the animal cart wheels, cast by a local factory;

iii) tyres to ADV specification, for the animal carts, supplied by Addis Tyre. This assumes that the ADV tyre construction technology is transferred to Addis Tyre. The alternatives are to use standard motor vehicle tyres and tubes from Addis Tyre or import ADV tyres from India;

iv) tyres and tubes for the cycle trailer from Addis Tyre;

v) rim tapes for the cycle trailer, from Ethio-Plastic;

vi) wooden frames for the sidecar seats, from a local private industry;

vii) it is proposed that, for the two wheeled motor cycle attachment, the building of the van and pick-up bodies should be done by an existing private body building industry. The building of the bodies is a much more substantial operation for this product than for the other vehicles, and the quantities required are small.

Some components for the vehicles must be imported;

i) all fasteners (nuts, bolts, rivets etc.);

ii) parts to build up the cycle trailer wheels;

iii) parts to build up the sidecar wheels;

iv) complete wheels and hubs for the pick-up/van attachment;

v) tyres and tubes for the sidecar and pick-up/van attachment - at least until the capacity to manufacture motor cycle tyres and tubes is established at Addis Tyre.

The manufacture of the vehicles is described in detail in Annex 14. It will use existing facilities in the press forming section (to make various mounting brackets and plates), the tube manipulation section (to cut and form tube for frames, for wheel hubs and for the bead of the split rim wheels), and in the machining section. There is substantial lathe work required, primarily to make axles for animal carts. Wheels for the trailer and sidecar will be assembled at the appropriate sub-assembly stations defined for bicycle and motor cycle production. The cycle trailer can be painted using the common facility (assumed to be powder coating but stove enamelling would be equally acceptable). However, for reasons defined in the Annex it is preferable for the animal cart components and the sidecar to be painted by hand spraying. The sidecar seats will be upholstered using the same facilities as for motor cycle saddles.

One additional manufacturing section - fabrication and assembly, is required for the vehicles. This will have facilities for sheet metal cutting, bending and rolling, to make the split rim wheels, trailer bodies and sidecar body panels, and for welding to make the various frames and split rim wheels. final assembly of the vehicles will also be carried out in this section. The equipment specified for this section includes a guillotine shearing machine. An ancillary use of this machine is to cut sheet into strips for press forming. This will be used for those press formed components on other products where the amount of material used is insufficient to justify it being supplied from Kalliti in slit coil form.

The tooling requirements consist of press tools for the various press formed components, and welding jigs for the split rim wheel, cycle trailer hitch, and trailer, sidecar and pick-up/van attachments. All this tooling can be designed as part of the technical assistance proposed to establish manufacture of the vehicles, and be made in Ethiopia.

The quality control requirements for these vehicles are less stringent than for the bicycle and motor cycle. The use of jigs ensures dimensional quality and correct alignment. Go-no go gauges will be used to check dimensions of turned components. The crack testing equipment will be used to check weld quality on selected frames from the production line. Finally, all products will be subjected to a thorough check after final assembly.

The manufacture of the vehicles will require twelve direct workers. Table 5.15 details the equipment and tooling needed, and Table 5.16 gives a summary of the direct attributable material, labour and equipment costs.

TABLE 5.15: EQUIPMENT REQUIRED FOR MANUFACTURE OF CARTS, TRAILERS AND MOTOR CYCLE ATTACHMENTS

	Birr
Press Forming Section	33,000
1 Blanking Tool (Trailer)	
1 Cropping Tool (Trailer)	
2 Bending Tools (Trailer)	
4 Blanking Tools (Sidecar)	
3 Piercing Tools (Sidecar)	
Tube Manipulation Section	5,000
1 Cut-Off Saw	
Machining Section	30,000
1 Chucking Lathe	
Painting Section	3,500
1 Hand Spraying Set	
Fabrication and Assembly Section	170,500
1 Guillotine Shearing Machine	
1 Sheet Metal Bending Machine	
1 Sheet Metal Rolling Machine	
3 MIG Welding Sets	
1 Hand Shear	
1 Portable Drill	
1 Hand Rivetter	
1 Hand Press	
1 Tyre Inflator	
3 Wheel Welding Jigs (Cart)	
1 Frame Welding Jig (Trailer)	
1 Hitch Welding Jig (Trailer)	

1 Frame Welding Jig (Sidecar)
1 Suspension Arm Welding Jig (Sidecar)
1 Frame Welding Jig (Pick-up/Van)
4 Sets Hand Tools
4 Sets Guillotine Templates
4 Benches
Plus mobile racks to feed components from store to assembly

Total	242,000

TABLE 5.16: DIRECT ATTRIBUTABLE COSTS OF MANUFACTURE OF CARTS, TRAILERS AND MOTOR CYCLE ATTACHMENTS

	Cost/Annum Birr
Materials	
Tube From Kalliti 87.9 Tonne @ 2,300 Birr/Tonne	202,230
Sheet From Kalliti 116 Tonne @ 2,000 Birr/Tonne	232,000
Imported Steel Bar 73.5 Tonne @ 1,375 Birr/Tonne	101,065
Imported Leather Cloth	10,000
Imported Fasteners	39,750
Imported Wheels and Tyres	240,000
Locally Made Tyres	345,000
Locally Made Bushes	80,000
Locally Made Leaf Springs	90,000
Local Body Building	125,000
Other Locally Supplied Items	17,000
Process Materials	34,750
	1,516,795
Labour	
12 Workers	39,600
Equipment	
(Depreciated at 10%)	24,200

6. PROPOSED LOW COST VEHICLES PLANT

6.1 Summary Of Proposed Plant

This Chapter reviews relevant aspects of the proposed Low Cost Vehicles Industry with an annual capacity, on a one shift basis of:

12,500	Bicycles
5,000	Motor Cycles
4,000	Animal Carts
1,000	Cycle Trailers
1,000	Motor Cycle Sidecars
250	Pick-up/Van Attachments for Motor Cycles

Although it is unusual to manufacture this range of vehicle products in a single plant, it has certain benefits in Ethiopia. Given the relatively low output levels proposed based on the demand survey, the use of common manufacturing facilities to produce components for different types of vehicle allows higher capacity utilisation of capital equipment, and greater overall efficiency. This is true for operations which use an integrated set of processing equipment (eg. plating and painting). However, it is also true for processes where several similar items of equipment are specified (eg. press forming and machining), since it allows the plant specification to be better matched to production requirements, and makes more efficient use of indirect labour (eg. for tool setting and material handling).

As has been discussed earlier, there are problems in making precise estimates of demand for vehicles which are to a large extent new to Ethiopia. It is therefore important that the plant has flexibility to respond to changes in demand, and to expand output as demand develops over a period of time. The use of production facilities common to several different products, and of largely standard, general purpose manufacturing equipment, provides the flexibility to alter the mix of output of different products, and to introduce new adaptation or types of low cost vehicle which use similar facilities. The technology proposed for the plant allows increase of production by incremental stages since the facilities in a particular section can be expanded stage by stage as capacity limits are reached. It should also be noted that since the analysis is based on single shift production, output can be nearly doubled by introducing two shift working. However, it is prudent to allow for future expansion of the plant by locating it on a site larger than is needed to meet initial requirements. The manfacturing technologies identified as appropriate for the plant are such that they will remain efficient (ie. the method of making a particular component will not change) for substantial increases in output beyond that proposed initially. The introduction of new processes as output increases will be:

i) to increase the local content of bicycles and motor cycles;

ii) to extend the product range by introducing additional types of low cost vehicle.

It should be noted that, although much of the machinery is general purpose manufacturing equipment rather than special purpose plant, production efficiency can be achieved at the levels of output proposed by producing components in substantial batches. A machine is set to make a particular component, produces a batch of these, and is then reset for another component.

As discussed in Chapter 3 there is potential for expansion of the range of products manufactured by the plant, as the market for low cost vehicles develops. This expansion in the product range could include:

* Additional models of bicycle;
* Additional models of motor cycle;
* Additional low cost motor vehicles;
* New adaptations of bicycles for load carrying;
* Wheel/axle assemblies and other steel parts for wheelbarrows and handcarts;
* Single-axle tractors and trailers.

Although many of the manufacturing operations are common to different vehicles, where certain types of equipment are only used by one product, where a product has specific quality control requirements, and for final assembly, it is preferable to separate activities by product. The various production sections of the plant therefore fall into two categories:

i) those defined by process for manufacturing operations which are common to different products:

    Press forming;
    Tube Manipulation;
    Machining;
    Upholstery;
    Painting;
    Plating;

ii) those defined by product for those processes which are specific to a particular product, or where separation is necessary to ensure product quality:

    Bicycle Frame and Fork Assembly;
    Motor Cycle Frame Welding;
    Bicycle Final Assembly;
    Motor Cycle Final Assembly;
    Fabrication and Assembly (for carts, trailers and motor cycle attachments).

In addition to these production sections, the factory will also require storage areas:

* Raw Materials: For storage prior to processing through the various manufacturing operations;

* Components: For storage of local and imported bought-in components, and in-plant manufactured components, prior to final assembly;

* Despatch: For storage of completd products prior to despatch;

* Process Materials: For storage of chemicals, paints etc. which require secure storage.

Two service sections will also be required:

* Tool Room: For plant maintenance, and for production and repair of tooling, jigs and fixtures;

* Quality Control and Laboratory: Although many of the quality control procedures are carried out in the manufacturing and assembly sections, a separate area is required for carrying out standard tests on selected items from the production line or delivered components. The laboratory is needed for control and monitoring of the plating plant.

Table 6.1 gives a summary of the operations of the proposed plant, detailing the major items of equipment for each section, the utilisation of equipment for the manufacture of different products, and the direct labour requirements. It should be noted that the machine utilisation times include an allowance, where appropriate, for tool setting time between component batches. The direct labour requirements are determined by analysing the numbers of bicycles to be produced, and then the additional labour needed for manufacture of motor cycles and other products[1].The Table illustrates clearly the common use of facilities in the various sections for manufacture of the different products. The total direct labour requirement is 79 workers.

6.2 Ancillary Industries

The proposed low cost vehicles plant will make substantial use of exsiting industries in Ethiopia in three ways:

i) as suppliers of raw material;

ii) as suppliers of components and sub-assemblies;

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1. Based on a 2,000 hour working year and operating at 80% efficiency, the maximum output per machine or per worker is 1,600 hours per annum.

TABLE 6.1: SUMMARY OF LOW COST VEHICLE PLANT OPERATIONS

Manufacturing Section and Major Items of Equipment	Machine Utilisation and Number of Workers					
	Bicycle		Motor Cycle		Other Products	
	Hours/ Annum	No. Of Workers	Hours/ Annum	No. Of Workers	Hours/ Annum	No. Of Workers
Press Forming Section						
6 Mechanical Presses	5,730	4	1,475	1	60	-
1 Wire Straightener	295)					
2 MIG Welders	1,980)		170)			
1 Pedestal Drill	750)	3	475)			
1 Pedestal Grinder	975)		)	1		
1 Spot Welder	105)		45)			
1 Wire Bender			300)			
Tube Manipulation Section						
1 Tube Cutting Lathe	590)		250)		300)	
1 Deburring Machine	520)	1	210)		255)	
1 Slotting Mahine	80)		)	1	)	1
1 Profiling Machine			250)		)	
1 Tube Bender			420)		250)	
1 Cut Off Saw					40)	
Machining Section						
1 Capstan Lathe	1,565	1				
3 Chucking Lathes	2,085)		60	-	2,000)	
1 Milling Machine	160)	2			)	2
1 Centreless Grinder	420)				)	
1 Pedestal Drill	870)		120	-	175)	
1 Tapping Machine	280)	1				
1 Chainwheel Roller	105)					
Upholstery Section						
Minor Equipment			1,250	1	250	-
Bicycle Frame and Fork Assembly Section						
Frame/Fork Assembly and Finishing Equipment	3,420	3				
Brazing and Debrassing Equipment	2,225	2				

TABLE 6.1: Continued

Manufacturing Section and Major Items of Equipment	Machine Utilisation and Number of Workers					
	Bicycle		Motor Cycle		Other Products	
	Hours/ Annum	No. Of Workers	Hours/ Annum	No. Of Workers	Hours/ Annum	No. Of Workers
Motor Cycle Frame Welding Section						
4 MIG Welders			5,850	4		
Fabrication and Assembly Section						
1 Guillotine Shear	105	-			1,215)	
1 Sheet Metal Bender					1,125)	3
1 Sheet Metal Roll					450)	
3 MIG Welders					4,625	3
Assembly Equipment					2,245	2
Painting Section						
1 Complete Painting Plant		3		1		
1 Hand Spraying Set					1,500	1
Plating Section						
1 Complete Plating Plant		3		1		
3 Polishing Lathes	4,200	3	1,000	-		
Bicycle Final Assembly Section						
3 Sub Assembly Stations	9,065	7			320	-
Final Assembly Line	9,800	7				
Motor Cycle Final Assembly Section						
1 Sub Assembly Station			1,500	1	160	-
Engine/Transmission Assembly			8,500	6		
Final Assembly Line			14,500	10		

iii) as manufacturers of components supplying the plant and other markets in Ethiopia.

Supply Of Raw Materials

The main supplier of raw materials will be Kalliti Steel Industries. Detailed below is a summary of the consumption of tube and sheet from Kalliti by the proposed industry:

	Tonne/Annum	Birr
Welded Tube (from cold rolled strip)	71.85	179,625
Welded Tube (from hot rolled strip)	87.9	202,230
Cold Rolled Sheet	83.5	185,100
Hot Rolled Sheet	166.0	232,000
Total	359.25	798,955

In addition, the bicycle chainwheels to be made by EMTF for the plant, will use a further 11.75 tonne of cold rolled sheet, value 25,850 Birr.

Ethio-Foam will supply foam products for upholstery to the value of 21,000 Birr/annum.

Supply Of Components And Sub-Assemblies

The following industries will be used to supply components and sub-assemblies under contract to the plant:

	Output/Annum	Value (Birr)
Ethio Plastics	12,500 Pair Bicycle Hand-grips	38,500
	27,000 Bicycle Rim Tapes	
	5,000 Pair Motor Cycle Hand And Twist Grips	12,500
	20,000 Motor Cycle Indicator Lenses	32,500
	10,000 Motor Cycle Rim Tapes	7,500
EMTF	12,500 Pressed Bicycle Chainwheels	50,000
	12,500 Pair Forged Bicycle Cranks	
	Heat Treatment Of Bicycle Components	12,500
Ethio Springs	1,500 Leaf Springs	90,000

Other Private Industries	16,000 Castings For Bushes	80,000
	1,000 Wooden Seat Frames	10,000
	250 Pick-Up/Van Bodies	125,000
	Bicycle Carriers and Parking Stands	37,500
Total		496,000

Manufacture Of Components For The Ethiopian Market

The establishment of the low cost vehicles plant will generate the demand to justify the manufacture of bicycle and ADV tyres and tubes by Addis Tyre, to supply the original equipment requirement of the plant, and the spare parts market. The demand from the plant will be as follows:

Per/Annum	Birr/Annum
25,000 Bicycle Tyres and Tubes	300,000
2,000 Trailer Tyres and Tubes	20,000
5,000 ADV Tyres and Tubes	325,000
Total	645,000

As the market for the motor cycles and attachments develops, it will also become worthwhile for Addis Tyre to produce tyres and tubes for them.

The manufacture of motor cycles provides the incentive for Ethio-Plastics to exploit its existing wire drawing and plastic extrusion facilities to make complete wiring looms for local vehicle industries. The demand from the low cost vehicles plant will be for 5,000 looms per annum, with a value of 60,000 Birr.

In summary, the low cost vehicles plant will consume about 370 tonnes/annum of locally produced steel sections, and a total value of locally supplied materials, components and sub-assemblies of just over two million Birr/annum.

As the low cost vehicle industry develops, utilisation of local industries should increase as a result of expansion of production, greater local content, and development of component industries serving all automotive plants in the country.

6.3 Implementation Schedule

There are two alternative approaches to the establishment of the plant:

i) introduce the products in phases, eg.:

Phase 1: Establish assembly and local manufacture of bicycles;

Phase 2: Establish assembly and local manufacture of motor cycles;

Phase 3: Establish local manufacture of other products.

This approach would minimise the management problems involved in setting up and running the plant, and allow skills in the production of the various vehicles, the operation of the plant and the technology of low cost vehicles to be developed over a period of time. However, it is desirable that the phasing should not be extended over a longer period than necessary, since certain facilities will be used inefficiently until the plant reaches full production;

ii) introduce the whole range of vehicles as quickly as possible, and then increase the local content over a period of time.

The second option is considered to be preferable for the following reasons:

i) as is discussed in Chapter 3, a major objective behind the proposed plant is to create demand for vehicles which are appropriate to conditions in Ethiopia, and can make a signficant contribution to improving transportation facilities to promote economic and social development. While the foreign exchange savings from maximising local content are clearly an important benefit, they are in a sense secondary to the benefit from making low cost vehicles more widely and easily available than at present. It is therefore sensible to establish, as quickly as possible, the facilities to assemble the two major vehicles (bicycles and motor cycles) and produce other products, then subsequently increase local content. This will also accelerate the process of developing the demand for low cost vehicles in the country as people become familiar with their uses and benefits;

ii) it allows a period of time for plant personnel to become familiar with the technology of the whole range of low cost vehicles, prior to embarking upon the introduction of the more complex manufacturing processes.

The recommended schedule for the establishment of production of low cost vehicles is therefore as follows:

Year 1 Assembly of bicycles and motor cycles from imported SKD kits;

Year 2 Manufacture of cycle trailers, cart wheel/axle assemblies and motor cycle attachments;

Supply of bicycle and ADV tyres and tubes from Addis Tyre, and plastic moulded bicycle and motor cycle components from Ethio-Plastics;

Assembly of motor cycle engines and transmissions.

Year 3 Manufacture of bicycle frames and front forks;

Manufacture of motor cycle frames;

Manufacture of motor cycle wiring looms by Ethio-Plastics;

Year 4 Manufacture of plated and machined components for bicycles;

Manufacture of other motor cycle assemblies and components.

At the end of this period there will be sufficient original equipment and spare parts demand for Addis Tyre to initiate local production of motor cycle tyres and tubes.

Chapter 5 and its Annexes provide the base data to analyse the financial implications of this and alternative scenarios for phasing the development of the production activities of the plant. However, based on the above schedule, manufacturing facilities will be required as follows:

Year 1 Bicycle final assembly section
Motor cycle final assembly section
Component store
Despatch store

Year 2 Fabrication and assembly section
Tube manipulation section
Upholstery section
1 Mechanical press in press forming section
2 Chucking lathes and 1 pedestal drill in machining section
Hand spraying facilities in painting section
Motor cycle engine and transmission assembly area
Raw materials store
Quality control section
Tool room

Year 3 Bicycle frame and fork assembly section
Motor cycle frame welding section
Remainder of press forming section
Painting plant
Process materials store

Year 4 Remainder of machining section
Plating section

6.4 Physical Facilities

Plant Location

The proposed plant will require normal light industry services - electricity and water supply, drainage, etc. -

but has no special requirement for services. Unlike some process industries it will not consume very large amounts of electricity or require large volumes of water. Therefore, in respect of service requirements, the choice of location is quite free. Discounting political considerations such as a desire to decentralise industry, the major factors in the choice of plant location are labour supply and transportation.

The plant will have a labour requirement, including ancilliary, administration and management staff, of about 140 people. This includes skilled production workers and qualified supervisory and management staff. It is desirable in cost terms that the plant is located in or near an urban centre with a suitable labour supply, rather than having to construct housing for workers or to provide transport to bring them to and from the plant.

Locally supplied inputs will have to be transported to the plant from Addis Ababa, and imported inputs from a port. Given the current disadvantages of locating a plant in the Asmara area and using its port facilities, imported inputs will be supplied through Assab or Djibouti. This suggests that the plant should be located within an area convenient for the road and railway links between Addis Ababa and these ports. In other words, in the area between Addis Ababa and Dire Dawa. The proposed plant is intended to create and meet a demand for low cost vehicles in rural and urban areas of Ethiopia. Though the export of vehicles is a possibility, it is a secondary consideration to local demand. In order to create and meet this demand, it is very important that the plant has a distribution system that allows it to reach and deliver to all parts of the country. This argues for a central location, to minimise distribution costs, with good access to the main road network.

These considerations suggest that the most appropriate location for the plant is somewhere along the Addis Ababa - Nazareth corridor. Location in this area would also facilitate communications with the various suppliers based in Addis Ababa, and the Purchasing Department of the National Metal Works Corporation who will be responsible for the procurement of imported components and materials. The three most likely locations for the plant (not in order of preference) are:

* On the southern side of Addis Ababa, perhaps near Kalliti Steel Industries, which will be the main local supplier and is adjacent to the highway to Assab;

* In Nazareth, which is a developing industrial centre and has good access to the road network;

* At Wodji, which is located at a major junction of the main road network.

Site

The site should be located on reasonably flat land and provide good access for heavy vehicles, delivering inputs and distributing finished products, to the public highway. Sites that will have difficult water drainage problems should be avoided since the provision of suitable drainage facilities will increase the cost of establishing the plant. Similarly, to minimise costs, the site should be conveniently located for connection to the electricity distribution system, and for the provision of water supply.

The size of the plant, and therefore of the site, is conditioned primarily by storage requirements. Three main storage areas will be required - raw materials, components and despatch:

i) for raw materials it is prudent to allow for storage of up to one years supply of imported items, and three months supply of local items. It is also important to separate different sizes and specifications of raw materials for convenience of distribution to the manufacturing sections. Based on these considerations, the estimated floor area required for storage is 250 m^2;

ii) as is discussed in Section 6.6 the proposed flow of materials is from the raw materials store, through the manufacturing sections to the components store. There the made-in components are batched with imported and locally supplied parts for issue to the assembly sections. It is desirable to keep the volume of made-in parts held in the components store to a minimum. However, to ensure continuity of production, much larger stocks of imported kits of parts must be held. It is assumed that provision must be made for holding up to six months supply of imported kits, but that most of this can be stored in crates in a secure open area outside the main building. Thus the space required for the components store is estimated on the basis of holding one month's stock of all finished components within the building. Sufficient space must also be allowed in this area for gangways, and and for batching components on mobile racks prior to issue to the assembly sections. On this basis 900 m^2 floor area is required for components storage;

iii) finished product storage requirements are calculated on the basis of holding two months' stock of all vehicles. To minimise space requirements, the bulky items such as trailers and sidecars are stored with wheels removed. Estimated floor area required is 1,200 m^2.

The estimated floor area required for the component manufacturing sections - press forming, tube manipulation, machining, upholstery, bicycle frame and fork assembly, motor cycle frame welding, painting and plating, is 700 m^2. for the assembly sections - fabrication and assembly, bicycle assembly and motor cycle assembly, 300 m^2 is required. In addition, provision must be made for a tool room and quality control section. It is therefore sensible to allow 1,200 m^2 for the production floor area. Allowing 300 m^2 for an office block, the total building area required is:

Production	1,200 m^2
Storage	2,350 m^2
Administration	300 m^2
Total	3,850 m^2

The total site area must allow for roadways, and for external storage of crated kits (estimated at 1,000 m^2). It is also prudent to select a site which provides space for the expansion of manufacturing facilities. A site area of 10,000 m^2 is recommended.

Plant Layout

The recommended plant layout is based on the flow of materials from the raw materials store, through the manufacturing sections, into the components store as finished components, then through assembly areas to the despatch store. Thus the raw materials store should be located at one end of the factory building, the components store centrally, and the despatch store at the other end. Supplies will be either to the raw materials store or the components store. The component manufacturing sections will be located between the raw materials and components stores:

i) the press forming, machining, tube manipulation and fabrication areas should be located adjacent to the raw materials store. These sections all use materials in bulk direct from the store, which can be supplied by overhead crane. The same crane can be used to unload and move to the store incoming raw materials. For movement of part-finished components through subsequent operations, floor transport - trolleys, pallet trucks and fork lift trucks - can be used. The above implies that, in terms of physical layout, the fabrication and assembly section should be separated into two parts:

   * Fabrication area adjacent to raw materials store;

   * Assembly area between components and despatch stores;

ii) In general, it is not necessary to separate different sections by partition walls, and indeed this is undesirable since it inhibits supervision and the flow of materials between sections. However, some form of physical separation is required for the following:

Painting	To prevent dust etc., from other sections affecting the quality of the paint finish;
Plating and Brazing	To prevent heat and fumes from adversely affecting working conditions in other areas;
Motor Cycle Frame Welding	Because of the particular quality requirements in this section.

iii) the painting, plating and brazing facilities are best located adjacent to outside walls since they will require extraction systems.

The assembly sections for bicycles, motor cycles and other products should be physically separate but need not be partitioned. The motor cycle assembly section should have access to the outside of the building so that the vehicles can be filled with fluids and road tested on the site.

The plant will require electricity distribution to all sections, compressed air supply to assembly areas, and water supply to the plating section. Good access from outside the building will be needed to the three stores, and gangways should be clearly delineated to allow free flow of materials and components.

6.5 Equipment

Equipment requirements are discussed under three headings - production machinery and tooling, quality control and tool room, storage and material handling.

Production Machinery and Tooling

Table 6.2 lists the items of manufacturing equipment required for the production of the range of low-cost vehicles. The Table gives estimated costs for each item of equipment. However, it should be noted that these are estimates based on knowledge of world prices, used in order to give an overall estimate of capital investment cost. Quotations should be obtained from potential suppliers prior to completion of the feasibility study. The Table also indicates sources of supply for the different items of equipment. They fall into three categories:

i) general-purpose manufacturing equipment which is available from a number of suppliers in different countries. Such equipment is best

TABLE 6.2: MANUFACTURING EQUIPMENT REQUIREMENTS

Machine	Estimated Cost (Birr)	Source of Supply
<u>Press Forming Section</u>		
6 Mechanical Crank Presses, Electrically Driven:		
1 75 Tonne Capacity	50,000	General Purpose
1 60 Tonne Capacity	45,000	General Purpose
2 40 Tonne Capacity	80,000	General Purpose
1 30 Tonne Capacity	35,000	General Purpose
1 15 Tonne Capacity	25,000	General Purpose
2 MIG Welding Sets	7,000	General Purpose
1 Pedestal Drill, 30 mm Capacity	7,000	General Purpose
1 Double Ended Pedestal Grinder 300 x 30 mm Wheels	3,500	General Purpose
1 Spot Welder, 5 mm Thickness Capacity	10,000	General Purpose
1 Wire Straightening and Cutting Machine, Capacity 5 mm Wide	9,000	General Purpose
1 Wire Bending Machine	6,000	Motor Cycle Collaborator
Sub Total Press Forming	277,500	
<u>Tube Manipulation Section</u>		
1 Tube Cutting Lathe Capacity 50 mm Tube	30,000	General Purpose
1 Deburring Machine	7,500	General Purpose
1 Slotting Machine	5,000	Bicycle Collaborator
1 Tube Profiling Machine	10,000	General Purpose
1 Hydraulic Tube Bender Capacity 50 mm x 2 mm Tube	40,000	General Purpose
1 Cut Off Saw, Capacity 50 mm Dia.	5,000	General Purpose
Sub Total Tube Manipulation	97,500	
<u>Machining Section</u>		
1 Capstan Lathe 200 mm Swing, 1 m Bed Length	40,000	General Purpose
3 Chucking Lathes, All 200 mm Swing 1 1 m Bed Length 1 1.5 m Bed Length 1 2.0 m Bed Length	100,000	General Purpose
1 Small Horizontal Milling Machine	25,000	General Purpose
1 Centreless Grinder	25,000	General Purpose
1 Pedestal Drill, 25 mm Capacity	6,500	General Purpose
1 Tapping Machine	15,000	Bicycle Collaborator

TABLE 6.2: Continued

Machine	Estimated Cost (Birr)	Source of Supply
<u>Machining Section Continued</u>		
1 Chainwheel Rolling Machine	7,500	Bicycle Collaborator
Sub Total Machining	219,000	
<u>Upholstery Section</u>		
1 Industrial Sewing Machine	5,000	General Purpose
1 Cutting Table	2,500	Local
Sub Total Upholstery	7,500	
<u>Bicycle Frame and Fork Assembly Section</u>		
1 Pedestal Drill, 30 mm Capacity	7,000	General Purpose
1 Special Purpose Tapping Machine	30,000	Bicycle Collaborator
1 Gas Welding Set	2,500	General Purpose
1 Electrically Heated Dip Brazing Furnace (Frame)	30,000	Best Obtained Through Bicycle Collaborator
1 Electrically Heated Dip Brazing Furnace (Fork)	25,000	Best Obtained Through Bicycle Collaborator
1 Electrolytic Debrassing Tank	15,000	Best Obtained Through Bicycle Collaborator
1 Hand Brazing Set	2,500	General Purpose
1 Bench	2,000	Local
1 Vice	1,000	General Purpose
1 Portable Drill	1,500	General Purpose
Sub Total Bicycle Frame and Fork Assembly	116,500	
<u>Motor Cycle Frame Welding Section</u>		
4 MIG Welding Sets	20,000	General Purpose
<u>Fabrication and Assembly Section</u>		
1 Electrically Driven Guillotine Shearing Machine, Capacity 5 mm	50,000	General Purpose
1 Sheet Metal Bender, Capacity 3 mm	15,000	General Purpose
1 Electrically Driven Sheet Metal Roll, Capacity 6 mm	40,000	General Purpose
3 MIG Welding Sets	10,500	General Purpose
1 Hand Shear	1,500	General Purpose
1 Portable Drill	1,500	General Purpose
1 Hand Rivetter	1,000	General Purpose
1 Hand Press	3,000	General Purpose

TABLE 6.2: Continued

Machine	Estimated Cost (Birr)	Source Of Supply
<u>Fabrication and Assembly Section Continued</u>		
4 Benches	7,000	Local
15 Mobile Racks	17,500	Local
Sub Total Fabrication and Assembly	147,000	
<u>Painting Section</u>		
1 Complete Powder Coating System Throughput 25,000 Units/Annum Consisting Of; - Shot blasting booth - Electrostatic spraying - Low bake and continuous drying oven	100,000	General Purpose
Hand Spraying Set	3,500	General Purpose
Sub Total Painting Section	103,500	
<u>Plating Section</u>		
1 Complete Nickel and Chromium Plating Plant, Capacity 25,000 Sets Of Components/Annum, Consisting Of; - Plating rectifiers - Immersion heaters - Bright nickel plating tank - Filter press - Air agitation equipment - Dull nickel plating tank - Chromium plating tank - Rinsing tank - Swilling tanks	100,000	Best Obtained Through Bicycle Collaborator
3 Double Ended Polishing Lathes	18,000	General Purpose
Sub Total Plating Section	118,000	
<u>Bicycle Final Assembly Section</u>		
2 Hand Presses	6,000	General Purpose
5 Vices	5,000	General Purpose
1 Wheelstand	2,000	Bicycle Collaborator
1 Truing Stand	3,000	Bicycle Collaborator
1 Tyre Roller	2,000	Bicycle Collaborator
1 Tyre Inflator	2,000	Bicycle Collaborator
6 Benches	10,000	Local
27 Mobile Racks	35,000	Local
4 Fixed Racks	4,000	Local
3 Bike Stands	2,500	Local

TABLE 5.2: Continued

Machine	Estimated Cost (Birr)	Source Of Suppy
Bicycle Final Assembly Section Continued		
1 Ground Level Track	15,000	Local
Sub Total Bicycle Final Assembly	86,500	
Motor Cycle Final Assembly		
1 Wheelstand	3,000	Motor Cycle Collaborator
1 Truing Stand	5,000	Motor Cycle Collaborator
1 Tyre Roller	3,000	Motor Cycle Collaborator
1 Tyre Inflator	2,000	Motor Cycle Collaborator
1 Fluid Filling Stand	10,000	Local
9 Benches	24,000	Local
33 Mobile Racks	50,000	Local
3 Fixed Racks	3,000	Local
1 Ground Level Track	20,000	Local
Sub Total Motor Cycle Final Assembly	120,000	
Total Equipment Cost	1,313,000	

purchased by competitive bidding to obtain suitable machinery at the lowest price;

ii) special-purpose machinery for the production of bicycles and motor cycles, which will be obtained through the overseas **collaborator** for these products. This includes those items which will be made by, or to the order of, the collaborators, and those machines which, even if they are available from other suppliers are best obtained through, and with the technical advice of, the collaborator;

iii) items which can be made or obtained locally in Ethiopia.

The total investment cost for the production machinery is estimated at 1,313,000 Birr. This is broken down as follows:

General Purpose	857,000 Birr
Bicycle Collaborator	236,500 Birr
Motor Cycle Collaborator	19,000 Birr
Local	200,500 Birr

Table 6.3 lists the production tooling requirements for the different vehicles. The prices are estimated on the same basis as for machinery. The main sources of supply of tooling for the bicycle and motor cycle are the overseas collaborators (note that prices are based on new, not redundant, tooling from these sources). However, some items are general purpose, and some can be made locally. For the other products it is assumed that the jigs and fixtures will be made locally, to the designs prepared as part of the technical assistance. The total cost of production tooling is estimated at 1,108,500 Birr, broken down as follows:

	Collaborator	General Purpose	Local	Total
Bicycle	277,500	13,500	-	291,000
Motor Cycle	563,000	25,000	7,000	595,000
Other Products	-	4,000	52,500	56,500
Tooling for Sub-contractors	139,000	3,000	24,000	166,000
Total	979,500	45,500	83,500	1,108,500

Quality Control and Tool Room

Table 6.4 lists the quality control and tool room equipment proposed for the industry. Most of the quality control equipment is referred to in the technical discussions in Chapter 5. However, in addition to the various gauges and test rigs, a set of measuring equipment is also included. the gauges and test rigs will be obtained through the bicycle and motor cycle collaborators. Other items are

TABLE 6.3: TOOLING REQUIREMENTS

Tooling	Estimated Cost (Birr)	Source Of Supply
Bicycle		
58 Press Tools For Frame and Fork	120,000	Bicycle Collaborator
43 Press Tools For Other Pressed Parts	90,000	Bicycle Collaborator
1 Chainstay Welding Fixture	3,000	Bicycle Collaborator
1 Seatstay Welding Fixture	3,000	Bicycle Collaborator
4 Drill Jigs	12,000	Bicycle Collaborator
1 Milling Jig	2,000	Bicycle Collaborator
3 Frame Assembly Fixtures	20,000	Bicycle Collaborator
1 Fork Assembly Fixture	4,000	Bicycle Collaborator
10 Frame Brazing Jigs	10,000	Bicycle Collaborator
1 Frame Setting Jig	5,000	Bicycle Collaborator
1 Fork Bending Fixture	4,000	Bicycle Collaborator
1 Handlebar Bending Fixture	4,000	Bicycle Collaborator
10 Sets Hand Tools	6,000	General Purpose
6 Pneumatic Screwdrivers	7,500	General Purpose
1 Eye Nut Inserter	500	Bicycle Collaborator
Sub Total Bicycle	291,000	
Motor Cycle		
76 Press Tools	456,000	Motor Cycle Collaborator
1 Stand Welding Fixture	1,000	Local
1 Footrest Welding Fixture	1,000	Local
1 Carrier Welding Fixture	1,000	Local
1 Handlebar Welding Fixture	1,000	Local
1 Carrier Bending Jig	3,000	Local
2 Drill Jigs	6,000	Motor Cycle Collaborator
1 Set Templates	1,000	Motor Cycle Collaborator
6 Frame Welding Fixtures	100,000	Motor Cycle Collaborator
10 Sets Hand Tools	15,000	General Purpose
8 Pneumatic Screwdrivers	10,000	General Purpose
Sub Total Motor Cycle	595,000	

TABLE 5.3: Continued

Tooling	Estimated Cost (Birr)	Source Of Supply
Other Products		
11 Press Tools	33,000	Local
3 Cart Wheel Welding Fixtrues	5,000	Local
1 Trailer Frame Welding Fixture	3,000	Local
1 Trailer Hitch Welding Fixture	1,500	Local
1 Sidecar Frame Welding Fixture	3,000	Local
1 Sidecar Suspension Welding Fixture	2,000	Local
1 Attachment Frame Welding Fixture	3,000	Local
4 Sets Hand Tools	4,000	General Purpose
4 Sets Guillotine Templates	2,000	Local
Sub Total Other Products	56,500	
Tools Supplied To Sub-Contractors		
5 Press Tools	30,000	Bicycle Collaborator
2 Forging Dies	15,000	Bicycle Collaborator
3 Moulding Tools	94,000	Motor Cycle Collaborator
2 Extrusion Dies	22,000	Local
1 Punch	2,000	Local
1 Heat Welder	3,000	General Purpose
Sub Total Tools Supplied to Sub-Contractors	166,000	
Total Tooling Cost	1,108,500	

TABLE 6.4: QUALITY CONTROL AND TOOL ROOM EQUIPMENT

Equipment	Estimated Cost (Birr)	Source of Supply
<u>Quality Control</u>		
1 Bicycle Frame Testing Rig	5,000	Bicycle Collaborator
1 Bicycle Fork Testing Rig	2,500	Bicycle Collaborator
1 Bicycle Handlebar Testing Rig	2,500	Bicycle Collaborator
1 Motor Cycle Frame Testing Rig	20,000	Motor Cycle Collaborator
1 Motor Cycle Handlebar Testing Rig	10,000	Motor Cycle Collaborator
1 Hardness Tester	10,000	General Purpose
1 Set Magnetic Crack Detection Equipment	5,000	General Purpose
1 Set Measuring Instruments and Surface Table	12,500	General Purpose
1 Set Laboratory Equipment	15,000	General Purpose
Go-No Go Gauges for Checking Bicycle Components	15,000	Bicycle Collaborator
Go-No Go Gauges for Checking Motor Cycle Components	10,000	Bicycle Collaborator
Go-No Go Gauges for Checking Machined Components Of Other Products	5,000	Local
Total	112,500	
<u>Tool Room</u>		
1 Centre Lathe 1.5 m Bed	40,000	General Purpose
1 Tool Room Milling Machine	25,000	General Purpose
1 Shaping Machine	15,000	General Purpose
1 Surface Grinding Machine	25,000	General Purpose
1 Tool and Cutter Grinder	11,500	General Purpose
1 Pedestal Grinder	2,500	General Purpose
Miscellaneous Tools and Equipment	5,000	General Purpose
Total	124,000	

general purpose testing and measuring equipment. The total cost of quality control equipment is estimated at 112,500 Birr.

The tool room has the facilities for plant maintenance, repair and re-sharpening of production tools, and for the manufacturing of simpler items of production tooling. All items are standard tool room equipment and can be purchased on the world market. The estimated total cost of tool room equipment is 124,000 Birr.

Storage and Material Handling

The material handling facilities for the assembly of the different products have already been discussed since they form part of the production equipment for those operations. However, the following additional storage and material handling facilities are required:

- i) overhead crane to serve the raw materials store and the press forming, tube manipulation, machining and fabrication sections. To be used for unloading raw materials into the store, and for delivery to the above manfuacturing sections;

- ii) mobile crane for unloading crates of imported kits of parts and transporting them to the store;

- iii) fork lift truck, for movement of components from crates to the store, of raw materials handled more conveniently by this method than by overhead crane, and for loading finished products for despatch;

- iv) racks, for storing raw materials, components and finished products.

- v) bins, pallets, trolleys and pallet trucks for holding work-in-progress and moving part finished components between manufacturing operations.

In addition, the plant should have one 10 tonne truck and one 1 tonne pick-up for general transport duties.

The major imported items are the overhead crane, mobile crane, fork lift truck, pallet trucks and pick-up. The estimated cost for these items is 300,000 Birr. The 10 tonne truck can be obtained from AMCE, cost 120,000 Birr, and the racks, bins, pallets and trolleys can be made locally, estimated cost 75,000 Birr.

In summary the equipment investment costs are estimated as follows:

	Overseas	Local	Total
Production Machinery and Tooling	2,137,500	284,000	2,421,500
Quality Control and Tool Room	231,500	5,000	236,500
Storage and Material Handling	300,000	195,000	495,000
Total	2,669,000	484,000	3,153,000

Note that this excludes equipment needed to supply and distribute services in the plant, and office equipment.

6.6 Materials And Inputs

Table 6.5 gives a breakdown of the imported components, direct materials and process materials consumed per annum by the proposed plant. The cost is broken down into CIF value (equivalent to foreign exchange cost), duty and transportation[1]. Table 6.6 gives a breakdown of locally supplied materials and components consumed per annum by the proposed plant. Summarised below is the total material cost for the plant, and its foreign exchange component.

	Material Cost/Annum Birr	Foreign Exchange Cost	%
Bicycle	1,521,340	896,490	49.4
Motor Cycle	8,197,335	5,513,335	67.3
Other Products	1,510,795	311,450	20.6
Total	11,521,340	6,721,275	58.3

Note that this is only a 'first order' analysis of foreign exchange cost since the tube and sheet supplied by Kalliti, and some components from local suppliers, use imported raw materials. Based on the above, the material cost of each product are as follows:

Bicycle	145.06 Birr/Unit
Motor Cycle	1,639.50 Birr/Unit
Animal Cart (average)	186.90 Birr/Unit
Cycle Trailer	141.90 Birr/Unit
Sidecar	378.50 Birr/Unit
Pick-Up/Van Attachment	1,012.00 Birr/Unit

Tables 6.7 to 6.9 show the flow of components and direct materials through the plant for the three product categories:

* Bicycles;

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1. Transaction tax is not included since it is assumed that this will be charged on the finished products.

TABLE 6.5: IMPORTED COMPONENTS AND RAW MATERIALS

	Cost/Annum (Birr)			
	CIF	Duty	Local Transport	Total
Bicycle				
12,500 Sets Bicycle Components	771,250	115,690	35,000	921,940
15.65 Tonne Mild Steel Black Bar	14,870	3,130	3,520	21,520
10 Tonne Mild Steel Rod	9,500	2,000	2,250	13,750
0.9 Tonne Mild Steel Welded Tube	2,320	180	200	2,700
0.4 Tonne Mild Steel Wire	630	80	90	800
0.9 Tonne Hard Bright Wire	2,320	180	200	2,700
Paint	47,400	14,220	880	62,500
Welding Wire	16,300	3,260	440	20,000
Brass	2,470	250	280	3,000
Plating Chemicals	26,550	7,965	485	35,000
Plating Anodes	2,880	295	325	3,500
Sub Total Bicycle	896,490	147,250	43,670	1,087,410
Motor Cycle				
5,000 Sets Motor Cycle Components	5,327,500	2,131,000	250,000	7,708,500
45 Tonne Carbon Steel Tube	104,625	9,000	10,125	123,750
3.75 Tonne Mild Steel Rod	3,565	750	845	5,160
2.5 Tonne Hard Bright Wire	6,435	500	565	7,500
Vinyl Leather Cloth	23,750	600	650	25,000

TABLE 6.5: Continued

	Cost/Annum (Birr)			
	CIF	Duty	Local Transport	Total
Motor Cycle Continued				
Paint	22,750	6,825	425	30,000
Welding Wire	16,300	3,260	440	20,000
Plating Chemicals	7,585	2,275	140	10,000
Plating Anodes	825	85	90	1,000
Sub Total Motor Cycle	5,513,335	2,154,295	263,280	7,930,910
Other Products				
Various Imported Components	205,000	60,750	14,000	279,750
73.5 Tonne Mild Steel Black Bar	69,825	14,700	16,540	101,065
Vinyl Leather Cloth	9,500	240	260	10,000
Paint	15,925	4,780	295	21,000
Welding Wire	11,200	2,240	310	13,750
Sub Total Other Products	311,450	82,710	31,405	425,565
TOTAL	6,721,275	2,384,255	338,355	9,443,885

TABLE 6.6: LOCAL COMPONENTS AND RAW MATERIALS

	Cost/Annum (Birr)
<u>Bicycle</u>	
55 Tonne Cold Rolled Mild Steel Tube	137,500
39.5 Tonne Cold Rolled Mild Steel Sheet	88,300
Packing Materials	62,500
12500 Pair Tyres and Tubes	300,000
12500 Pair Rim Tapes	12,500
12500 Pair Hand Grips	25,000
Various Components From EMTF	62,500
Bicycle Carriers and Parking Stands	37,500
Sub Total Bicycle	725,800
<u>Motor Cycle</u>	
16.85 Tonne Cold Rolled Mild Steel Tube	42,125
44 Tonne Cold Rolled Mild Steel Sheet	96,800
Foam	15,000
5,000 Pair Rim Tapes	7,500
5,000 Hand and Twist Grips	12,500
20,000 Indicator Lenses	32,500
5,000 Wiring Looms	60,000
Sub Total Motor Cycle	266,425
<u>Other Products</u>	
87.9 Tonne Hot Rolled Mild Steel Tube	202,230
116 Tonne Hot Rolled Mild Steel Sheet	232,000
16000 Castings For Bushes	80,000
1,000 Pair Tyres and Tubes (trailers)	20,000
2,500 Pair Tyres and Tubes (carts)	325,000
1,000 Pair Rim Tapes (trailers)	1,000
1,000 Wooden Seat Frames	10,000
250 Pick-Up/Van Bodies	125,000
Sub Total Other Products	1,085,230
TOTAL	2,077,455

TABLE 6.7: MATERIAL FLOW - BICYCLE PRODUCTION

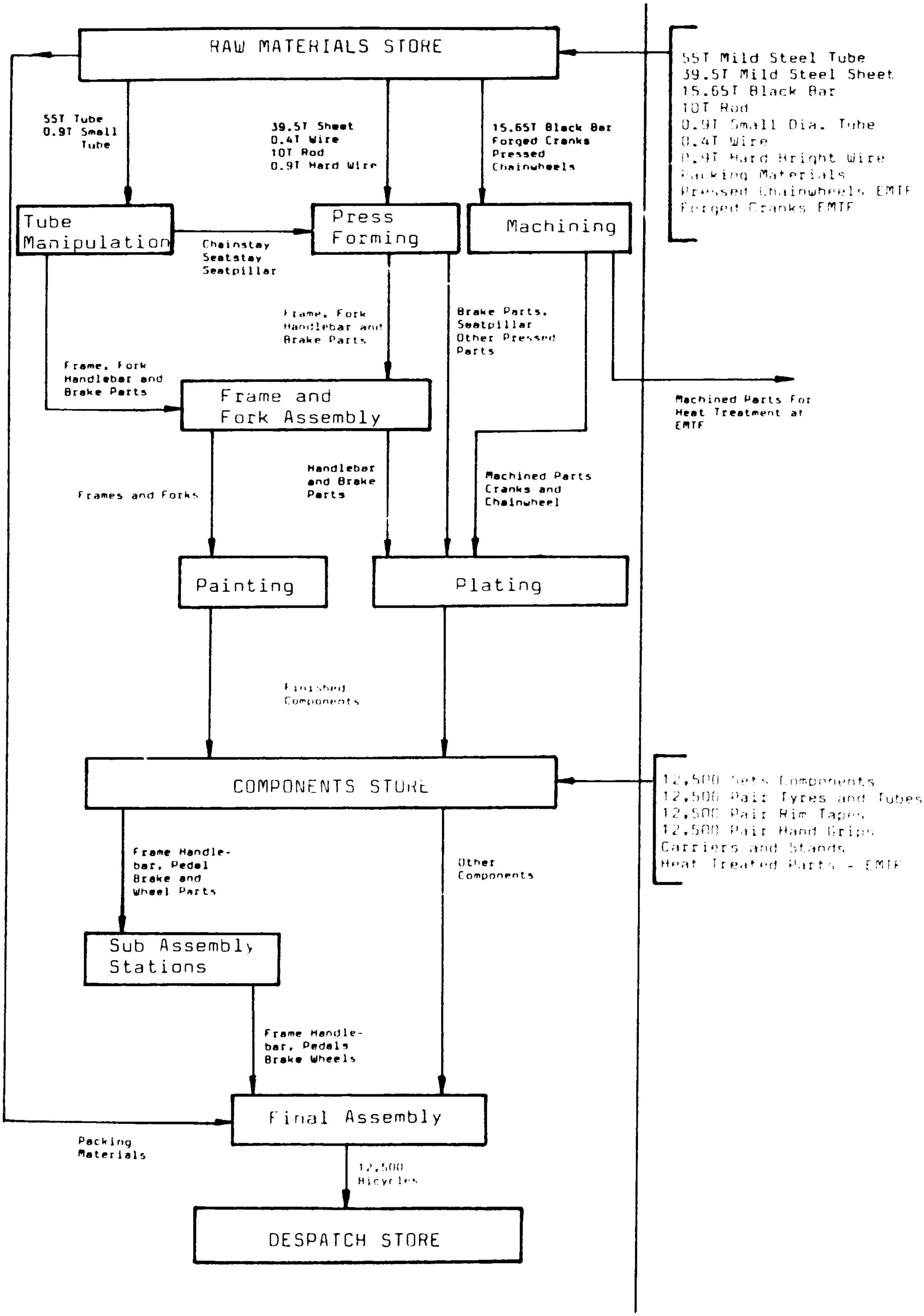


TABLE 6.8: MATERIAL FLOW - MOTOR CYCLE PRODUCTION

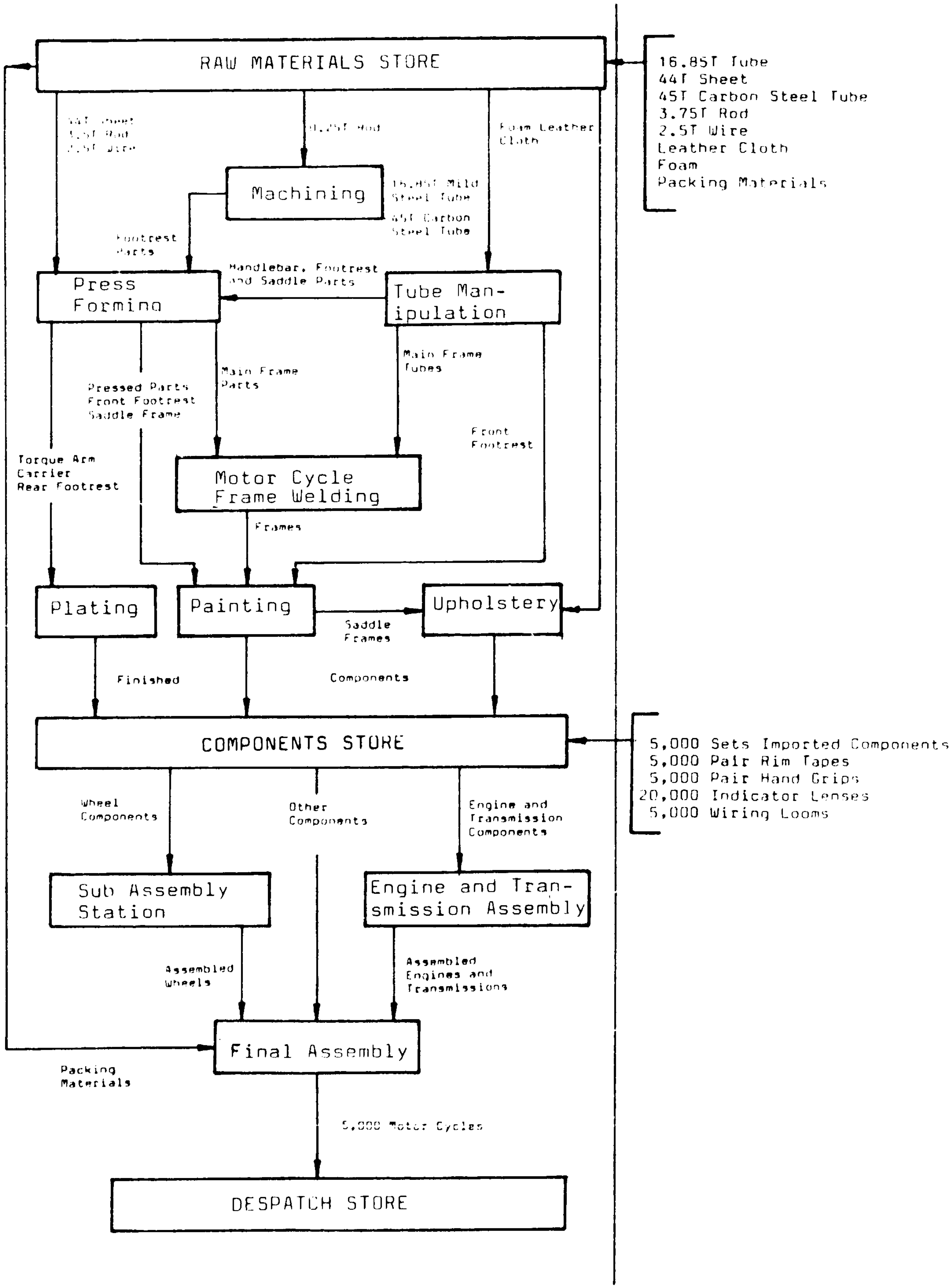
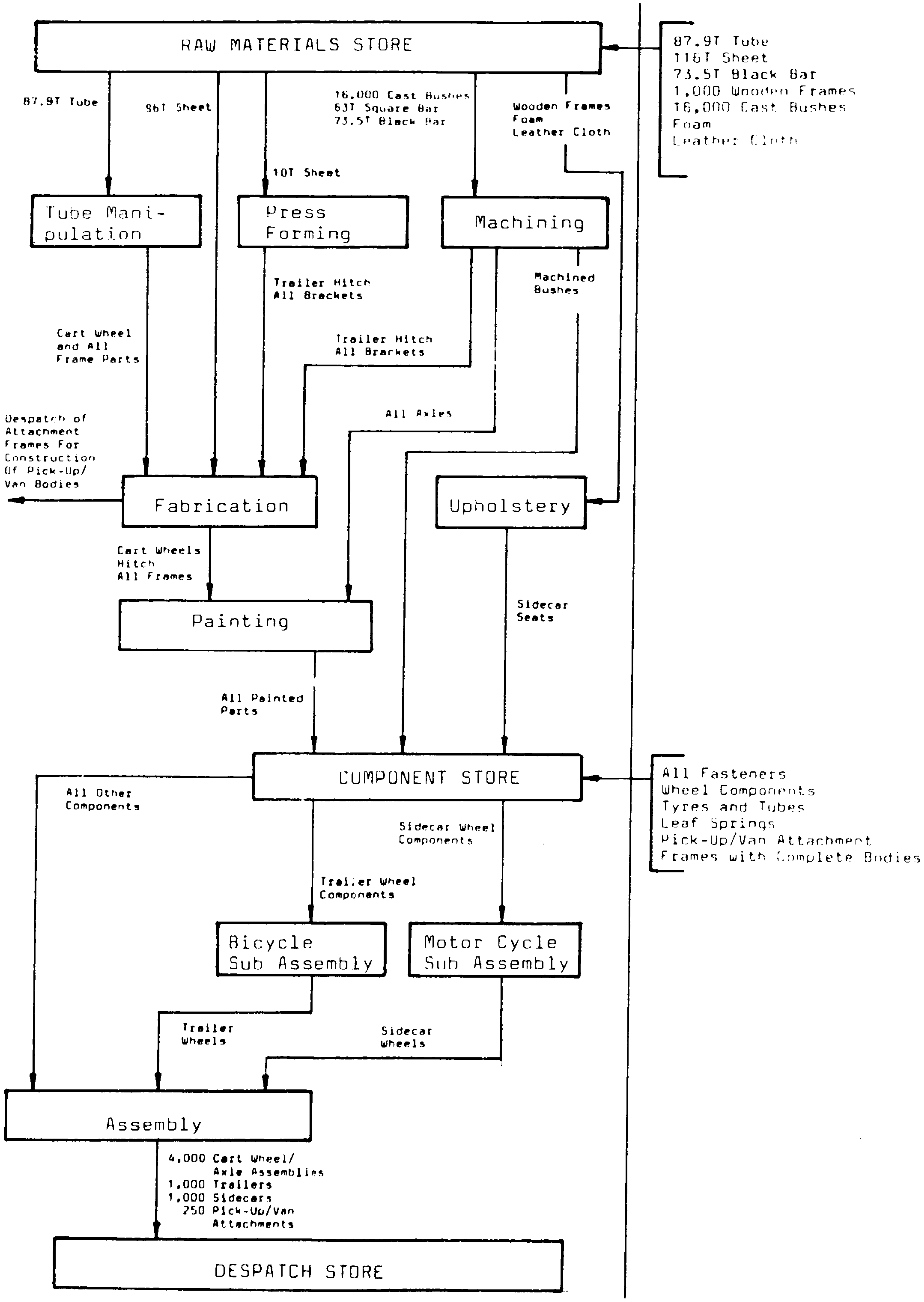


TABLE 6.9: MATERIAL FLOW - CART, TRAILER AND MOTOR CYCLE ATTACHMENT PRODUCTION



* Motor cycles;

* Cart wheel/axle assemblies, trailers and motor cycle attachments.

The flow of materials is based on three stores:

* All raw materials and bought-in part-finished components are delivered to the **raw materials store**;

* All bought-in finished components are delivered to the **component store**;

* Raw materials are issued to the appropriate manufacturing section. If the material has to pass through more than one section for processing it is delivered direct from one section to the next as work-in-progress. When processing is complete the finished components are delivered to the **component store**;

* Complete sets of made-in and bought-out components are issued from the components store to the final assembly area. Finished, assembled products are placed in the **despatch store**.

The three tables therefore show the inputs of raw materials and components; the distribution of raw materials from the store and the flow through manufacturing sections to the component store; and the flow of components from there to the despatch store. The figures in the tables are of annual throughput of materials and components.

6.7 Quality Control

Detailed quality control procedures for different production operations have been discussed in Chapter 5. This section gives an overview of the approach to quality control and its different elements.

Standards and Specifications

Overall specifications for the different vehicles have already been discussed in previous chapters. Some details of the specifications for the bicycle and motor cycle will have to be agreed with the selected collaborators, including the procedures for rig testing of the critical structural components - frame, fork and handlebar for bicycle, and frame and handlebar for motor cycle. Detailed specifications for the other products will be prepared as part of the technical assistance. All steel materials will be purchased to international specifications - those supplied by Kalliti are based on raw materials purchased internationally to such specifications.

Incoming Materials and Components

Steel raw materials purchased overseas by NMWC are accepted on the basis of a certificate of compliance from the supplier that they meet the agreed specification. This also applies to the material which Kalliti purchase for processing into tube and sheet. However, it is prudent to check that all incoming materials are supplied to the specified dimensons and, in the case of tube from Kalliti, that the diameter is within standard tolerances (detailed in their catalogue). The Ethiopian Standards Institute is developing the facilities for material testing and ideally a sample of each delivery of steel should be submitted to them to confirm that it meets the material specification.

The agreement with the bicycle and motor cycle collaborators should specify that the components and sub-assemblies supplied by them conform to their standards and have passed their normal quality control procedures. Incoming kits of parts will be subject to visual checks. Similarly locally supplied components should be subject to such checks prior to acceptance of deliveries. Heat treated components supplied by EMTF will be tested to check that the hardness is within the agreed specification.

Control During Processing

There are several aspects to control of quality during different production operations:

i) skilled toolsetters will be employed to set various items of machinery to produce particular components. Part of their responsibility will be to check that the initial components produced from the machine are correct;

ii) for components where dimensional tolerances are crucial, go-no go gauges will be used to check that they are within tolerance;

iii) the use of jigs and fixtures in many of the operations provides an additional measure of quality control, since if components will not fit into the jig or fixture, they are incorrect;

iv) for critical structural assemblies, samples will be selected from the production line and subjected to testing. These tests fall into two categories. Bicycle frames, forks and handlebars, and motor cycle frames and handlebars will be subjected to static strength tests where standard loads are applied. The deflection of the component under those loads must be within defined limits. for motor cycle frames this is complemented by subjecting the welds of selected frames to crack detection testing. For these selective tests, the procedure is that samples are selected from a batch of components. If the samples pass the test, the batch is approved. If the samples fail, the complete batch must be subjected to testing;

v) components will be visually inspected at different stages during the production process. This is particularly important for finishing operations such as painting and plating.

Finished Products

As discussed in Chapter 5, all products will be subjected to thorough checking and inspection at the end of the assembly line prior to despatch to the finished products store.

Staff Responsibility

It is desirable that a degree of responsibility for quality control be given to production workers. This allows 100% checking of components, for example:

i) visual checking of incoming components by storemen;

ii) dimensional checking using go-no go gauges immediately after processing;

iii) checking of finish quality immediately after painting or plating.

This procedure allows problems to be identified and resolved quickly. However, the plant will also employ quality control staff who will have two functions:

i) to carry out technical testing - eg. hardness, structural or crack detection tests;

ii) to carry out selective checks at all stages of the production process - incoming components and materials, manufacturing operations and assembly - to monitor the control being exercised by production workers. Again the procedure is that if selected samples are unacceptable, the complete batch must be checked.

Finally, in the case of motor cycles it is almost certain that the overseas collaborator will wish to exercise a measure of control over quality. This can take a number of forms - definition of quality control procedures, training, and technical assistance, particularly in local manufacture of components. It may also involve periodic reviews of quality standards by staff from the collaborator.

6.8 Staffing

Four categories of staff are discussed here:

* Direct production workers;

* Ancillary production workers;

* Quality control and tool room workers;

* Production and technical supervision and management.

Direct Production Workers

Table 6.1 details the direct production workers required for the planned output of the plant. These are summarised by section below:

	No. Of Workers
Press Forming Section	9
Tube Manipulation Section	3
Machining Section	6
Upholstery Section	1
Bicycle Frame and Fork Assembly Section	5
Motor Cycle Frame Welding Section	4
Fabrication and Assembly Section	8
Painting Section	5
Plating Section	7
Bicycle Final Assembly Section	14
Motor Cycle Final Assembly Section	17
Total	79

In estimating labour costs, these direct workers have been divided into 4 grades, and wage rates for each grade estimated on the basis of the figures used in the recent IPS study of a Cement Bonded Particle Board Plant:

Grade 1: Semi-skilled, carrying out one or a limited number of repetitive jobs that can be learnt very quickly - Rate 150 Birr/Month

Grade 2: Requires skill in a particular activity but can be learnt by on-the-job training - Rate 225 Birr/Month.

Grade 3: Requires a degree of formal training but restricted to one or a limited number of activities - Rate 300 Birr/Month.

Grade 4: Requires wider range of skills, or the degree of responsibility involved in the production task justifies a higher wage rate - Rate 350 Birr/Month.

Based on these grades, the classification of production workers is detailed below. In making this classification it is assumed that toolsetters are employed to do the skilled work of setting machines such as presses, lathes etc. to produce particular components.

	Grade	Birr/Annum
<u>Press Forming Section</u>		
4 Press Operators	1	7,200
2 Welders	3	7,200
3 Operators For Other Machines	2	8,100
Total		22,500

<u>Tube Manipulation Section</u>		
1 Operator For Tube Bender	2	2,700
2 Operators For Other Machines	1	3,600
Total		6,300
<u>Machining Section</u>		
3 Lathe Operators	3	10,800
1 Capstan Lathe Operator	2	2,700
2 Operators For Other Machines	2	5,400
Total		18,900
<u>Upholstery Section</u>		
1 Worker	3	3,600
Total		3,600
<u>Frame and Fork Assembly Section</u>		
5 Workers	2	13,500
Total		13,500
<u>Motor Cycle Frame Welding Section</u>		
4 Welders	4 (This grade selected to ensure high quality welding)	16,800
<u>Fabrication and Assembly Section</u>		
3 Skilled Sheet Metal Workers	4	12,600
3 Welders	3	10,800
2 Assembly Workers	2	5,400
Total		28,800
<u>Painting Section</u>		
1 Senior Operator	3	3,600
4 Assistants	2	10,800
Total		14,400
<u>Plating Section</u>		
1 Senior Operator	3	3,600
3 Assistants	2	8,100
3 Polishers	1	5,400
Total		17,100

Bicycle Final Assembly Section

2 Checkers	4	8,400
3 Wheel Builders	3	10,800
9 Assembly Workers	2	24,300
Total		43,500

Motor Cycle Final Assembly Section

3 Checkers	4	12,600
1 Wheel Builder	3	10,800
6 Engine Assemblers	3	21,600
7 Assembly Workers	2	18,900
Total		56,700

In summary the labour is classified as follows:

Grade 1	9 Workers
Grade 2	37 Workers
Grade 3	21 Workers
Grade 4	12 Workers

The total annual cost of direct production workers is 242,100 Birr.

Ancillary Production Workers

Three categories of ancillary production works are required:

i) Toolsetters

Toolsetters are required in the press forming, tube manipulation, machining, and frame and fork assembly areas. Four toolsetter, at 400 Birr/Month each, an annual cost of 19,200 Birr.

ii) Stores

Good stores control is important to the efficient operation of the plant. Each store should have a storekeeper (at 400 Birr/Month) with assistants as follows:

Raw Materials: 2 at 150 Birr/Month
Components: 5 at 225 Birr/Month (to batch components for issue to assembly)
Despatch: 2 at 150 Birr/Month

In addition 1 crane driver and 1 fork lift operator, each at 225 Birr/Month are needed.

iii) Labourers

There is a substantial amount of movement of materials within the plant. This is best carried out by labourers, with one assigned to each of the main sections, a total of 10 at 100 Birr/Month each.

Quality Control and Tool Room

Five quality control workers, plus one laboratory technician are proposed, at the following rates.

1 Laboratory Technician	400 Birr/Month
5 Quality Control Workers	300 Birr/Month

The tool room will require 2 skilled machinists and 2 mechanics for general plant maintenance, each at 400 Birr/Month.

Supervision and Management

The plant will have a technical head, reporting to the general manager. The technical head will be responsible for production control and production engineering. The proposed management structure is that, reporting to the technical head will be:

i) a production engineer responsible for quality control, tooling, equipment and plant maintenance. Reporting to him will be a maintenance foreman, responsible for the tool room, and a quality control supervisor;

ii) a production controller responsible for stores and for the manufacturing and assembly sections. Reporting to him will be the three storekeepers and the foremen. Since numbers of production workers are relatively low, it is not necessary to have one foreman for each section. For supervision and management purposes they can be combined as follows:

Press Forming, Tube Manipulation, Machining and Fabrication - One Foreman.;

Frame and Fork Assembly, Motor Cycle Frame Welding, Painting, Plating and Upholstery - One Foreman;

All Final Assembly Sections - One Foreman.

Finally, consideration should be given to including a design engineer in the technical staff, in order to develop capability in the technology of low cost vehicles, for design of production tooling, and to act as the technical contact with overseas collaborators. He would report directly to the technical head.

The proposed technical supervisory and management staff is therefore, as follows:

	Birr/Month
1 Technical Head	1,000
1 Production Engineer	750
1 Production Controller	750
1 Design Engineer	750
1 Maintenance Foreman	500
3 Production Foremen	500
1 Quality Control Supervisor	500

In summary, the staffing requirements for the plant are:

	Birr/Annum
1 Technical Head	12,000
3 Section Heads	27,000
5 Supervisors and Foremen	30,000
3 Storekeepers	14,400
11 Store Workers	26,100
6 Quality Control Workers	22,800
4 Tool Room Workers	19,200
4 Toolsetters	19,200
79 Direct Production Workers	242,100
10 Labourers	12,000
126 Total	424,800

This does not include non-technical management, accounting, marketing and administrative staff.

6.9 Training and Technical Assistance

For the manufacture of bicycles and motor cycles, training and technical assistance will be provided by the overseas collaborators. Training falls into two categories:

i) development of the capability and experience of senior supervisory and management staff, which is best achieved by them spending time in the overseas plants;

ii) training of production workers and lower level supervisory staff, which is best carried out in the proposed plant and achieved by the provision of technical assistance from the overseas collaborator.

Based on the implementation schedule discussed in Section 6.3 the proposed inputs for bicycles are therefore as follows:

i) 6 man-months overseas training of two senior staff in the collaborator's factory prior to commencement of assembly of bicycles in Ethiopia. Estimated cost 31,000 Birr (to cover staff salaries, subsistence and air fares);

ii) 3 months overseas training of one senior staff member in the collaborator's factory during the second year of operation, prior to establishing local manufacture of bicycle components in Ethiopia. Estimated cost 12,500 Birr (to cover subsistence and air fares);

iii) provision of one man from the collaborator´s staff for 1 years technical assistance to the factory in Ethiopia prior to starting, and in the early months of assembly of bicycles to advise on assembly procedures and train local staff. Estimated cost $3,000/month, total 75,000 Birr (to cover salary and overheads, subsistence and air fares);

iv) provision of one man from the collaborator´s staff for 1 years technical assistance to the factory in Ethiopia prior to initiating, and in the early months of, local manufacture of bicycle components, to advise on manufacturing methods and train production staff. Estimated cost $3,000/month, total 75,000 Birr.

The proposed inputs for motor cycles are as follows:

i) 6 man-months overseas training of two senior staff in one of the collaborator´s plants prior to commencement of assembly of motor cycles in Ethiopia. Estimated cost 42,000 Birr (to cover staff salaries, subsistence and air fares);

ii) 3 months overseas training of one senior staff member in one of the collaborator´s plants during second year of operation, prior to establishing local manufacture of motor cycle frames in Ethiopia. Estimated cost 18,000 Birr, (to cover subsistence and air fare);

iii) a total of 2 man-years technical assistance to the factory in Ethiopia as follows:

* 1 man for one year prior to starting, and in the early months of, local assembly of motor cycles, to advise on procedures and train staff;
* 1 man for 6 months in second year of operation, to assist in establishing local assembly of engines and transmissions and train staff;
* 1 man for 6 months in third year of operation, to assist in establishing local manufacture of motor cycle frames and train staff.

Estimated cost $5,000/month, 250,000 Birr.

iv) it is also prudent to allow for a one month visit by a technical person from the overseas collaborator in each of the first four years of production, to review progress, resolve any technical or quality control problems, and provide additional training. Estimated cost $6,000 per month, 50,000 Birr.

For the other products - carts, trailers and motor cycle attachments - the provision of technical assistance to prepare final design specifications and initiate production will include training of local staff. One man year´s technical assistance will be required, estimated at $6,000/month, 150,000 Birr.

6.10 Financial Summary

Detailed below are the main costs associated with establishing the proposed low cost vehicle plant:

Annual Operating Costs

	Birr/Annum
Raw Materials and Components	11,521,340
Production Workers	385,800
Technical Management	39,000
Total	11,946,140

To this must be added the costs of utilities, overall management, administration and sales.

Fixed Investment Costs

Manufacturing Equipment and Tooling	2,658,000
Storage and Material Handling	495,000
Pre-Production Training and Technical Assistance	703,500
Building (estimated at 800 Birr/m^2)	3,080,000
Total	6,936,500

To this must be added the costs of office equipment.

Working Capital

Based on allowing 12 months working capital for imported materials and components, and 3 months for local costs, the total working capital requirement is estimated at 8,125,000 Birr.

It is not the role of this report to make a financial analysis of the proposed plant since much detailed work remains to be done before carrying out that exercise. However, based on the financial data available it is useful to make a preliminary estimate of the selling prices of the different vehicles. Detailed below is an estimate of total annual costs based on the following assumptions:

i) equipment is depreciated at 12%, buildings at 5%, and pre-production costs at 20%;

ii) working capital is charged at 10%;

iii) a minimum profit margin is assumed by charging a 14% return on investment;

iv) 19% is added to factory costs to cover sales and transaction taxes;

v) an allowance of 350,000 Birr is assumed for other operating costs.

	Birr/Annum
Material Cost	11,521,340
Production Labour	385,800
Technical Management	39.000
Other Operating Costs	250,000
Depreciation:	
Building 5%	154,000
Equipment 12%	378,360
Pre-Production Cost 20%	140,700
Cost of Working Capital	812,500
14% Return on Investment	2,108,610
Taxes at 19%	3,000,159
Total Cost	18,790,469

Say 18.8 million Birr.

The various operating and investment costs have to be distributed between the different products. As a first approximation this is done in the same ratio as that of material costs. On this basis the distribution of costs between different products is as follows:

Bicycles	2.95	Million Birr
Motor Cycles	13.40	Million Birr
Other Products	2.45	Million Birr
Total	18.80	Million Birr

On this basis, the minimum selling prices for the two main products are:

Bicycle	236 Birr
Motor Cycle	2,680 Birr

For the other products, costs are again distributed on the basis of ratio of material costs to give the following minimum selling prices:

Cart Wheel/Axle Assemblies	
1 Tonne ADV Tyre	376 Birr
1/2 Tonne ADV Tyre	357 Birr
1/2 Tonne Motor Cycle Tyre	249 Birr
1/2 Tonne Steel Wheel	166 Birr
Bicycle Trailer	232 Birr
Sidecar	620 Birr
Pick Up/Van Attachment	1,690 Birr

There are obviously some distortions in the allocation of costs, most seriously for the pick-up/van attachment which, since the body is built outside the factory, is over priced by this method of analysis. However, the figures do show that both bicycles and motor cycles can be made available at a substantial saving over current prices by local manufacture, and that a range of other vehicles can be supplied at low prices.

7. RECOMMENDATIONS

As stated at the start of the report, the consultant's input was made in the early stages of the feasibility study, and focussed primarily on technical aspects. Much detailed work remains to be done to complete the study. These recommendations highlight certain issues that should be addressed by the IPS Project Team during the remainder of the study.

1. Demand estimates for low cost vehicles have been made to provide a basis for the technical analysis of the different options. Because of the nature of the study, precise analysis of demand is difficult. However, an attempt should be made to refine these preliminary estimates where possible and in particular:

   i) obtain more detailed information on the present use of motor cycles by government, and on plans for utilisation in the future;

   ii) expand the currently very limited data on the numbers of animal drawn carriages in use;

   iii) explore further with the Ministry of Agriculture the potential for animal drawn carts;

   iv) continue the analysis that has commenced of transport demands in rural areas in relation to crop production, the development of co-operatives and access to markets.

2. The functions of existing industries in Ethiopia in the manufacture of low cost vehicles are discussed in the report. However, it is recommended that IPS hold further discussions with:

   i) Addis Tyre on detailed technical and cost aspects of bicycle and ADV tyre and tube production;

   ii) Ethio-Plastics on the production of wiring looms.

3. As noted earlier, equipment and tooling costs are estimated on the basis of recent world prices. Quotations should be obtained from suppliers in different countries for the major items of general purpose equipment.

4. The IPS agreement with NMWC includes an overseas study tour by IPS staff to low cost vehicle industries. Prior to departure from Addis Ababa, recommendations were made for an itinerary including bicycle, motor cycle, animal cart and other industries in India, China, and the Philippines. This will provide an opportunity for the Project Team to improve their general understanding

of low cost vehicle manufacture, but the opportunity should also be taken to pursue the following specific issues:

i) compare the characteristics of bicycle industries in India and China, and their respective merits as overseas collaborators;

ii) obtain prices of production tooling and special purpose machinery for bicycle manufacture in India;

iii) discuss with Dunlop in Calcutta the technical requirements and commercial procedures for the transfer of ADV tyre technology to Ethiopia;

iv) review in the Philippines the role of ancillary industries in the production of components for the automotive sector;

v) take the opportunity while in the Philippines to examine the production technology, investment costs and local content of BTV manufacture. This will provide additional information for discussions with the National Metal Works Corporation as to whether the production of BTV´s in Ethiopia should be examined further. Annex 15 provides some background information on BTV´s which will assist investigations in the Philippines.

15579
(2 of 2)

I. T. Transport Ltd

Consulting Engineers

STUDY OF THE POTENTIAL FOR A LOW COST VEHICLES ASSEMBLY/ MANUFACTURING PLANT IN ETHIOPIA

Report of the consultant on low cost vehicle manufacturing technology.

VOLUME 2 ANNEXES

by
Ian Barwell
for
Industrial Projects Service
of the Ministry of Industry,
Government of Socialist Ethiopia,
on behalf of
Feasibility Study Section
United Nations Industrial Development Organisation.

January 1986

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Volume 2 - Annexes

ANNEX 1: CONSULTANT'S TERMS OF REFERENCE

ANNEX 1

Study of the Potential of a Low-Cost Vehicles Assembly Plant in Ethiopia

Terms of Reference for Low-Cost Vehicles Manufacturing Technology Consultant (under UNIDO Project DP/ETH/83/001 - Assistance to the Industrial Projects Service)

BACKGROUND INFORMATION

There are two assembly plants for heavy vehicles (four-wheel drives, trucks and buses), one in Addis Ababa, and another in Asmara, but none for light vehicles. In view of the increasing demand for fuel and high cost of automobile imports, the National Metal Works Corporation, one of the Corporations under the Ministry of Industry, has, for some time now been looking into the possibilities of establishing a bicycle assembly plant.

Studies so far conducted on the subject are minimal. An overall assessment of the advantages of starting up the technology of low cost vehicles (LCV's) in developing countries was done by UNIDO prior 1978. The emphasis in that UNIDO series was the gradual transfer and development of the insignificant local LCV's manufacturing technology to a very high level. Successful instances of this technological development have been cited from Indian and other Far Eastern experiences.

A study was conducted in Ethiopia in 1981/82 to analyse the potentials of establishing a bicycles assembly plant. It was done by a UNIDO expert, Mr. K.R. Shetty. The approach adopted was to establish an assembly plant which would eventually develop into a bicycles manufacturing plant with minimum foreign inputs. The establishment costs were estimated to be Birr 2.4 million, and the demand level 7500 units per year. Price per piece at the early stage was projected at Birr. 219.00, declining eventually as demand levels increase.

However, serious doubts were raised on the adequacy of the study for implementation, particularly on the demand levels assumed; 1967-77 imports of bicycles and tricycles averaged 5000 pieces. Moreover, even if the demand were accepted as potential, it was not known whether it would amount to an economic scale. Furthermore, the physical terrain of the country was also mentioned as significantly different from those countries where similar technology was successfully developed.

In light of the above background information, NMWC commissioned the Industrial Projects Service (IPS) to carry out a potential survey on the possibilities of establishing an LCV's assembly plant and its eventual development into an LCV's manufacturing set-up, with a view to alleviating the problem of short distance transport of both people and products.

IPS is a consultancy house within the Ministry of Industry entrusted with the study of industrial projects. Although it is a young institution, it has already built-up a national professional staff with a wide range of expertise. It has also made arrangements for back-up services with recognized international consultancy houses.

With regard to the proposed survey on the establishment of an LCV's assembly plant, IPS plans to carry out a study of the demand levels for:

- Animal drawn carts and carriages
- Bicycles, tri-cycles, motor-bicycles, motor scooters
- Motor-bicycles with side cars, and
- Three-wheeled vehicles, vans

for transporting people and products in urban, sub-urban and rural areas.

IPS would like to get the services of a low-cost vehicles manufacturing technologist from a recognised foreign consultancy firm to assist it in preparing a study of the potentials of a low-cost vehicles assembly plant as outlined in the attached work programme.

OBJECTIVE

To assist the Industrial Projects Service in preparing a study of the potentials of a low-cost vehicles assembly plant in Ethiopia.

SCOPE OF CONSULTANCY SERVICE

A. Prior to the fielding, the consultants will review, at their home office, existing low-cost vehicle technologies applied world-wide, in preparation for the assignment to be undertaken in Ethiopia.

The consultant will undertake the following scope of work in Ethiopia:

1. Market and Capacity Study

Based on projected demand levels, by type and mix, of LCV's:

- Establish the appropriateness for Ethiopia, and the economic scale of production (assembly) that would be justifiable;

- Select the suitable technology for the type and scale of production envisaged, and

- Assess the possibility of fabricating in local plants, some of the component items for the LCV's and indicate such costs that may be necessary to integrate components manufacturing into existing systems in local plants.

2. Materials and Inputs

- Evaluate the use of locally available/fabricated materials to manufacture components;

- Select/indicate the appropriate materials and processing technology that may be developed into local contents manufacturing;

- Estimate annual requirements and cost of component materials and inputs required in the assembly/local fabrication of components;

- Provide charts showing flow and balance of components, materials and other inputs, and

- Determine the types and sizes of facilities required for handling and storing of components, local materials/components and other inputs.

3. Location and Site

Identify and evaluate alternative possibilities of the most appropriate location and site for the assembly plant taking into account proximity to market, labour, infrastructure and utilities, potential suppliers of local components and other relevant factors.

4. Technology

- Survey the evolutionary development of the LCV's manufacturing technologies with reference to the experiences of other developing countries, and outline such gradual developments, clearly identifying the stages to be followed and components to be supplied from local makers at each stage;

- Set criteria for the gradual localization of components supplies and the selection of technology appropriate for such growth;

- Indicate commercially available alternative sources of such technologies that would enhance the envisaged gradual increase of local content;

- Select the most appropriate technology suitable for the evolutionary development of LCV's manufacturing in Ethiopia starting from existing conditions;

- Describe the assembly process at the initial and subsequent stages by type of LCV;

- Draw up guidelines for designing a suitable plant and process lay-out;

- Work out the quality requirements, standards and specifications for each type of LCV in line with the envisaged local demands, and

- Design adequate quality control systems/ procedures compatible with the needs of LCV's to be used in Ethiopian conditions.

5. Manpower Requirement and Organization

- Determine the total direct and indirect manpower requirements by function, including the requirements of subsequent years;

- Recommend the type, number and duration of expatriates that would be required for the transfer of the technology and know-how, and

- Draw up suitable training programme for the production personnel, indicating the content, duration, cost and place of training.

B. Upon completion of the field study in Addis Ababa, the consultants will finalise the report prepared in Addis Ababa and carry out any necessary follow-up technical enquiries from IPS.

GENERAL TIME SCHEDULE

The consultant will be fielded within two weeks after receipt of the contract. The man/month required for the preparatory work at home office will be 0.25 m/m. The field assignment would be 1.5 m/m. Follow-up service after the field work is required and 0.25 m/m is reserved for this purpose. The field work is expected to be initiated as soon as possible, preferably before August 1985.

Award of contract	A
Fielding to Addis Ababa	A + 0.5 months
Completion of field work	A + 2.0 months
Completion of draft final report	A + 3.0 months

REPORT

The draft final report in English (two copies) summarising the output of the field assignment will be submitted to UNIDO and IPS within one month after the field work. Five copies of the Final report will be submitted to UNIDO within 30 days after receipt of UNIDO comments.

ANNEX 2: LIST OF PERSONS MET

ANNEX 2: LIST OF PERSONS MET

United Nations

Mr. Vencatachellum - UNIDO SIDFA
Mr. S. Piazzi - UNIDO Programme Officer

Development Projects Study Agency (DPSA)

Ato Getinet W/Giorgis - General Manager

Ministry of Industry

Ato Tadewos - Vice Minister

Ministry of Agriculture

Ato Haile Mariam Lemma - Acting Head, Rural Technology Development Department

Ato Debela Dinka - Head, Agricultural Devel pment Office for South Eastern Zone

Ato Abdi - Head, Rural Technology Centre, Assela

National Metal Works Corporation (NMWC)

Ato Yeheyes Assefa - Head Office
Ato Getacheu - Head Office
Ato Medhane Gebrehiwet - Head, Commercial Department

Industrial Projects Service (IPS)

Ato Bruck Kebede - General Manager
Ato Kifle Gebre - Deputy General Manager
Ato Kifle Mariam - Deputy General Manager
Ato Gebre Kiros Habtu - Leading Engineer
Ato Negash Tekeste - Leading Engineer
Ato Elias Tesheberu - Senior Project Analyst
Ato Menbere Taye - Senior Project Analyst
Ato Tilahun Jabessa - Engineer
Mulumebet Jembere - Project Analyst
Mr. A. Heinemann - UNIDO Associate Expert

Ethiopia Transport and Construction Authority (ETCA)

Ato Alemayehu Ambo - Acting Head, Monitoring and Evaluation Branch, and Consultant to IPS for Low-Cost Vehicles Project

Mr. R. Cahoon - ILO Chief Technical Advisor to pilot project on labour-based road construction

Addis Tyre Co.

General Manager
Technical Manager

Akaki Iron and Steel Works

Ato Yilma Haile - Technical Head

Automotive Manufacturing Company of Ethiopia (AMCE)

Ato Tewolde Tekie - General Manager

Ethiopia Metal Tools Factory (EMTF)

Ato Mehari Abraham - Technical Manager

Ethiopia Tractor and Agricultural Equipment Plant

Ato Damtew G/Giorgis - General Manager

Kalliti Steel Industries (KASI)

Ato Fisseha Seyoum - Technical Manager

SACA Auto Supply Parts PLC

Ato Ayalew Tessema - General Manager

Consultants

Discussions were also held with the following short-term consultants who were in Ethiopia at the time of my visit and were able to provide useful inputs on specific aspects of the study:

Professor M. O'Donoghue	- UNIDO consultant to the Ministry of Industry, who advised on industrial development aspects of the study
Mr. E. Chard	- UNIDO consultant to IPS who advised on the state of the plastics industry in Ethiopia, and the potential for local manufacture of plastic moulded components
Dr. R. Bowen	- forestry consultant, who advised on the availability of timber in the country.

Other Inquiries

During my visit, various members of the project team held meetings with government departments and other organisations to obtain information relevant to the study:

- Ministry of Agriculture - various sections
- Ministry of State Farms
- National Metal Works Corporation - Sales Department
- National Statistics Office
- Road Transport Authority
- Municipial Authorities
- Project Team implementing the 'FATA' Spare Parts Factory Project
- Bicycle Import Agents and Suppliers

ANNEX 3: REFERENCES

ANNEX 3: REFERENCES

GENERAL PUBLICATIONS ON LOW-COST VEHICLES, RELEVANT TO THE STUDY IN ETHIOPIA

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REFERENCES SPECIFIC TO ETHIOPIA USED IN THE STUDY

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2. Schetty, K.R. Feasibility Study of Bicycle Manufacture in Ethiopia, 1982.

3. Outline Proposal for Bicycle Assembly Plant in Ethiopia - prepared by delegation from Tianjin Economic Development Corporation, Peoples' Republic of China, 1985.

4. Transport and Mobility in Addis Ababa 1982 - 2000 - prepared by Cesen-Ansaldo/Intermeccanica Group for Ministry of Mines and Energy, 1985.

5. Ethiopia Foreign Trade Statistics for the years 1971-1984 (xcluding 1973).

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ANNEX 4: BRIEFING NOTE - RANGE OF LOW-COST VEHICLE OPTIONS

ANNEX 4: BRIEFING NOTE - RANGE OF LOW-COST VEHICLE OPTIONS

Prepared by the Consultant upon arrival in Ethiopia.

This note lists the range of vehicle options that will be considered in the market/demand assessment to identify specific types of vehicles appropriate to conditions in Ethiopia and to local assembly/manufacture, and presents a preliminary classification of those vehicles.

1. Vehicles Listing

The terms of reference for the consultant define the following range of vehicle options to be considered:

- Animal drawn carts and carriages;
- Bicycles;
- Tricycles;
- Motor cycles and Scooters;
- Motor cycles with sidecars;
- Three-wneeled vehicles, vans.

To ensure completeness during the initial assessment of vehicle types appropriate to Ethiopia, I propose the following additions to and interpretation of this listing;

i) The complete range of low cost vehicles includes, at the simplest, cheapest level, aids to carrying, pack animals, sledges, wheelbarrows, handcarts etc. The current project should not address those simple devices which can only sensibly be made at village/carpenter/blacksmith level. However I suggest that we do include wheelbarrows and handcarts since it is feasible to consider a metal working industry making wheel/axle assemblies for these and distributing them to cottage industries etc. for building into complete vehicles.

ii) The scope of pedalled vehicle investigations should be extended to include two-wheeled bicycle trailers.

iii) The Terms of Reference specifies motor cycles with sidecars and 3-wheeled motor vehicles/vans. I suggest we re-classify these load-carrying motorised means of transport as follows:

1. Attachments to motor cycles, i.e. devices which can be fitted to a motor cycle, to increase its load carrying capacity, without modification of the basic vehicle:

    - sidecars
    - trailer
    - 2 wheeled van/pick up conversion.

2. Adaptations of motor cycles, i.e. vehicles which start with a motor cycle as the basis, but involve adaptation to convert it into a 3-wheeled load carrier.

3. Purpose designed and built 3-wheeled load carriers. Here we should distinguish between those designed for urban use, and those more suited to rural operation.

iv) For initial analysis we should include single axle tractors and trailers, though their relevance is critically dependent on the suitability of single axle tractors to Ethiopian agriculture.

v) The complete range of low-cost vehicle options includes four-wheeled motor vehicles which are "low cost" in the sense that they are less expensive than conventional motor vehicles:

- basic pick up powered by single cylinder diesel engine (as used in South Korea and Thailand);

- Basic Transport Vehicles (BTV) of the type found in the Philippines and some other parts of Asia.

This gives the following vehicle listing:

1. Wheelbarrow
2. Handcart
3. Animal drawn cart and carriage
4. Bicycle
5. Tricycle
6. Bicycle and trailer
7. Motor cycle
8. Moped/Scooter
9. Motor cycle and trailer
10. Motor cycle and sidecar
11. 4-wheeled motor cycle conversion
12. Motor cycle based 3-wheeler
13. Urban 3-wheeler
14. Rural 3-wheeler
15. Single axle tractor and trailer
16. Diesel engine 4-wheeler
17. Basic Transport Vehicle (BTV)

2. Vehicle Classification

It is useful to have a preliminary classification of the vehicles in terms of characteristics relevant to the market study and to introduction of the technology.

i) Location of Use

The IPS proposal to NMWC states that the study will encompass both urban and rural transportation. It is necessary, for analysis of vehicle applications, to define these terms in more detail and I suggest we use the following categories:

1. Intra-Urban

Urban centres which are sufficiently large to have a significant demand for transport within the urban and peri-urban area. e.g. for movement of people to and from work, and for collection, delivery and distribution of goods.

2. Long-distance Transport

There is a demand for long distance transport either inter-urban, linking major urban centres, or linking a major urban centre with a large, surrounding rural region. Long distance transport, (let us say greater than 50km one way) is generally not a suitable application for low-cost vehicles, but there are isolated exceptions.

3. Rural

Local transport linking villages, connecting villages to small towns and markets, or feeding into the major road network where long-distance services operate. Generally there is only limited demand for transport within the bounds of a small town/market and vehicles that serve this need will usually also operate in the surrounding rural area.

4. On-Farm

This is a particular element of rural transport but is worth classifying separately. It includes transport in and around villages, between village and field and between village and roadside, primarily for agricultural and household requirements. Its main characteristic is that much of it takes place remote from the road network.

ii) Types of Load Carried

It is useful to distinguish between vehicles that carry people, vehicles that carry goods, and those that do both.

iii) Ownership and Use

Some vehicles will primarily be used by their owners to meet personal/family requirements.

Others are most likely to be operated for hire providing services for the transport of goods or people.

v) Source of Technology

While the local assembly/manufacture of certain types of low-cost vehicle will require some form of collaboration with an overseas source of product or production technology, others can be produced independently of such collaboration.

The accompanying table presents a classification of the vehicles under consideration.

Notes on Table

(1) rural use restricted to reasonable quality of roads

(2) transport of passengers is feasible, and common in Asia, but may be unacceptable for social reasons.

(3) independent manufacture refers to the attachment/adaptation, not to the original vehicle that provides the source of power.

(4) not ideally suited to passenger carrying.

(5) could be manufactured independently, but would require significant development work.

(6) can be used in urban areas (as is done in Sri Lanka) but expensive and inefficient.

	LOCATION				LOADS		USE		MANUFACTURE	
	Intra-Urban	Long Distance	Rural	On-Farm	People	Goods	Personal	Service	Inde-pendent	Colla-boratio
Wheelbarrow			x	x		x	x		x	
Handcart	x		x			x	x	x		
Animal drawn cart/ carriage			x	x	x	x	x	x	x	
Bicycle	x		x	x	x	limited	x			x
Tricycle	x		(1)		(2)	x		x		x
Bicycle and trailer	x		x	x		x	x	x	x(3)	
Motor cycle	x	x	x		x	limited	x			x
Moped/scooter	x				x		x			x
Motor cycle and trailer	x	x	x			x	x	x	x(3)	
Motor cycle and sidecar	x		x		x	x		x	x(3)	
4-wheeled motor cycle conversion	x				x	x		x	x(3)	
Motor cycle based 3 wheeler	x				x	x		x	x(3)	
Urban 3-wheeler	x				x	x		x		x
Rural 3-wheeler			x	x	(4)	x	x	x	(5)	
S/Axle Tractor and trailer	(6)		x	x	(4)	x	x			x
Diesel-engined 4-wheeler	x		x		x	x		x	(5)	
Basic Transport Vehicle	x	x	x		x	x		x		x

ANNEX 5: MATERIAL COSTS

ANNEX 5: MATERIAL COSTS

1. Locally Supplied Materials

The main locally supplied materials will be welded mild steel tube from Kalliti (or Akaki) and mild steel sheet from Kalliti.

Kalliti make the complete range of tube sizes required for low-cost vehicles (except very small tube for making bicycle brake components). Tube will be required in two specifications:

- formed from cold rolled strip (primarily for bicycle frame)

- formed from hot rolled strip.

The current Kalliti sales price for tube formed from hot rolled stip is between 2250 and 2300 Birr/tonne.

A figure of 2360 Birr/tonne has been used.

Based on most recent import prices, cold rolled strip is about 160 Birr/tonne more expensive than hot rolled strip. Since the tube making process is identical, the cost assumed for tube supplied by Kalliti from cold rolled strip is 2500 Birr/tonne.

Mild Steel Sheet is required in three specifications:

Hot Rolled	- for fabrication
Cold Rolled	- for pressforming
Cold Rolled Annealed	- for pressforming involving deep drawing.

For hot rolled sheet current Kalliti prices range from 1960 Birr/tonne to 2070 Birr/tonne. An additional 200 Birr/tonne is allowed for cold rolled sheet and 100 Birr/tonne for annealing. No allowance is made for providing the sheet in slit coil form since this operation simply replaces the operation of cutting wide coil into sheets at Kalliti. Hence the prices used are:

Hot rolled sheet	2000 Birr/tonne
Cold rolled sheet	2200 Birr/tonne
Cold rolled annealed sheet	2300 Birr/tonne

Foam supplied from Ethio-Foam cut to size and shape for upholstery is estimated at 3 Birr/piece.

2. Imported Materials

Imported material costs are based on the most recent and nearest equivalent quotes received by the Purchasing Division of NMWC. To these CIF costs are added the following:

Duty at 200 Birr/tonne
Transport, Assab-Addis Ababa at 225 Birr/tonne (based on 12.5c per tonne km).

No allowance is made for transaction tax since it is assumed that this will be charged on the finished products, not on the imported raw materials.

Prices of imported steel materials are as follows:

Bright finish mild steel bar	1225 Birr/tonne CIF	1650 Birr/tonne Addis Ababa
Black finish mild steel round and hexagon bar	950 Birr/tonne CIF	1375 Birr/tonne Addis Ababa
Small diameter mild steel wire	Assume 2000Birr/tonne Addis Ababa since there will be some premium over larger diameter bar.	
Hard bright wire		3000 Birr/tonne Addis Ababa
Carbon steel tube	Based on current world prices	2750 Birr/tonne Addis Ababa
Small diameter steel tube	Based on current world prices	3000 Birr/tonne Addis Ababa

Prices of imported plastic materials are as follows:

	CIF	Addis Ababa
Plastisol PVC	1600 Birr/tonne	2025 Birr/tonne
Acrylic	3100 Birr/tonne	3525 Birr/tonne
Thermoplastic Polyurethane	3100 Birr/tonne	3525 Birr/tonne

Vinyl Leather Cloth - estimated at 5 Birr/piece.

Process materials are estimated as follows:

Brass for brazing	2400 Birr/tonne
Paint	5 Birr/bicycle frame
	6 Birr/motor cycle
	2 Birr/cart
	5 Birr/cycle trailer
	8 Birr/sidecar
Welding Wire	1.6 Birr/bicycle
	4 Birr/motor cycle
	1.5 Birr/cart
	3 Birr/cycle trailer
	4 Birr/sidecar
	3 Birr/pick up/van attachment

Process materials for plating are estimated for the complete facility, and then subdivided to different operations.

Salts and Chemicals	45,000 Birr/annum
Anodes	4,500 Birr/annum

ANNEX 6: COMPONENT ANALYSIS
OF STANDARD ROADSTER BICYCLE

ANNEX 6: COMPONENT ANALYSIS OF STANDARD ROADSTER BICYCLE

1. The attached chart details the individual components that go to make up a standard roadster bicycle. For convenience the bicycle is broken down into a series of sub-assemblies which constitute the functional elements of the bicycle. Each sub-assembly has a 1000 number;

   1000 - Frame Set
   2000 - Handlebar Set
   3000 - Brake Set
   4000 - Front Mudguard Set
   5000 - Rear Mudguard Set
   6000 - Front Wheel Set
   7000 - Rear Wheel Set
   8000 - Transmission Set
   9000 - Saddle Set

2. Groups of components which form permanently joined sub-assemblies (i.e they are welded, brazed, rivetted, etc, together) are defined as a sub-group. The sub-group is given a 100 series number, e.g. The brazed main frame is given the sub-group number 1100. It is made up of the components 1101, 1102, 1103 etc.

3. Where an identical component appears in more than one sub-group only a single component number is used. However the component is listed under each sub-group in which it appears.

4. The components included in the nine sub-assemblies make up the minimum basic specification of the roadster bicycle. Accessories which can be added to the basic specification are listed under Sub Assembly 10,000. Each accessory is given a sub-group number.

5. The standard roadster bicycle can be built in different frame sizes with no changes in the numbers of components. However the dimensions of the following components will vary according to the size of the frame.

   Item 1102 Seat Tube
   Item 1104 Head Tube
   Item 1201 Seat Stay L.H.
   Item 1202 Seat Stay R.H.
   Item 1307 Fork Column

   In each case the length of the component varies according to frame size. All other dimensions of these components are unchanged.

6. There are two possible variations on the basic roadster frame:

i) Double top tube model

This requires the following changes in the component listing:

delete	Item 1108	-	Bottom Head Lug
add	Item 1131	-	Double Head Lug
	Item 1132	-	Intermediate Tube
	Item 1133	-	Intermediate Lug

ii) Ladies model

This requires the following changes in the component listing:

delete	Item 1105	-	Top Tube
	1106	-	Seat Lug
add	Item 1133	-	Intermediate Lug
	1142	-	Ladies Seat Lug
	1143	-	Cross Tube

<u>1000 Frame Set Sub Assembly Components</u>

		No. off/bicycle
1100 - Sub Group -	Main Frame	1
1101	Bottom Bracket	1
1102	Seat Tube	1
1103	Down Tube	1
1104	Head Tube	1
1105	Top Tube	1
1106	Seat Lug	1
1107	Top Head Lug	1
1108	Bottom Head Lug	1
1109	Top Tube Liner	2
1110	Down Tube Liner	1
1111	Seat Tube Liner	1
1112	Chain Stay L.H.	1
1113	Chain Stay R.H.	1
1114	Chain Stay Liner (Front)	2
1115	Fork End	2
1116	Chainstay Bridge	1
1117	Pump Pegs	2
1118	Rivetting Pegs	10
1119	Badge	1
1120	Rivets	2
1121	Transfers	2

		No. off/bicycle
1200 - Sub Group - Seat Stay		1
1201 - Seat Stay L.H.		1
1202 - Seat Stay R.H.		1
1203 - Seat Stay Bridge		1
1300 - Sub Group - Front Fork		1
1301	Fork Blade L.H.	1
1302	Fork Blade R.H.	1
1303	Fork End	2
1304	Fork Crown	1
1305	Fork Blade Liner	2
1306	Fork Crown Insert	2
1307	Fork Column	1
1308	Fork Column Liner	1
1309	Fork Column Ring	1
1401	Bottom Ball Race Seating	1
1402	Top Ball Race Seating	1
1403	Ball Race (Inner)	2
1404	Bottom Ball Race (Outer)	1
1405	Top Ball Race (Screwed)	1
1406	Lamp Bracket	1
1407	Locking Nut	1
1408	Balls	50
1411	Seat Bolt	1
1412	Seat Nut	1
1421	Chainstay Bolt	2
1422	Chainstay Washer	2
1423	Chainstay Nut	2

2000 Handlebar Set Sub Assembly

2100 - Sub Group - Handlebar		1
2101	- Handlebar	1
2102	- Handlebar Lug	1
2103	- Handlebar Stem	1
2200 - Sub Group - L.H. Brake Rod		1
2201	Brake Tab Rear	1
2202	Brake Rod Rear	1
2300 - Sub Group - R.H. Brake Rod		1
2301	Brake Tab Front	1
2302	Brake Rod Front	1
2401	Eye Bolt	4

		No. off/bicycle
2402	Eye Bolt Washer	4
2403	Eye Bolt Nut	4
2404	Lever L.H.	1
2405	Lever R.H.	1
2406	Lever Spring	2
2407	Lever Washer	2
2408	Lever Nut	2
2409	Expander Bolt	1
2410	Expander Bolt Washer	1
2411	Expander Bolt Cone	
2412	Handlebar Grip	2

3000 Brake Set Sub-Assembly Components

3100 - Sub Group -	Front Brake Stirrup	1
3101	Brake Tube Connector	1
3102	Front Brake Tube	1
3103	Brake Stirrup Connector	1
3104	Brake Stirrup	1
3105	Stirrup Pin	2
3200 - Sub Group -	Rear Brake Linkage	1
*3101	Brake Tube Connector	1
3202	Rear Brake Tube	1
3203	Tube Connector	1
3204	Grub Screw	1
3205	Lever L.H.	1
3206	Lever R.H.	1
3207	Rivets	3
3208	Long Brake Rod	1
3209	Bell Crank L.H.	1
3210	Bell Crank R.H.	1
3211	Short Brake Rod	1
3300 - Sub Group -	Rear Brake Stirrup	1
*3101	Brake Tube Connector	1
3302	Short Brake Tube	1
*3103	Brake Stirrup Connector	1
*3104	Brake Stirrup	1
*3105	Brake Stirrup Pin	2
3401	Draw Bolt	3
3402	Draw Nut	3
3403	Draw Washer	3
3411	Brake Shoe	4
3412	Brake Block	4
3413	Bolt	4
3414	Nut	4

		No. off/bicycle
3415	Washer	4
3421	Brake Clip Outer	4
3422	Brake Clip Inner	4
3423	Clip Screw	4
3424	Clip Nut	4
3425	Clip Washer	8
3431	Lever Bolt	1
3432	Lever Nut	1
3433	Lever Washer	1
3441	Bell Crank Bolt	1
3442	Bell Crank Nut	1
3443	Bell Crank Washer	1

4000 Front Mudguard Set Sub Assembly Components

4100 - Sub Group - Front Mudguard		1
4101	Front Mudguard	1
4102	Mudguard Bridge	1
4103	Mudguard Stay	2
4104	Mudguard Stay Nut	2
4105	Mudguard Tab	2
4106	Front Mudguard Clip	1
4201	Front Mudguard Set Screw	1

5000 Rear Mudguard Set Sub Assembly Components

5100 - Sub Group - Rear Mudguard		1
*4102	Mudguard Bridge	1
*4103	Mudguard Stay	2
*4104	Mudguard Stay Nut	2
*4105	Mudguard Tab	2
5106	Rear Mudguard clip	1
5200 - Sub Group - Reflector		1
5201	Reflector Body	1
5202	Reflector Glass	1
5203	Bolt	1
5301	Rear Mudguard clip	1
5302	Rear Mudguard Bolt	1
5303	Rear Mudguard Nut	1
5304	Rear Mudguard Washer	1

		No. off/bicycle
5311	Reflector Nut	1

6000 Front Wheel Set Sub-Assembly Components

6100 - Sub Group -	Front Hub	1
6101	Hub Barrel	1
6102	Spoke Flange	2
6103	Ball Cup	2
6104	Dust Cap Washer	2
6105	Oil Clip	1
6201	Axle	1
6202	Fixed Cone	1
6203	Adjustable Cone	1
6204	Balls	18
6205	Nuts	2
6206	Washers	2
6207	Spokes	32
6208	Nipples	32
6209	Nipple Washers	32
6210	Rim	1
6211	Rim Tape	1
6212	Tape Clip	1
6213	Tube with Valve	1
6214	Tyre	1

7000 Rear Wheel Set Sub-Assembly Components

7100 - Sub Group -	Rear Hub	1
7101	Hub Barrel	1
7102	Distance Piece	1
*6103	Ball Cup	2
*6104	Dust Cap Washer	2
*6105	Oil Clip	1
7106	L.H. Flange	1
7107	R.H. Flange	1
7200 - Sub Group -	Freewheel	1
7201	Body	1
7202	Sprocket	1
7203	Pawls	2
7204	Pawl Pin	2
7205	Pawl Spring	2
7206	Pawl Washer	2
7207	Cone	2
7208	Balls	108

		No. off/bicycle
7301	Axle	1
7302	Fixed Cone	1
7303	Adjustable Cone	1
*6204	Balls	18
7305	Nuts	2
7306	Washers	2
*6207	Spokes	40
*6208	Nipple	40
*6209	Nipple Washer	40
7310	Rim	1
*6211	Rim Tape	1
*6212	Tape Clip	1
*6213	Tube with Valve	1
*6214	Tyre	1

8000 Transmission Set Sub-Assembly Components

8100 - Sub Group - Chainwheel and Crank		1
8101	Chainwheel	1
8102	Crank R.H.	1
8200 - Sub Group - Chain		1
8201	Inner Plate	112
8202	Bush	112
8203	Roller	112
8204	Outer Plate	112
8205	Bearing Pin	111
8206	Connecting Pin	2
8207	Spring Clip	1
8301	Pedal Tube	2
8302	Ball Cup	4
8303	Pedal Rubber	4
8304	Stretcher Bar	4
8305	Pedal Plate	4
8306	Balls	48
8307	Pedal Axle L.H.	1
8308	Pedal Axle R.H.	1
8309	Pedal Cone	2
8310	Washer	2
8311	Axle Nut	2
8312	Dust Cap	2
8313	Stretcher Bar Nut	8
8314	Spring Lock Washer	8

		No. off/bicycle
8321	Axle	1
8322	Fixed cup	1
8323	Adjustable Cup	1
8324	Locking Ring	1
8325	Balls	22
8326	L.H. Crank	1
8327	Cotter Pin	2
8328	Nut	2
8329	Washer	2
8330	Spring Washer	2

9000 Saddle Set Sub-Assembly Components

9100 - Sub Group -	Saddle	1
9201	Seat Pillar	1

10000 ACCESSORIES

10100	Pump	1
10200	Luggage Carrier	1
10300	Stand	1
10400	Chain Cover	1
10500	Bell	1
10600	Lighting Set	1
10700	Mud Flap	2
10800	Lock	1
10900	Tool Kit	1

ANNEX 7: ASSEMBLY OF BICYCLE FROM SKD KIT

ANNEX 7: ASSEMBLY OF BICYCLE FROM SKD KIT

Table 1 lists the form in which the components will be supplied to assemble one complete bicycle from an SKD kit. The kit, and the assembly process, is exactly the same whether the bicycle is a single top tube, double top tube or ladies type, since the frame is supplied complete. For the same reason the assembly process is identical for different sizes of bicycle.

The main elements of the assembly process are:

1. Unload crates at factory site;
2. Check contents of crates and separate to store (report any errors or shortages for remedial action);
3. Batch components for sub and final assembly operations and deliver to appropriate work stations;
4. Prepare sub-assemblies
   - Handlebar Sub-Assembly (2000)
   - Brake Sub-Assembly (see detailed chart)
   - Wheel Sub-Assembly and Truing (6000 and 7000)
   - Pedal Sub-Assembly (8301-8314)
   - Frame Sub-Assembly (1100 + head cups, pedal axle and cranks)
5. Final assembly
6. Check and pack
7. Deliver to final store
8. Despatch to customers.

TABLE 1 CONTENTS OF SKD KIT FOR BICYCLE ASSEMBLY

Component/ Sub-Group No.	Qty/Bicycle		Component/ Sub-Group No.	Qty/Bicycle	
1100	1		3431	1	
1200	1		3432	1	
1300	1		3441	1	
1401	1		3442	1	
1402	1		3443	1	
1403	2		4100	1	
1404	1		4201	1	
1405	1		5100	1	
1406	1		5200	1	
1407	1		5301	1	
1408	50		5302	1	
1411	1		5303	1	
1412	1		5304	1	
1421	2		5311	1	
1421	2		6100	1	
1422	2		6201	1	Front hub
1423	2		6202	1	supplied
2100	1		6203	1	assembled
2200	1		6204	18	
2300	1		6205	2	
2401	4		6206	2	
2402	4		6207	72	
2403	4		6208	72	
2404	1		6209	72	
2405	1		6210	1	
2406	2		6211	2	
2407	2		6212	2	
2408	2		6213	2	
2409	1		6214	2	
2410	1		7100	1	
2411	1		7301	1	Rear hub
2412	2		7302	1	supplied
			7303	1	assembled
3100	1		6204	18	
3200	1		7200	1	
3300	1		7305	2	
3401	3				
3402	3				
3403	3				
3411	4	supplied	7306	3	
3412	4	assembled	7310	1	
3413	4		8100	1	
3414	4		8200	1	
3415	4		8301	2	
3421	4		8302	4	
3422	4		8303	4	
3423	4		8304	4	
3424	4		8305	4	
3425	8		8306	48	

8307	1
8308	1
8309	2
8310	2
8311	2
8312	2
8313	8
8314	8
8321	1
8322	1
8323	1
8324	1
8325	22
8326	1
8327	2
8328	2
8329	2
8330	2
9100	1
9201	1

Accessories

To suit market

Table 2 details the sequence of assembly operations (items 4-6 above), the components added at each stage, and the estimated direct labour time for each operation. The labour times quoted are based on a reasonable working pace under Ethiopian conditions.

Based on the capacity of 12,500 units per annum with an operating efficiency of 80% (i.e. basing the calculations on each worker contributing 7.5 min work per bicycle), a direct labour force of fourteen persons is required, with the work organised as follows:

i) A sub-assembly area with three work stations

- Frame sub-assembly	(ops 01-03)	1 worker
- Wheel sub-assembly	(ops 31-36)	3 workers
- Handlebar, brake and pedal sub assembly	(ops 11-14, 21-22, 41-44)	3 workers

ii) A final assembly line with six work stations

- Assembly station 1	(ops 51-52)	1 worker
- Assembly station 2	(ops 53-55)	1 worker
- Assembly station 3	(ops 56-57)	1 worker
- Assembly station 4	(ops 58-59)	1 worker
- Assembly station 5	(ops 60-62)	1 worker
- Checking and packing	(ops 63-64)	2 workers

The sub assembly operations are carried out at benches. The operations for the first four final assembly stations are carried out with the frame upside down, located by the seat tube on a spigot. The most convenient way of arranging this is to have a simple track, on which run independent trolleys, each with a spigot for locating the frame. The frames are passed through the first four final assembly stations mounted on these trolleys. When they reach the end of the track, the frames are removed and the trolleys returned to the start of the track by a gravity feed. It is necessary to have an excess of trolleys, and each must be fitted with a simple brake so it can be locked in position at each assembly station. The fifth assembly station requires the frame to be turned upright and mounted in a stand. Similarly the completed bicycles will be located in stands for the checking operation.

Components are issued from the component store in batched sets, on purpose-built wheeled racks, to each work station. If batched sets are supplied twice daily, each work station needs two supply racks each holding 25 sets of parts (one rack being worked from, the other being filled). The sub-assembly stations work one day in advance of final assembly to avoid shortages in supply. Completed sub-assemblies are supplied direct to the appropriate final assembly station, again on purpose-built racks - each sub-assembly work station requires at least three of these racks. The detailed equipment requirements for the assembly process are:

Sub Assembly Area

i) Frame sub-assembly (1 worker)

- 1 bench
- 1 hand press
- 2 vices
- 1 cup spanner
- 1 lockring spanner
- 1 hammer
- 1 spanner
- 1 file (for filing cotter pin to size)

- 2 mobile supply racks
- 1 fixed rack, (to store frames at start of assembly line)

ii) Wheel sub-assembly (3 workers)

- 1 bench
- 1 wheel stand (to hold hub while asssembling wheel)
- 1 pneumatic screwdriver
- 1 truing stand
- 1 spanner
- 1 nipple key
- 1 tyre fitting bench
- 1 tyre roller
- 1 pneumatic tyre inflator

- 2 mobile supply racks
- 3 mobile delivery racks (to final assembly)
- 2 fixed racks (to hold wheels between assembly and truing, and truing and tyre fitting

iii) Handlebar, brake and pedal sub-assembly (3 workers)

- 3 benches
- 3 vices (one each for handlebar, brakes and pedal)
- 1 eye nut inserter
- 1 tommy bar
- 2 screwdrivers
- 4 spanners
- 1 hand press
- 1 cone spanner

- 2 mobile supply racks
- 6 mobile racks for delivery to three different work stations

Final Assembly Line

i) For assembly stations 1-4 a ground level track, 15 independent trolleys, and a gravity feed trolley return.

ii) Assembly station (1 worker)

1 pneumatic spanner with interchangeable heads 1 set hand tools	2 mobile supply racks

iii) Assembly station 2 (1 worker)

1 pneumatic screwdriver with interchangeable heads 1 set hand tools	2 mobile supply racks

iv) Assembly station 3 (1 worker)

1 pneumatic screwdriver with interchangeable heads 1 set hand tools	2 mobile supply racks

v) Assembly station 4 (1 worker)

1 pneumatic screwdriver with interchangeable heads 1 set hand tools	2 mobile supply racks 1 fixed rack to store partly assembled bicycles at end of track

vi) Assembly station 5 (1 worker)

1 bicycle stand 1 pneumatic screwdriver with interchangeable heads 1 set hand tools	2 mobile supply racks 1 fixed rack to store assembled bicycle prior to checking

vii) Checking and packing station (2 workers)

2 bicycle stands 2 complete sets of tools for making adjustments to each bicycle	2 mobile supply racks racks for packing materials

The assembly process remains unchanged as local content is progressively increased, as all made in components and sub groups are delivered to the component store from the manufacturing sections prior to final assembly.

TABLE 2: ANALYSIS OF BICYCLE ASSEMBLY SEQUENCE

ASSEMBLY OPERATION		COMPONENTS		TIME PER BICYCLE MINS
Frame Sub Assembly				
01	Press Head Cups into Frame	1100	1	0.5
		1401	1	
		1402	1	
02	Fit Pedal Axle	8321	1	
		8322	1	
		8323	1	
		8324	1	
		8325	22	2
03	Fit Cranks	8100	1	
		8326	1	
		8327	2	
		8328	2	4
		8329	2	
		8330	2	

Deliver to Final Assembly op.51.

Handlebar sub-assembly

11	Fit Eye Bolts	2100	1	
		2401	4	
		2402	4	2
		2403	4	
12	Fit Levers and Brake Rods	2200	1	
		2300	1	
		2404	1	
		2405	1	1.5
		2406	2	
		2407	2	
		2408	2	
13	Fit Expander Bolt	2409	1	
		2410	1	1
		2411	1	
14	Fit Grips	2412	2	0.5

Deliver Sub Assembly 2000 To Final Assembly op.53

Brakes Sub Assembly

21	Assemble Front Brake	2100	1		
		3401	1		
		3402	1		
		3403	1		
		3411	2	supplied	
		3412	2	assembled	
		3413	2		1.5
		3414	2		
		3415	2		

Deliver Partly Assembled Front Brake to Final Assembly op.54

22	Assemble Rear Brake	3200	1		
		3300	1		
		3401	2		
		3402	2		
		3403	2		
		3411	2	supplied	
		3412	2	assembled	3
		3413	2		
		3414	2		
		3415	2		

Delivery Partly Assembled Rear Brake to Final Assembly op.56

Wheels Sub-Assembly

31	Loosely Assemble Front Wheel	6100	1		
		6201	1	supplied	
		6202	1	assembled	3.5
		6203	1		
		6204	18		
		6207	32		
		6208	32		
		6209	1		
32	Loosely Fit Nuts and Washers	6205	2		
		6206	2		0.5

Deliver Front Wheel to op.35

33	Loosely Assemble Rear Wheel	7100	1	supplied assembled	
		7301	1		
		7302	1		
		7303	1		
		6204	18		3.5
		6207	40		
		6208	40		
		6209	40		
		7310	1		
34	Fit Freewheel and Loosely Fit Nuts and Washers	7200	1		
		7305	2		1.0
		7306	2		

Deliver Rear Wheel to op.35

35	Tension and True Wheels	Front Wheel	1	
		Rear Wheel	1	8
36	Fit Tyre and Inflate	6211	2	
		6212	2	
		6213	2	
		6214	2	3

Deliver Sub Assembly 6000
To Final Assembly op.55
Deliver Sub Assembly 7000
To Final Assembly op.57

Pedals Sub Assembly (LH and RH Set)

41	Press Cups into Pedal Tube	8301	2	1
		8302	4	
42	Fit Axle Balls and Cone	8306	48	2
		8307	1	
		8308	2	
43	Fit End Plates and Rubbers	8303	4	
		8304	4	3
		8305	4	
		8313	8	
		8314	8	
44	Set Cone. Fit Locknut and Cap	8310	2	2
		8311	2	
		8312	2	

Deliver Pedals to Final Assembly op.61

51. <u>Final Assembly</u>

	Frame		
Fit Seat Stay (do not tighten Seat Bolt)	1200	1	
	1411	1	
	1412	1	2
	1421	2	
	1422	2	
	1423	2	
52. Fit Front Fork	1300	1	
	1403	2	
	1404	1	5
	1405	1	
	1406	1	
	1407	1	
	1408	50	
53. Fit Handlebar	2000		2
54. Fit Front Brake	Partly Assembled Front Brake		2
55. Fit Front Wheel and Mudguard	4100	1	
	4201	1	
	6000	1	4

56.	Fit Rear Brake	Partly Assembled Rear Brake 3431 3432 3433 3441 3442 3443	 1 1 1 1 1 1	2
57.	Fit Rear Wheel and Mudguard (leave wheel nuts loose)	5100 5200 5301 5302 5303 5304 5311 7000	1 1 1 1 1 1 1 1	4
58.	Fit and Tension Chain	8200	1	2
59.	Fit Brake Clips and Set Rear Stirrup	3421 3422 3423 3424 3425	4 4 4 4 4	3
60.	Set Handlebars and Front Brake, and Rear Brake Linkage			2
61.	Fit Pedals	IRH, ILH Pedal		2
62.	Fit Pillar and Saddle	9100 9200	1 1	2

63. Check Completed Bicycle 14

i) Visual check that bicycle is complete, and no damage to paintwork

ii) Wheels

- bearing adjustment
- wheel alignment
- wheels run freely

iii) Transmission

- bearing adjustment
- chain adjustment
- chainwheel alignment
- transmission and freewheel run freely

iv) Steering

- bearing adjustment
- handlebar alignment
- fork turns freely

v) Braking

- adjustment of linkage and shoes
- brake effectiveness

64. Pack and Despatch to store 1

ANNEX 8: MANUFACTURE OF BICYCLE FRAME AND FRONT FORK

ANNEX 8: MANUFACTURE OF BICYCLE FRAME AND FRONT FORK

Local manufacture of the bicycle frame and front fork is based on deletion from the imported kit of parts of the following sub-groups:

1100 - Main Frame
1200 - Seat Stay
1300 - Front Fork

To replace them, the following individual components are imported as part of the kit:

1101 - Bottom Bracket
1117 - Rivetting Pegs
1119 - Badge
1120 - Rivets
1121 - Transfers

The following components are made locally:

1102 - Seat Tube
1103 - Down Tube
1104 - Head Tube
1105 - Top Tube
1106 - Seat Lug
1107 - Top Head Lug
1108 - Bottom Head Lug
1109 - Top Tube Liner
1110 - Down Tube Liner
1111 - Seat Tube Liner
1112 - Chain Stay L.H.
1113 - Chain Stay R.H.
1114 - Chain Stay Liner (Front)
1115 - Fork End
1116 - Chain Stay Bridge
1118 - Rivetting Pegs
1201 - Seat Stay L.H.
1202 - Seat Stay R.H.
1203 - Seat Stay Bridge
1301 - Fork Blade L.H.
1302 - Fork Blade R.H.
1303 - Fork End
1304 - Fork Crown
1305 - Fork Blade Liner
1306 - Fork Crown Insert
1307 - Fork Column
1308 - Fork Column Liner
1309 - Fork Column Ring

Table 1 details the raw material quantities and costs for these locally made components. In addition to these direct materials, process materials are required as follows:

Brass - estimated @ 1.25 tonnes at 2400 Birr/tonne
Paint - estimated @ 62,500 Birr per annum
Welding Wire - estimated @ 20,000 Birr/annum

Table 2 details the sequence of operations for the manufacture of each of the individual components, for the preparation of sub-assemblies, and for the assembly and brazing of the frame and front fork. The Table details the equipment and tooling required, and the labour input per bicycle for each operation. Based on this analysis the production of bicycle frames and forks will require the following manufacturing sections:

Pressforming
Tube Manipulation
Frame/Fork Assembly and Brazing
Painting and Finishing

Each of these is discussed below:

i) Pressforming Section.

This section will contain the equipment for press-forming frame lugs and other components, and for the other operations to complete these parts. It will also contain the wire cutting machine and a spot-welder.

The total direct operation times for the operations carried out in this section are:

Pressforming	686 secs. per bicycle
Welding	540 secs. per bicycle
Grinding	260 secs. per bicycle
Reaming	135 secs. per bicycle
Wire Straightening and cutting	40 secs. per bicycle
Spot Welding	30 secs. per bicycle

Allowing time for tool setting, it would just be possible to complete all the pressing operations using two mechanical presses. However to suit the requirements of the different pressing operations, and to maintain a good flow of components through the section, 4 mechanical presses will be required. Two welding sets will be required, and one each of a pedestal grinder, pedestal drill and tools (for reaming), a wire straightening and cutting machine and a spot welder.

TABLE 1: RAW MATERIAL FRAME AND FORK PRODUCTION

Material	Size	Amount/Bicycle kg	Amount/Annum tonne	Cost/tonne Birr	Cost/annum Birr	Source
ERW Cold Rolled Steel Tube	Various Round Sections	3.2	40	2,500	100,000	Kalliti
Cold Rolled Mild Steel Sheet	1.0, 1.2 & 1.6mm thick	1.18	14.5	2,200	31,900	Kalliti
Cold Rolled Annealed Mild Steel Sheet	1.6mm thick	0.6	7.5	2,300	17,250	Kalliti
Mild Steel Wire	3.0mm dia	0.031	0.4	2,000	800	Imported

This section will also require considerable investment in production tooling:

58 Press Tools (include those to make lugs for the double top tube model)
1Chainstay Welding Fixture
1 Seat Stay Welding Fixture

The direct labour force would be organised as follows:

Pressforming and Wire Cutting	3 workers
Welding, Grinding and Reaming	3 workers

ii) Tube Manipulation Section.

The total direct operation times for this section are:

Tube Cutting	110 secs/bicycle
Deburring	90 secs/bicycle
Slotting	12 secs/bicycle

Thus one of each machine is sufficient, and one worker can carry out all operations.

iii) Frame Fork Assembly/Brazing Section.

This section will have two dip brazing furnaces - one for forks and one for frames, and one electrolytic de-brassing tank.

Frame assembly will require 3 fixtures (one for each frame size) and a portable electric drill. Also a set of simple frame brazing jigs to hold the rear fork ends at the correct width, and the correct distance for the seat lug during brazing. The frame finishing operations will require one frame setting jig, one pedestal drill (for machining the seat and head tubes) and a special-purpose tapping machine to cut the bottom bracket threads.

Fork assembly will require one fixture, and a gas welder for tack welding. Finishing will require a fork blade bending fixture.

Five direct workers will be required in this Section:

Frame and Fork Assembly	- 2
Brazing	- 2
Frame and Fork Finishing	- 1

iv) Painting and Finishing Section.

As discussed in the main text, there is a choice of different processes for painting. However whichever method is chosen, it is proposed that there be one complete painting facility (preparation, paint application, and drying/curing) to serve all products made in the plant. For bicycle manufacture this section will be used to paint the frame, fork and seat stay, and apply the badges/transfers to the frame. This will require three workers.

v) Ancillary Equipment.

Additional equipment will be required for material handling (trays, trolleys etc) and for quality control. The latter will include "go-no go" checking gauges, a frame testing rig for applying a standard non-destructive test to selected frames taken from the production line after brazing, and a similar rig for testing forks.

Finally, it should be noted that one item - the fork column - has a thread machined on it. This operation would be carried out in the machine shop discussed subsequently.

TABLE 2: MANUFACTURE OF BICYCLE FRAME AND FRONT FORK

1. Pressformed Components

Component No.	Component Name	Operation No.	Operation Description	Equipment	Tooling	Operation Tim per bicycle (secs)
1106	Seat Lug	1	Pierce & Black	Mechanical Press	Progression Tool	6
		2	Draw	Mechanical Press	Drawing Tool	10
		3	Bend	Mechanical Press	Bending Tool	8
		4	Close	Mechanical Press	Closing Tool & Mandrel	10
		5	Weld	MIG Welder Welding Bench	-	30
		6	Grind	Pedestal Grinder	-	20
		7	Ream	Pedestal Drilling Machine	-	45
1107	Top Head Lug	1	Blank	Mechanical Press	Blanking Tool	6
		2	Draw	Mechanical Press	Drawing Tool	10
		3	Bend	Mechanical Press	B nding Tool	8
		4	Close	Mechanical	Closing Tool	10
		5	Weld	MIG Welder	-	30
		6	Grind	Pedestal Grinder	-	20
		7	Ream	Pedestal Drilling Machine	-	45
1108	Bottom Head Lug					
		1	Blank	Mechanical Press	Blanking Tool	6
		2	Draw	Mechanical Press	Drawing Tool	10
		3	Bend	Mechanical Press	Bending Tool	8
		4	Close	Mechanical Press	Closing Tool & Mandrel	10

		5	Weld	MIG Welder	-	30
		6	Grind	Pedestal Grinder	-	20
		7	Ream	Pedestal Drilling Machine	-	45
1109	Top Tube Liner (2-off)					
		1	Blank	Mechanical Press	Blanking Tool	12
		2	Bend	Mechanical Press	Bending Tool	16
		3	Close	Mechanical Press	Closing Tool & Mandrel	20
1110	Down Tube Liner					
		1	Blank	Mechanical Press	Blanking Tool	6
		2	Bend	Mechanical Press	Bending Tool	8
		3	Close	Mechanical Press	Closing Tool & Mandrel	10
1111	Seat Tube Liner					
		1	Blank	Mechanical Press	As 1110/1	6
		2	Bend	Mechanical Press	As 1110/2	8
		3	Close	Mechanical Press	As 1110/3	10
1114	Chain Stay Liner (2-off)					
		1	Blank	Mechanical Press	Blanking Tool	12
		2	Bend	Mechanical Press	Bending Tool	16
		3	Close	Mechanical Press	Closing Tool with Mandrel	20
1115	Fork End (2-off)					
		1	Blank	Mechanical Press	Blanking Tool	12
1116	Chainstay Bridge					
		1	Pierce & Blank	Mechanical Press	Progression Tool	6
		2	Bend	Mechanical Press	Bending Tool	8

		3	Close	Mechanical Press	Closing Tool & Mandrel	10
1118	Rivetting Peg (10-off)					
		1	Cut to Length	Wire Straightening & Cutting Machine	-	40
1203	Seat Stay Bridge					
		1	Pierce & Blank	Mechanical Press	Progression Tool	6
		2	Bend	Mechanical Press	Bending Tool	8
		3	Close	Mechanical Press	Closing Tool & Mandrel	10
1301/1302	Fork Blades					
		1	Blank	Mechanical Press	Blanking Tool	12
		2	Bend	Mechanical Press	Bending Tool	16
		3	Close	Mechanical Press	Closing Tool & Mandrel	20
		4	Weld	MIG Welder Welding Bench	Vice	300
		5	Grind	Pedestal Grinder	-	200
1303	Fork End (2-off)					
		1	Blank	Mechanical Press	Blanking Tool	12
1304	Fork Crown					
		1	Pierce & Blank	Mechanical Press	Progression Tool	6
		2	Draw	Mechanical Press	Drawing Tool	10
1305	Fork Blade Liner (2-off)					
		1	Blank	Mechanical Press	Blanking Tool	12
		2	Bend	Mechanical Press	Bending Tool	16
		3	Close	Mechanical Press	Closing Tool & Mandrel	20

1306	Fork Crown Insert (4-off)					
		1	Blank	Mechanical Press	Blanking Tool	24
1308	Fork Column Liner					
		1	Blank	Mechanical Press	Blanking Tool	6
		2	Bend	Mechanical Press	Bending Tool	8
		3	Close	Mechanical Press	Closing Tool & Mandrel	10

2. <u>Tubular Components</u>

1102	Seat Tube					
		1	Cut to Length	Tube Cutting Lathe	-	10
		2	Deburr	Deburring Machine	-	10
1103	Down Tube					
		1	Cut to Length	Tube Cutting Lathe	-	10
		2	Deburr	Deburring Machine	-	10
1104	Head Tube					
		1	Cut to Length	Tube Cutting Lathe	-	10
		2	Deburr	Deburring Machine	-	10
1105	Top Tube					
		1	Cut to Length	Tube Cutting Lathe	-	10
		2	Deburr	Deburring Machine	-	10
1112/1113	Chain Stay LH/RH					
		1	Cut to Length	Tube Cutting Lathe	-	20
		2	Deburr	Deburring Machine	-	20
		3	Slot	Slotting Machine	-	12
		4	Bend to shape & x-section	Mechanical Press	-	16

1201/1202	Seat Stay LH/RH					
		1	Cut to Length	Tube Cutting Lathe	-	20
		2	Deburr	Deburring Machine	-	20
		3	Bend to Shape	Mechanical Press	Bending Tool	16
		4	Flatten Ends	Mechanical Press	Squeezing Tool	24
		5	Punch Holes	Mechanical Press	Piercing Tool	32
		6	Clip Ends to shape	Mechanical Press	Clipping Tool	32
1307	Fork Column					
		1	Cut to Length	Tube Cutting Lathe	-	10
		2	Deburr	Deburring Machine	-	10
		3	Thread	Lathe	Die Box	20
1309	Fork Column Ring					
		1	Cut to Length	Tube Cutting Lathe	-	10
		2	Deburr	Deburring Machine	-	10

3. <u>Sub-Assemblies</u>

Chain Stay 1112/1113/1114/1116					
	1	Insert Liner into Stay & Press flat	Mechanical Press	As 1201/4	20
	2	Punch Slot	Mechanical Press	Blanking Tool	16
	3	Trim to Shape	Mechanical Press	Clipping Tool	16
	4	Spot Weld	Spot Welder	-	30
	5	Weld Chain Stay Assembly	MIG Welder Welding Bench	Welding Fixture	45
Seat Stay 1201/1202/1203					
	1	Weld Assembly	MIG Welder	Welding Fixture	45

Fork Blades 1301/1302/1303

2	Insert End into Blade & Press Flat	Mechanical Press	Squeezing Tool	
3	Punch Slot	Mechanical Press	Blanking Tool	20
4	Weld	Welding Bench	-	16
				60

4. <u>Assembly & Brazing of Frame</u>

Items 1101-1111
1118 Chainstay Assy

1	Assemble Components 1101-1111 in jig	-	Frame Fixture	90
2	Drill joints & fit pegs	-	Portable Drill Hand Tools	240
3	Assemble chainstay to frame, drill joints & fit pegs	-	Portable Drill Hand Tools	120
4	Dip Braze	Dip Brazing Furnace	Frame Brazing Jig	250
5	De-Brass	Electrolytic De Brassing Tank	-	90
6	Set frame	-	- Frame Setting Jig	60
7	Tap Bottom Bracket	Special Purpose Tapping Machine	-	90
8	Machine Head tube	Pedestal Drilling Machine	-	60
9	Machine Seat tube	Pedestal Drilling Machine	-	30

5. Assembly & Brazing of Fork

Items 1301-1309	1	Assemble components into jig	-	Fork Fixture	60
	2	Tack Weld	Gas Welder	-	60
	3	Dip Braze	Dip Brazing furnace	-	90
	4	De-brass	Electrolytic De-Brassing Tank	-	90
	5	Bend blades to shape	Fork Bending Machine	-	60

ANNEX 9: MANUFACTURE OF TUBULAR AND PRESS FORMED PLATED CYCLE COMPONENTS

ANNEX 9: MANUFACTURE OF TUBULAR AND PRESS FORMED PLATED CYCLE COMPONENTS

This includes the local manufacture of the following components:

1401 Bottom Ball Race Seating
1402 Top Ball Race Seating
1406 Lamp Bracket
2101 Handlebar
2103 Handlebar Stem
2201 Brake Tab Rear
2302 Brake Tab Front
2404 Lever LH
2405 Lever RH
3102 Front Brake Tube
3104 Brake Stirrup
3105 Stirrup Pin
3202 Rear Brake Tube
3205 Lever LH
3206 Lever RH
3208 Long Brake Rod
3209 Bell Crank LH
3210 Bell Crank RH
3211 Short Brake Rod
3302 Short Brake Tube
3411 Brake Shoe
3421 Brake Clip Outer
3422 Brake Clip Inner
9201 Seat Pillar

Table 1 details the raw material quantities and costs, for these locally made components. In addition, process materials will be required for plating:

Salts and Chemicals	25,000 Birr/Annum
Anodes	2,500 Birr/Annum

Table 2 summarises the manufacturing and assembly operations for the components. The press forming is presented more briefly than in the previous Annex, but is based on exactly the same approach to the sequence of operations.

The local manufacture of these components will require the establishment of a plating section, with the other operations being carried out in the sections specified for frame and fork production:

1. Press Forming Section

The total direct operation times for the operations carried out in this section are:

Press Forming	640 Seconds/Bicycle
Welding	30 Seconds/Bicycle
Grinding	20 Seconds/Bicycle
Reaming	40 Seconds/Bicycle
Wire Straightening	44 Seconds/Bicycle

TABLE 1: MATERIAL REQUIREMENTS - PRESS FORMED AND TUBULAR PLATED COMPONENTS

Material	Size	Amount/ Bicycle kg	Amount/ Annum Tonne	Cost/Tonne	Cost/Annum	Source
ERW Cold Rolled Steel Tube	22 mm od x 1.5 mm + 25 mm od x 1.2 mm	1.17	15	2,500	37,500	Kalliti
Cold Rolled Mild Steel Sheet	Various Thicknesses	0.90	11	2,200	24,200	Kalliti
Cold Rolled Annealed Mild Steel Sheet	Various Thicknesses	0.52	6.5	2,300	14,950	Kalliti
Mild Steel Rod	10 mm Dia.	0.75	10	1,375	13,750	Imported
Hard, Bright Mild Steel Wire	Various Diameters	0.07	0.9	3,000	2,700	Imported
Small Diameter Tube	2.5 mm id	0.07	0.9	3,000	2,700	Imported

TABLE 2: MANUFACTURE OF PRESS FORMED AND TUBULAR PLATED COMPONENTS

Component No.	Component Name	Operation	Equipment	Tooling	Operation Time (Seconds)
1. Press Formed Components					
1401	Bottom Ball Race Seating	1. 4 Press Forming Operations 2. Plate and Polish	Mechanical Press	4 Press Tools	32
1402	Top Ball Race Seating	1. 4 Press Forming Operations 2. Plate and Polish	Mechanical Press	4 Press Tools	32
1405	Lamp Bracket	1. 2 Press Forming Operations 2. Plate and Polish	Mechanical Press	2 Press Tools	14
2101	Handlebar Lug	1. 6 Press Forming Operations	Mechanical Press	6 Press Tools	50
		2. Weld	MIG Welder		30
		3. Grind	Pedestal Grinder		20
		4. Ream	Pedestal Drill		45
2201	Brake Tab Rear	1. 2 Press Forming Operations 2. Plate	Mechanical Press	2 Press Tools	14
2301	Brake Tab Front	1. 2 Press Forming Operations 2. Plate	Mechanical Press	2 Press Tools	14
2404/5	Braker Levers LH RH	1. 3 Press Forming Operations 2. Plate and Polish	Mechanical Press	3 Press Tools	44
3104	Brake Stirrup	1. 3 Press Forming Operations	Mechanical Press	3 Press Tools	44

TABLE 2 Continued

Component No.	Component Name	Operation	Equipment	Tooling	Operation Time (Seconds)
3205/6	Lever LH/RH	1. 2 Press Forming Operations 2. Plate and Polish	Mechanical Press	2 Press Tools	28
3209/10	Bell Crank LH/RH	1. 2 Press Forming Operations 2. Plate and Polish	Mechanical Press	2 Press Tools	56
3411	Brake Shoe	1. 2 Press Forming Operations 2. Plate and Polish	Mechanical Press	2 Press Tools	56
3421	Brake Clip Outer	1. 3 Press Forming Operations 2. Plate and Polish	Mechanical Press	3 Press Tools	88
3422	Brake Clip Inner	1. 3 Press Forming Operations 2. Plate and Polish	Mechanical Press	3 Press Tools	88
2. Tubular Component					
2101	Handlebar	1. Cut to Length	Special Purpose Cutting Lathe		10
		2. Deburr	Deburring Machine		10
2103	Handlebar Stem	1. Cut to Length	Special Purpose Cutting Lathe		10
		2. Deburr	Deburring Machine		10
		3. Slot	Slotting Machine		12
3102	Front Brake Tube	1. Cut to Length	Special Purpose Cutting Lathe		10
		2. Deburr	Deburring Machine		10

TABLE 2: Continued

Component No.	Component Name	Operation	Equipment	Tooling	Operation Time (Seconds)
3202	Rear Brake Tube	1. Cut to Length	Special Purpose Cutting Lathe		10
		2. Deburr	Deburring Machine		10
3302	Short Brake Tube	1. Cut to Length	Special Purpose Cutting Lathe		10
		2. Deburr	Deburring Machine		10
[illegible]	Seat Pillar	1. Cut to Length	Special Purpose Cutting Lathe		10
		2. Deburr	Deburring Machine		10
		3. Form End	Mechanical Press	1 Press Tool	10
		4. Plate and Polish			
3. Wire Components					
2202	Brake Rod Rear	1. Wire Straighten and Cut	Wire Straightening and Cutting Machine		6
		2. Form Eye	Mechanical Press	2 Press Tools	16
		3. Plate and Polish			
2302	Brake Rod Front	1. Wire Straighten and Cut	Wire Straightening and Cutting Machine		6
		2. Form Eye	Mechanical Press	As 2202/2	16
		3. Plate and Polish			
3105	Stirrup Pin	1. Wire Straighten and Cut	Wire Straightening and Cutting Machine		20
		2. Plate and Polish			
3208	Long Brake Rod	1. Wire Straighten and Cut	Wire Straightening and Cutting Machine		6
		2. Form Eye	Mechanical Press	2 Press Tools	16
		3. Plate and Polish			

TABLE 3: Continued

Component No.	Component Name	Operation	Equipment	Tooling	Operation Time (Seconds)
3211	Short Brake Rod	1. Wire Straighten and Cut	Wire Straightening and Cutting Machine		6
		2. Form Eye	Mechanical Press	As 3208/2	16
		3. Plate and Polish			
4. Assembly Operations					
2101/ 2102/ 2103	Handlebar	1. Assemble and Braze	Dip Brazing Tank		60
		2. Debrass	Electnolytic De-brassing Tank		60
		3. Bend	Handlebar Bending Fixture		30
		4. Drill	Pedestal Drill	Drilling Jig	45
		5. Plate and Polish			
	Brake Stirrups, Tubes etc.	1. Assemble and Braze	Hand Brazing Set		40
		2. Plate and Polish			

All operations except press forming can be completed using the equipment and labour already specified for frame and fork production. It is just possible, allowing for tool setting times, to fit in the press forming operations on the four mechanical presses already defined. However, it is sensible to specify one small additional press, to make the small brake items, and one additional worker. 43 additional press tools are required, but many of them are quite simple, for the manufacture of small parts.

2. Tube Manipulation Section

The total direct operation times for the operations carried out in this section are:

Tube Cutting	60 Seconds/Bicycle
Deburring	60 Seconds/Bicycle
Slotting	10 Seconds/Bicycle

All these operations can be carried out using the equipment and labour already specified for frame and fork production.

3. Frame/Fork Assembly and Brazing Section

Here the assembly, brazing (using fork brazing furnace), debrassing, bending and drilling of the handlebar will be carried out. A handlebar bending fixture is required, and also a drilling jig. The drilling operation is done on the pedestal machine used for machining the frame head and seat tubes. A hand brazing set, bench and vice are required to make up the brake sub-assemblies. No additional labour is required.

4. Plating Section

A single plating facility will serve to meet the requirements of all products manufactured in the proposed factory. It will consist of:

i) Nickel plating equipment of sufficient capacity to meet total plant requirements, including:

* Plating rectifier
* Bright nickel plating tank
* Filter press
* Air agitation equipment
* Immersion heaters
* Dull nickel plating tank
* Swilling tank

ii) Chromium plating equipment with sufficient capacity to meet total plant requirements, including:

* Plating rectifier

* Chromium plating tank

* Rinsing tank

* Swilling tank

* Immersion heater

iii) Polishing Machines

An estimated fifteen minutes polishing time is required for the plated components considered here. For this it is sensible to specify two double-ended polishing lathes, and two operators.

Three direct workers will be needed to carry out the actual plating operations.

The complete plating plant will include material handling equipment for transferring components between stages of the plating operation, together with laboratory facilities for quality control of the process.

ANNEX 10: MANUFACTURE OF MACHINED CYCLE COMPONENTS, C[illegible]NWHEEL AND CRANKS

ANNEX 10: MANUFACTURE OF MACHINED CYCLE COMPONENTS, CHAINWHEEL AND CRANKS

This includes manufacture of the following components:

1403 Top and Bottom Inner Ball Races
1404 Bottom Outer Ball Race
1405 Screwed Race
1407 Locking Nut
8321 Bottom Bracket Axle
8322 Bottom Bracket Fixed Cup
8323 Bottom Bracket Adjustable Cup
8324 Locking Nut
8101 Chainwheel
8102 RH Crank
8326 LH Crank

Of these items 1403, 1404, 1405, 8321, 8322 and 8323 are case hardened. The remainder are plated.

The chainwheel will be pressed, and the cranks forged, at the Ethiopian Metal Tools Factory. Finish machining operations on the cranks and assembly of crank to chainwheel will be carried out in the factory. The material requirements for the made-out parts are:

11.75 tonne/annum 3 mm Cold Rolled Mild Steel from Kalliti @ 2,200 Birr/tonne	25,850 Birr/annum
23.65 tonne/annum Imported Mild Steel Bar 32 mm diameter @ 1,375 Birr/Tonne	32,520 Birr/annum

The material requirements for the made-in machined components, all imported mild steel black bar are:

	tonne/annum
25 mm diameter	6.75
40 mm diameter	4.25
45 mm diameter	3.67
50 mm diameter	0.77
25 mm diameter	6.75
40 mm hexagonal	0.21
Total	15.65

@ 1,375 Birr/tonne - 21,520 Birr/annum

In addition, process materials will be required for plating:

Salt and Chemicals	10,000 Birr/annum
Anodes	1,000 Birr/annum

Table 1 summarises the manufacturing operations for the machined components. It also summarises the machining operations for the cranks. The total direct times for the machining operations are:

	secs/bicycle
Capstan Lathe	370
Chucking lathe	410
Milling Machine	30
Pedestal Drill	250
Grinding Machine	120
Tapping Machine	80

Therefore, allowing for tool setting time, one of each machine is sufficient, except that two chucking lathes will be required. There will be four workers in the machining section, two for turning and two for other operations. The machining section will also include the chainwheel rolling machine. Four drilling jigs and one milling jig will be required.

An additional polishing lathe, and one additional worker, will be required in the plating section.

Finally, 5 press tools and 2 forging dies must be supplied to the Metal Tools Factory.

TABLE 1: MANUFACTURING OPERATIONS - MACHINED COMPONENTS

Component No.	Component Name	Operation	Machine	Operation Time (Seconds)
1403	Top and Bottom Inner Ball Races	1. Drill, Turn Bore, Turn Groove, Part Off	Capstan Lathe	80
		2. Harden		
1404	Bottom Outer Ball Race	1. Drill, Turn, Turn Bore Turn Groove, Part Off	Capstan Lathe	40
		2. Chamfer	Chucking Lathe	20
		3. Harden		
1405	Screwed Race	1. Drill, Tap, Turn Recess, Turn Groove, Knurl Chamfer, Part Off	Capstan Lathe	60
		2. Harden		
1407	Locking Nut	1. Drill, Recess, Tap, Profile Part Off	Capstan Lathe	50
		2. Plate and Polish		
9321	Bottom Bracket Arm	1. Turn Outside Profile, Part Off, Turn Ends	Checking Lathe	120
		2. Mill	Milling Machine	30
		3. Harden		
		4. Grind	Centreless Grinder	120
9322	Bottom Bracket Fixed Cup	1. Drill, Turn Recess, Turn Outside, Cut Thread, Chamfer, Part Off	Capstan Lathe	70
		2. Drill Holes	Pedestal Drill	30
		3. Harden		

TABLE 1: Continued

Component No.	Component Name	Operation	Machine	Operation Time (Seconds)
8323	Bottom Bracket Adjustable Cup	1. Drill, Turn Recess, Turn Outside, Cut Thread, Chamfer, Part Off	Capstan Lathe	70
		2. Drill Holes	Pedestal Drill	30
		3. Harden		
8324	Locking Nut	1. Drill, Cut Thread, Part Off	Chucking Lathe	30
		2. Drill Holes	Pedestal Drill	30
		3. Plate and Polish		
Machining Operations - Cranks				
8102	RH Crank	1. Drill Centre Holes	Pedestal Drill	60
		2. Face	Chucking Lathe	120
		3. Tap Pedal Hole	Tapping Machine	40
		4. Drill Cotter Pin Holes	Pedestal Drill	20
8326	LH Crank	1. Drill Centre Holes	Pedestall Drill	60
		2. Face	Chucking Lathe	120
		3. Tap Pedal Hole	Tapping Machine	40
		4. Drill Cotter Pin Holes	Pedestal Drill	20

ANNEX 11: BREAKDOWN OF COMPONENTS OF MOTOR CYCLE

ANNEX 11: BREAKDOWN OF COMPONENTS OF MOTOR CYCLE

The attached list gives a breakdown of the components of a motor cycle of the type to be produced in Ethiopia. The motor cycle is divided into nine groups of components, each of which is given a '000 series number:

1000 Frame
2000 Engine and Transmission
3000 Rear Suspension
4000 Rear Wheel
5000 Electrical System
6000 Front Suspension
7000 Handlebar and Controls
8000 Front Wheel
9000 Fittings

No attempt has been made to breakdown the specification to each individual component since:

i) given the relative complexity of the motor cycle, this would form a very long list, and many of the individual components can only be produced economically in much larger quantities than are envisaged for Ethiopia. The breakdown used is intended to focus on those elements where there is potential for local content either in the short term, or as the industry develops, and to provide the basis for analysis of local assembly;

ii) in terms of both the production of individual components, and the methods of assembly, there will be variations from model to model and from manufacturer to manufacturer. The level of component breakdown used allows analysis of assembly and component manufacture taking account of such variations. It also allows the analysis to cover assembly of both general purpose and trail motor cycles, even though there are substantial differences between these two models at the component design level.

The breakdown is based on a 125 cc general purpose motor cycle manufactured in the Philippines. It is therefore a model which, at least in detailed respects, has been adapted for use in a developing country and for manufacture on a relatively small-scale. The specification includes those fittings which are required to meet registration requirements (eg. lights, indicators, number plate mountings) and for convenient operation (eg. carrier rack). However, it does not include accessories which may be requested by individual customers (eg. rear view mirrors, windscreen etc).

COMPONENT BREAKDOWN OF MOTOR CYCLE

1000 Frame

1001 Main Frame
1002 Front Footrest
1003 Front Footrest Rubbers
1004 Footrest Clamp
1005 Nuts, Bolts and Washers for 1004
1006 Parking Stand
1007 Parking Stand Spring
1008 Parking Stand Pivot
1009 Bolts and Washers for 1008

2000 Engine and Transmission

2001 Main Engine, Clutch, Transmission Assembly
2002 Grommets for Mounting 2001 in Frame
2003 Nuts, Bolts and Washers for 2001/2002
2004 Exhaust Pipe
2005 Gasket
2006 Bolts and Washers for attaching exhaust pipe to engine.
2007 Pipe Mounting Clamp
2008 Nuts and Bolts for 2007
2009 Kick Start Lever
2010 Bolt for 2009
2011 Kick Start Pedal
2012 Kick start Rubber
2013 Clamp for 2011
2014 Bolt for 2011
2015 Gear Change Pedal
2016 Bolt for same
2017 Chain
2018 Sprocket
2019 Chain Cover
2020 Nuts, Bolts and Washers for 2019
2021 Air Cleaner Body
2022 Air Cleaner Top
2023 Air Filter
2024 Nut for 2022
2025 Mounting Nuts, Bolts and Washers for 2021
2026 Pipe to Connect Air Cleaner to Engine
2027 Autolube Tank
2028 Autolube cap
2029 Pipe to Connect 2027 to Engine
2030 Clamps for 2029
2031 Fuel Tank
2032 Fuel Tank Cap
2033 Mounting Nuts, Bolts and Washers for 2031
2034 Fuel Filter Body
2035 Fuel Filter Cap
2036 Fuel Filter
2037 Pipes to Connect 2031/2034 to Engine

3000 Rear Suspension

3001 Suspension Arm
3002 Suspension Arm Pivot
3003 Suspension Arm Bushes
3004 Nuts and Washers for 3002
3005 Shock Absorbers
3006 Nuts, Bolts and Washers for 3005
3007 Rear Footrest
3008 Rear Footrest Rubbers
3009 Pivot for 3007
3010 Pin for 3009

4000 Rear Wheel

4001 Hub
4002 Bearings
4003 Brake Plate
4004 Brake Arm
4005 Nuts, Bolts and Washers for 4004
4006 Axle
4007 Mounting Nuts and Washers for 4006
4008 Chain Adjuster
4009 Nuts and Washers for 4008
4010 Spokes
4011 Nipples
4012 Washers
4013 Rim
4014 Rim Tape
4015 Inner Tube
4016 Tyre
4017 Brake Torque Arm
4018 Mounting Bolts, Nuts and Washers for 4014
4019 Brake Linkage
4020 Drawbolt for 4019
4021 Nut and Washer for 4020
4022 Spring and Adjustment Nuts for 4019

5000 Electrical System

5001 Rear Light and Stop Light Backing Plate and Fittings
5002 Bolts, Nuts and Washers for 5001
5003 Rear Light Lens Cover
5004 Mounting Screws for 5003
5005 Indicator Lights Mounting Bracket and Fittings (same front and rear)
5006 Mounting Nuts and Washers for 5005
5007 Indicator Light Lens Cover
5008 Mounting Screws for 3007
5009 Head Light Bowl and Fittings
5010 Head Light Reflector
5011 Head Light Lens
5012 Head Light Trim
5013 Horn and Fittings
5014 Mounting Bolts, Nuts and Washers for 5013
5015 Instrument Panel Mounting

5016 Nuts, Bolts and Washers for 5015
5017 Speedometer and Fittings
5018 Warning Light Panel and Fittings
5019 Ignition Switch and fitting
5020 Light Switch and Clamp
5021 Bolts and Washers for 5020 (fitted to handlebar)
5022 Battery Box
5023 Battery
5024 Battery Strap
5025 Earth Lead and Fitting
5026 Wiring Loom Complete with all Terminals
5027 Fuse Holder
5028 Bulbs Various
5029 Fuses Various

6000 Front Suspension

6001 Fork Pivot
6002 Bearings for 6001
6003 Nuts and Washers etc. for 6001
6004 Upper Fork Plate
6005 Lower Fork Plate
6006 Clamping Bolts and Washers for 6005
6007 Telescopic Suspension Member LH
6008 Telescopic Suspension Member RH
6009 Top Mounting Nuts and Washers for 6007/6008
6010 Front Mudguard
6011 Front Mudguard Stay
6012 Clamps for 6011
6013 Screws, Nuts and Washers to Assemble 6011/6012
6014 Bolts for Attaching Mudguard to Fork

7000 Handlebar and Controls

7001 Handlebar
7002 Handlebar Clamps
7003 Bolts and Washers for 7002
7004 Handgrip
7005 Twist Grip Moulding
7006 Twist Grip Mechanism and Clamp
7007 Bolts and Washers for 7006
7008 Throttle Cable and Fittings
7009 Clutch Lever and Clamp
7010 Bolts and Washers for 7009
7011 Clutch Cable and Fittings
7012 Brake Lever and Clamp
7013 Bolt and Washers for 7012
7014 Brake Cable and Fittings
7015 Choke Lever and Clamp
7016 Bolt and Washer for 7015
7017 Choke Cable and Fittings
7018 Speedometer Cable and Fittings

8000 Front Wheel

8001 Hub
8002 Bearings
8003 Brake Plate
8004 Brake Arm
8005 Nut, Bolt and Washer for 8004
8006 Axle
8007 Nuts and Washers for 8006
8008 Spokes
8009 Nipples
8010 Nipple Washers
8011 Rim
8012 Rim Tape
8013 Inner Tube
8014 Tyre

9000 Fittings

9001 Rear Mudguard
9002 Mounting Nuts, Bolts and Washers for 9001
9003 Rear Carrier
9004 Mounting Nuts, Bolts and Washers for 9003
9005 Rear Number Plate Bracket
9006 Mounting Nuts, Bolts and Washers for 9005
9007 Saddle Frame
9008 Saddle Frame Hinge
9009 Saddle Frame Clip
9010 Spring for 9009
9011 Mounting Nuts, Bolts and Washers for 9008
9012 Saddle Springs
9013 Saddle Padding
9014 Saddle Upholstery
9015 Nearside Trim Panel
9016 Mounting Nuts, Bolts and Washers for 9015
9017 Front Number Plate Bracket

ANNEX 12: ASSEMBLY OF MOTOR CYCLE FROM SKD KIT

ANNEX 12: ASSEMBLY OF MOTOR CYCLE FROM SKD KIT

The assembly sequence described here is essentially the same for both general purpose motor cycles and trail bikes. The main elements are:

1. Unload crates at factory site;
2. Check contents of crates and separate to store, (report any errors or shortages for remedial action);
3. Batch components for sub and final assembly stations, and delivery to appropriate work station;
4. Sub-assembly;
5. Final assembly;
6. Check and pack;
7. Deliver to final store;
8. Despatch to customers.

The stages of assembly (4, 5 and 6) are described in more detail on the following pages.

1. Sub-Assemblies

Given the low production rate, and therefore the relatively high amount of time (19.2 minutes) each worker can spend on each motor cycle, most of the assembly operations can be completed on the main line. The only sub-assembly operation required is for the front and rear wheels, including truing and tyre fitting. 1 skilled worker can complete assembly of both wheels with the following equipment:

1 Bench
1 Wheelstand
1 Pneumatic Screwdriver
1 Truing Stand
1 Tyre Fitting Bench
1 Tyre Roller
1 Pneumatic Tyre Inflator
Set of Tools
2 Mobile Supply Racks
3 Mobile Delivery Racks
2 Fixed Racks (to hold wheels between assembly and truing).

2. Final Assembly

A similar system to the bicycle is proposed with a ground track and trolleys, onto which the frame is mounted. However, at the start of the line the front footrest and parking stand components are fitted to the frame at a bench. The assembly line is divided into four stages:

Stage 1: 2 Workers (to facilitate fitting the heavy engine/ tranmission assembly).

i) Fit footrest and parking stand at bench;

ii) Mount frame onto assembly line;

iii) Fit engine, clutch and gearbox assembly;

iv) Fit rear suspension system - suspension arm, rear foot rests and shock absorbers;

v) Fit exhaust pipe;

vi) Fit rear wheel and chain.

Stage 2: 2 Workers.

i) Fit rear brake lever and connect linkage;

ii) Attach wiring loom to frame;

iii) Fit rear mudguard rack and lights and connect wiring;

iv) Fit air cleaner and connect engine wiring.

Stage 3: 2 Workers (to facilitate fitting front forks).

i) Complete connection of engine wiring;

ii) Fit front forks and mudguard;

iii) Fit front lights and horn and connect up wiring;

iv) Fit handlebar with controls and cables;

v) Connect clutch and throttle cables.

Stage 4: 1 Worker.

i) Fit chain cover, kick start and gear lever;

ii) Fit front wheel, connect up front brake and speedometer cable;

iii) Fit fuel tank and connect up fuel lines;

iv) Fit saddle;

v) Fit trim panel.

The equipment required for these assembly operations is as follows:

7 Sets pneumatic spanners with assorted tools.
16 Mobile supply racks.
1 Fixed rack to store motor cycles at the end of the line.
1 Ground level track with 12 independent trolleys.
1 Bench.

3. Inspection

Three inspectors carry out a complete check of assembled motor cycles:

i) Visual check that motor cycle is correctly assembled and no damaged parts;

ii) Check alignment and free movement of wheels;

iii) Check tyre pressure;

iv) Check no excessive play in wheel bearings;

v) Static check of front and rear suspensions;

vi) Adjust brakes and clutch;

vii) Fit and connect battery, bulbs and lenses;

viii) Add transmission oil, engine lubricant and petrol,

ix) Check all electrical systems;

x) Test ride machine;

xi) Drain petrol, disconnect battery, pack and deliver to store.

The equipment required for inspection is:

3 Complete sets tools
Fluid filling stand (outdoors) for oils and petrol

The assembly and inspection process remains unchanged as local content is progressively increased, as all parts made in-factory are delivered to the component store prior to assembly.

ANNEX 13: MANUFACTURE OF MOTOR CYCLE COMPONENTS IN-FACTORY

ANNEX 13: MANUFACTURE OF MOTOR CYCLE COMPONENTS IN-FACTORY

The motor cycle components identified for manufacture within the factory fall into three categories:

* Assemblies;
* Press Formed Components;
* Tubular Components.

Each of these categories is analysed, and then the overall material, equipment and labour requirements are detailed.

1. Assemblies

The following assemblies are considered for local manufacture;

1001 Frame
1006 Parking Stand
3007/3009 Rear Footrest
9003 Rear Carrier
9007-9012 Saddle

1.1 Frame

The frame is made up of nine lengths of carbon steel tube, two of which have to be bent to shape, and a total of 18 brackets. The tubes are cut to length, deburred, and profiled at the ends to ensure a good joint for welding. At the scale of production envisaged, the two bent tubes can be formed to shape using a hydraulic tube bender. The brackets are press formed. The various items are assembled and welded using special welding jigs. Separate jigs will be required for the general purpose and trail bike frames. The frame is painted using the same facilities as for the bicycle.

Material Requirements

Cold Rolled Sheet From Kalliti @ 2,200 Birr/Tonne - 4.7 kg/motor cycle.

Carbon Steel Tube, Imported @ 2,750 Birr/Tonne - 9 kg/ motor cycle.

Production Requirements

Tube Cutting	90 Seconds/Motor Cycle
Deburring	90 Seconds/Motor Cycle
Profiling	180 Seconds/Motor Cycle
Tube Bending	60 Seconds/Motor Cycle
Press Forming	286 Seconds/Motor Cycle
Frame Welding	4,200 Seconds/Motor Cycle

Tooling

44 Press Tools
6 Welding Jigs

1.2 Parking Stand

The parking stand consists of two separate but identical legs, each made up of 3 pressed components, which are welded together and painted.

Material Requirements

Cold Rolled Sheet from Kalliti @ 2,200 Birr/Tonne - 1 kg/ Motor Cycle.

Production Requirements

Press Forming	152 Seconds/Motor Cycle
Welding	120 Seconds/Motor Cycle

Tooling

8 Press Tools
1 Welding Jig

1.3 Rear Footrests

Each rear footrest is made up from a length of tube and two blanked plates, and is located on a machined pivot.

Material Requirements

Tube (From Cold Rolled Strip) From Kalliti @ 2,500 Birr/ Tonne - 0.22 kg/Motor Cycle

Cold Rolled Sheet From Kalliti @ 2,200 Birr/Tonne - 0.1 kg/Motor Cycle

Imported Rod @ 1,375 Birr/Tonne - 0.05 kg/Motor Cycle

Production Requirements

Tube Cutting	20 Seconds/Motor Cycle
Deburring	20 Seconds/Motor Cycle
Press Forming	52 Seconds/Motor Cycle
Welding	40 Seconds/Motor Cycle
Drilling (Press Shop)	30 Seconds/Motor Cycle
Lathe Turning	30 Seconds/Motor Cycle
Drilling (Machine Shop)	30 Seconds/Motor Cycle

Tooling

1 Welding Jig
2 Drilling Jigs

1.4 Rear Carrier

Made from mild steel rod, consisting of a bent outer frame with cross pieces welded on. Plated after assembly.

Material Requirements

Imported Mild Steel Rod @ 1,375 Birr/Tonne - 0.75 kg/Motor Cycle

Production Requirements

Wire Straightening and Cutting	60 Seconds/Motor Cycle
Wire Bending	60 Seconds/Motor Cycle
Press Forming	32 Seconds/Motor Cycle
Welding	60 Seconds/Motor Cycle

Tooling

2 Press Tools
1 Bending Jig
1 Welding Jig

1.5 Saddle

The metal part of the saddle consists of a tubular outer frame, a series of wire springs, and a hitch and clip for attachment to the main frame of the motor cycle. This metal structure is upholstered with foam padding and a leather cloth covering.

Material Requirements

Tube (From Cold Rolled Strip) From Kalliti @ 2,500 Birr/Tonne - 1.4 kg/Motor Cycle.

Cold Rolled Sheet From Kalliti @ 2,200 Birr/Tonne - 0.5 kg/Motor Cycle.

Imported Wire @ 3,000 Birr/Tonne - 0.5 kg/Motor Cycle.

Foam From Ethio-Foam @ 3 Birr/Motor Cycle

Imported Leather Cloth @ 5 Birr/Motor Cycle.

Production Requirements

Tube Cutting	10 Seconds/Motor Cycle
Deburring	10 Seconds/Motor Cycle
Tube Bending	90 Seconds/Motor Cycle
Wire Straightening and Cutting	60 Seconds/Motor Cycle
Wire Bending	150 Seconds/Motor Cycle
Press Forming	56 Seconds/Motor Cycle
Welding	90 Seconds/Motor Cycle
Upholstering	90 Seconds/Motor Cycle

Tooling

6 Press Tools
1 Wire Bending Jig
1 Set Templates For Cutting Leather Cloth

2. Press Formed Components

The following press formed components are considered for local manufacture.

1004 Footrest Clamp - 2 Off
4017 Brake Torque Arm
5015 Instrument Panel Mounting
5022 Battery Box
9005 Rear Number Plate Bracket
9017 Front Number Plate Bracket

All items except the Brake Torque Arm, which is plated, are finished by painting. These components are made by press forming and the battery box is assembled by spot welding.

Material Requirements

Cold Rolled Sheet From Kalliti @ 2,200 Birr/Tonne - 2.5 kg/Motor Cycle.

Production Requirements

Press Forming	220 Seconds/Motor Cycle
Spot Welding	30 Seconds/Motor Cycle

Tooling

20 Press Tools

3. Tubular Components

Two tubular components are considered for local manufacture;

7001 Handlebar
1002 Front Footrest

The handlebar consists of the main tube which is cut to length, deburred and bent to shape, and a stretcher bar, which is cut to length and deburred, the two items are welded together prior to plating. The footrest is a single length of tube cut to length, deburred, bent to shape and painted. The hydrualic tube bender, located in the tube manipulation section to make the main frame tubes, will be used for shaping these items.

Material Requirements

Tube (From Cold Rolled Strip) From Kalliti @ 2,500 Birr/Tonne - 1.75 kg/Motor Cycle.

Production Requirements

Tube Cutting	30 Seconds/Motor Cycle
Deburring	30 Seconds/Motor Cycle
Tube Bending	120 Seconds/Motor Cycle
Welding	30 Seconds/Motor Cycle

Tooling

1 Handlebar Welding Fixture
1 Handlebar Test Rig

4. Materials

Table 1 gives a summary of the material requirements for the production of motor cycle components in-factory.

5. Equipment And Labour

Summarised below are the total production requirements, by section, for the manufacture of motor cycle components in-factory.

Tube Manipulation Section

Tube Cutting	150 Seconds/Motor Cycle
Deburring	150 Seconds/Motor Cycle
Tube Profiling	180 Seconds/Motor Cycle
Hydraulic Tube Bending	270 Seconds/Motor cycle

There is spare capacity on the Tube Cutting and Deburring machines specified for bicycle production to carry out these operations. However, the following additional equipment will be required:

1 Tube Profiling Machine
1 Hydraulic Tube Bender

One additional worker will be required in the Tube Manipulation Section.

Press Forming Section

Press Forming	798 Seconds/Motor Cycle
Welding	340 Seconds/Motor Cycle
Spot Welding	30 Seconds/Motor Cycle
Wire Straightening and Cutting	120 Seconds/Motor Cycle
Wire Bending	210 Seconds/Motor Cycle

There is spare capacity on the machines specified for bicycle production to carry out all these operations except press forming and wire bending. Allowing for time to change tools, 1 additional mechanical press is required. Wire bending requires a special jig already specified.

TABLE 1: MATERIAL CONSUMPTION - MOTOR CYCLE COMPONENTS

	Local	Imported	Total Birr/Annum
Frame	Mild Steel Sheet 23.5 Tonne @ 2,200 Birr/Tonne 51,700 Birr/Annum	Carbon Steel Tube 45 tonne @ 2,750 Birr/Tonne 123,750 Birr/Annum	175,450
Parking Stand	Mild Steel Sheet 5 Tonne @ 2,200 Birr/Tonne 11,000 Birr/Annum	-	11,000
Footrest	Mild Steel Tube 1.1 Tonne @ 2,500 Birr/Tonne Mild Steel Sheet 0.5 Tonne @ 2,200 Birr/Tonne 3,850 Birr/Annum	Mild Steel Rod 0.25 Tonne @ 1,375 Birr/Tonne 350 Birr/Annum	4,200
Carrier	-	Mild Steel Rod 3.5 Tonne @ 1,375 Birr/Tonne 4,810 Birr/Annum	4,810
Saddle	Mild Steel Tube 7 Tonne @ 2,500 Birr/Tonne Mild Steel Sheet 2.5 Tonne @ 2,200 Birr/Tonne Foam 5,000 Pieces @ 3 Birr/Piece 38,000 Birr/Annum	Hard Bright Wire 2.5 Tonne @ 3,000 Birr/Tonne Vinyl Leather Cloth 5,000 Pieces @ 5 Birr/Piece 32,500 Birr/Annum	70,500
Pressed Components	Mild Steel Sheet 12.5 Tonne @ 2,200 Birr/Tonne 27,500 Birr/Annum		27,500

Tubular Components	Mild Steel Tube 8.75 Tonne @ 2,500 Birr/Tonne 21,875 Birr/Annum		21,875
Process Materials		Paint 30,000 Birr Salts and Chemicals 10,000 Birr Anodes 1,000 Birr Welding Wire 20,000 Birr	61,000
TOTAL	153,925	222,410	376,335

Two additional workers will be needed in the Press Forming Section.

Machining Section

Turning (Chucking Lathe)	30 Seconds/Motor Cycle
Drilling	60 Seconds/Motor Cycle

There is spare labour and machinery capacity in the facilities specified for bicycle production to complete these operations.

Motor Cycle Frame Welding Section

This is a new section. The time allowed for welding the complete motor cycle frame is 70 minutes. This will require four welding machines and four skilled welders. The jigs have already been specified.

Upholstery Section

This is a new section. Upholstering the saddle is estimated to take 15 minutes per motor cycle. Thus one worker is required, together with the following equipment:

1 Industrial Sewing Machine
1 Cutting Table

Painting and Plating Section

A single painting and a single plating facility are specified for all products made in the factory. However, one additional worker is required in each section for the throughput of motor cycle parts.

ANNEX 14: MANUFACTURE OF CART WHEEL/AXLE ASSEMBLY, CYCLE TRAILER AND MOTOR CYCLE ATTACHMENTS

ANNEX 14: MANUFACTURE OF CART WHEEL/AXLE ASSEMBLY, CYCLE TRAILER AND MOTOR CYCLE ATTACHMENTS

This Annex describes the manufacture of the animal cart wheel/axle assembly, the cycle trailer, and the motor cycle attachments. Each is described separately and then a summary is given of the material, labour and equipment requirements.

The manufacture of these products utilises the production sections already specified for bicycles and motor cycles together with one new section - Fabrication and Assembly. The operations to be carried out in this section consist of fabrication of sheet metal items, welding of tubular frames, and final assembly of the products.

1. Cart Wheel/Axle Assembly

Analysis of cart manufacture is based on the assumption that the 4,000 wheel/axle assemblies will be made up as follows:

2,000	40x40mm axles, 1 tonne payload
2,000	30x30mm axles, 1/2 tonne payload
2,500pr.	split rim wheels to accept ADV tyre
500pr.	split rim wheels to accept motor cycle tyre
1,000pr.	steel spoked wheels

Table 1 details the material and component requirements for these wheel/axle assemblies. The mild steel tube and sheet can be supplied by Kalliti but the bar for the axles must be imported. Cast iron bushes, ready for machining, can be supplied from a local foundry. It is assumed that the ADV tyres are made by Addis Tyre in 7.00x14 size. However motor cycle tyres and tubes, and the various fasteners, must be imported. The breakdown of material costs is as follows:

Local Materials:	182,030	
Imported Materials:	86,625	
Local Components:	405,000	
Imported Components:	60,000	
Total	733,655	Birr/annum
Average	183.4	Birr/assembly

The breakdown of costs for different specifications of wheel/axle assembly is as follows:

1 tonne axle	ADV tyre	226.8 Birr
1/2 tonne axle	ADV tyre	215.1 Birr
1/2 tonne axle	motor cycle tyre	148.9 Birr
1/2 tonne axle	steel wheel	98.1 Birr

Process materials will also be required as follows:

Paint:	2 Birr/assembly
Welding wire:	1.5 Birr/assembly

Manufacture of the wheel/axle assemblies will use facilities in the Tube Manipulation, Machining, Fabrication and Assembly, and Painting Sections. Each of these is discussed below. Note

TABLE 1: MATERIAL AND COMPONENT REQUIREMENTS FOR CART WHEEL/AXLE ASSEMBLIES

Material	Application	Quantity/ Cart	Cost/Birr	Cost/Annum Birr	Source
Mild Steel Black Square Bar					
40 x 40 mm	1 Tonne Axle	20 kg	1,375/Tonne	55,000	Imported
30 x 30 mm	½ Tonne Axle	11.5 kg	1,375/Tonne	31,625	Imported
Hot Rolled Mild Steel Sheet	Split Rim Wheel (ADV)	15 kg	2,000/Tonne	75,000	Kalliti
	Split Rim Wheel (M/C)	16 kg	2,000/Tonne	16,000	Kalliti
	Steel Spoked Wheel	18 kg	2,000/Tonne	36,000	Kalliti
Mild Steel Tube (From Hot Rolled Strip)	Hubs	2.2 kg	2,300/Tonne	20,240	Kalliti
	Split Rim Wheel (ADV)	2.5 kg	2,300/Tonne	14,375	Kalliti
	Split Rim Wheel (M/C)	3.25 kg	2,300/Tonne	3,740	Kalliti
	Steel Spoked Wheel	7.25 kg	2,300/Tonne	16,675	Kalliti
Cast Iron Bushes	Bushes	4	20/Set	80,000	Local
AD. Tyres and Tubes		2	130/Pair	325,000	Addis Tyre
Motor Cycle Tyres and Tubes		2	60/Pair	30,000	Imported
Nuts and Bolts	Split Rim Wheels	8	4/Set	12,000	Imported
Castellated Nuts	Retain Wheels	2	4/Set	16,000	Imported
Split Pins	Retain Wheels	2	0.5/Set	2,000	Imported

that, because the mix of components is quite complex, operation times are given per annum, not per cart.

Tube Manipulation Section

This section will be used to cut to length and deburr the tubular hubs, the tubular beads for the split rim wheels and the tubular spokes for the steel wheels. Operation times are as follows:

Tube Cutting:	150 hours/annum
Deburring:	150 hours/annum

Machining Section

In this section the ends of the axles will be turned to size, threaded, and holes drilled for the split pins that retain the castellated nuts. Also the raw castings that form the bushes will be bored and faced. All operations except drilling use a chucking lathe. Turning times are 10 minutes per axle and three minutes per bush. Thus operation times are:

Turning (chucking lathe):	1500 hours/annum
Drilling	100 hours/annum

Fabrication and Assembly

Here the following operations are carried out:

* Guillotining of sheet for split rim wheel rims and centre piece, and of the rim for the steel spoked wheel;
* Rolling of the rims and the beads for the split rim wheels, and of the rim for the spoked wheel;
* Assembly and welding in jigs of the split rim wheel and the steel spoked wheel;
* Final assembly of wheels, bushes, axles and fasteners after painting.

Operation times are as follows:

Guillotine	300 hours/annum
Rolling	450 hours/annum
Welding	2000 hours /annum
Final Assembly	1200 hours/annum

The following tools will be required:

3 wheel welding jigs
1 hand press - to push in bushes
1 set hand tools
1 set guillotine templates
1 tyre inflator

Painting Section

The paint finisth on the wheels and axle is not critical and hand spraying with a paint which dries at room temperature is acceptable

2. Cycle Trailer

Table 2 details the material cand component requirements for the manufacture of cycle trailers. The cost/annum is based on an output of 1,000 cycle trailers/annum. The main materials required are mild steel tube and sheet from Kalliti for the frame, body and hitch, and imported mild steel black bar for hitch components. Components for the heavy duty wheels will have to be imported (probably from the same source as the cycle conponents) as will bolts, nuts and rivets. The rim tapes can be supplied by Ethio Plastic to the same specification as those made for bicycles. Tyres and tubes can be supplied by Addis Tyre, the tube to the same specification as for the bicycle, the tyre made from the same mould, but of stronger construction. The breakdown of material costs is as follows:

Local Materials:	62,700
Imported Materials:	1,720
Local Components:	21,000
Imported Components:	43,500
Total	128,920
Average	129 Birr per cycle trailer

Process material will also be required as follows:

Paint	5 Birr/trailer
Welding Wire	3 Birr/trailer

Manufacture of the Cycle Trailer will use facilities in the Tube Manipulation, Press forming, Maching, Bicycle Assembly, Fabrication and Assembly and Painting Sections. Each of these is discussed below.

Tube Manipulation Section

The tubular members of the frame will be cut to length, deburred and bent to shape here. There are eleven different tubular components, a total of eighteen pieces, nine of which require bending. Machine utilisation is as follows:

	secs/trailer	hours/annum (1,000 trailers)
Tube Cutting	180	50
Deburring	180	50
Hydraulic Bending	270	75

TABLE 2: MATERIAL AND COMPONENT REQUIREMENTS FOR CYCLE TRAILER

Material	Application	Quantity/ Cycle Trailer	Cost/Tonne (Birr)	Cost/Annum (Birr)	Source
Mild Steel Tube (From Hot Rolled Strip) 25 mm Dia. x 1.5 mm	Frame	14 kg	2,300	32,200	Kalliti
Hot Rolled Mild Steel Sheet (0.8 mm Thick)	Body	11.25 kg	2,000	22,500	Kalliti
Hot Rolled Mild Steel Sheet (6.0 mm Thick)	Wheel Mounting Plates Hitch	4 kg	2,000	8,000	Kalliti
Mild Steel Black Bar 16 mm and 50 mm Dia.	Hitch	1.25 kg	1,375	1,720	Imported
Nuts and Bolts	Hitch	3 each	-	1,500	Imported
Rivets	Body	Quantity	-	2,000	Imported
Components For Heavy Duty Wheels (Spokes, Nipples, Hubs, Rim)	Wheels	2 Sets	-	40,000	Imported
Tyres and Tubes	Wheels	2	-	20,000	Addis Tyre
Rim Tapes	Wheels	2	-	1,000	Ethio-Plastic

Press Forming Section

The wheel mountings - four per trailer - will be blanked from strip here. The three strip components of the hitch will be cropped to length, and two will be bent to shape. Machine utilisation is as follows:

	secs/trailer	hours/annum
Press forming	68	20

The following simple press tools will be required:

1 blanking tool
1 cropping tool
2 bending tools

Machining Section

The hitch rod will be turned to length, and the hitch ball machined here on a chucking lathe. Also the holes will be drilled in the hitch components. Machine utilisation is as follows:

	secs/trailer	hours/annum
Chucking lathe	180	50
Pedestal drill	75	21

Two drilling jigs will be required.

Bicycle Assembly Section

The trailer wheels will be assembled at the same sub-assembly station as those for bicycles. The process is exactly the same - loose assembly, truing and tyre fitting. The estimated time is 19 mins per trailer, 320 hours/annum. This can be done with the labour and equipment allocated to the section for bicycle wheel assembly.

Fabrication and Assembly Section

Here all the frame components will be welded together, as will the hitch socket. Estimated time to weld the frame and hitch assemblies is 1 hour per trailer. Two jigs will be required:

1 frame welding jig
1 hitch welding jig

The body will be fabricated using the guillotine and a sheet metal bender. the body consists of three parts - 2 sides and a combined front, base and rear. The sections are cut to shape on the guillotine and corner pieces for folds cut by hand prior to bending . The body is assembled by drilling the joints with a portable drill, and fitting rivets with a hand rivetter. Estimated operation times are:

	mins/trailer	hours/annum
Guillotine	20	350
Hand shear	10	170
Sheet Metal Bending	30	500
Hand Drill and Rivet	15	250

The following tooling is required:

2 guillotine templates
1 hand shear
1 portable drill
1 rivetting gun

Finally the hitch, frame, wheels and body are assembled together after painting. Operation time 15 minutes per trailer. Tooling required:

1 set hand tools

Painting Section

The frame, body and hitch are painted separately using the common painting facility.

3. Sidecar Attachment

A typical Philippine design has been used as the basis for the manufacturing analysis. An output of 1000 units per annum is assumed. Table 3 details the material and component requirements. The frame and suspension arm are made from two sizes of mild steel tube which can be supplied by Kalliti. The body is made from mild steel panels tack welded to the frame, and the material can be supplied by Kalliti. Thicker section sheet from Kalliti, and imported bar, are used to make the brackets and pivots for attachment to the frame and for the suspension. The suspension uses a single leaf-spring which can be supplied by Ethio-Springs. A standard motor cycle wheel is specified for the sidecar, all components of which must be imported. The seat is built up on a wooden frame, to be supplied by a local private industry, and is upholstered with foam and imported leather cloth. Nuts and bolts for clamping the sidecar to the motor cycle frame and locating the suspension pivots must be imoported. A breakdown of material and component costs is given below:

Local Materials.	174,600	
Imported Materials:	16,875	
Local Components:	70,000	
Imported Components:	105,000	
Total	366,475	Birr/annum
Average	366.5	Birr per sidecar

In addition process materials will be required as follows:

Paint	8 Birr/sidecar
Welding Wire	4 Birr/sidecar

TABLE 3: MATERIALS AND COMPONENTS FOR SIDECAR ATTACHMENT

Material	Application	Quantity/ Sidecar	Cost/Tonne (Birr)	Cost/Annum (Birr)	Source
Mild Steel Tube From Hot Rolled Strip					
38 mm x 1.5	Frame	30 kg	2,300	69,000	Kalliti
25 mm x 1.5	Frame	12 kg	2,300	27,600	Kalliti
Mild Steel Hot Rolled Sheet					
0.8 and 1 mm	Body	30 kg	2,000	60,000	Kalliti
3 mm	Brackets and Suspension Mounting	6 kg	2,000	12,000	Kalliti
Mild Steel Block Bar	Bracket and Suspension	5 kg	1,375	6,875	Imported
Leaf Spring and Shackles	Suspension	1 kg	-	60,000	Ethio-Springs
Nuts and Bolts	Attachments to Body and Suspension	Quantity	-	5,000	Imported
Wheel Components	Wheel	1 Set	-	70,000	Imported
Tyre and Tube	Wheel	1 Set	-	30,000	Imported
Foam	Seat	2 Pieces	-	6,000	Ethio-Foam
Leather Cloth	Seat	2 Pieces	-	10,000	Imported
Wooden Frame	Seat	2 Pieces	-	10,000	Local

Manufacture of the sidecar utilises facilities in the Tube Manipulation, Press Forming, Machining, Motor Cycle Assembly, Fabrication and Assembly, Upholstery and Painting Sections. Each of these is discussed below.

Tube Manipulation Section

In this section the tubing for the frame and suspension arm will be cut to length, deburred, and bent to shape. 19 lengths of tube are required with fifteen bends. The operation times are detailed below.

	secs/sidecar	hours/annum
Tube Cutting	190	55
Tube Deburring	190	55
Hydraulic Tube Bending	450	125

Press Forming Section

In this section will be made the wheel mounting plates (2 per sidecar), the brackets for the lower and rear shock absorber attachment points and two identical brackets for the suspension pivot. Operation times are as follows:

	secs/sidecar	hours/annum
Press forming	106	3

The following simple tools will be required:

4 blanking tools
3 piercing tools

Machining Section

In this section the front suspension pivot and housing, the pivot for the leaf spring mounting, and the front attachment to the frame will be turned on the chucking lathe. Machining times are as follows:

	secs/sidecar	hours/annum
Turning (chucking lathe)	150	42

Motor Cycle Assembly

The wheel sub-assembly station will be used to assemble the sidecar wheel. The process is exactly the same as for the motor cycle wheels - loose assembly, truing and tyre fitting. The work can be done using the operator and equipment specified for motor cycle production.

Fabrication and Assembly

The following operations will be carried out in this section:

* Guillotining and folding of body panels;
* Welding of the frame and suspension arms in jigs;

* Tack welding of the body panels to the frame;
* Final assembly of frame, suspension, wheel and brackets after painting.

There are six body panels - floor, front, 2 sides, rear and roof, of which the floor and roof will require folding. Operation times are as follows:

	mins/sidecar	hours/annum
Guillotine	30	500
Sheet Metal Bending	30	500
Welding	75	1250
Final Assembly	15	250

Two welding jigs will be required, one for the frame, and one for the suspension arm, together with hand tools for assembly, and a set of guillotine templates.

Upholstery Section

Here the seat and seat back will be made. The work can be completed using the worker and equipment specified for upholstery of the motor cycle saddle.

Painting Section

Because of the large internal and external surface area, the sidecar will be expensive to paint using powder coating or stove enamelling. It is therefore proposed that it should be sprayed by hand.

4. Pick-Up/Van Attachment

This item will only be made in small quantities (250 per annum), and requires much more significant body building work than the other vehicles. The proposed approach is therefore as follows:

i) The basic chassis, brackets for attachment to the motor cycle, and the axle to be made in the factory;

ii) The basic chassis to be supplied to a local private body builder for construction and painting of the pick-up or van body;

iii) The completed body and chassis to be returned to the factory for final assembly of axle, springs and wheels.

Material requirements for this attachment are detailed in Table 4. The frame for this attachment is most conveniently made from square section welded tube in 40 mm and 25 mm x 1.5 mm sizes. This can be supplied by Kalliti, as can sheet for making brackets, but the bar for these items must be imported. The axle is made from imported bar, in similar fashion to that for the animal carts. The leaf springs can be supplied by Ethio-Springs but it is assumed that, initially at least, suitable wheels, which accept standard motor cycle tyres, will be imported

TABLE 4: MATERIAL AND COMPONENT REQUIREMENTS FOR PICK-UP/VAN ATTACHMENT

Material	Application	Quantity/ Attachment	Cost Birr	Cost/Annum (Birr)	Source
Square Section Mild Steel Tube (From Hot Rolled Strip)	Chassis	32 kg	2,300/Tonne	18,400	Kalliti
Mild Steel Hot Rolled Sheet	Brackets	5 kg	2,000/Tonne	2,500	Kalliti
Mild Steel Black Bar	Brackets	5 kg	1,375/Tonne	1,720	Imported
	Axle	12 kg	1,375/Tonne	4,125	Imported
Leaf Spring Complete With Shackles	Suspension	Pair	120/Pair	30,000	Ethio-Springs
Wheels Complete	Wheels	Pair	280/Pair	70,000	Imported
Nuts and Bolts	Brackets	Set	5/Set	1,250	Imported

complete with hubs. Miscellaneous nuts and bolts to attach the brackets to the motor cycle must be imported. A breakdown of material costs is given below:

Local Materials	20,900	
Imported Materials	5,845	
Local Components	30,000	
Imported Components	71,250	
Total	127,995	Birr/Annum
Average	512	Birr/Attachment

To this must be added the cost of building and painting the body by a local industry. This is estimated at 500 Birr per attachment.

Processing materials will also be required:

Welding Wire 3 Birr/Attachment

Manufacture of the attachment will utilise facilities in the Tube Manipulation, Machining, and Fabrication and Assembly Sections of the factory. Each of these is discussed below:

Tube Manipulation Section

The chassis members are cut to length here. Since the chassis is best made from square rather than round section tube a cut-off saw is required to make the members. The chassis is made up from 28 lengths of tube and the cutting time is 560 seconds per attachment, 40 hours per annum.

Machining Section

The axle is machined here, in the same way as for the animal cart. Also components for the mounting brackets and rear rollers are turned and drilled. Operation times:

	min/attachment	hours/annum
Turning (Chucking Lathe)	35	150
Drilling	6	35

Fabrication and Assembly Section

Because quantities are low, even simple press tooling is not justified for making the brackets. They will therefore be cut and bent from sheet using facilities in this section. The section is also used to weld the basic chassis on a jig, and for final assembly of brackets, axle, springs and wheels to the completed body/chassis unit. Operation times are:

	min/attachment	hours/annum
Guillotine	15	65
Sheet Metal Bender	30	125
Welding	90	375
Assembly	30	125

A welding jig, a set of templates for guillotining and a set of hand tools are also required.

5. Material, Equipment and Labour

Table 5 details the annual requirement of materials and components for the manufacture of the animal cart, bicycle trailer and motor cycle attachments. Tooling needed for these items has already been detailed. The utilisation of plant in the various sections of the factory is analysed below to determine the additional labour and equipment requirements:

Tube Manipulation Section

	hours/annum
Tube Cutting	255
Deburring	255
Hydraulic Tube Bender	200
Cut-Off Saw	40

All these operations can be accommodated using the equipment specified for bicycle and motor cycle production, even allowing for tool setting time, except that one cut-off saw must be purchased. One additional worker will be required for this section.

Press Forming Section

Press Forming	50 hours/annum

This can be accommodated using the existing equipment and workers in this section.

Machining Section

Turning (Chucking Lathe)	1,745 hours/annum
Drilling	150 hours/annum

The turning of components will require one additional chucking lathe. Two additional workers will be required in this section.

Upholstery Section

The operations here amount to 250 hours/annum and can be accommodated using the existing equipment and worker.

Painting Section

The trailer is painted using the same plant as for bicycle and motor cycle production. A hand spraying system is required for painting the wheel/axle assemblies and sidecars. One additional worker will be needed.

Fabrication and Assembly Section

This is an additional section required for the manufacture of these items. Operation times are:

TABLE 5: ANNUAL REQUIREMENT OF MATERIALS AND COMPONENTS

	Cart Wheel/Axle Assembly	Bicycle Trailer	Motor Cycle Attachments	Total
Steel Tube From Kalliti	23.9 Tonne 55,030 Birr	14 Tonne 32,200 Birr	50 Tonne 115,000 Birr	87.9 Tonne 202,230 Birr
Steel Sheet From Kalliti	63.5 Tonne 127,000 Birr	15.25 Tonne 30,500 Birr	37.25 Tonne 74,500 Birr	116 Tonne 232,000 Birr
Imported Mild Steel Bar	63 Tonne 86,625 Birr	1.25 Tonne 1,720 Birr	9.25 Tonne 12,720 Birr	73.5 Tonne 101,065 Birr
Local Components	405,000 Birr	26,000 Birr	100,000 Birr*	526,000 Birr
Imported Components	60,000 Birr	43,500 Birr	186,250 Birr	289,750 Birr
Imported Process Materials	14,000 Birr	8,000 Birr	12,750 Birr	34,750 Birr

* Excludes Pick-up/Van Bodies built by local industry - estimated value 125,000 Birr/Annum

	hours/annum
Guillotine	1,215
Sheet Metal Bender	1,125
Sheet Metal Rolls	450
Welding	4,625
Product Assembly (including hand shearing and rivetting for trailer	2,245

This will require the following items of equipment:

1 Guillotine
1 Sheet Metal Bender
1 Sheet Metal Rolling Machine
3 Mig Welding Sets

Eight workers will be required, three for sheet metal work, three for welding and two for product assembly. The three sheet metal workers provide the capacity to use the Guillotine to prepare sheet for press forming operations on bicycle and motor cycle components.

Note that wheels for the trailer and sidecar are assembled using existing facilities and staff in the bicycle and motor cycle assembly sections.

ANNEX 15: THE BASIC TRANSPORT VEHICLE (BTV)

ANNEX 15: THE BASIC TRANSPORT VEHICLE (BTV)

The concept of the BTV (sometimes also known as the Asian Utility Vehicle) was introduced by several of the major international automotive manufacturers in the early 1970s. Aimed specifically at developing country markets, there were two major reasons for its introduction:

i) light commercial vehicles constitute a significant part of the motor vehicle market in most developing countries. A market was therefore identified for a low-cost, simple but rugged, light commercial vehicle with good load carrying capacity, adaptability to different uses, and reasonable performance.

ii) developments in production technology were tending to raise the level of output at which vehicle manufacture became economically viable. At the same time there was pressure in many developing countries to establish vehicle industries, but the level of demand was too low to justify anything other than local assembly of conventional motor vehicles. The BTV's were therefore designed to increase the level of local content that was viable at low output levels.

Thus BTV's were designed to perform the same transport functions as conventional pick-up trucks of 1-1.5 tonne payload capacity. Their distinctive design features were aimed at simplicity, low-cost, and local manufacture at low output levels.

All BTV's are "forward-control" vehicles, that is to say the driving cab is over, rather than behind, the front mounted engine. Like pick-ups they have a separate chassis and can therefore be fitted with a variety of different bodies. The most common applications use a pick-up or van body or a pick-up with a canopy and two rows of bench seats to carry passengers.

All BTV's use drive-line assemblies from the manufacturer's standard product range. They share the same drive-line layout as conventional pick-ups - front-mounted engine (always a four cylinder, four stroke usually of 1300 or 1600cc capacity, though some models are now available with diesel, rather than petrol, engines of larger capacity), clutch and gearbox mounted directly behind the engine, with a propeller shaft driving to the rear axle, which is located on leaf springs and telescopic shock absorbers.

Conventional pick-ups use a chassis formed from a series of large pressings that require heavy investment in equipment and tooling. To suit small-scale local production, the chassis of a BTV is a welded structure formed from standard steel sections and simple brackets fabricated from sheet steel. Thus the chassis can be produced economically at low output levels using standard metal working and fabrication equipment, and welding jigs.

The cab structure of a conventional pick-up is constructed from a series of pressings which in manufacturing terms are complex shapes, again requiring heavy investment in equipment and tooling. The cab structure of the BTV is constructed by spot welding together a series of panels. Each panel is a simple shape, either flat, or with sharp or single curvature bends, that can be made from flat sheet using simple fabrication equipment. To ensure that the cab is simple to make the windscreen and side windows are of flat glass, there is no plated trim and no radiator grill, simply a hole in the bodywork to allow throughflow of cooling air. The simplicity of the structure extends to the cab interior. The floor and dashboard panels are fabricated from steel sheet to simple shapes. Interior fittings are basic to keep costs low, with the minimum number of instruments, and no interior trim. The doors (if fitted, since BTV's can be made with open body sides) are fabricated from sheet steel and standard sections and have sliding rather than winding windows. The rear bodywork is made by similar fabrication methods using standard materials.

Thus by appropriate design, a significant element of the total content of the vehicle, the body and chassis, can be produced economically at low output levels using standard metal-working facilities. This feature, combined with the basic specification of the interior and body, keeps the price low. The design of the vehicle also facilitates the local production, either in the factory or by ancilliary industries, of other components:

i) all windows are simple to make being of flat rather than curved glass;

ii) the seat designs are simple so that the tubular frames can be made and upholstered locally;

iii) some designs use a beam front axle mounted on leaf springs, rather than the conventional, and more complex, independent front suspension using coil springs. The beam axle and leaf springs (front and rear) suit local manufacture;

iv) it is also feasible to make locally items such as the fuel tank, control pedals, exhaust pipe and plastic moulded fittings;

v) where suitable ancilliary industries exist, other locally made components can be incorporated:

- batteries;
- tyres and tubes;
- shock absorbers;
- brake and steering parts;
- engine components;
- window seals.

Thus in summary the BTV provides the capabilities of a pick-up, is simpler to maintain because of its basic specification, and can be manufactured with significant local content. Price comparisons vary from country to country, but it is reasonable to expect that a BTV could be made available for about 75% of the cost of an imported pick-up. Local content is more difficult to quantify because it is dependent on the definition used, on the state of development of the component industry, and to an extent on the level of output. This is best investigated in more detail in the Philippines, where several makes of BTV are in use.