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MAINTENANCE OF ROADS IN THE IVORY COAST

by

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ABSTRACT

The author discusses the part played by the existing road network in the Ivory Coast in the continuing economic growth of the country, and relates this to the growth in average daily traffic. The construction and maintenance of road types is described in detail, as are the effects of climatic conditions and axle loads on the work load of the respective maintenance departments.

A complete breakdown is given of the government departments associated with the road network, both in relation to equipment and personnel. The author indicates that a high level of service is required from the maintenance departments, and discusses how this may best be achieved within the limits of available finance.

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MAINTENANCE OF ROADS IN THE IVORY COAST

1. INTRODUCTION

The continuous development of road transport is characterised by:

- the preponderant part played by the roads (70%) in the distribution of the total volume (in kilometric tons) of passenger and goods traffic.
- the increase in the numbers of heavy vehicles (on average, 10%) shows the essential role taken by the road in the development of the Ivory Coast. For this reason, one of the constant anxieties in the Ivory Coast has always been the maintenance of the road network in good condition.

The maintenance of the roads is undertaken in accordance with the following requirements classified in decreasing order of importance:

- to ensure the passage of traffic under specific conditions, which must be known to users. The roads may be permanent or seasonal.
- to maintain the safety of vehicles travelling along the roads.
- to preserve the characteristics of the existing road network by keeping under surveillance the factors which govern the duration of life of the road.
- to protect the amenities of road users.
- to keep the roads in good appearance.

These objectives can be attained simultaneously by preserving the characteristics of the road given to it by its builder. Unfortunately, as the maintenance services are always limited, they are used in the order of priority indicated.

Methods of road maintenance have already been studied by various eminent authors throughout the world and, in the following survey, I shall mention only various aspects of road maintenance, as practised in the Ivory Coast. The survey contains the following chapters:

- 1 - Introduction.
- 2 - The existing road network.
- 3 - Geographical conditions.
- 4 - Organisation of the road maintenance departments.
- 5 - Maintenance of the road network.
- 6 - Professional training.
- 7 - The maintenance policy.

2. THE EXISTING ROAD NETWORK

2.1 History

2.1.1 General development of the road network

The road network in the Ivory Coast developed rapidly after the last world war, increasing from about 10,000 kilometres to over 30,000 kilometres.

It consists of:

- Class 'A' main roads, about 6,000 km, of which somewhat more than 1,300 km are surfaced.

- Class 'B' provincial roads, about 7.000 km.
- Class 'C' roads or tracks of local importance, about 20,000 km.

There are also tracks opened up by foresters and which, with the passage of time, may be classified as 'C' roads.

2.1.2 Policy followed for the development of the road network

The primary concern of road engineers has been to develop a network of roads essential to the development of the country. Priority has therefore been given to the opening up of tracks which very often receive only summary treatment. Thus, in 1948, of 10,800 km of usable roads there were only 50 km of surfaced roads. Road traffic increased very rapidly, and travelling on a high percentage of these tracks became precarious, especially because of the rains, and the need to build better roads very soon became apparent.

The first improved roads were 10 to 15 cm thick and they were surface dressed. The materials consisted of laterite from Bingerville and crushed granite. The crushed granite was very expensive, and gravel was resorted to, being a naturally occurring material.

In 1950, after research and tests, a soil mixture was introduced for the construction of the roadbase, consisting of 70% to 80% gravel and 20 to 30% sand.

The natural materials were, however, not very suitable for the construction of the roadbase, and an improvement was sought in order to stabilise it:

- stabilisation of clayey coastal sand by the use of bitumen
- stabilisation by the use of cellulose resins.

Finally, stabilisation of the sandy or gravelly soils was obtained by the use of cement, and this was generally utilised. This type of road base has been in use since 1962.

At the same time, the surface dressing previously used was replaced by coated materials and these considerably strengthened the roads and gave a more even surface.

Since 1960, a sand-bitumen mix has nearly always been used. In fact, crushed gravel being very much more expensive than sand, the coated materials were therefore dearer than the sand-bitumen mix.

At the present time, the surfaced roads are often not strong enough to withstand the traffic they have to bear. This is not a matter of error but the result of a road policy which, taking into account the financial possibilities, gave priority to the length of road developed.

It should also be noted that, whilst efforts have been made to resurface the main roads, considerable work has been done to perfect the maintenance of the earth roads.

2.2 Constitution of the road network

2.2.1 Kilometrage

TABLE 1
Road classification and type - kilometrage

CLASSIFI- CATION	RURAL AREA			BUILT-UP AREA			TOTAL		
	Not sur- faced	Sur- faced	Total	Not sur- faced	Sur- faced	Total	Not sur- faced	Sur- faced	Total
'A' Roads	5,157	976	6,133		128	128	5,157	1,104	6,261
'B' Roads	7,299	26	7,325		44	44	7,299	70	7,369
'C' Roads	20,991		20,991				20,991		20,991
Urban network				380	148	528	380	148	528
	33,447	1,002	34,449	380	320	700	33,827	1,322	35,149

Of a total area of 322,000 square kilometres, the Ivory Coast Republic has at present a road network of 35,000 km made up as follows:

- 1,300 km of bituminous roads (A and B)
- 13,000 km of earth roads (A and B)
- 20,000 km of rural earth roads (C)

According to the Government classification, there are three categories of national roads:

- the main roads 'A' ensuring connection between the capital and the principal centres and with neighbouring states.
- 'B' roads, of regional importance, serving a secondary centre and its suburbs.
- 'C' roads or rural roads in general, of a seasonal nature, in order to serve the villages.

2.3 Constructional features

2.3.1 Earth roads

Widths

The road widths between the drainage ditches are as follows:

- 'A' road..... 8 to 9 m
- 'B' road 6 to 8 m
- 'C' road 4 to 6 m

Structures

On 'A' roads, all structures are permanent in the southern section of the Ivory Coast. Some wooden bridges and semi-permanent structures still exist

in the northern part of the country.

On 'B' roads, there are still many temporary wooden bridges.

On 'C' roads, most of the temporary structures are of wood.

There is no indication as to the vehicle load limit admissible on temporary wooden bridges, but it is generally taken that there is no risk with a load of up to 10 tons.

The permanent bridges are designed by reference to the circular issued by the French Ministry of Equipment.

Special points.

There are some floating bridges of 10 to 30 tons for the crossing of rivers and lagoons. Those of 10 to 15 tons are generally winch-operated and those of 16 to 30 tons are motorised.

Drainage and clearance.

'A' roads are sufficiently drained. In forest regions, special care has to be taken with bush clearance of the ground to permit sunlight and clear the ditches of vegetation on the bituminous roads.

On 'B' and 'C' roads, ditches and drains require cleaning out. Ditches for surface water drainage are either formed manually or with the use of equipment.

Gradients and curves

Class 'A' earth roads

Design speed : 80 km/h

Gradient : 8 per cent

Curves of a radius of 300 m or over.

Class 'B' earth roads

Design speed : 60 to 70 km/h

Gradient : 8 per cent

Curves of a radius of 100 m or over

Viability of the network.

'A' and 'B' roads are usable in all seasons.

'C' roads may be considered seasonal, many of them not being usable during the rainy season.

2.3.2 Bituminous roads

The specification for new roads is that indicated in Circular No. 34 of 12th April 1958 by the Ministry of Public Works in France.

The design speeds considered for geometric design are 100 km/h for 'A' and 'B' roads in flat country; in hilly country, 100 km/h for level sections and 80 km/h for undulating sections.

The width of these surfaced roads is 6 to 7 m on a 'plateforme' of 9 to 11 m.

Surfaced roads generally consist of:

Before 1972

- a surface layer of approx. 3 cm of sand bitumen (or, more rarely, of denser mixture) or a double layer of gravel.
- a base course of 12 to 15 cm of lateritic gravel stabilised with 3 to 5 per cent of cement.
- a sub-base of 15 to 18 cm of lateritic gravel.

From 1972

- a double layer of gravel or dense bituminous mixture of approx. 5 cm.
- a base course of crushed material 0/30 or 0/20 of 15 to 20 cm.
- a sub-base of lateritic gravel of 20 to 30 cm, on average.

2.3.3 Government regulations (Vehicles)

- width of less than 2.50 m.
- length of less than 11 m for a rigid vehicle, 15 m for an articulated vehicle
- tractor and trailer: 22 m for the combined tractor and trailer.

The maximum load authorised for a single axle is 10 tons, twin axle: 17 tons, distance between two consecutive axles 1.35 m.

The maximum laden weights of the vehicles are as follows:

- two-axle vehicles : 15 tons
- 3-axle vehicles : 23 tons

Articulated vehicles, tractors and trailers.

3 axles (III) : 25 tons
4 axles (121-112) : 32 tons
5 axles (122) : 41 tons

The actual loads often exceed the above-mentioned limits (frequently exceeded on the tree-trunk carriers).

2.3.4 Composition of traffic

The proportion of 6 to 20 ton trucks, out of the total number of vehicles in circulation, varies between 20 per cent and 35 per cent according to the proximity of the built-up areas on the main roads.

3. GEOGRAPHICAL CONDITIONS

3.1 Climatic conditions

3.1.1 Rainfall

There are four rainfall conditions in the Ivory Coast, the principal characteristics of which are shown in Table 2.

TABLE 2
Rainfall conditions and characteristics

CONDITIONS	AREA AFFECTED	ANNUAL RAINFALL	WET SEASON
1. Tropical transition area	North of the country	1250 to 1700 mm	July - Aug./September
2. Equatorial attenuated transition area	Between 8th parallel and the line Abengourou Toumo-di Soubre - southern section	1100 to 1600 mm	March to June September and October
3. Equatorial transition area	Southern part	1500 to 2000 mm	April to July September to November
4. Mountainous area	West of the country	1400 to 2300 mm	March to October Maximum in September

Periods of flooding for the various areas.

Tropical transition area.

An annual flood always occurs and is the result of either a succession of rainfalls of average amounts, or of an exceptional rainfall within 2 or 3 consecutive days. It occurs generally in August, September or October.

Equatorial transition area.

The first period of high rainfall occurs between June and July, the second period in October/November.

The lowest rainfall occurs in August/September and especially December to March.

Equatorial attenuated transition area.

This falls between the two aforementioned areas. The season for the high and average rainfalls occurs between May and November, but the rainfall in the later part of the season is not often heavy.

Mountainous area.

Heavy rainfalls occur here in isolated areas. The season for average and high rainfalls ranges from April to October, with a maximum in September.

Vegetation.

The Ivory Coast comprises forest in the South and Savannah in the North. The dividing line is approximately the 8th Northern parallel, except in the centre of the Ivory Coast, where it takes a V shape.

3.1.2 Geological conditions

From an examination of the geological map of the Ivory Coast, the following may be seen:

- geological formations in certain areas, consisting almost entirely of very ancient terrain of the Precambrian era.
- superficial formations representing mainly the products of decomposition of the basic rocks, with a more or less lateritic change.

The sedimentary terrain forms only a narrow coastal band of 20 to 30 km along the Gulf of Guinea.

The northern half, beyond the 8th parallel, where the savannahs are situated, is almost crystalline. The southern half, which is forest, is dominated by the crystalline to the west, and the schists to the east.

Deposits of lateritic gravels suitable for the surfacing of earth roads are found nearly everywhere, except in the coastal region. The deposits are generally fairly near to the roads, so that the transport distances are usually less than 5 km.

A survey made in 1963 by the Government of the Ivory Coast showed that, in the forest areas, the terrain consists of a succession of plateaux and of lateritic ridges, followed by lower levels where the terrains are either sandy, or very clayey. Thus, a soil profile in these plateaux shows two or three layers of gravel overlying micaceous clays and red, yellow or violet schists. The properties are indicated in Table 3.

TABLE 3

Material type and properties

Type of material	Average value			
	Plasticity index %	Percentage of fines less than 80 microns	CBR (1) %	Dry density of modified Proctor test (Mg/m^3)
1st layer called G1, thickness 0.10 to 0.20m	from 10 to 15	from 15 to 20%	from 20 to 70	from 2.20 to 2.40
2nd layer called G2, thickness 0.2 to 0.40m	from 15 to 25	from 15 to 25%	from 20 to 40	from 2 to 2.20
3rd layer called G3, from 0.20 to 0.50m thickness	from 20 to 27	from 20 to 30%	from 10 to 20	from 1.80 to 2
Clayey silt, fairly micaceous, with slight expansion, 0.50 to 1m thick.	from 25 to 30	from 25 to 40%	from 10 to 20	from 1.70 to 1.90
Yellow, red and violet schists, thickness several metres.	from 10 to 20	from 50 to 80%	from 0 to 10	from 1.50 to 1.70
Clayey bed: yellowish clay, called banana or cocoa soil	Exceeding 20	-	nil	from 1.50 to 1.60
Low sandy beds	Sand equivalent 20 to 40	Diameter 0.1 to 2 mm	from 15 to 25	from 2 to 2.20

(1) CBR after 96 hours soaking and 99 per cent compaction for G1, G2, G3 and at 90 per cent compaction for the other materials.

The following implications may be drawn:

- the gravelly, lateritic materials usable for the roads are in abundant supply, but they form a very thin layer, and special prospecting is needed (excavation of holes of 100 m side) and bulldozing over large areas.

- these materials constitute very useful improvement materials for earth roads, but bearing in mind their characteristics and heterogeneous nature, they can be used on surfaced roads only under the following conditions:

- : constant and accurate supervision
- : stabilisation for the base course.

3.2 Economic conditions

The southern part of the country, the forest region, contains most of the country's resources: timber and exportable tropical products. The road traffic in the south is therefore much heavier. The main activity in the north was the cultivation of subsistence crops, but during the last few years plans have been prepared for the production of export crops, especially cotton, sugar cane and sisal.

4. ORGANISATION OF THE ROAD MAINTENANCE DEPARTMENTS

4.1 Organisation of the Ministry of Public Works and Transport

The Ministry of Public Works, apart from the Minister's own Office, controls and co-ordinates the work of ten separate Managements of varying importance, as shown in the attached chart. . Seven of these Managements are technically competent, where the transport system is concerned, and the remaining three constitute logistic support.

4.2 General Management of the Public Works Department

4.2.1 Structure and duties

The maintenance of the roads is entirely under the control of the Public Works Administration, which comprises:

- a General Management
- central departments
- external departments.

The Director General of Public Works (DGTP) is in charge of:

- public road works, maritime and lagoon works, and domestic water supply.

He is entrusted especially with:

- the construction and maintenance of the communication channels (class 'A', 'B' and 'C' roads).
- navigable waterways within the urban network.
- management of public lands.
- the construction of ports and wharves, except for the Ports of Abidjan and San Pedro.
- in the case of the water supply system, the survey and construction of drains and the technical supervision of the water supply lines.

For the execution of the tasks with which he is entrusted, the Director General with the aid of an Assistant Director General, supervises and co-ordinates the activities of the Managements, Sub-Managements and District Managements, referred to hereafter, and placed under his command.

Central Departments

The Sub-Management of the Administrative Departments is in charge of:

- the secretariat
- the mail
- records
- staff management
- relations with the various departments subordinate to the DGTP.

The Accounts Sub-Management is in charge of:

- the management of financial affairs, the execution of budgets for operations and equipment of the Public Works Department.
- the handling of receipts and expenses relating to the Road Maintenance Fund.
- relations with the various administrative departments, in respect of the authorisation of credits made by the services attached to the Public Works Department.

This Sub-Management comprises the following sections:

- secretariat
- budgets : BSIE - FER - FAC - FED.
- transit : entrusted with the checking of DGTP equipment.

The Survey Department which co-ordinates and supervises the activities of the following three Sub-Managements:

The Sub-Management of Roads, entrusted with:

- liaison with the National Bureau of Technical Planning in relation to communications ('A', 'B' and 'C' class roads).
- simple surveys of road structures
- the preparation of technical records and submission of the relevant contracts.
- advice on documents relating to public lands.

The Sub-Management of the Water Supply system, entrusted with:

- liaison with the National Bureau of Technical Planning in respect of drainage surveys.
- supervision of hydraulic surveys, in co-operation with the Ministry concerned.
- the establishment of working programmes relating to drainage
- technical supervision of the water supply system
- preparation of technical records relating to drainage and the preparation of the relevant contracts

- drainage and hydrological surveys.

The Sub-Management of Methods and Technical Regulations, entrusted with:

- the establishment of investment programmes relating to the road infrastructure
- the establishment of working programmes, the stage of progress of road works, and correction of the causes of any delays
- preparation of the analyses of the cost of work executed by the Public Works Department.
- reorganisation of administrative and technical methods
- inspection of the filing system and of documents relating to the technical regulations applicable to public works.

The Public Works Equipment Management, entrusted with:

- the management of the depot for mechanical vehicles (road equipment)
- the maintenance and renewal of this depot
- the purchase of vehicles (light vehicles and trucks)

The Periodical Maintenance Management, entrusted with:

- the execution of important maintenance work under Government control

For the execution of its task, this Department possesses several sections, as listed hereafter, each containing a variable number of subsections.

- earthworks and structures sections, entrusted with the correction of alignments, improvement of the vertical profile of old roads where there is heavy traffic.
- regravelling sections, for laying sub-bases and road bases.

External departments

They comprise:

Seven District Managements of Public Works, based respectively at:

ABIDJAN - SAN PEDRO - MAN - KORHOGO - ABENGOUROU - DALOA - and BOUAKE.

These have territorial Subdivisions of Public Works.

They execute, and supervise directly, all work relating to the Public Works Department to ensure the preservation of the National Public Domain, rendering assistance in the relevant technical fields, where departmental work is concerned.

4.3 The Public Works Equipment Management (DMTP)

4.3.1 Organisation of the DMTP

TABLE 4
DMTP Organisation

Departments	Sections	Sub-Sections
DMTP Management	Secretariat Organisation and Methods Office	
Administrative Department	Movement section. Transport section	
Motorised vehicle department	-	
Stores	Spares Repair shop store Current requirements store	
Schools	-	
Technical departments	General engineering workshop	Maintenance Repair Machine shop Tools Stores
	Motorised vehicle shop	Tyres
	Appliance shop	Breakdown service Assembly section Maintenance of vehicles in parking area.
	Assembly shop for standard spare parts	-
	Woodwork shop	-
	Engine shop	Assembly section Test section Injection section
	Electrical workshop	-
	Light engineering	Welding section Forging section Painting section

4.3.2 Personnel

There is a staff of 252 operatives in service, including 30 qualified mechanics, with a theoretical staff of 273. Thirty-three breakdown mechanics are included in these totals and they have been allocated to the various subdivisions.

4.3.3 Duties of the DMTP

The task of the DMTP is to keep permanently available to the various subdivisions, equipment which is in good running order, to enable them to execute the work of road maintenance.

For this purpose, the DMTP centralise all matters relating to equipment, with the exception of liaison vehicles and trucks in service in the subdivisions.

They are responsible for the equipment, its repair and general overhaul, and the examination of any technical or accounting matters relating to it. They also arrange for the training of the personnel, drivers and mechanics.

The DMTP fulfils tasks in relation to the subdivisions:

- the hire of equipment
- the operation of the workshops in the subdivisions.

4.3.3.1 Hire of equipment

The equipment is hired on the basis of a table of analysis, according to the price of the equipment, duration of hire and conditions of use. The table comprises three classes of equipment: full-track, wheeled and non-motorised equipment. The table is revised every five years. The various items indicated in the daily hire table are shown below:

1. Depreciation
2. Spare parts
3. Labour
4. Parts subject to wear
5. Fuel
6. Sundry materials
7. Driving
8. Minor repairs

The amount of the hire resulting from these various items is increased by twentyfive per cent, to take into account the DMTP's general expenses (Management, Accounts, Staff Training).

The equipment is hired to the subdivisions at a monthly rate calculated on the basis of 200 days a year, irrespective of their actual use. This rate includes items 1 to 4 of the hire table, including repairs carried out by DMTP (workshop transfers).

4.3.3.2 Operation of the workshops in the subdivisions

The DMTP assigns to each subdivision a mechanic who is entrusted with:

- the supervision of current and systematic maintenance, in accordance with the rules established by the DMTP.

- preventive maintenance (checking adjustments and clearances, clutch and belt adjustment, track plates etc)
- repairs, breakdown service, changing current spare parts for which the workshops in the subdivisions have the necessary parts available, supplied from the DMTP general store.
- the general supervision of the operation of the equipment, with a view to its renewal or systematic reconditioning.
- to ensure permanent liaison in a general way between the DMTP and the subdivision, in all matters relating to the equipment.

4.3.3.3 The DMTP fleet of equipment

DESCRIPTION	NUMBER
Earthworks equipment:	
Heavy duty full-track tractors	20
Medium duty full-track tractors	28
Light duty full-track tractors	26
Loading equipment:	
Loader on full tracks	18
Loader on pneumatic tyres	44
Mechanical shovels	3
Levelling equipment:	
Heavy duty graders	93
Light duty graders	84
Compacting equipment:	
Automatic compactor	11
Smooth-wheeled roller	3
Towed roller	36
Sheepsfoot roller	10
Single cylinder vibrating roller	21
Two cylinder vibrating roller	4
Vibrating plate	2
Agricultural type tractors	48
Road maintenance equipment:	
Super grader	8
Rotary crusher	3
Spreading equipment:	
Tip-up truck	2
Spreader truck	1
Transport equipment:	
Road tractor	8
10-12 ton dumper	1
400-litre dumper	1
Tipper-truck 6 m ³ or 10 to 12 ton	60
Tipper-truck 3 m ³ or 3.5 to 7 ton	241
Platform truck 10 to 12 ton	3
Platform truck with tarpaulin	88

Water-tanker truck)	
Fuel-tanker truck)	6
Drinking water trailer)	
Fuel oil trailer)	1
Equipment carrier - semitrailer	9
Cross-country equipment:	
Mini-tractor for maintenance	1
Mechanical maintenance equipment:	
Lubricator-truck	1
Fixed lubrication unit	2
Liaison vehicles:	
Covered small truck	171
Land Rover - Vans, various	43
Saloon cars	92
Renault R4 L	60
Motor-cycles	6

4.3.4 Management

4.3.4.1 General management procedure

The DMTP have an "Organisation & Method Office" (BOM) which commenced, at the beginning of 1968, analytical accounting making it possible to control both DMTP expenses and the cost of maintenance of the equipment used by the subdivisions.

All entries in the DMTP accounts are coded, and the control sheets make it possible to check the transfers:

- transfers to TP subdivisions
- transfers to various DMTP clients
- internal transfers, establishing the cost prices for:
 - . work done in the workshops, and outgoing materials from the stores
 - . maintenance and operational costs
 - . transport and liaisons
 - . general expenses, etc. ...

The mechanically-prepared information makes it possible to check accurately the cost of repair and maintenance of the equipment. This is analytical industrial accounting.

At present, the calculation of the cost prices in the subdivisions is extremely elementary, and it is not taken as a basis for all operations. The basis of all sound management of an organisation such as the TP is the knowledge of costs.

The analysis of work done in the subdivisions for the execution of maintenance jobs on the roads would make it possible to obtain analytical operational accounts and, by correct assessment of the maintenance costs, to improve the methods of maintenance and reduce these costs.

The great effort which has been made must therefore be continued, in order to obtain in addition to analytical industrial accounting, a system of analytical operational accounting.

4.3.4.2 Management of workshop jobs

There is supervision of the preparation of the work, the preparation of estimates, the execution of the work, checking and invoicing. When a job is applied for, a record is prepared with a reference number which will be used for all assignments and accounting operations.

4.3.4.3 Spare parts control

Supplies are obtained:

- either by purchase on the local market
 - or by contracts placed with the agents for the makers (of vehicles etc.)
- All the operations relating to spare parts are copied, by typing, permitting checking and distribution, by operation and by unit of equipment.

4.3.4.4 Management of equipment

This comprises:

- the technical operational control by means of daily cards, for use of the equipment, and control and maintenance cards.
- expense control: cards for the consumption of fuel, sundry materials and lubricants.

A monthly statement of operational expenses is prepared for each specific job or workshop. This is a summary obtained according to the nature of the expense, taken from the daily checking sheets.

5. MAINTENANCE OF THE ROAD NETWORK

5.1 Maintenance methods

5.1.1 Nature of the maintenance

The maintenance of a road is divided into three parts:

- the maintenance of the areas adjoining the road (shoulders, ditches, pipes, signals, etc...)
- the maintenance of the road surface:
 - regrading of unsurfaced roads
 - surface dressing for surfaced roads
- maintenance relating to the "wear" of the road:
 - regravelling of earth roads
 - surface dressing or wearing course for surfaced roads.

The last-named operation is carried out every few years, according to the traffic and the type of road.

These maintenance jobs are generally executed by different gangs.

5.1.2 Earth roads

The gangs used for the maintenance of earth roads are:

- the road section gangs
- the regrading gangs
- the regravelling gangs

5.1.2.1 Road sections

The road section gangs are entrusted with the execution of maintenance work on the shoulders and areas adjoining the roads.

A road section gang comprises:

- one section foreman
- 12 to 15 labourers
- one 3.9 ton Renault tipper truck
- one set of manual tools

5.1.2.2 Regrading gangs

The regrading gangs are entrusted with the maintenance of the road surface, that is to say:

- the improvement of the conditions for traffic circulation by correction of the deformations in the road surface (especially undulations).
- the reshaping of the road, to resist bad weather conditions.

The regrading gang generally consists of:

- two 100 to 130 h.p. heavy duty graders
- two 60 to 75 h.p. light duty graders
- one 3.9 ton service truck
- one foreman
- one driver and one assistant for each motorised vehicle
- two or three labourers.

This arrangement may be altered, according to the width of the road to be recambered, but the use of a heavy duty grader is usually indispensable.

Two principal methods are used for regrading:

- regrading by banking up : i.e. by bringing to the centre of the road material taken from the sides. This method is used when the materials are damp, i.e. during the rainy season (at least, at the beginning and the end of the rainy season, where the sections are very clayey). This protects the layer beneath. At the same time the gang clears the ditches and drainage outlets. Using this method, the rate of progress of a gang equipped with 3 or 4 graders is about 14 km per day.
- regrading by cutting: this consists of dumping on to the road edges the materials taken from the elimination of surface irregularities, such

as undulations. This method is used in the dry season, and the rate of progress is about 28 km per day.

The frequency of these operations depends, in particular, upon the intensity of the traffic and the speed of the vehicles. At present, it varies on the 'A' and 'B' circuits from every 15 days to every two months. The gangs operate in accordance with the circuit arrangements made by the Manager of the Subdivision.

Whilst taking care never to slow down the frequency of regrading, the gangs also execute the following work:

Correction of road contour

This is a slow job. It has to be executed within a limited time and without much interruption of the normal use of the equipment. This work is done at the end of the dry season, in order to obtain a satisfactory transverse profile prior to the commencement of the rains. The risk of being held up by mud in the winter has to be avoided. The use of a heavy duty motorised grader is indispensable.

Road widening

This is done by banking up or using spoil earth, using a heavy duty motorised grader. The widening must be done progressively over a width of 10 to 20 cm on each pass. Faster work would slow down the rotation of the gang and would create heaps of material, the compaction of which would involve difficulties.

Superelevation on curves

Materials are moved from the inside of the curve to bank up the outside. In speedy work, the blade of the machine has to be adjusted before the bend to prevent a reverse superelevation.

Construction of ditches

This work is rarely necessary because, if the road is correctly cambered, the water drains off to the edges of the road. The natural longitudinal profile suffices to discharge the water towards the lower points or to the drains.

Spreading of earth supplied by section

In the case of small local regravelling carried out by the section, the materials are deposited when the gang transits the particular site.

Shaping of new tracks

New tracks are opened up with the use of a bulldozer. The shaping is done by the regrading gang during one of their visits to the neighbourhood.

Maintenance circuits and areas for a regrading gang

The most efficient results are obtained by regrading in a single operation, hence the importance of looped circuits. The transport of machines with lifted blades is thus eliminated. One gang can provide maintenance of 800 to 900 km of road, by rotation every three or four months, where there is no heavy traffic, or in 14 days for a road where the number of vehicles per day is from 100 to 300.

The frequency may reach 7 days in the case of a particularly difficult road.

5.1.2.3 Regravelling gangs

The regravelling gangs provide for the maintenance necessitated by the wear of an unsurfaced road. The resurfacing is done by supplying and laying new materials to make up for loss of material and the decreased road-bearing quality of the remaining materials.

The frequency of the regravelling depends upon the composition and intensity of the traffic, and the quality of the materials previously used. To resurface under correct conditions for the execution and progress of the work, the mechanised units used must form a coherent whole. The best-equipped sets comprise:

- 1 heavy duty bulldozer
 - 1 light duty bulldozer
 - 1 heavy duty grader
 - 1 loading machine
 - 4 tipper trucks
 - 1 compacting unit
 - 1 3.9 ton auxiliary truck
- and possibly a tanker.

5.1.2.4 Structures gangs

To improve the drainage of their roads, the Subdivisions have trained structures gangs, consisting mainly of masons who prepare prefabricated tiles which are laid either by the sections or by the work gang themselves. These gangs also build light temporary bridges of up to 6 metres in length. The abutments and piles are of the gabion type, and the bridgedecks of steel girders or wooden beams with wooden planking.

5.1.3 Surfaced roads

The units used for the maintenance of a surfaced road are the bituminous section and road contractors.

5.1.3.1 Bituminous section

This comprises:

- 1 section manager
- 1 gang foreman
- 1 bituminous operative
- 3 drivers
- 10 labourers
- 2 3.9 ton trucks
- 2 12 ton trucks, one of which has a chipping spreader
- 1 vibrating roller

The bituminous section provides for the maintenance of the edges and adjoining parts of the road.

These repairs are executed by spreading cold-coated materials or by laying a wearing course, after preparation of the defective area.

5.1.3.2 Work given to road contractors

The work given to the contractors comprises:

- maintenance of the road surface, by substitution of the contractors for the bituminous section
- the laying of wearing courses or strengthening layers.

Since the construction of paved roads in the Ivory Coast, few of them have been given normal maintenance service, by the laying of wearing courses at sufficient frequency for the nature of the traffic and of the roads themselves. Instead of this normal maintenance, systematic strengthening of the road has been made at intervals, according to the degree of wear. Some of the sections have been strengthened several times.

5.1.3.3 Major local repairs and reshaping

This means road reconstruction, involving areas of from a few square metres, up to some hundreds of square metres. (Very bad sections caused by contamination of the road base with clay). This work involves several layers of the road and the same constructional techniques are used as for the building of new roads.

Under this heading also, there is recambering and removal of potholes to correct both transverse and longitudinal deformations of the road surface, when there is danger to traffic. The only method which can be recommended is the use of hot-coated materials.

5.1.3.4 Renewal of road surfaces and patching

This work re-establishes the evenness and skidding resistance of the surface and the impermeability of the road. Gravel surface dressing or hot-coated materials are used.

Surface dressings obtained by spreading a hot binder provide the least costly solution (about francs (CFA) 300 per square metre) to the problem of skidding and impermeability.

The hot dense mixtures are exclusively used ensure the restoration of the evenness of the defective road, or the strengthening of an insufficient road structure. (Composition : binder 60/70; grading 0/10; thickness 3 to 4 cm.).

The purpose of the resurfacing is gradually to adapt the road structure to the intensity of the traffic, and to compensate for the wear, through material fatigue, by the use of hot-coated mixtures. The thickness is about 5 cm for open mixtures and 3 to 4 cm for dense mixtures.

5.1.3.5 Maintenance of the road sides

The maintenance of the road sides is essential for the good performance of the road.

Deterioration of the road side edges is shown principally by erosion of soil of poor cohesion, by the deposit of materials caused by water and by inadequate aeration or lack of sunlight also by obstruction of visibility, as a result of increase in vegetation.

5.1.3.6 Levelling of shoulders

Roadside shoulders have a natural tendency to become thicker and they must be levelled periodically, down to the level of the road. Graders are used for this purpose.

Grading and adjustment of shoulders

This means filling in ruts which have formed at the sides of the road, and levelling up by adding or removing material.

Banking up consists of filling in materials on sunken shoulders to bring them up to road level.

Ditches and drainage

This work has to be executed frequently, to ensure the elimination of deposits which clog them. At present this work is done manually by the section gang. Tests are in progress with a view to the mechanisation of this job, using mechanical cutters.

Slopes

The principal maintenance work is designed to ensure that the slopes are well-kept, and thus eliminate any dangers to road users.

5.1.3.7 Vegetation

Clearance of shoulders and slopes

This is essentially a manual operation, especially on shoulders where signs are erected. The road gang are at present responsible for this work. However, mechanical clearance of brushwood with a mowing machine having a horizontal rotor equipped with flails leads us to hope that general mechanical operation will become a possibility in the near future.

Pruning of trees

This work is done, above all, to ensure clear visibility and prevent danger to traffic.

5.1.3.8 Maintenance of road structures

Annual visits of inspection are made by the subdivision gangs of accessible structures. For others, the services of specialised contractors are used. A maintenance programme is prepared following these visits of inspection.

5.1.3.9 Road signs

Carriageway signs

These are renewed from time to time. There is, however, as yet no standardisation of the paints used, and difficulty is experienced with adhesion.

Post-mounted signs

The preservation of signs and beacons is a very difficult matter, as they are damaged by pedestrians or by herds of cattle.

5.1.4 Road units

The basic road units, entrusted with the maintenance and preservation of this important infrastructure comprise, under the aegis of the Public Works Department : 234 specialised sections distributed as follows:

120	road sections
27	administration sections
6	bituminous maintenance sections
8	urban district sections
47	regrading gangs, of which
	- 18 heavy duty
	- 12 medium duty
	- 17 light duty
18	regravelling gangs
8	gangs for the opening of new tracks

A very large staff of 4090 operatives of all grades carry out this work, comprising:

19	French technical assistants
26	Contractors for technical assistance
465	Civil servants
165	Temporary civil servants
3,415	Day labourers

The finance assigned in 1969 to the maintenance of the national road network amounted to TWO MILLIARDS AND ONE MILLION FRANCS, CFA.

5.2 Cost of maintenance

5.2.1 Present annual cost of road maintenance units (in millions of CFA francs)

This falls under three headings, defined as follows:

Personnel: indicates the salary paid to all operatives in this group.

Equipment: includes depreciation, maintenance and repair charges, spare parts, fuel, sundries and general expenses, the latter being about 25 per cent of the amount under this heading.

Supplies and materials means "small tools and materials"

5.2.1.1 Road sections

Personnel	3.660
Equipment	1.951
Supplies and materials	0.144
	<hr/>
Cost	5.755

5.2.1.2 Road regrading gangs

- Heavy duty (3L)

Personnel	3.190
Equipment	20.451
	<hr/>
Cost	23.641

Medium duty (2L + 1L)

Personnel	3.190
Equipment	17.046
Cost	<u>20.236</u>

Light duty (1L + 2L)

Personnel	3.190
Equipment	13.637
Cost	<u>16.827</u>

5.2.1.3 Resurfacing gangs

Personnel	4.210
Equipment	12.700
Cost	<u>16.910</u>

5.2.1.4 General work gangs

Personnel	3.670
Equipment	6.347
Supplies of materials	4.506
Cost	<u>14.523</u>

5.3 Average cost in 1970 of the maintenance of one km of road

It is impossible to gauge with accuracy the average cost of maintenance of the roads, in the absence of analytical accounting.

5.3.1 Earth roads

The cost of maintenance of the earth roads is arrived at from the cost of operation of the road section, the regrading gangs and regravelling gangs. At present, this cost depends upon the classification of the roads "A", "B", or "C", and upon the number of vehicles travelling along these roads. The "A" roads especially, irrespective of the traffic using them, are kept in better condition than "B" roads, and the maintenance of "C" roads is very limited, because of the large kilometrage.

The lack of analytical accounting in the subdivisions has made it necessary to analyse the total expenditure of operation, with distribution by class of road, based on a hypothetical calculation. This hypothesis is based on all the factors recorded during road reconnaissance and on a specific survey made for the Northern Province. It assigns to each class of road the following weighted coefficients:

"A" roads, coefficient 1 (7 times the maintenance of "C" roads)
"B" roads, coefficient $5/7$ = (5 times the maintenance of "C" roads)
"C" roads, coefficient $1/7$ = 0.143.

The following figures are obtained from an examination of these hypotheses:

TABLE 5

Maintenance costs by road type and traffic

Type of road	Average total daily traffic		Average annual maintenance cost per km of road, in Frs. (C.F.A.)
	From	to	
"A" road	0	200	100,000
	100	400	125,000
	exceeding 400		150,000
"B" road	0	100	70,000
	100	200	90,000
	exceeding 200		110,000
"C" roads			14,000

5.3.2 Surfaced roads

The cost of maintenance of surfaced roads is as follows:

- cost of operation of the bituminous section
- expenses relating to contractual work

In 1969, the annual cost of the bituminous section, per kilometre of surfaced road, was about Frs (C.F.A.) 84,000 per km and the cost of contracted work Frs. (C.F.A.) 187,000 per km, making a total of Frs. (C.F.A.) 271,000 per km.

5.4 Road maintenance budget

Financing

This is provided by the Road Fund and the General Budget of Operations.

The Road Fund receipts are the result of a Decree issued in 1966, providing for taxes on fuels, as follows:

- 5 Francs (C.F.A.) per litre on petrol
- 4.50 Francs (C.F.A.) per litre on diesel.

Although the taxes on fuels have been regularly increased, the amount assigned to road maintenance has remained fixed, and it has thus been reduced by the effect of the increase in the cost of living. For some years past, the balance has been found by an additional allocation from the General Budget.

6. TRAINING

Apart from the "Public Works School" which trains the highly-skilled Engineers and Technicians, the Ministry of Public Works has opened:

- a school for section managers
- a driving school for vehicle drivers
- a school for mechanical engineering foremen to act as supervisors of the resurfacing and regrading gangs.

- a training centre for master-mechanics and a centre for drivers of the M.P.U. according to the needs for the vacancies to be filled.

The trainees are recruited at the 'CAP' level and from some of the better Public Works staff. The Driving School recruits and trains candidates holding educational certificates.

7. THE MAINTENANCE POLICY

The United Nations Development Programme has agreed to include assistance to the Government of the Ivory Coast Republic, for the execution of a general transport survey. The IBRD has been appointed as the organisation for the execution of this survey.

The first phase has been devoted to the general study of all types of transport and the second phase has been devoted especially to road maintenance.

This survey has shown that the cost of maintenance for the existing service levels is related to the surface conditions, which are often mediocre or bad, especially in the case of the "C" roads.

A provisional programme for four years has been prepared and this will be followed up in the course of the decade.

7.1 Reorganisation of the Public Works Department

The object of this reorganisation is:

- to prepare for a systematic programme of investment and maintenance;
- to check, by records, the quantities used and the resulting costs, and to correct any mistakes or anomalies
- to assist the work of the District Directorates and Subdivisions, by the hire of equipment and by surveys.

7.2 Improvements in current maintenance

The General Management, in order to control the amount of this current maintenance work, must:

- establish the required maintenance level and prepare plans, in good time, for their maintenance gangs
- supervise the actual execution and quality of the work
- watch the use made of the financial amounts available, which should be related, analytically, to the work actually carried out.

7.3 Improvement in, and regravelling of, 1,600 km of earth roads

The regravelling of earth roads is executed at present by 13 small gangs supervised by the Subdivisions, and their output is hardly more than about 30 km per year, which is far short of the actual requirements. It is proposed to reorganise, eliminating these gangs and forming heavy duty gangs attached to the DGTP. In the first instance, these gangs (at first two, and then three) will operate a five-year plan of earthworks and regravelling on main roads, where they are inadequate for traffic during the rainy season. These gangs will then be converted into regravelling gangs with fewer personnel.

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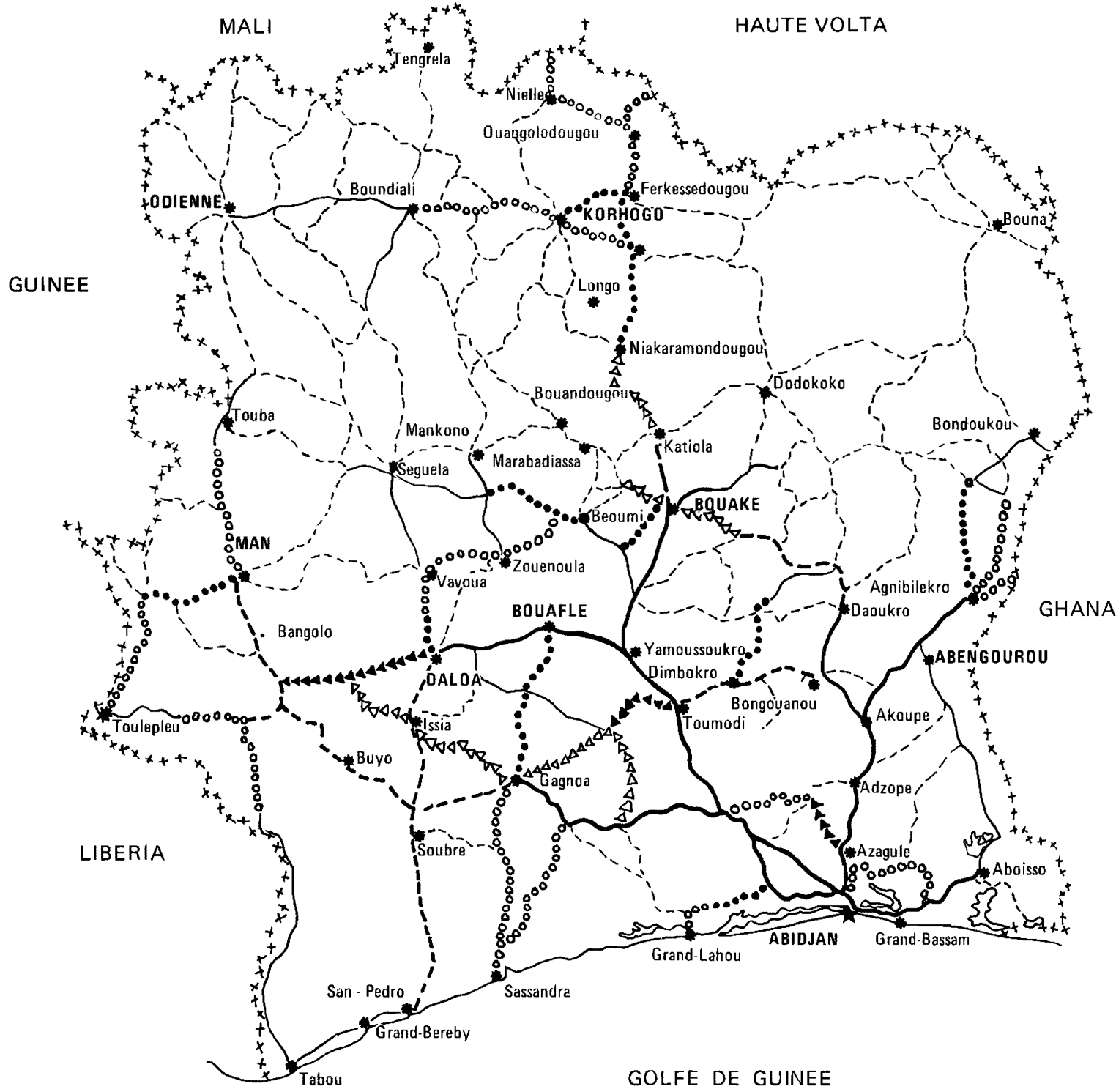
7.4 Training of the DGTP personnel

There are two types of operation:

- those intended for the rapid training of the operatives on site, to teach them new methods (e.g. the analytical accounting of road maintenance) or about new equipment (the training of drivers and mechanics for new vehicles) and which are of an immediate and temporary nature.
- those arising from the regular training and revision programme.

FIGURE 1

NIVEAUX DE TRAFIC DES DIFFERENTS
AXES DU RESEAU ROUTIER IVOIRIEN EN 1970
TRAFFIC VOLUMES ON THE VARIOUS LINKS
OF THE IVORY COAST ROAD NETWORK IN 1970



LEGENDE

Route revêtue existante
Route revêtue en projet
ou en construction

Route en terre d'un
trafic journalier total

LEGEND

Existing surfaced road
Surfaced road projected
or under construction

Earth road with a
total daily traffic of

$> 200 v j$	◄◄◄
$150 \leq TT < 200 v j$	◄◄◄
$75 \leq TT < 150 v j$	●●●
$50 \leq TT < 75 v j$	○○○
$30 \leq TT < 50 v j$	—
$\leq 30 v j$	- - -

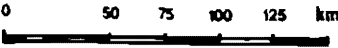
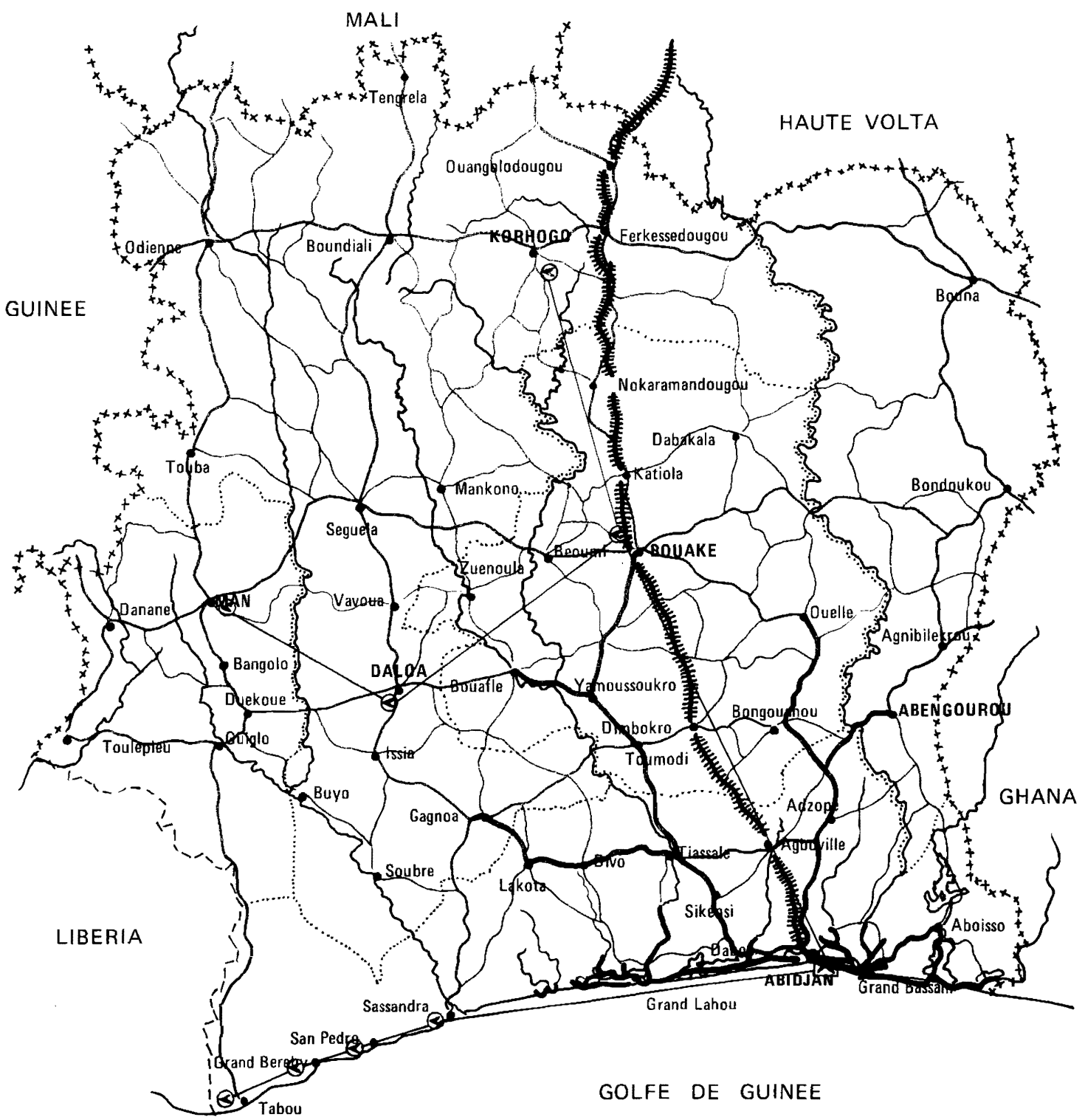


FIGURE 2

RESEAU DE TRANSPORT EN 1970
TRANSPORTATION NETWORK IN 1970



LEGENDE

Voie navigable

Aéroport international

Aéroport desservi par Air Ivoire

Ligne Air Ivoire

LEGEND

Waterway

International airport

Airport served by Air Ivoire

Air Ivoire route

GOLFE DE GUINEE

Route A revêtue

Route A non revêtue

Route B

Limite d'état

Limite de département

Voie ferrée étroite (1 m)

A road paved

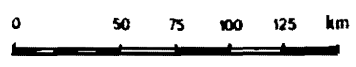
A road unpaved

B road

National boundary

Department boundary

Railway, narrow gauge (1 m)



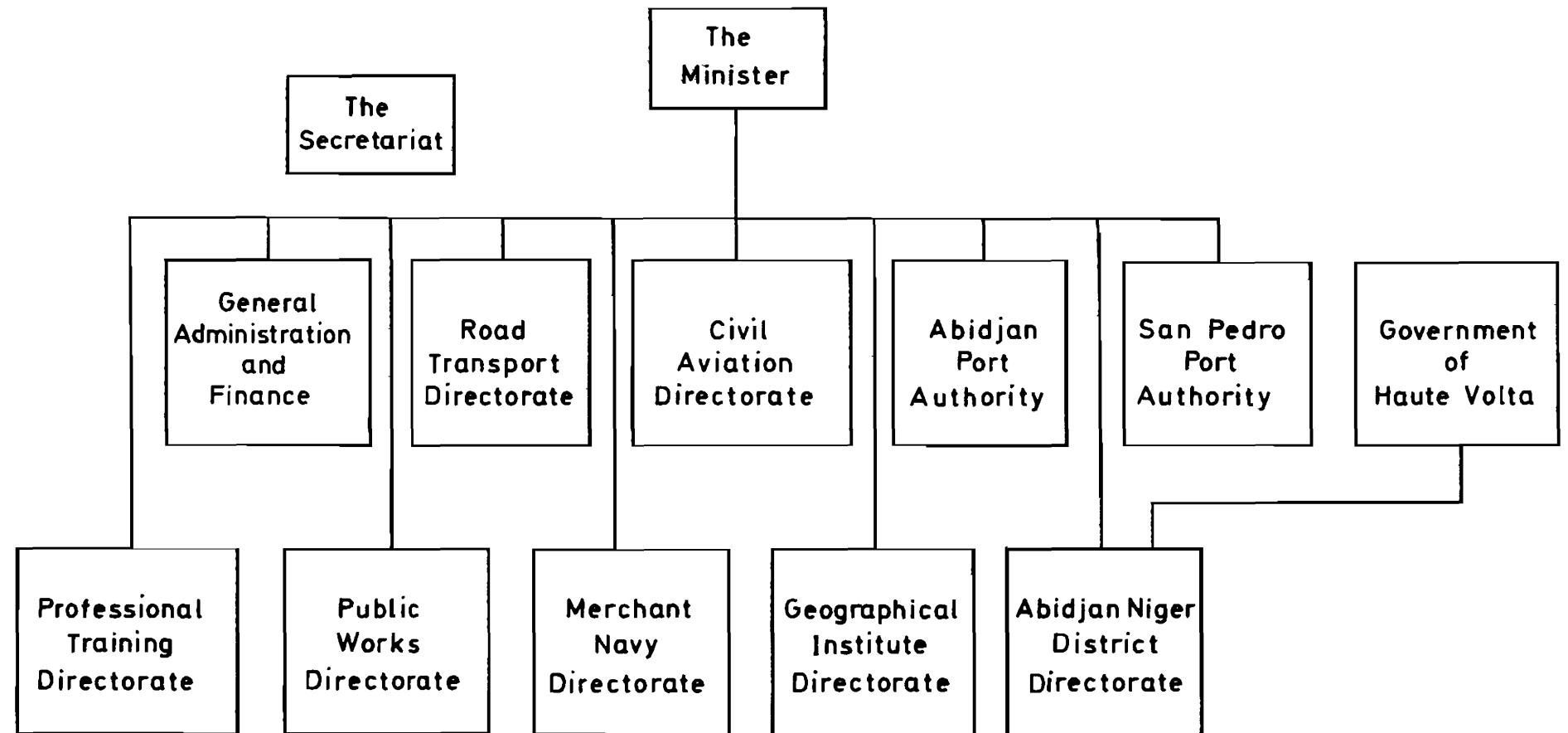


Fig. 3 STRUCTURE OF THE MINISTRY OF PUBLIC WORKS AND TRANSPORT IN 1970