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Equipment maintenance management in Cape Verde, Porto da Praia : toward an improvement

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Equipment Maintenance Management in Cape Verde - Porto da Praia, Towards an Improvement.

By

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is include for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACTS

Title of Dissertation: **Equipment Maintenance Management in Cape Verde - Porto da Praia, Towards an Improvement.**

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This dissertation focuses on the Maintenance Management in a port of Cape Verde, especially in Porto da Praia, with an insight into the effects poor maintenance has on the performance of Porto da Praia.

A quick look is taken at the present maintenance of equipment procedures, an evaluation of the actual inventory level of equipment in Porto da Praia, the economic life of the equipment in this port, the process of acquisition of spare parts, the demand and supply of the equipment in port activities and operations are also analysed.

The investigation for this study was based in the collection of information in ENAPOR, the Porto da Praia and Porto Grande which complements a detailed analysis of maintenance policy adopted in Porto da Praia.

Finally, the paper concludes with an emphasis of the importance of attaining autonomy for Porto da Praia related to the maintenance policy in order to make the port more efficient and competitive.

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LIST OF ABBREVIATIONS

EMIS	Engineering Management Information system
ENAPOR	Empresa Nacional de Administração de Portos
FEL	Front End Loader
FLT	Fork Lift truck
GDP	Gross Domestic Product
IT	Information Technology
JIT	Just in Time
MIS	Management Information System
OMIS	Operation Management Information System
SWT	Safe Working Load
T	Tonne
TEU	Twenty Foot Equivalent Unit
UNCTAD	United Nations Conference on Trade and Development
WMU	Word Maritime University

CHAPTER I

1. Introduction

Management of ports has become increasingly specialised and complex nowadays, due to the evolution of modern seagoing vessels catering to the increase in world trade. During the last three decades, world trade has been growing spectacularly. To be able to meet the demands of world trade and to ensure high performance, ships have become more specialised, increasing not only in size but also in speed. Ships have also become bigger in order to achieve economies of scale.

The quick turnaround of ships in port has become a significant part of this evolution. Consequently, the time that the ships spend in port becomes crucial. The only way to meet this new demand is the mechanisation of operations in port as much as possible.

At the same time, to compensate for the physical limitations of port expansion, cargo handling had to be mechanised to the degree of automation that we have today. For instance, as mentioned in UNCTAD IPP 3, in a conventional general cargo berth, a gang of 26 men can only handle between 100 and 200 tonnes in a shift. At a modern container berth, a team of 12 to 14 men serving a single gantry crane can achieve up to 1,800 tonnes in the same shift. This means that while each man in a conventional berth handles typically 5.5 tonnes per shift his equivalent on the container terminal moves 150 tonnes per shift.

Ports have definitely not been left out in the evolution of sea transport. Technological development, the degree of specialisation in sea transport and high performance level led to the mechanisation of port operations. Cargo handling equipment has become more specialised for each specific commodity and automation of this equipment has become the only way to ensure the quick turnaround of ships in port. The role of cargo handling equipment in this process cannot be overemphasised. It can be viewed as one of the most important factors for efficiency of berth operations. Due to the recent changes in cargo handling techniques, as well as to technological progress, most ports in the world have invested heavily in sophisticated equipment.

It is also equally important that cargo handling equipment in port should operate smoothly and without any breakdown. This can only be realised through a proper maintenance culture. There is no doubt that any single handling equipment that is not well maintained can affect all operations in the port. Sometimes the breakdown may cause huge losses for ports and shipping companies, which is of course, very counterproductive. This can affect the reputation of ports with the consequent loss of market share to other competitors.

Because ports have to purchase large quantities of specialised equipment, with high-capacity and complex cargo handling systems, the management of that equipment needs to be more cost effective in all aspects, including maintenance and repairs. Therefore, a very high proportion of the capital and operation budget of a major port is now devoted to the purchase, operation and maintenance of mechanical handling equipment.

The increase in capital costs of modern port handling equipment, together with its technical complexity and specialisation, underline the importance of optimum reliability and performance. Consequently, any breakdown in port handling

equipment is no longer acceptable as it can have a considerable negative impact on port operations, which may reflect on other indicators of port performance.

Considering all these factors, and to achieve optimum reliability of port operation at minimum costs, a systematic approach to optimal maintenance policy is essential. Indeed, a poor maintenance policy in modern port equipment can no longer be tolerated.

For all these reasons, the maintenance department in a port must ensure that the handling and transfer equipment are operating at the required level of productivity and efficiency and are available whenever the ships call at the port. It is known that the poor maintenance of port equipment can cause other effects such as low availability because of an inevitable increase in the number of breakdowns, which in turn can cause low productivity and low performance. When a machine breaks down while in operation, its availability goes down and overall equipment output decreases.

During the times of peak demand, low availability of equipment can be caused by the failure of equipment during the operation. The productivity and performance of a port decreases due to the shortage of equipment. In order to meet the performance requirements of the operation, ports make additional investment in extra equipment to cover for those that are failing. Of course, the decision to buy more equipment will increase the operational cost. Finally, poor maintenance prevents ports from being competitive, because all extra costs of operations will affect the final port traffic adversely.

Due to heavy dependence on port activities in the Republic of Cape Verde, which is an archipelago of ten islands and five islets situated to the north of West Africa in the Atlantic Ocean, the author has chosen the topic of port equipment maintenance management in Cape Verde, focussing on the improvement of the equipment

maintenance policy of Port da Praia. The aim of this dissertation is to collect, analyse and discuss the present structure and the policy of maintenance in the Port of Praia. An evaluation of the performance will be made related to the existing inventory of equipment in the port, the age and the economic life of the equipment.

An evaluation of the nature and extent of maintenance of the equipment and the causes of the major problems in the port will be made. Furthermore, a review of the policies, strategies, and management techniques used in equipment maintenance will be made in order to identify the weaknesses in this process.

Because the maintenance management of port equipment is a very wide subject, it will not be possible to cover all the areas of this subject in detail. However, this paper will focus on the review of the policy, strategies and management techniques used in the Porto da Praia. It will identify the weaknesses in the maintenance process, and make some maintenance policy proposals for essential items of equipment together with recommendations for good management practices. Guidance and recommendations will be given in order to have a good strategy for spare parts management and an adequate equipment maintenance policy for the Port da Praia to meet the operational needs.

2. Present Status of Ports in Cape Verde

2. 1 Institutional and Administrative Framework

In the year 1982 decree number 20/92, establishing The National Port Administration Enterprise (ENAPOR) provided it with administrative, financial and patrimonial autonomy. The head-office is located in the city of Mindelo, S.Vicente Island, and shares the same building with the head office of the principle port of country, Porto Grande. ENAPOR was created with an intention of providing a central policy for the

development of ports. The enterprise should operate under the supervision of the Government as the institution responsible for all port sectors.

Ports in Cape Verde are typically service ports in nature. ENAPOR is the autonomous state enterprise in charge of building the basic infrastructure (such as quay walls and entrance facilities), building the superstructures (such as storage facilities), and purchasing all equipment for loading, unloading and transferring of cargoes. Furthermore, it is responsible for commercial and operational activities through the management of its own stevedoring company.

In order to provide a clear understanding of Port Authority (ENAPOR) its functions and limitations are shortly explained here with some of its main characteristics:

a) Port Administration is a duty carried out by the State, also users, which are represented by the Chamber of Commerce and/or private participants with their representatives who are involved in the management

b) the Port Authority is a public service with judicial status in charge of the management and operation of the ports

c) the Port Authority acts as a body independent of the government, that is, in cases to appear responsible to user claims. The Authority has the ability to respond with its own budget.

2.2. Port Characteristics

The archipelagic nature of the country the requires setting up of a relatively high number of ports to serve the islands' population. Each island unavoidably needs at least one port. This is a burden on the central administration and makes the process of choosing the type of port organisation for them difficult.

The existence of this natural constraint forces the National Port Administration (ENAPOR) to incur unprofitable social costs in the management and upkeep of small ports. Amongst many small ports, the two main ports under the responsibility of ENAPOR are:

Porto Grande (S.Vicente Island)
Porto da Praia (Santiago Island)

This paper focuses on Porto da Praia, and those administrative matters only when there is some bearing on the maintenance policy of this port. The total movement of cargo in the ports of Cape Verde was about 735.897 tons, of which Porto da Praia accounted for more than 54% of this amount.

Porto da Praia has the following physical characteristics as given in table 1. Its lay out is shown in the appendix 3.

Table 1: Physical Characteristics of Porto da Praia

Quay Num	**Length (m)**	**width (m)**	**draft (m)**
01	218.00	30.00	9.50
02	314.00	30.00	7.50
03	80.00	19.50	5.00
04	80.00	19.50	5.00
05	55.00	24.50	3.00

Source: ENAPOR - Porto da Praia

The storage facilities of the port consist of two waterside warehouses of 2400 square meters each, two land side warehouses with capacities of 2400 and 1800 square meters and 17.470 square meters hectares of open areas that are dedicated to container and unitised cargo.

The available equipment is shown in table 2:

Table 2: Porto da Praia Inventory

Equipment Type	Characteristic (Model)	Inventory Level	Age (Years)	Equipment Operational	Capacity (Tonnes)
Mobile Crane	Gottwald 125	01	13	1	30,0
Mobile Crane	Nelcon NL 25	01	13	1	15,0
Mobile Crane	Nellen NL 125	01	13	1	15,0
Mobile Crane	Nelcon 109	01	13	1	5,0
Front-End-Loader (FEL)	Hyster	01	03	1	40.0
Front-End-Loader (FEL)	Lansing	01	13	1	25.0
Forklift-Truck (FLT)	Toyota FD 4.0	01	23	0	4.0
Forklift-Truck (FLT)	Lansing 3.0	04	13	2	3.0
Forklift-Truck (FLT)	Lansing 2.5	04	13	2	2,5
Forklift-Truck(FLT)	Toyota FD30	03	23	01	3.0
Forklift-Truck(FLT)	Toyota FD30	03	3	3	3.0
Trailer Tractor	Mercury RM 801	04	13	02	20.0
Trailer Tractor	Mercury RM801	02	3	2	20.0

Source: ENAPOR - Porto da Praia

Apart from the equipment used in port operations, Porto da Praia has some vehicles used mainly for welfare purposes or in administrative assistance. All of these are diesel engine cars, so their maintenance has not been a problem for the workshop.

Table 3: Administration Vehicles Inventory

MODEL	MARKS	AGE
Mercedes 309 D (Buss)	Mercedes Benz	18
Toyota 2.8 (Mini-Buss)	Toyota Hiace	8
Toyota 2.8 (truck)	Toyota Hillux	7
Toyota Corrola 2.0 (Auto)	Toyota Corolla	4
Toyota Dyna 280 2 (Trucks)	Toyota Dyna	2

Source: ENAPOR – Porto da Praia

The organisational structure of ENAPOR, according to its statute, is as follow:

the Board of Directors
the General Director
the Users Council.

The Ministerial Council nominates the General Manager and the four Administrators for a period of three years.

The Board of Directors should meet every month. Their functions are mainly concerned with the approval of planned activities, annual budget, possible investments, wages and matters related to assurance of the management and development of the enterprise.

The General Director is appointed by a Governmental decree for a mandate of 3 years which is renewable and has the functions such as supreme co-ordination of all activities of the enterprise. He is the chairman of both the Board of Directors and the Users' Council.

The Users' Council is composed of the General Director of Customs, representative of the Chamber of Commerce, representatives of institutions related to the port and finally representatives of private companies involved in trade, such as shipping agencies, shipowners, commercial associations, insurance companies and companies dedicated to fuel activity.

They ordinarily meet on a monthly basis and their functions are generally to give advice about the following port activities: cargo traffic, cargo storage, port productivity, port traffic and other related activities in the ports.

An illustration of what can be considered the complete organisational structure is given in table 3 where the importance of the two main ports, Porto da Praia and Porto Grande is indicates. Each one of the main ports has its own Regional Manager.

Each Regional Manager for Porto da Praia and Porto Grande is nominated by the General Manager. Nevertheless the minister tutelage of port activities takes the final decision to accept or not, the candidates for those positions.

Regional Managers have limited autonomy as a manager of their ports. Nevertheless, each regional port has its structure, within decisions such as operation, commercial, maintenance and administration divisions. Those regional divisions have overlapping functions with divisions of the main structure of ENAPOR.

The signal of Regional Managers limitation is clearly written in the decree of enterprise. For instance, the regional manager has a pre-established amount in the budget for spending on purchasing spare parts. This amount can not exceed a value of five thousand US dollars in the local market, and it is prohibited to order any spare parts in foreign currencies.

Legend of ENAPOR of organisational Chart

CA	Board Director
DG	General Director
CUt	User's Council
AJC	Judicial and Legal Advisor Body
AI	Internal Audit
Mart	Marketing
DF	Financial Management
DADRH	Administration and Human Resource Development Management
DPG	Porto Grande Management
DPP	Porto da Praia Management
Dv.Fin	Financial Division
Dv.Inform	Data Processing Divisions
Dv.Ex.P	Port Exploitation Division
Dv.E	Equipment Division
Dv.AF	Administrative and Financial Division
S.Aprov	Supplies Service
S.Tes	Treasury Service
CG	General Accounting
Sv.CA&P	Analytical and Real Value Accounting Service
SAD	Administrative Service
SP	Staff Service
SDRH	Human resource Development Service
SOT	Traffic & Operation Service
SA	Warehouse Service
SPSP	Port Preventive & Safety Service
SE	Equipment Service
SM - PG	Maintenance Service - Porto Grande
SM _ PP	Maintenance Service _ Porto da Praia
SC	Commercial Service

CHAPTER II

2. Maintenance Policy

2. 1. BACKGROUND

Maintenance is associated with mechanisation, and became prominent when industry started to use machines to increase performance. Once you have machinery, the possibility of breakdown pushes the necessity to fix the devices when they break down. There are no doubts that every industry must have a suitable maintenance plan in order to avoid inopportune stoppage of the system. Nowadays, it is a known fact that the efficiency of ports depends on the degree of mechanisation. As E. N. White says in Maintenance Planning Control and Documentation:

> The pressures on those managers and supervisors, who are responsible for the provision, operation, maintenance and eventual disposal of physical assets. . . grow as investment costs increase, output or usage values increase, automation spreads, and labour patterns change, international competition or comparisons take effect, and management for profit or for continuity of use demands a planned and controlled approach to assets management.

With the development of cargo handling operations, the necessity for a correct maintenance policy has increased considerably. Bearing in mind that maintenance has

become part of every production, the necessity to organise this task has become a key issue in order to reduce the maintenance costs to the minimum value, and to try to get the maximum efficiency from the machines.

The handling equipment of ports, of course, can not escape this rule, especially due to the high degree of automation that is used in all operations of loading, unloading, stripping, stuffing logistics and other services provided by the ports.

Maintenance in a port is not only the process of fixing particular equipment, but rather is a system linking many activities together. Therefore, maintenance in port should have the view of total planning that embraces all the activities necessary to plan, control and record all work in connection with keeping the port operation at the acceptable standard.

When we talk about maintenance we refer to which kind of maintenance policy we should adopt, such as corrective, preventive, design out, the management of spare part related with acquisition, the way to manage the people tied to maintenance, and so on. In this chapter, some of these concepts will be discussed and some points will be made in relation to the policy used in the Port of Praia.

2. 2. Maintenance Policy in Porto da Praia

Porto da Praia is a small port with relatively good infrastructure, but it has a very poor maintenance system, as is generally the case in some developing countries.

The main factor that can affect the maintenance management is the way that the company is been managed. The right policy for the maintenance has to come from the

main policy of the company in so that the department in charge can make the maintenance program suit in an efficient way.

There are mainly three broad categories of maintenance policy available:

Preventive maintenance

Corrective maintenance

Designed-out

2. 3. Preventive Maintenance

Preventive maintenance stands for carrying out the maintenance work on equipment, or components, or pieces of equipment before failure occurs. It is based on the objective of carrying out checks and inspections either on a calendar basis, which can be weekly, monthly, yearly, or based on the wear and tear. In addition, it can be related to tons, number of hours that the machine has been used, or kilometres run. It can be sub-divided into two main branches:

Systematic maintenance

Condition-based maintenance

2. 3. 1. Systematic maintenance

This is a kind of simple and routine maintenance mainly and consists of: necessary lubrication, preventive maintenance inspection, adjustments and repair restricted to a maximum time per machine of say, ten minutes. Any thing over this time will be reported to the foreman and be covered by a special work order.

Another mode of preventive maintenance is called conditional maintenance that consists of action take after a signal or an alarm. For example, one requiring a change of brake linings or compensation of brake fluid for the brake system as indicated by the alarm light signal, by an infrared signal, or indicated by excessive vibrations.

This kind of maintenance is the least expensive and it is the essential for smooth functioning (operation) of all kinds of equipment. Carrying out the collection of the data necessary to perform this type of maintenance does not require specialised technical training. It can be performed by the drivers themselves during their daily routines because nowadays the machines are equipped with instrumentation that keeps the operators informed of the condition of the machine. For this reason, Porto da Praia has generally used this kind of maintenance.

2. 3. 2 Condition-based maintenance

Condition-based maintenance is a recent innovation which is gaining acceptance in many industries, and which has been introduced successfully by some ports. The definition stated by White is worth quoting: " Maintenance work initiated as result of knowledge of the condition of an item from routine or continuous checking" (White, 1979, 146). The aim is to inspect all components and systems regularly, with as

minimum a disturbance as possible, with the intention of noting any signs of deterioration and changing the component or system just before the component or system is about to fail. The advantages of this approach are that:

- it reduces the expenditure on preventive maintenance. The working life of the component is stretched until almost the last moment, and items are only replaced when they need to be;

- there is no unnecessary dismantling of plant items. The systems are only dismantled at long intervals, and unintentional damage caused by the maintenance procedures is avoided;

- there is less occurrence or severity of breakdowns, consequently the equipment reliability is high;

- there is avoidance of consequential damage, therefore the pressure on the workshops and technicians is low as possible.

Condition monitoring determines the health of the asset from an external inspection and by the detection of faults, consequential damage can be minimised.

There are two major constraints in applying condition-based maintenance, which are:

(i) Engineering Management Information

(ii) Identifying parameters.

2. 3. 2. 1. Engineering Management Information System - EMIS

Condition-based maintenance must be based on an extremely efficient and comprehensive Engineering Management Information System (EMIS). EMIS must be an integral component of the port's overall Management Information System, which must be extremely efficient and comprehensive to hold and analyse the large amount of data that has to be recorded. The data must be collected during routine operation of the equipment.

Once we have an EMIS, the maintenance system should use this data for planning and scheduling the maintenance work. While the equipment is in operation the data indicated by the instruments is collected and recorded. With an accurate system of collecting and recording condition, the history of equipment can be generated and then, when the equipment is subjected to preventive maintenance, all kinds of anomalies recorded during the operation can be investigated and repairs carried out during this period.

In modern equipment, a fully computerised system can issue a data sheet describing all jobs to be done, the spare parts that should be changed, also the steps, and the way the maintenance should follow. The faults and anomalies recorded earlier during the operation should be taken into account to prepare an appropriate work specification. This will help to rectifying all defects at the time of maintenance, which will be scheduled depending on the berthing activities.

With the condition monitoring system, we have to collect information, and routinely input data directly to EMIS, thus allowing preventive maintenance planning by advance warning of component or system deterioration or their failures. Consequently, the task

can be classified as corrective instead of emergency maintenance and can be planned in advance.

This approach allows maintenance intervals to be extended to their maximum practicable limits, reducing unnecessary servicing. Even if condition monitoring is not formally followed, EMIS still allows the adjustment of maintenance intervals and schedules. With this system the working hours for the maintenance staff must be more flexible.

In the case of ports in developing countries, such as Port of Praia, to be precise, it should take the advantages of this system of flexible time using as much as possible the information for monitoring and drafting the maintenance plan.

2. 3. 2. 2 Monitoring Parameters

The second concern of condition-based maintenance is to identify parameters which can be routinely and easily monitored, and which, without disturbing systems and assemblies, will provide a reliable and relevant indicator of the condition of the systems and components.

There are two forms of condition monitoring that apply to the running machinery for identifying maintenance requirements and the state of operations:

(i) The human sense inspection monitoring

(ii) Equipment monitoring using fixed and portable equipment.

Workshop technicians and the drivers undertake a series of pre-shift checks before any machine leaves the park for work on the terminals. Items such as tyre pressure, tread condition, oil level, level of intercooler liquid system and battery electrolyte levels are checked and faults put right. Checks are carried out by the operator of cargo-handling equipment when it is in use, because it is assumed that operators have the minimum of knowledge of the mechanical functioning of the equipment.

This task is done by using sight, hearing, touch and smell and by obtaining a sensory impression of the condition of the asset. In modern equipment, diagnostic warning lights and signals giving a continuous report on the condition of the components and systems and assist the sensing. At this stage, the observation skills of operators are used in order to be able to interpret the signals and use the devices accurately when monitoring.

Signs and symptoms are afterwards recorded in the equipment logbook and reported to the engineers. Thereafter, the inspection is assisted by a range of portable instruments to make a variety of measurements. These inspections may not be possible for all the components to build up their history file. Quantities and characteristics are recorded and variation observed and interpreted. The technicians assess the internal condition of components without dismantling, test their working relationships and often can predict the type and time of failure.

2. 4. Corrective Maintenance

Corrective maintenance is the maintenance which is carried out to restore an item to its efficient working condition, or restore it to an acceptable working condition. In other words it is used when the equipment fails while in operation. This policy is more like a

repair rather than an organised maintenance system. Yet, because of the consequence on production, it is a deliberate decision on the part of management to operate the equipment up to failure without a preventive inspection on the machine.

This is the principal method of maintenance presently used in Porto da Praia due to the lack of proper maintenance management and therefore the port faces the consequence of low productivity. This method is only justifiable from the economic point of view when the component is cheap and easy to replace.

On the other hand it can increase the down time and consequently cause the efficient operation of the port. However, when the breakdown occurs advantage is taken of the situation to carry out other maintenance, attending to other common spare parts that can be replaced at the same time of the break down repairs.

It is proven that repairs upon failure can never be profitable on complex machinery, but this type of "quick fixing" is not rare even in complex equipment due to several reasons, such as:

1 - when the required labour skill is unavailable;

2 - the resources and maintenance management are inadequate;

3 - when the pressure from productivity targets is such that preventive maintenance planning is impossible.

However, excessive reliance on corrective maintenance tends to disorganise the maintenance structure. Circumstances decide when this kind of maintenance will take place because the breakdowns are unpredictable and no proper schedule is possible.

2. 5. Designed-out maintenance

A corrective maintenance policy should be considered as an attempt to minimise the effects of failure of equipment during operations. Designed-out maintenance sets out to reduce the need of maintenance itself. In other words, designed out maintenance is a process that consists of re-designing an element, or items of a system, in order to increase their reliability. It corrects anomalies of equipment in order to make them more reliable and more adaptable for the intended purposes.

Designed-out maintenance, in fact, should start at the specification and design stages of equipment. The intervention of a maintenance engineer during the design stage will ensure that specific elements are taken into account, thus avoiding problems later on. Most developing countries cannot afford to adopt this process due to the limitation of the budget or lack of planning for the acquisition of equipment. Many ports buy equipment in accordance with the supply in the equipment market.

Designed-out maintenance goes along the equipment lifetime. Thanks to systematic analyses of repetitive or serious breakdowns, once the cause of the breakdown is identified that part can be redesigned so as to remedy the problem forever.

2. 6. Maintenance Strategies

Maintenance of port equipment and other assets, in most developing countries, used to be done by the port's staff using their own infrastructure. Due to the complexity of port equipment used in ports nowadays, engineers need to think about the other options available for the maintenance of equipment and other assets, and to adopt appropriate and cost-effective policies.

Therefore, with the increase in complexity and cost of equipment and as delays to ships and cargo operations become more and more expensive, the need of effective maintenance planning becomes more important. On the other hand, because no suitable external contractors are available in most of the ports in developing countries with adequate expertise to assure proper maintenance and secondly, because they are unable to obtain support from equipment manufacturers or their local agents, Port da Praia, like other ports in the region has to run an expensive maintenance structure. Most of the time the maintenance with own department is more costly if other strategies, such as external contractors are not used.

In the case of the Port of Praia the majority of maintenance is performed in the maintenance workshop of the port itself. However, specialised contractors do some precise tasks. For example, services like a special kind of welding that requires a high level of skill and specialisation, or the rebuilding of electric motors (bobbing of electrical motor) are normally done by specialised contractors.

We can consider that the scope for expansion of external maintenance contracts in developing countries is limited because of the low volume of specialised repair work. Most of the time ports are the only major users of cargo handling equipment. However, the ports should explore the possibilities of having technical assistance from equipment manufacturers on a temporary or regular basis because they have supplied such high cost equipment and should be asked to provide the after sales service support.

2. 6. 1. On-Site Maintenance

The maintenance service department in the Port of Praia is virtually responsible for all preventive maintenance and repairs of all types of equipment. It is also responsible for

all technical services such as electric power supply and distribution, the lighting system for cargo handling and other operational areas, firefighting and also maintenance of standby generating equipment to ensure that essential services can be sustained in the event of power supply failure.

Adopting this strategy, the maintenance service of the Port of Praia has to provide a workshop structure, required equipment and technicians with a wide range of skills, regardless of the levels of demand for individual services. Because of this reason overheads are excessively high and maintenance is more costly than it should be. It is worth mentioning that this cost is partly due to the recruitment of unqualified staff who may not have a sufficient volume of work.

At the same time there are advantages for the ports having their on-site maintenance. With their own resources and maintenance engineers, ports can have complete control over the equipment, scheduling of maintenance and better planning of equipment allocation. This planning can reduce the downtime consequently, making the port more efficient.

2. 6. 2. External Maintenance Contractor

External maintenance contractors, however, can be viewed as an alternative for cutting the expenses of overheads and also for reducing the numbers of port labour tied to maintenance services. However, the external maintenance option may have a huge limitation with respect to availability of competent manufacturing companies, component suppliers, manufacturers' agents and representatives operating near the ports and offering both competent and competitive services. Unlike what can be found in

developed countries, in a developing country the availability of such services is very low.

2. 7. Conclusion

Amongst all theoretical maintenance systems we should choose one that best suits our system. However, we should always bear in mind that having the correct policy of maintenance within the company involves all sectors of the management of the port. The policy of maintenance can only work well if it is an integral part of the company. If the maintenance policy of the port is related to the second plan we may not meet the efficiency for our equipment, as is the case of the Port da Praia.

Another important consideration is that there is no one option for maintenance policy that can be used in any one port. Due to the huge variety of equipment and the variety of systems used in handling cargo equipment nowadays, the importance of the functions that each equipment should perform at a certain time and the schedule of operations of the port should be taken into consideration when choosing the strategy of maintenance in the port.

The economic factors that the ports are facing can influence the port to choose a mix of all strategies, using one for each specific equipment and task.

Therefore the best strategy is the one that can compensate for the limitations of a port, improve the efficiency of the equipment, is as safe as possible, and is suitable for the social-economic situation of port.

CHAPTER III

The Supply of Handling Equipment and its Suitability

3. 1. Background

The aim of all ports is essentially to provide service activities, in particular for vessels, cargo and inland transport. The degree of customer satisfaction is based on how well the port can perform the operations to load, unload and transfer cargo and other related activities. This emphasises the vital role of proper equipment selection, as to the number of units needed and the efficiency of the equipment. The equipment should be harmoniously utilised, because the operations will not be successful unless the availability of the machines are guaranteed and their working conditions are satisfactory.

In the late 1980s, ENAPOR was pushed to make some investments in some specialised equipment for the Port da Praia, in order to cope with the general trend in growth of cargo as shown in the table 1.

The sector of sea transportation has been growing considerably in Cape Verde due to an annual GDP real growth averaging 5% in recent years. The increase in port activities can be easily explained by the growth of GNP, which was 312 US$ in the 1970s but has grown to almost 940 US$ today.

The table below shows the increase in containerised cargo and general cargo in Porto da Praia from 1994 - 1998.

Table 4: The Evolution of traffic in Porto da Praia

Year	TEUs	General Cargo
1994	4823	300183
1995	6334	323898
1996	7277	304304
1997	7628	349678
1998	9896	345690

Source: ENAPOR - Porto da Praia (1994-1998)

As the statistics of Port of Praia indicate, the importation of goods in containers has increased to more than double in number over the last 4 years. Therefore, the necessity has arisen to supply the Port of Praia with suitable equipment. The main policy and strategy was to buy a multipurpose mobile crane with a capacity for handling containers. This was the only way to update the facilities and berth operations of the port.

The decision to buy a mobile crane was a big problem due to the lack of funds available to cover the high price. Of course, the principal reason was the amount to be spent that can justify economically the annual throughput of Port da Praia.

On the other hand, the process of discharging containers could justify the investment. There was big pressure from the shipper, shippowner and other operators relating to the high of freight cost of containers, because until this time only ships with their own gear could afford to call at this port.

Before purchasing this mobile crane, many other processes for the discharge of containers were experimented. For instance, a combination of two jib cranes with fifteen tonne capacity each was used to discharge heavy containers with more than fifteen tonnes. There were also cases where containers were stripped on board until achieving admissible weight to be discharged by the jib gears or ship's gear.

However, the process of purchasing a mobile crane was very difficult due to the constraint related with the available budget as said. The alternative option obviously was to buy a second-hand mobile crane with its possible consequences of breakdowns and inefficiency.

The second concern was the failure to budget as a result of lack of financial planning by the port in allocation of funds for the acquisition of new equipment. Usually, the traditional approach for purchase of equipment has been to buy the equipment that the budget can afford, then adapt it for the purpose. This is what happens in the Port of Praia.

This approach has consequences relating to the performance of the equipment, for instance, sometimes the port that wants to sell its used equipment does this because they want to solve the problem that they have been facing related to this unit. Because the equipment is not new, the cost of maintenance is likely to be much higher depending on the period of life cycle that the equipment is in. However, we might consider that it was the best option available for ENAPOR in the short-term to quickly solve the immediate problem of coping with the growth of containerisation in the Port of Praia.

A further consideration that we should take into account with the purchase of a second-hand mobile crane is the total amount necessary to be invested to update the container

terminal operation to a minimum desirable service level. For example, ENAPOR bought not only the multipurpose crane (Gottwald HMK 150 49 -30), but also:

i) 40 t FEL with hydraulically adjustable spreader (Hyster H40),

ii) four FLT for stuffing and stripping containers (Toyota FD30),

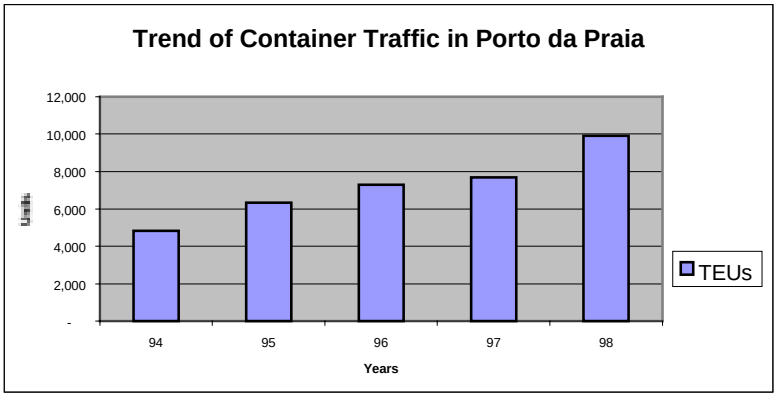
iii) three tractors with capacity of 40 t (R. Mercury RM801)

iv) and four weighbridges.

With these acquisitions the container operations started to improve and the productivity of the port changed for the better. The amount of money allocated for the acquisition of new equipment would not allow expenditure for a new crane, but the port exercised a good option in deciding to buy the second-hand crane.

Although productivity improved, the utilisation of equipment still could not cover the amount invested because the number of movements per year is very small. It seems, however, that this equipment is the minimum requirement for the operation of any number of containers, large or small. Also it should be noted that this mobile crane is used in a multipurpose terminal, therefore it is not only used in container operations but also in general cargo which improves the utilisation and the return on investment.

Figure 2: Trend of container traffic in Porto da Praia



Source: Servico de estatistica da ENAPOR (1994 – 1998)

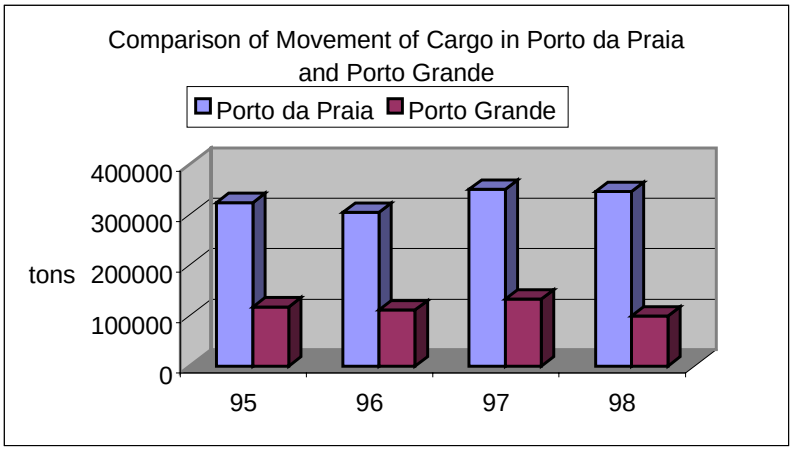
3. 2. The Activities of Porto da Praia - Hinterland

The geographical configuration of the Republic of Cape Verde, an archipelago, by itself explains the importance of ports to the nation. Ports are the most important gateway for the export and import of commodities.

The Port of Praia, is situated in the north on one of the biggest islands, (see appendix), where half of the population of the country lives, which explains why this port is the most important in Cape Verde.

Although this port is neither the biggest nor the best equipped, it is first in terms of throughput. With respect to physical area and equipment, it is the second biggest port of country, but in terms of the amount of import and export cargo moved per year it is the most profitable, as shown in the figure 3.

Figure 3: Comparison of movement of in Porto da Praia and Porto Grande



Source: Servico de Estatistica da ENAPOR –1995 -1998

The above graph shows the comparison of throughput between the two principal ports, Port Grande and the Port of Praia the period 1995 to 1998.

It should be mentioned that most of the national trade takes place through Porto da Praia. Among the activities of loading and unloading, the port can perform important services such as logistic chain activities. Many activities such as packing and distribution are done within the port area or in the immediate surroundings.

It is well known nowadays that ports should not only be the point of loading and unloading of goods, but also of other related activities related to the logistic chain. The Port da Praia has been trying to follow this role, given its limitations.

For instance, an intensive activity has developed involving the imported bulk commodities that pass through the port such as cement, maize, and gas in bulk. All

these products are imported in bulk, unloaded, stored and further distributed in small packages, for instance the packaging of maize and cement, distribution of container tanks or bottles of gas. Thus, there are some dry bulk silo and liquid gas activities taking place within the port area.

Once the process of discharging of bulk commodities is done, the activities of storage, blending and distribution continue until the re-exportation to other islands. From the operations point of view, almost half of the imported bulk products have to be transhipped to other islands. Once the products are discharged, they are stored in the silos to await processing. Cement and maize are packaged in 50-kg bags and then distributed to others island. The same happens with 7,526 tonnes, as mention in Booz-Allen & Hamilton Inc, of imported liquid gas that is redistributed to all nine islands in special gas containers and small bottles of 24,5 kg each.

3. 3. Equipment

3. 3. 1. For General Cargo Operations

The trend of general cargo movements in the port of Praia has been on the increase steadily as is shown in table 2. This results in an increase of dependence on equipment to meet the increased operational demand on the port. More reliable equipment is required in order to fulfil this demand.

Most import cargoes are discharged by vessel gears because of the lack of cargo handling equipment in the port. To add to the problem of insufficient equipment, there

is the problem of poor maintenance that leads to the unreliability of equipment for precise operations. Vessel's gears discharge more than fifty per cent of the cargo.

For the loading and unloading of commodities, the port has been using two old mobile cranes. The normal capacity is fifteen tonnes each, but for the safety of work and due to unreliable maintenance, these cranes are only operating with 10 tons of capacity. A 30-ton mobile crane for handling containers is also used for general cargo, especially when the cargo is heavy.

Because of this situation where only three cranes are available, the port cannot supply equipment for all the ships that call at the port, and ships are allowed to use their own equipment for loading and unloading operations.

There is no doubt that this is the main cause of the long turnaround time of ships in the port and leads to port congestion. If the operations of loading and unloading are performed by ship's gear most of the time, it becomes more difficult to measure the performance of the port operations. Each ship that calls at port has its own characteristics in terms of the design of the hold and hatch, the speed of its gear and other factors that affect the operation.

Another factor relating to the congestion of the port is the berth working time. Due to labour union constraints, the working time is only twelve hours, from seven in the morning until seven in the evening. This means that the idle time is almost fifty per cent while the ships are at berth.

3. 3. 2. For Dry Bulk Cargo Operations

The process of unloading dry bulk commodities in the Porto da Praia is one of the important activities in the port because it involves activities, such as storage, packaging and redistribution, as said before.

More than half of the import of cereals is through the Porto da Praia. This activity brings more added values to the port, because almost one third of these cereals have to be flown again to other islands.

The process of unloading cereal is by the installation of the port's grabs to the cargo gear of the ships or, if they are available, to the cranes supplied by the port, the grabs discharging into a funnel (filler) and then to trucks which are supplied by private companies. Once they are loaded, they go to silos that are within the port's area to discharge the cargo.

The other dry bulk cargo operation is the unloading of cement to be stored in cement silos, which were recently built within the port area. In this case of the cement company controls the operation entirely, using a suction discharge process and transporting the cement from shipside by the pipeline into the silos for storage.

The Cement Company does the maintenance of all silo systems, and the port charges only for the port duties, berth facility, and the land where the silos are located. Therefore, maintenance in the dry bulk system is restricted to the maintenance of the grabs, the funnel and, of course, the maintenance of the cranes.

3. 3. 3. For Container Operations

This is the activity which is Porto da Praia's major concern because of the short inventory level of equipment. The port has only a single mobile crane capable of carrying out container operations, especially when the containers weigh more than 10 tons.

Other activities, such as transferring containers from the quay apron to the container yard are assured by FELs, tractor trucks. As matter of fact, a simple breakdown of a single crane may result in a total paralysation of the operation of the port.

CHAPTER IV

4. Present Situation and Problems of Maintenance in Porto da Praia

4.1. Background

Maintenance is an extremely important aspect of management responsibility. The important aspects of equipment maintenance are the proper procedures to keep equipment operating efficiently. Maintenance, when correctly applied, reduces delays and preserves capital that has been invested in purchasing different kinds of equipment needed to make the port efficient and effective.

To analyse the maintenance in Porto da Praia the following should be pointed out: how this sector is organised, how the equipment is distributed in the different sectors, Procedures for actual maintenance and repair, the inventory control, the process of acquisition and how the spare parts are managed.

4.2. Structure of the Maintenance Organisation in Porto of Praia

By analysing the organisational charter of ENAPOR it can be realised that there is an overlap of functions of some departments of each port. For example, Porto da Praia has its own department for the maintenance of equipment and Porto Grande has a division of

maintenance, but most of the time it appears that this is an implicit organ belonging to the structure of ENAPOR.

Many decisions for maintenance from Porto da Praia go through the division of maintenance of Porto Grande instead of being analysed by ENAPOR directly. Porto da Praia's maintenance affairs have to go through the Porto Grande's maintenance division and only then action can further be taken in response.

This situation has created some embarrassment and conflict between the two ports and it is also noted that the influence of judgement of the Porto Grande's maintenance has increased the red tape in decision making in favour of Porto da Praia. Also this situation has increased the procedures of acquisition of spare parts, especially when dealing with imported spares.

4.2.1. Personnel Qualifications in the Maintenance Department

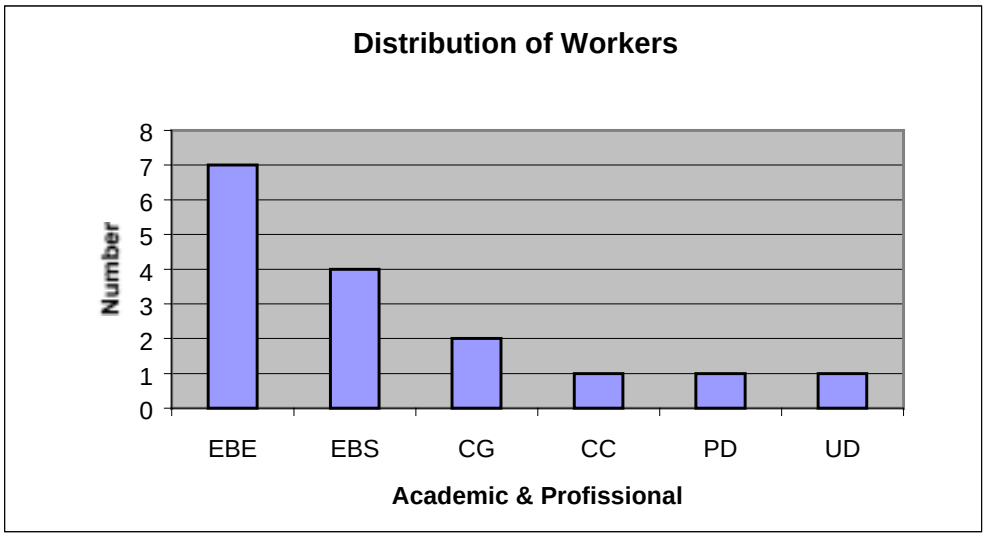
The current policy in the Port da Praia is to maintain all the handling equipment there, on site with the human resources. The number of effective people directly dealing with maintenance is about 16 persons, except the extraordinary workforce that is contracted on short or long-term contracts. This labour force is made up of unskilled labour and it is assumed, therefore, that they are not so relevant for this analysis.

The amount spent on the salaries of people having a linkage direct to the workshop is almost 10% of whole of the salary expenses in the port. The manpower distribution according to their functions is mainly the chief of maintenance service, that is a Mariner Engineer, one technical engineer, who is the link between the chief engineer and other levels of maintenance staff. Two electricians have functions which are not clearly defined; however one is mostly in-charge of maintenance of equipment and the other has

duties mostly related with the maintenance of buildings and infrastructure. There are three mechanics of the first level; they are involved in big repairs and maintenance, three mechanics of the second level; two are involved in routine maintenance inspection of machines before their distribution for the operational activities and two blacksmiths who carry out, among others services, the welding activities. One turner does all the metalwork tasks and there are three mechanic apprentices.

With the exception of the chief engineer and the junior engineer that hold university diplomas in engineering, the other staff are unskilled and they can carry out only the manual work. The personnel qualification as it is demonstrated in the figure, needs to be analysed. With the electrical, hydraulic and electronic systems installed in the cargo-handling equipment it is obvious that the situation requires an urgent intervention related to personnel qualifications and certainly this is under the heading of the major problem for the port when the trends of technology used in cargo-handling equipment are considered.

Figure 4: Academic distribution of workers in maintenance department



Source: Human Resource of ENAPOR

E.B.E. Elementary School (4 years)

E.B.S. Complementary Instruction School (6 years)

C.G. General Course (9 years)

C.C. Complementary Course (11 years)

P.D. Technical-Professional Diploma (14 years)

U.D. University Diploma (16 years)

4.2.2. The Workshop and Current Maintenance Practices

The workshop infrastructure is considered satisfactory for the size of the port, however there are certain concerns related to the tools and facilities, albeit sometimes precarious, that are provided for all tasks. One can easily notice that the responsibility for the maintenance management rests primarily with the workshop superintendent and the supervisors in the mechanical, electrical and other sections of the workshop.

The staff comprises a chief engineer who is in charge of maintenance management, personnel matters and administrative duties related to staff. A second engineer is supposed to be the link between the chief engineer and other manpower. His duty is to carry out the maintenance in practice, to co-ordinate maintenance as such and also, to distribute the various tasks that should be carried out in the workshop.

It is noticed that failure of maintenance in the Port of Praia is caused by the lack of co-ordination between the technical officers and the other manpower. For the staff at low levels there is neither clear job distribution nor defined span of responsibility. Jobs are assigned randomly and in a way that allows no delegation of the responsibility nor authority. Individuals have no accountability for their performance.

Technical staff and those at lower levels take no part at all in the organisation of their work and consequently tend to exert the minimum of effort, taking little interest in the work of the sections. In this sort of atmosphere, maintenance is obviously badly done and employee discipline is lax.

4.2.2.1. The Demand for Repairs of Equipment

Due to a lack of planning schedule of maintenance, the workshop is continually busy with a number of cargo handling machines waiting for repairs or waiting for spare parts. The workload of the workshop depends upon the peak of berths operations.

As a rule of thumb there is an increase in maintenance activity (repairs of machines) due to the unpredicted breakdown of equipment which rises with increased operations of loading, unloading and transfer operations.

The complexity of some technical systems used in certain equipment, such as electrical, hydraulic and electronic systems installed in cargo-handling equipment, combined with a lack of skills in various areas, also contribute to causing the bottlenecks observed in the workshop.

The majority of stoppages of equipment take place while the port is in operation, because of lack of communication between the two sectors, i.e. operation and maintenance departments, each department blaming the other**.**

4.2.2.2. Working Hours

The working time of the maintenance department is on the basis of the normal working time of the administration in the head office of the port. This means that the workshop functions daily between eight to twelve a. m. and between two to six p.m. and overtime is permitted when requested.

The port works only 12 hours per day so if the maintenance working hours were made independent, the remaining 12 hrs could be available for maintenance work. All kinds of maintenance could be performed in the idle time of the port, thereby considerably increasing the availability of the equipment.

The pressure of work added to the deficiencies stated earlier makes work organisation difficult. Once again the workshop staffs spend many hours and give priority to major breakdowns and repairs to accidental damage. Lack of planning, again, drives the staff to give priority to major breakdowns and to neglect the small defects in the machines until they transform into major ones, which require a much longer time to rectify.

4.3. Procedures for Actual Maintenance and Repair

As said before, the working-hours of Port da Praia is only from 7 a.m. to 7 p.m. and the working-hours of maintenance is from 8 a.m. to 6 p.m. This means that the equipment is available for maintenance at least half of the period of a day including Sunday. Therefore, the maintenance could be carried out during the idle time of berth operations.

The procedures of the current maintenance in Porto da Praia are mainly a mix of all defined maintenance policy. Therefoire, the mix of procedures can go from the diary

inspections of equipment, to planned schedule maintenance, to the circumstantial repairs of equipment when an unexpected breakdown occurs.

Due to a variety of equipment in the port the maintenance cannot be performed the same way for all types of equipment. The shortage of certain types of equipment in the port can impose different schemes for different ranges of equipment. For instance, for maintaining a FLT under the planned scheme is not difficult, because the port has a satisfactory supply of this equipment. In this case on other units can easily replace one unit that is for maintenance.

The same situation cannot be applied to mobile cranes or FELs because of the critical level of mobile cranes, as there are only three in the port. Considering that the Gottwald crane is a single option in its range, the planned maintenance is dependent largely on the demand of operations, and good co-ordination between the operation, maintenance and commercial departments. The situation faced with FELs is almost the same as with mobile cranes, only one FEL of 40-ton capacity is available.

The main activity carried out in the maintenance department is the corrective maintenance due to unexpected breakdowns. As soon as this happens, the unit is brought to the workshop for diagnosis. In such a case one of the most experienced mechanics is in charge of the first contact and then gets into communication with the department.

The main problem in the next step is the lack of historic data concerning the equipment. Most of the time this historic data depends on the memory of some mechanic, based on the past, when he worked on it in workshop, i.e. nothing that could help in the diagnosis. There are no standardised job cards describing the procedures and registration of the consumption of spare parts based on scientific procedures.

Software maintenance is ready for implementation in the maintenance department, as assured by the chief engineer of maintenance, but the difficulty to implement such a system is the lack of planning. The system could be useful for the port if there is total integration and people are prepared for the new system.

4.4. Equipment Acquisition and Spare Parts Procurement

4.4.1. Equipment Acquisition

The lack of appropriate procurement policies and strategies has caused considerable operating and maintenance difficulties as this leads to the acquisition of unsuitable machinery. Obviously some deficiencies are found in the inventory planning procedures, mainly due to a lack of technical advice or lack of forecast of the trend of international transportation. Fifteen years ago the port embarked on buying some equipment, such as two cranes of 15 tons each and several FLTs of 2.5 and 3.0 tons, mainly to be used for the operation of general cargo.

The deficiency in forecasting was mainly because the trend of containerisation at that time, so neither these cranes nor the FLTs fulfil the requirements of operations today. The lift capacities of the cranes are not enough for the containers and the masts of the FLTs are not triplex, so they cannot be used in stripping containers.

This situation is understandable because, at that time, the equipment was bought by the Ministry of Sea within the package of construction of the new port.

4.4.2. The Spare Part Acquisition Procedures and Policy

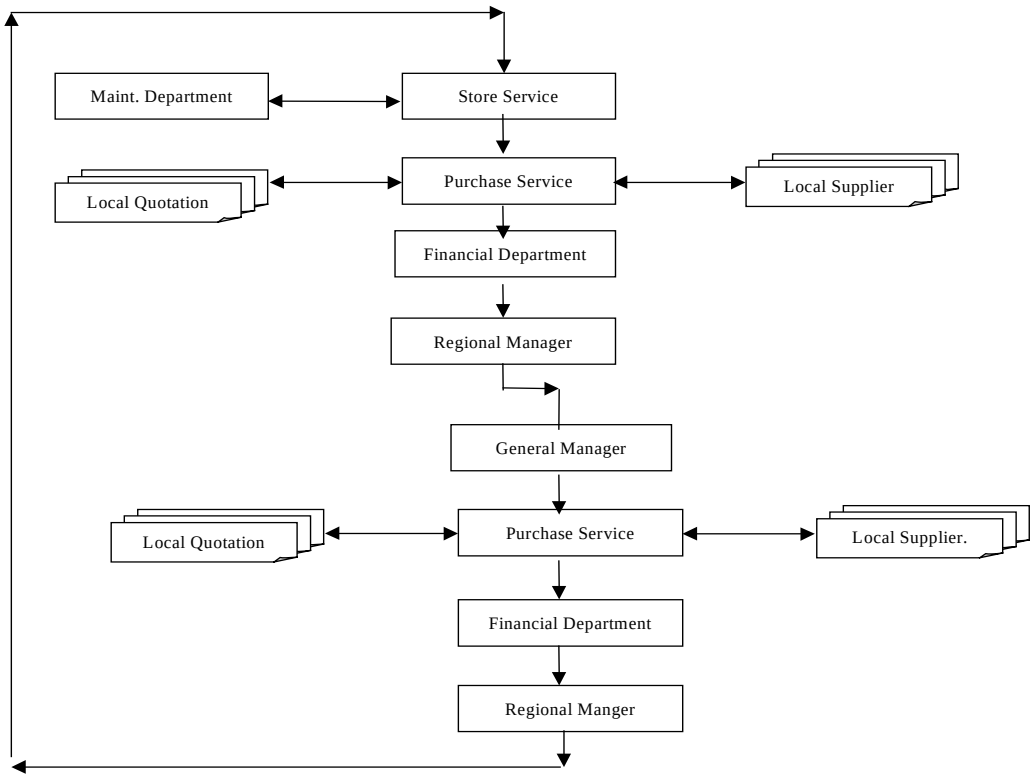
The annual operating budget of ENAPOR does not contemplate any fixed amount for a maintenance program. For maintenance there is no previous program that can indicate the specific amount spent on the various items of maintenance; for instance, the amount spent for consumable, the amount for spares on the local market, or the amount of foreign exchange for acquisition the spare parts abroad are not properly budget for.

The expense with maintenance costs is on the basis of reactive, instead of proactive procedures. The cost of maintenance is roughly calculated at the end of each year, instead of a fixed amount to be spent.

The status of ENAPOR limits the amount for buying on the local market and the process of purchase in the foreign market is complicated and also faced with the bureaucracy of other institutions such as the Financial Ministry, the Customs and other laws in force in the country.

The Supplies Service of the Financial Division is responsible for purchasing all the spare parts required by the Maintenance Department. The stock levels are set by the Supplier Service and approved by the Director of Porto da Praia. All purchases must be requested by the Maintenance Department to the Supplier Service, authorised by the Financial Department and approved by the General Manager as shown in the figure below.

Figure 5: The procedures of acquisition of spare parts



Port regulations require at least three quotations for stock items to be purchased whether locally or from foreign suppliers. For purchases involving foreign exchange, funds have to be allocated from the Central Bank with the approval of the Finance Ministry.

For this reason the current delivery for imported parts usually takes months. Because the problem of delays is too frequently encountered, technicians practise the so-called cannibalisation of equipment, whenever it is possible, on more seriously affected machines.

4.5. Distribution of equipment in the Porto da Praia

The Port da Praia is a typical multiple-purpose port where a variety amount of mixed cargo passes through the same berth, from dry or liquid bulk, neo-bulk to unitised cargo such as containers, cars or forest products.

A large variety of cargoes handled by the port impose a requirement of careful allocation and distribution of equipment for the 750 meters of quay wall and for their storage facility. As has been said before, the majority of cargo operations ship to quay and vice versa is performed by the ship's gear. However, as related to the container activity, the operation is heavily dependent on the single mobile crane capable of carrying out the container handling operations. To complement the container activity, the port allocates the equipment as shown in the follows:

Table 5: Inventory container handling equipment

Kind of Equipment	**Inventory Level**	**Capacity T = tonnes**	**Units in Operation**
Mobile Crane	1	30 t	1
Mobile Crane	2	15 t	2
FEL	1	40 t	1
FEL	1	24 t	1
FLTs	6	2.5t	6
Tractors	6	20 t	4
Weighbridge	4	30 t	4

Souce: ENAPOR - Porto da Praia

The table below can easily describe as to how low the equipment is used in Porto da Praia. The analysis refers to the level of availability of equipment of Porto da Praia during January 10, 1997 to January 10, 1998.

Table 6: Performance of Porto da Praia's equipment

Inventory Level of Equipment in Container Operation During 1998						
Equipment	**Invent level**	**Availability of Operation**	**Utilisa-tion**	**Maitnan Effecien**	**Age.**	**Cap.**
GOTTWALD 150-49	1	74.1 %	34.4 %	71.4 %	13	30t
Nelcon N 125-LHO	1	76.6 %	37.2 %	70.0 %	13	15 t
Nellen 125-LHO	1	69.4 %	31.7 %	72.9 %	13	15 t
Nelcon N 109LB	1	81 %	40.0 %	68.7 %	13	10 t
Hyster H40.00	1	83 %	41.6 %	90.4 %	3	40 t
Lansing 25.0TR	1	79.2 %	40.0 %	85.8%	14	25 t
Toyota 2FD30	3	84.4 %	41.6 %	90.4%	3	3.0 t
Toyota 2FD30	2	79.2 %	40.0 %	72.1	13	3.0 0
Mercury Reliance 801	2	84 %	37.3%	90.4	3	20 t
Mercury Reliance 801	1	80.1 %	35%	71.3	13	20 t

Source: Maintenance Department of Porto da Praia (1997 –1998)

In the table above, the inventory level means the number of equipment that the port has for container operations. In the case of ship to shore or shore to ship, both the operations can be performed mainly with a mobile crane with 30 tons of capacity or a combination of the two 15 ton cranes. For transfer operations, FELs combined with tractors are mainly used and FLTs are used to perform other activities like stripping, stuffing, and sorting the commodities for Bill of Lading (BL) in the warehouse.

Availability of equipment is the percentage of the time that the equipment is available after deducting the actual time that the equipment is drawn for maintenance. It is calculated by subtracting from the Possible Machine Hours in that period, all the times when the equipment is out of service because of breakdowns, maintenance, repairs or other reasons.

It must be acknowledged, however, that there is a disagreement over whether the formula to be used should be Possible Machine Hours or Total Hours in the period; some operators claim that, in a working week, a machine should be considered as theoretically available for 168 hours (7 days at 24 hours), since the machine could, if it is in working order, be used at any time in the 24 hours. Others, however, take the view that it is unrealistic to include the hours when the berth does not work. They use the Possible Machine Hours for Utilisation, on the basis that this measure represents the maximum number of hours in which, in reality, the equipment could be working. Providing consistency is insisted on when making comparisons, it does not really matter a great deal which approach is adopted, although in this analysis the Possible Machine Hours measure is used throughout.

Once again, we should take the multiple purpose mobile crane to analyse the real situation of maintenance at Porto da Praia, due to the port's dependence on this equipment. Last year, as the chief engineer of the maintenance department said, for example, the mobile principal crane was out of service for maintenance and repairs for 30 % of the time during the year.

Taking into consideration that the working hours of the port are almost 72 hours per week, 30 % of this time is 22 hours per week when the equipment is under repair or being maintained on average. Because the port working hours is only 12 hours per day

this indicates that the equipment spends nearly two days per week on average out of service.

The major breakdown of this equipment is failure in the electrical and electronic systems. The background of two engineers of Porto da Praia is in the mechanical area. Porto da Praia has to call for the expert from Porto Grande when the electrician of Porto da Praia cannot solve the cause of a breakdown.

This is the main reason for the long periods that the equipment is out of service, causing the low availability of such equipment. Either each time the technician from Porto Grande has to come to solve the problem or some components have to be sent to be fixed in Porto Grande. Hence, the equipment is idle for some days waiting for the technician or the component to come.

The cost of maintenance of this equipment cannot be calculated in a straightforward manner because of the lack of managerial systems in the ENAPOR that can allow the calculations of the unitary cost for each piece of equipment.

This situation implies that there is an increase in all maintenance costs. The port can lose the profits because the equipment cannot be used for operations for a long time and also the frequent breakdown can affect the efficiency of the port. The efficiency of Porto da Praia is heavily dependent on the efficiency of this mobile crane; most of the time the work in the port has been stopped, it has been due to the breakdown of this equipment.

The ratio of utilisation is the effective working hours in a given time period of equipment per actual possible working hour in percentage. The possible working hours in Porto da Praia is about 12 hours per day. The port generally works only 6 days per week. Consequently, the maximum working hours possible in Porto da Praia is only

50% of hours of the day. In principle this means that the utilisation of equipment could be 50 % of a day without any breakdown if the maintenance and repairs are not performed during the berth working hours.

Because the working hours of the workshop coincide with the working hours of the administration of the port, the maintenance is performed within the berth working hours in general. Of course this contributes to a decrease in the utilisation of equipment to the level that is shown in the table above.

Another concern that can affect the operational productivity is the displacement of equipment. Many times a mobile crane capable of handling a container is requested from one ship to another ship only to lift a few containers.

The mixed cargo movement in the port, as said before, requires the use of a mix of equipment, such as a small FLT, tractor-trailers and also heavy FEL, some of which have a low rate of the utilisation.

The maintenance efficiency ratio is the percentage of the time that the equipment is being maintained during the working hours of the berth. As said before, all maintenance in the port is performed between 8 a.m. to 6 p.m. This shows that the equipment is put out of order to be submitted for maintenance and repair.

Another concern that can be pointed out is the allocation of quay transfer equipment. Because of the mix of cargo, as said before, not only are small fork lift trucks (FLTs) and tractor trailers used but a heavy front end loader truck (FEL) is also requested most of the time, with a low rate of utilisation.

4.5.1. The Effect of Lack of Co-ordination Between Departments

The equipment in Porto da Praia is implicitly under the control of the operation department, although there are no written policies that determine if the equipment is under the control of the Maintenance Department or the Operation Department. Because drivers are under the control of the Operation Department, it is assumed that the equipment is also under the control of the Operation Department.

The lack of co-ordination starts when the Operation Department draws the plan for the following day's operational activities without any consultation with the Maintenance Department, not knowing if the equipment is available or the equipment is being maintained.

The Operation Department has been complaining that the Maintenance Department holds on to the machines once they have them in the workshop, that they take excessive time to service and repair them and that they refuse to releases a machine to meet any unexpectedly high cargo-handling demands. On the other hand, the Maintenance Department blames the problems on the poor quality of equipment handling saying that drivers seem to have a very careless attitude to their work. They show no sense of responsibility, even when driving large, expensive and potentially dangerous machines, which may be the major cause of frequent breakdowns.

This situation has created a lot of embarrassment especially when something happens that affects the operational procedures or provokes delays to the turnaround of the ship in the port.

4.6. Inventory Control

The inventory level of any port depends upon of the level of utilisation, the availability and the downtime of equipment in the port.

Assuming that the equipment utilisation is a measure of the proportion of time that a machine is actually doing useful work, it is clear that this port has a low utilisation of its equipment because the working hours are only 12 hours, on average, per day.

There are also some surpluses of the same types of equipment. For example, the port has more than enough FLTs of 3.0 tons and 2.5 tons for their needs. Others equipment is at a satisfactory level, such as FELs that are two for the transfer of container activity. However, the same equipment is deficient in numbers and this becomes crucial for efficient port operations. This is the case for equipment that assures the cargo handling ship to shore and vice-versa, for example, a crane**.**

This means that the breakdown of different equipment will have a different effect on the operations. For example, the breakdowns of the only one available crane capable of carrying out the container operation. When this happen all the operations of containers in the port stop, because it is the only option in this port for containers or heavy cargo. In the case of the failure of other equipment, such as FELs or FLTs, other units are available to replace them for the repairs and to maintain the cargo operations.

The Available Machine Hours are the hours that the equipment is actually available for use in a prescribed period this can be a day, a week, a month, etc. It is calculated by subtracting from the Possible Hours, in that period, all the hours when the equipment is out of service because of breakdowns, maintenance repairs or for other reasons. On the

other hand, the Demand Availability is a measure of the percentage of time that the equipment is available when requisitioned by the operators. It is an indicator of the shortfall between demand and supply. Finally, Downtime is the technical term used to describe the time when equipment is out of service and unavailable for use during berth working hours.

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

5. 1. Conclusion

The author, in an attempt to analyse the present situation in the ENAPOR, especially related with the Maintenance Department of Porto da Praia, has tried to point out the major problems that have been affecting this Department in the Porto da Praia.

It is clear that the maintenance in Porto da Praia has been affected greatly by the way in which the ENAPOR has been managing all ports in Cape Verde. The organisational structure of this enterprise that manages ports is a big obstacle in streamlining the processes of maintenance in the port.

The inadequate maintenance policy, particularly adopted by the Maintenance Department of Porto da Praia, contributes to the current state of the equipment in this port. The inventory level of Porto da Praia is also an issue to be taken into consideration. Apart from the insufficient numbers of specific equipment capable of carrying out the current major operations in the port, most of the equipment exceeds the economic age. Consequently, the Maintenance Department of Porto da Praia has to set up the right maintenance policy in order to make the ports' equipment more efficient.

In the second chapter, the theoretical maintenance systems were discussed and a comparison between the theoretical maintenance and the maintenance policy that has been used in Porto da Praia were analysed. It is clear that the port has not been using any theoretically sound maintenance policy and a vicious circle of repairing equipment after unpredicted breakdowns, as a purely reactive action, has been adopted. It is essential that all short and long-term plans be adopted with a sound maintenance policy for increased efficiency and the development of the Porto da Praia.

As far as the maintenance policy is concerned in the Porto da Praia, there is no doubt that the port has not used an adequate maintenance policy even though an acceptable workshop's infrastructure is available for maintenance. Special attention is given to the scarceness of hand tools, which is an organisational matter that can be solved immediately.

The third chapter describes the trend of activities in Porto da Praia. The container movements have increased to the order of 15% per year on average during the last four years. On the other hand, the general cargo has had a slight increase of 3% for the same period. The necessity to update the port with suitable equipment capable of carrying out the container operations is essential.

Moreover, the sort of equipment available is not ideal, which has an effect on the performance of the port. For instance, there is only one crane carrying out the container operations and the other two cranes are not new. It is evident that the throughput of the port does not justify not having more than one multiple purpose crane, especially as an increase in container activities is anticipated.

By looking into the organisational structure of ENAPOR, it can be realised that there is an overlap of functions in some departments of each port, mainly Porto Grande and

Porto da Praia. It does not make sense to involve Porto Grande in the decision taking of the Porto da Praia. This situation is the reason for increased bureaucracy, and has been the cause of most of the delays in decision taking for the port of Porto da Praia.

The procedures of acquisition of spare parts, especially when dealing with imported parts, if directly authorised by the Regional Manager, rather than the long bureaucratic procedures going till the final approval of ENAPOR, will be much more suitable. A mechanism of control of these procedures is also essential.

Regarding the personnel requirements, the maintenance staffs seem quantitatively sufficient. However, as described in the fourth chapter, upgrading staff is urgently required. This certainly qualifies as one of the major problems for the maintenance department. Because of the total dependency of the port on a single crane it is necessary that an expert, or a team of experts, be developed, who are able to cope with all the electronic and electrical failures that this crane can develop. This should be immediately arranged until other suitable long-term arrangements are made.

The current maintenance practices, which suffer from a lack of proper procedures, are another problem to be considered. Clear lines of communication between the chief engineer, the second engineer and regular mechanics need to be established within the department. Furthermore, proper operational procedures and channels of responsibility need to be defined in order to better organise the maintenance department.

The demand for scheduled maintenance rather than the unpredicted repair of equipment should be planned according to the workload of berth activities. Because the availability of equipment for the maintenance is almost 50% of the time in the port, the major maintenance that requires the stoppage of the essential equipment for the operation in this port should not be carried out within the berth working time. Flexible working

hours of workshop maintenance staff working in shifts can reduce the down time of equipment.

The lack of a proper computerised maintenance system is another area in need of urgent attention. Although the port purchased a maintenance software package more than five years ago, it is still not in use. This has resulted in maintenance being based on the memory of mechanics rather than an accurate computer database. The immediate implementation of this software is important, because although after five years it may not be up-to-date, its for better than nothing.

The port needs to concentrate on providing maintenance, as best as possible, for the main equipment, making it work effectively in order to compensate for the inadequacy of maintenance or the variety of equipment. The volume of the movement of cargo does not justify new acquisitions. On the other hand, to improve the performance of maintenance, the spare part policy needs to be changed. The Regional Managing Director should have more autonomy in the process of acquisition of spares, as this will drastically reduce the time consuming bureaucracy involved in the present system of ordering spares through the central port authority, ENAPOR.

5. 2. Recommendations

Based on the findings, it is recommended that in order to improve equipment maintenance, the following recommendations should be considered:

- The Maintenance Department should establish an effective record of data using a suitable software program in order to establish a MIS to improve maintenance and inventory control.

- The organisational structure of ENAPOR should be revised in order to give Porto da Praia complete autonomy concerning the acquisition of spare parts.

- A correct policy of equipment maintenance should be adopted for the Maintenance Department rather than a reactive attitude of repair of equipment after breakdown.

- A better co-ordination between the Operation, Maintenance and Financial Departments in Porto da Praia should be established in order to have a better distribution of resource and use of equipment.

- Porto da Praia should establish an appropriate training program to upgrade the skills of the staff. In the mean time an immediate requirement is an expert, or a team of experts whom should be employed to repair and maintain the electrical/electronic system resulting in minimum down time.

- Porto da Praia should create a specialised team with a background in areas such as electrical and electronics repair maintenance.

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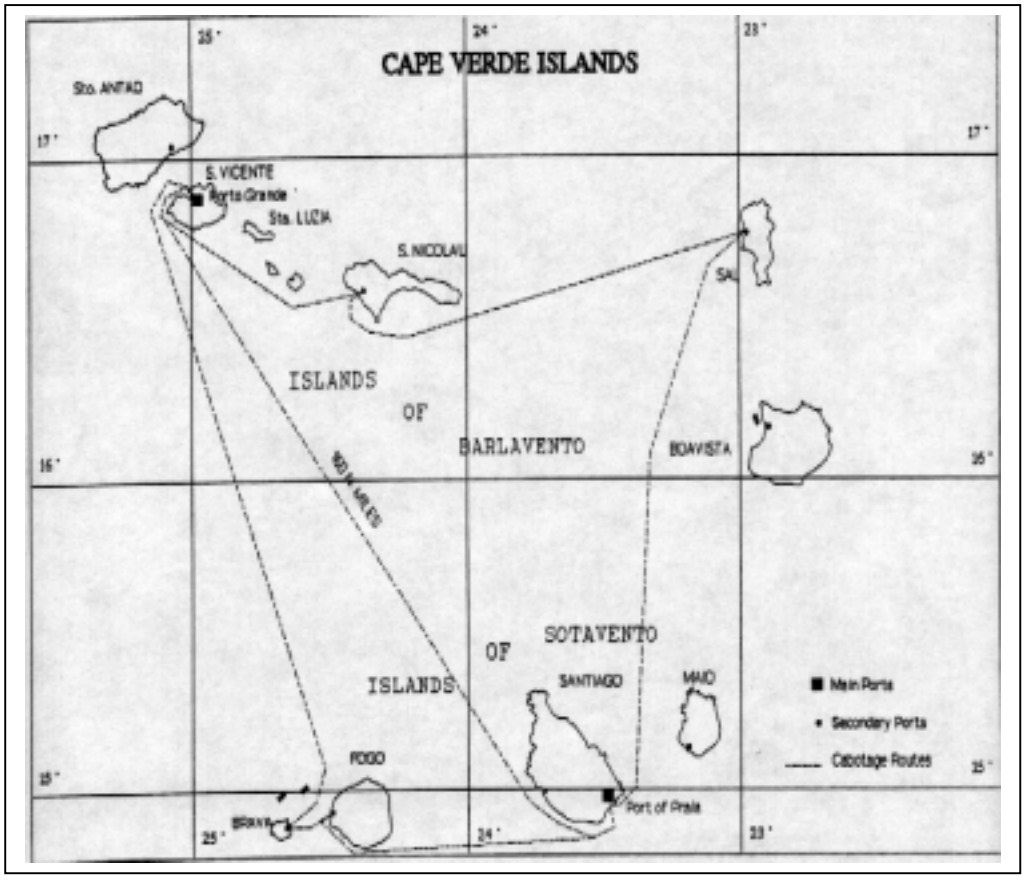
APPENDIX 1

Geographic location of Cape Verde Islands

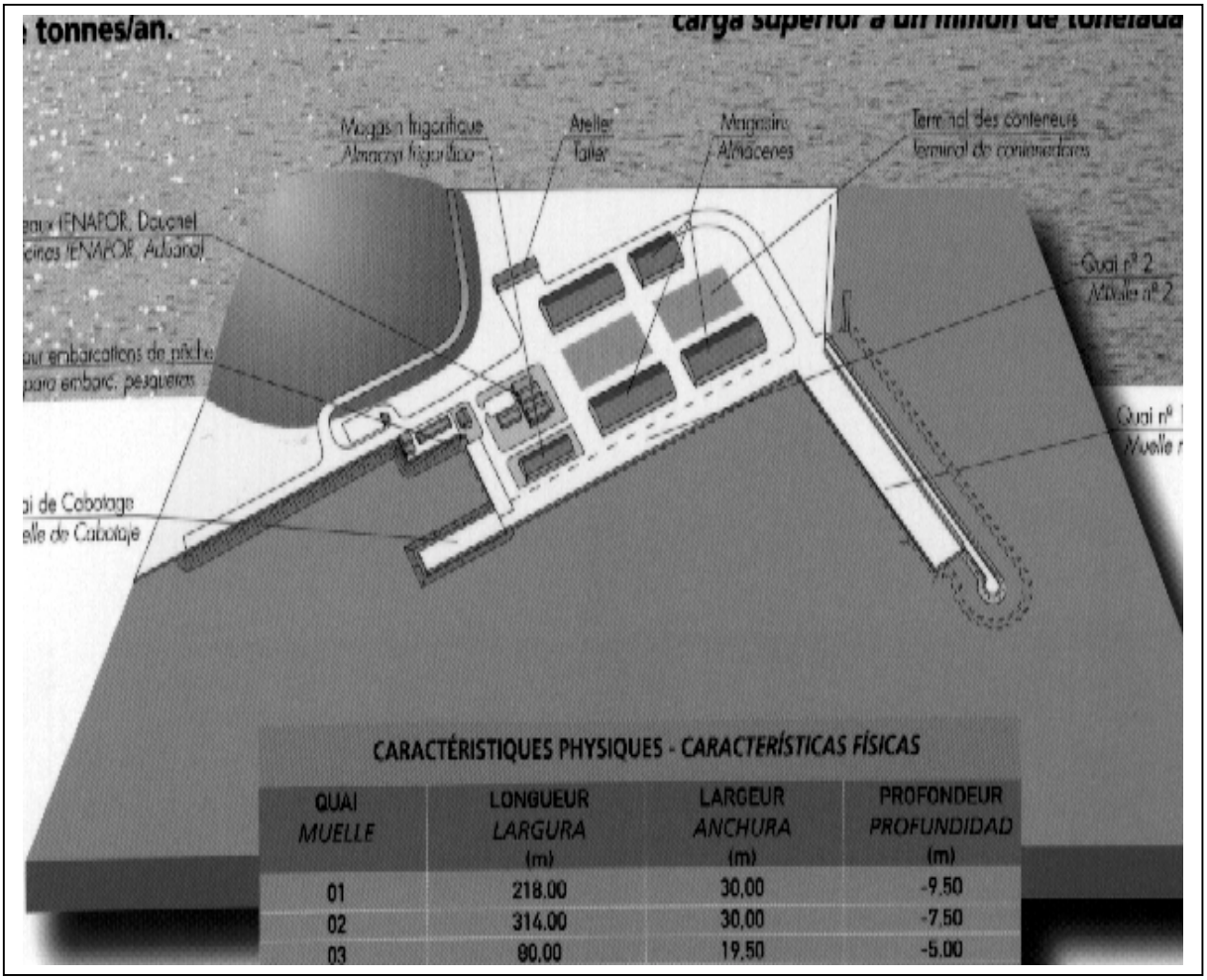
APPENDIX 2

Cape Verde Islands Ports and Routes



APPENDIX 3

Porto da Praia – Santiago Island



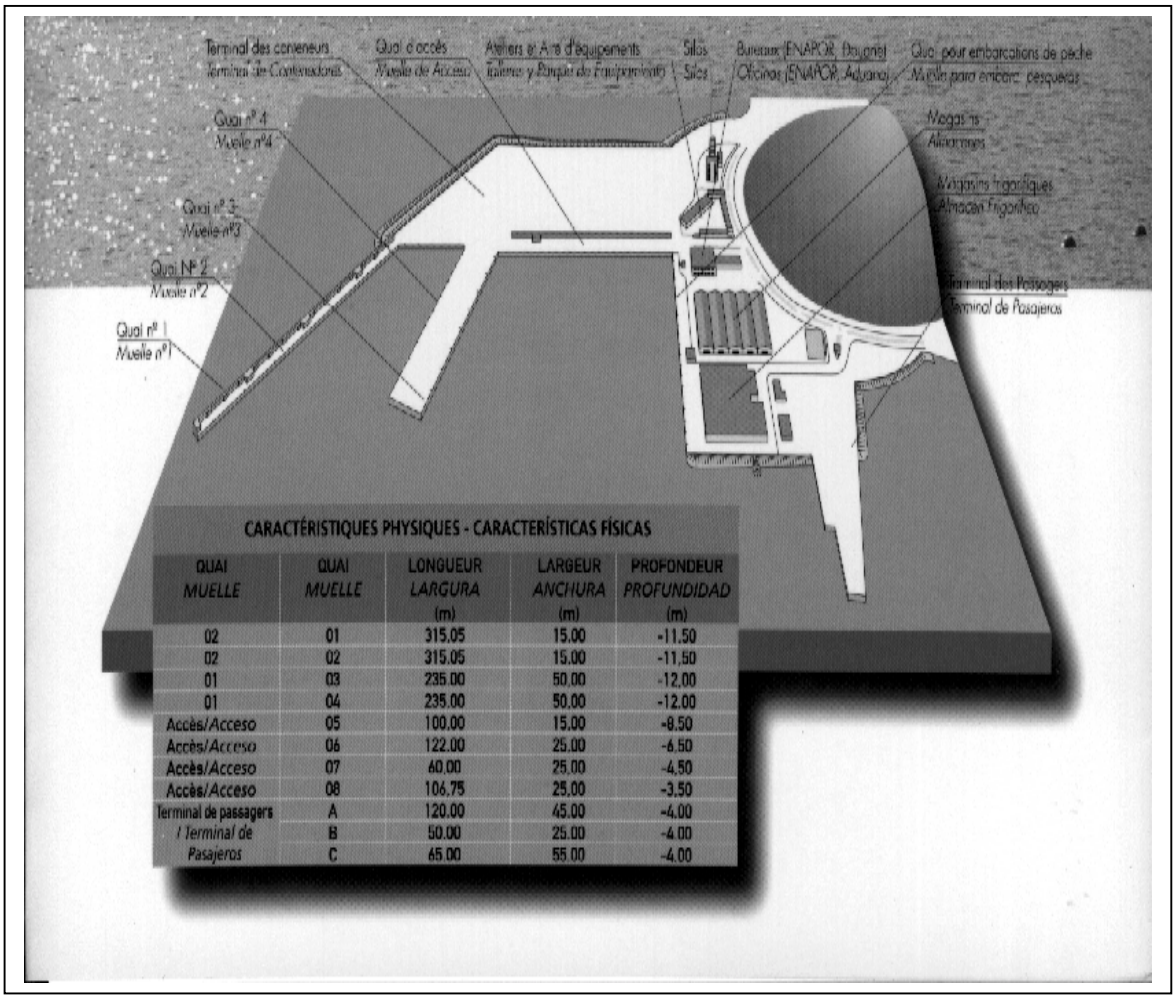
CARACTÉRISTIQUES PHYSIQUES - *CARACTERÍSTICAS FÍSICAS*

QUAI *MUELLE*	LONGUEUR *LARGURA* (m)	LARGEUR *ANCHURA* (m)	PROFONDEUR *PROFUNDIDAD* (m)
01	218.00	30,00	-9,50
02	314.00	30,00	-7,50
03	90.00	19,50	-5.00

Source: ENAPOR

APPENDIX 4

Porto Grande – S. Vicente Island



Source: ENAPOR