GUJARAT MARITIME BOARD

RO-RO FERRY SERVICES IN THE GULF OF CAMBAY

DRAFT FINAL REPORT

Beckett Rankine Partners
Kashec
Ray Infrastructure

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GUJARAT MARITIME BOARD RO-RO PROJECT

DRAFT FINAL REPORT

CONTENTS

APPENDICES

0.0 EXECUTIVE SUMMARY

0.1 Gujarat Maritime Board (GMB) appointed the consortium of Beckett Rankine Partnership, Kashec and Ray Infrastructure to conduct the detailed study report of five potential terminals for operation of a passenger cum ro-ro ferry service in the Gulf of Cambay.

0.2 This draft final report contains the findings of this project. This main report volume contains a description of the work carried out and highlights the key aspects of the study. The separate volumes of appendices contain the design drawings for the terminals together with the data on which these designs are based. This includes the topographic, hydrographic, geotechnical and hydraulic site investigations that were carried out for this project.

0.3 As the ro-ro concept is relatively new to India, we have included a section relating to the international practice for this type of ferry service. Examples have been included to demonstrate how effective these ferries have become at other locations.

0.4 Three sites were designated by GMB as ferry terminals at the start of the project, namely Dahej, Gogha and Suvali. Ferry terminals have been designed for these locations as part of this study. A further two sites, at Jafrabad and Pipavav, were identified as possible locations. The relative merits of these sites have been studied and as a result it is suggested that a ro-ro terminal will, in due course, be developed at the Port of Pipavav.

0.5 Likely ferry routes have been examined and indicative costings have been attributed to the provision and operation of shore facilities and the ferries themselves. A mathematical model has been run to simulate the numbers of users for the ferry service, based on origin-destination data collected for GMB before the start of the study. A ferry route linking to Mumbai has been included, but consideration of terminal facilities is outside the scope of this study.

0.6 Attempts have been made to defray the costs of terminal development by attracting joint venture partners who would utilise part of the marine infrastructure.

0.7 Saurashtra Cement has been identified as a joint venture partner for the terminal at Dahej. A jetty is to be constructed so that cement can be imported at the terminal.

0.8 No joint venture partner has been found for Gogha.

0.9 The position at Suvali is complex because of other port developments at that site, in partic the proposed LNG terminal for which Shell have been awarded the concession. The f terminal has been designed to fit in as part of the overall port development.

This report concludes that:

- There is a potential demand for ferry services across the Gulf of Cambay.
- Revenues generated from the single ferry service between Gogha and Dahej will support the construction cost of the terminals.
- A ferry service between Gogha and Suvali is the best ferry route between the thr terminals, but, although returning an operating profit, may not support the full costs the terminals.
- The best prospect for a successful ferry service is to develop a network that include links to Mumbai and Pipavav.
- The Suvali terminal is critical to the creation of any ferry service and needs to be a integral part of any port developed at Hazira.
- Private sector ferry operators will only become interested in this project if som Governmental controls are relaxed.
- Ferry operators with international experience will be needed for the successf operation of a ferry service in the difficult waters of the Gulf of Cambay.
- Water depth at the terminal at Dahej and in the approach channel is likely to b affected by the construction of the Petronet LNG terminal.
- Effective designs have been prepared for the ferry terminals. However some aspect could be refined through model testing which was outside the scope of this study.

1.0 INTRODUCTION

1.1 Terms of Reference

1.1.1 The Gujarat Maritime Board (GMB) is planning the introduction of a network of ferry services and around the Gulf of Cambay. In this first stage, up to four terminals are to be constructed selected locations on the east and west coasts of the Gulf.

1.1.2 The ferry network is intended to speed up travel within southern Gujarat and betwe Saurashtra and south Gujarat and at the same time relieve congestion on the state highwa around the Gulf. Ferries will link the four terminals and there will in addition be a link Mumbai. Further expansion will develop routes serving destinations further south in India wi the possibility of international routes to the Gulf States to the west

1.1.3 There have been previous attempts to set up ferry services across the Gulf, but for variou reasons none of these has been successful, and indeed only one actually resulted in a operational ferry service. Some facilities were constructed at Gogha and Dahej but are no suitable for incorporation in the present development proposals; facilities at Pipavav were never brought into service and have subsequently collapsed. The reason for the lack o success is explained by previous studies, confirmed by our own, which have shown that the initial costs of constructing the terminals and infrastructure and commissioning the ferries are higher than can be supported by revenues during the development stage of the service. We have therefore looked for additional sources of finance by seeking joint venture partners to share the costs of terminal construction; in addition, we understand that the State Governmen will support the venture on the basis that it will offer social value.

1.1.4 The Terms of Reference issued on 7th June 1996 require the study and design of ferry terminals at Gogha, Dahej, Suvali and Pipavav/Jafrabad, together with supervision of construction in respect of Gogha, Dahej and Suvali. Operational and economic studies are also included.

1.1.5 Following assessment of tenders for the study, the contract was awarded in August 1997 to a consortium comprising:

- The Beckett Rankine Partnership, London, UK
- Kashec, Royston,UK (including Indian subsidiary Kashec, Pune)
- Ray Consultants, Baroda, India (subsequently renamed Ray Infrastructure)

1.1.6 This project is divided into five tasks::

Task One - Site Selection

Selection of specific sites within the broad geographic locations. In particular a target depth of 5m is required to be available at all times.

Task Two - Development Plan

Studies are undertaken at the detailed sites and alternative layouts and forms of construction are evaluated. A preferred layout and design is selected

Following selection of a preferred design, detailed design is undertaken and documentation is drawn up for tendering.

Task Three - Techno-Economic Study

A Techno-Economic study is made to consider the operation of the terminals in conjunction with an economic assessment of the ferry operations.

Task Four - Ferry Operations

In this task, operational issues relating to the ferries are considered with an emphasis on safety and contractual aspects.

Task Five - Supervision of Construction

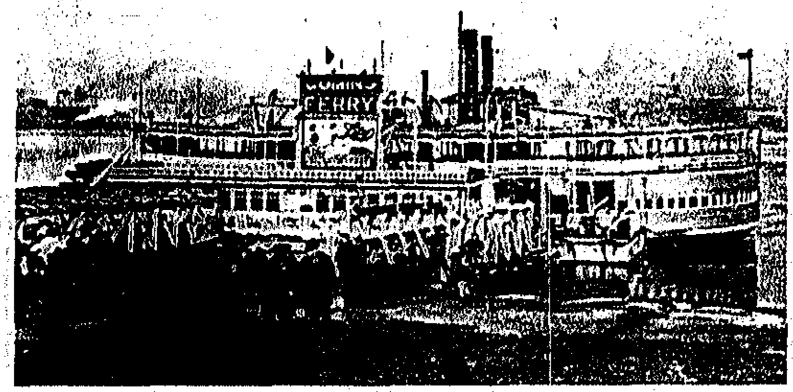
This task includes the tendering process and selection of preferred contractor(s). Supervision of the work on site will be the principal activity and this will include ongoing administration of the construction contracts. This task will also include training of terminal operating staff.

1.1.7 This report is the third to be submitted for the project and draws together and builds on the conclusions reached in the first report (the Progress Report of September 1997) and the second report (the Interim Report of April 1998). A Final Report will be submitted after review of this report.

1.2 Ferries, Ro-Ro and Application to Gulf of Cambay

Ferries

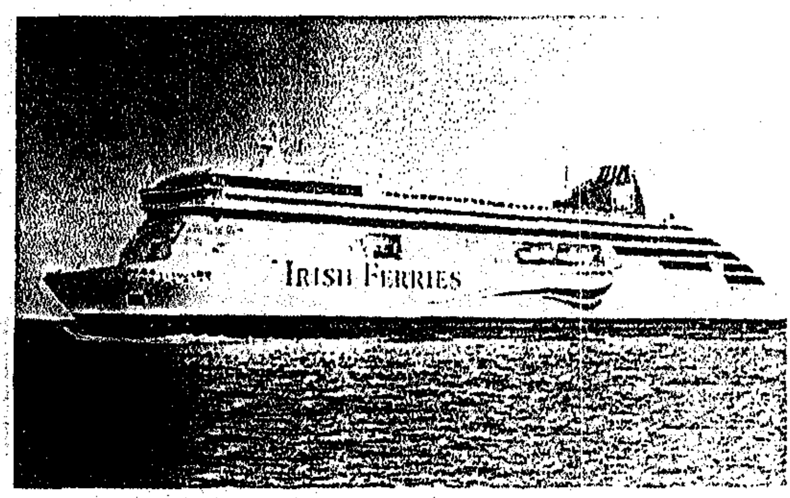
1.2.1 Goods and passengers are transported from one shore to another by ferry boats in many parts of the world. This is an activity that has continued from early times from paddle and wind assisted vessels, evolving gradually through the ages to the sleek high performance vessels of the modern era.



An Early Passenger Ferry

1.2.2 The essential requirement for a ferry service to exist is a water crossing, whether this is a river, estuary, gulf or sea. This crossing is usually reasonably short with a duration timed in minutes or hours rather than days. For the ferry service to be successful it must be either cheaper or quicker than an alternative means of transport or preferably both of these. This is relatively easy to achieve in the case of sea crossings or inter island transport. However when crossing an estuary or a Gulf the alternative of driving around the head of the inlet must always be considered.

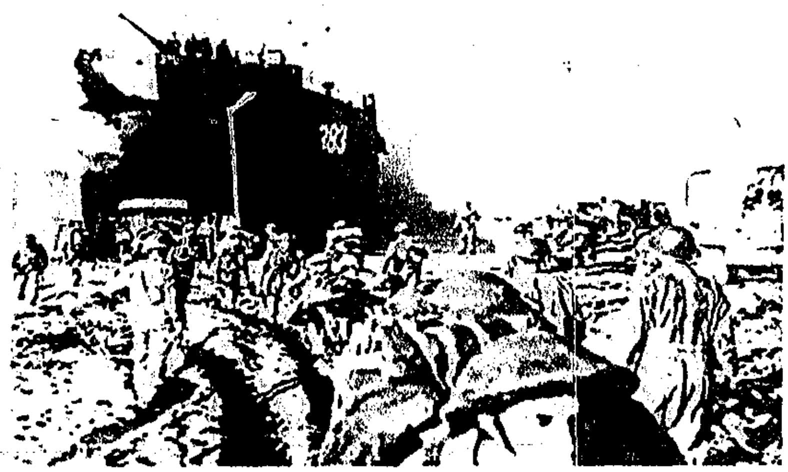
1.2.3 Nowadays there are many types of ferry to consider, as set out elsewhere in this report. The three principal categories are passenger only, passenger combined with freight and freight only.



Ulysses – The largest Ro-Pax Ferry in 2001

Ro-Ro

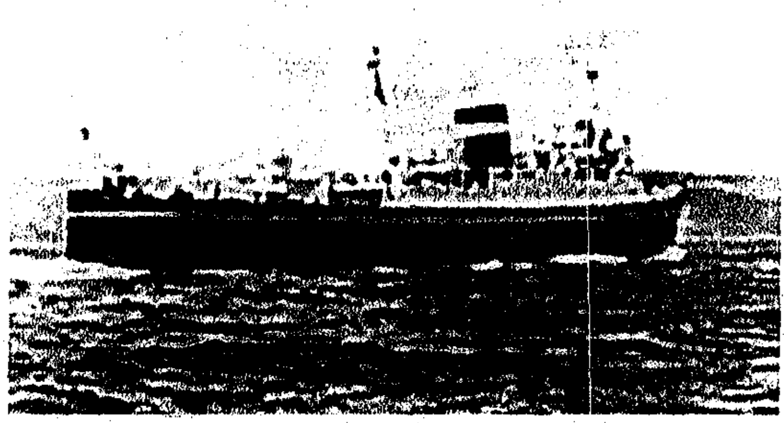
1.2.4 Roll-on, roll-off (or Ro-Ro) ferries are special vessels onto which vehicles can drive and be accommodated for the sea journey on special vehicle decks within the vessel. These ferries often have significant accommodation for passengers and will carry cars, trucks, buses or trailers to their destination together with the drivers and passengers. Some ro-ro ferries are freight only carrying unaccompanied trailers, containers or other types of freight.



LST in Action During World War II

1.2.5 Ro-Ro ferries have developed from military vessels such as landing craft and the LST (Landing Ship Tank), from the Second World War. These were used with great success to land tanks and other military vehicles on enemy shores with temporary harbours or directly onto beaches where no harbours existed.

1.2.6 Following the end of the war in 1945 some of these LST's were used as commercial ferries. The world's first purpose built commercial ro-ro vessel, Bardic Ferry, was fabricated in Scotland in the 1950's and put into service on the Preston to Larne route between England and Northern Ireland. This vessel could carry lorries, buses and even tanks should a military emergency arise.



Bardic Ferry

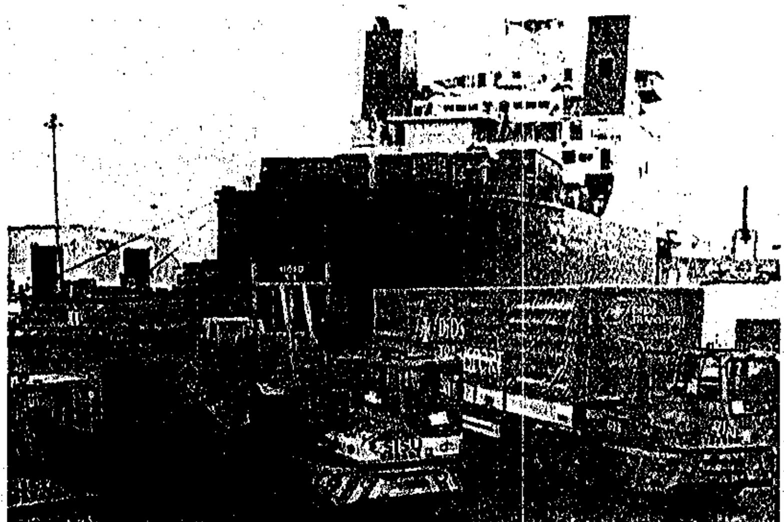
1.2.7 Since then ro-ro ferries have become ever more sophisticated with owners constantly striving for greater efficiencies and improved quality of service. The principal driver for the development of ro-ro vessels has been the English Channel with a multitude of ferry routes linking the UK with the ports of northern France, Belgium and Holland. Until the channel tunnel was constructed to provide a fixed rail link there was no alternative and ferry operations were profitable on these routes. Scandinavia has also traditionally had an extensive route network across the Baltic Sea and recently there has been a considerable development of the ferry links between UK an Ireland across the Irish Sea.

Types of Ro-Ro

1.2.8 There are several quite distinct types of ro-ro services that currently operate on the world's shipping lanes. Each has its own dedicated class of vessel to enable efficient operation for the designated purpose.

1.2.9 'Car ferries' that have traditionally been operated at many ports have been developed and refined over the years and are now referred to as 'Ro-Pax' indicating a combination of accommodation for (car and truck) ro-ro together with passengers. During the last five years we have seen the introduction of new fast ro-ro ferries. Initially these vessels were introduced as passenger ferries with a car deck, evolution continued with the additional capability of carrying coaches and now some fast ferries transport trucks as well.

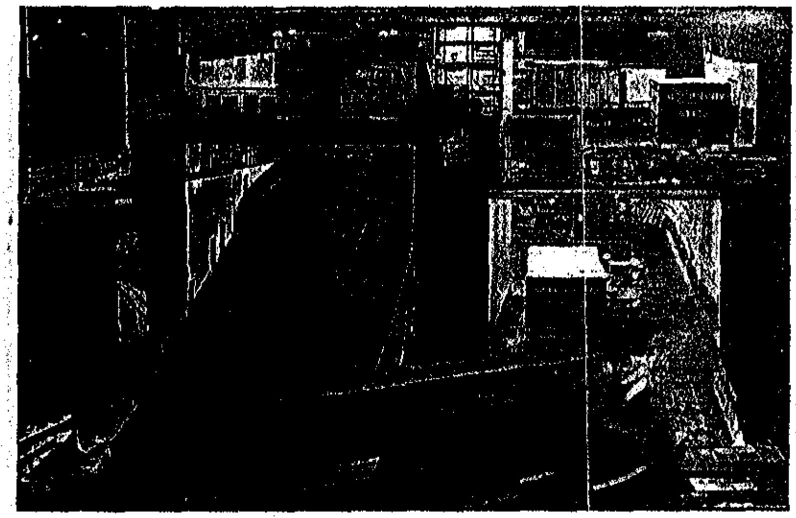
1.2.10 In addition to the most commonly conceived notion of ro-ro vessels transporting road going cars and trucks, the ro-ro mode of shipping can also be an efficient means of handling palletised cargoes as well as being a competitive system for transporting containers. It is clearly more flexible than conventional shipping in so far as units of almost any size can be loaded together and loaded quickly. Another advantage over lift-on, lift-off is the lack of need for sophisticated ports with container cranes. Ro-ro ships require berthing dolphins to moor against and pontoon with bridge or linkspan to the shore. In many places it is even possible to lease most of the shore equipment.



Unaccompanied Trailers discharging from Ro-Ro Vessel

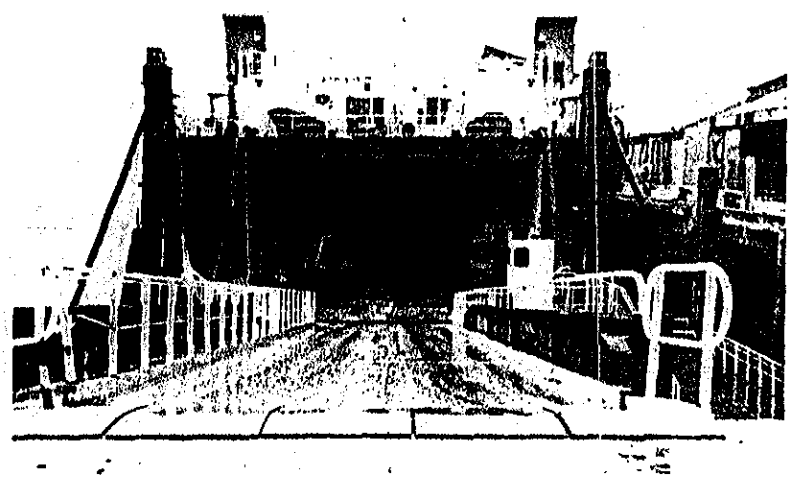
1.2.11 In recent years more and more commodities have been containerised in most parts of the world and many ports have constructed specialised berths with ship-to-shore container gantry cranes. With the cost of large ro-ro vessels approaching 50% more than an equivalent container ship, deep sea shipping operators have a clear preference for container vessels rather than ro-ro. However, for short sea operation the situation is different with the speed and flexibility of ro-ro giving this mode a benefit, particularly where there is a large volume of diverse cargoes. This can be carried efficiently in relatively small ro-ro vessels.

1.2.12 Ro-ro traffic includes all cargoes that can be wheeled on and off a ship, either under its own power with a driver (accompanied freight) or as a trailer by itself (unaccompanied). In a variation of unaccompanied freight cargo is placed on low 'MAFI' trailers which are not road going. MAFI trailers can carry containers up to 2 high, palletised cargo or anything else. These trailers remain at the ro-ro vessel for the sea crossing and are then discharged by tractor units at the destination.



Loading Freight Ro-Ro at Night including 2-high containers

1.2.13 In a further variation of the ro-ro system, cargo is taken off the trailer once inside the ship and block stowed on the deck. This is called Sto-Ro and is principally used for forest products.



Cargo Stowed on a Ro-Ro Ferry Deck

Requirements for Ro-Ro

1.2.14 The essence of a ro-ro service is that it provides an extension of the road system. Quick turnaround is essential and close proximity to a twin lane highway is highly desirable.

For a ro-ro ferry service to operate efficiently and successfully it is necessary to have:

- Specialist ro-ro vessels of suitable types;
- Shore terminals with appropriate facilities;
- Efficient and straightforward operating procedures.

Ro-Ro Vessels

1.2.15 Purpose built ro-ro vessels have a watertight door in either the bow or stern which is capable of opening to form a ramp for vehicles to drive in and out of the vessel. The hold of the vessel comprises a series of decks for vehicles to park with sloped roadways or elevators to enable vehicle access to the upper and lower decks. The size and layout of crew and passenger accommodation is dependent on the requirements for any particular route and can range from modest to extensive with several lounges, restaurants, shops and cabins on popular longer destination routings.

Shore Terminals

1.2.16 Shore terminals for ro-ro vessels are rather different to conventional ports. Naturally a safe and sheltered berth is required for the ferry. A ramp is needed to link between the vessel's vehicle deck and the shore jetty or dockside. This ramp of often called a linkspan and it has to accommodate both the various deck levels on different vessels as well as the varying sea levels for different states of the tide. The ship's ramp rests on the linkspan while vehicles are driven between ship and shore. Most ro-ro vessels are reasonably shallow drafted with many ports able to operate with depths of 5m while even the largest ro-ro ferries have a draft of only about 9m.

1.2.17 A considerable amount of paved land is required at the shore terminal. Unlike a container or bulk port where the berth capacity is largely dictated by the speed of the cargo handling equipment, a ro-ro berth's capacity is dictated by the supporting land area. Ro-ro berths can be hugely land hungry particularly if the cargo has a long dwell time in the port as can happen, for example with trade cars.

Operations

1.2.18 Successful ro-ro ferries services are operated with great efficiency, usually by private sector companies. The important elements to the efficiency are:

- Fast turnaround at the berth with vehicles unloaded and loaded quickly and rapid servicing with fuel and provisions;
- The charges for ferry are suitable to make it viable.
- A regular and well published time table of sailing that is closely adhered to; safety precauti
- Good management, operation with great efficiency, etc –
- No interference to schedules by unnecessary official procedures. - customs clearance port clearance etc.

1.2.19 These ferry services will be well patronised if they provide a transport service that delivers cargo and passengers more quickly from origin to destination than any alternative. For any ferry route it is therefore essential to consider the alternative means of transport between the start and finish of the desired route. This comparison is especially relevant when there is a road system making it possible to drive between origin and destination, as opposed to the case of connection to an island where the alternative would be other shipping routes or by air.

1.2.20 The cost to the user is also an important factor that influences the success of a ferry service. Clearly these costs have to be in line with alternatives – this means a lower cost unless there is a specific reason that a premium can be charged.

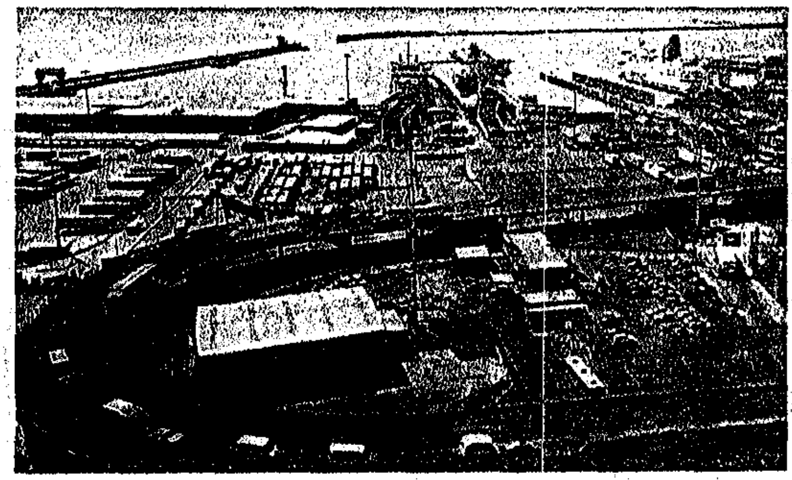
1.2.21 Ferry companies operate ferries on specific routes with the objective of making a commercial profit. Fares that are charged have to reflect the operating costs with an appropriate premium which will depend on their commercial risk. The basic fare prices can be augmented by sales of food and drink etc both on board the vessels and at the terminals. In recent years the ferries on the English Channel have generated considerable profits for the shipping companies through sales of duty-free alcohol. With a change in regulations on taxation, duty-free is now not applicable and ferry operators have had to consolidate to stay profitable with the added competition from the channel tunnel.

Safety

1.2.22 The safety of passengers and crew on a ro-ro vessel is of paramount importance. With correct procedures the vessels can be operated safely. However, there have been some tragic accidents which demonstrate the inherent instability of ro-ro vessels when water is permitted to flood the vehicle decks. Similarly, the ship to shore linkspans and access bridges are used safely every day at dozens of ports around the world. But, again, there have been accidents, resulting from a failure in design and construction of critical support elements.

Examples of Ro-Ro Services Currently in Operation

1.2.23 With an increasing number of ro-ro terminals coming into use and an ever-increasing capacity in the international ro-ro fleet, it is interesting to look at some examples of how this system is utilised successfully elsewhere in the world.


The Ro-Ro Ferry Port of Dover, UK

Dover

1.2.24 Dover is the UK's top port in terms of Ro-Ro cargo with an annual throughput of 1.7m units (13.0mt). This compares with approximate figures for the UK's container ports at Felixstowe 2.2m units (31.5mt), Southampton 0.49m units (6.00mt) and 0.34m units at Tilbury.

1.2.25 A significant amount of cars and passengers travel through Dover with annual levels of 18.2m passengers and 3.0m cars,

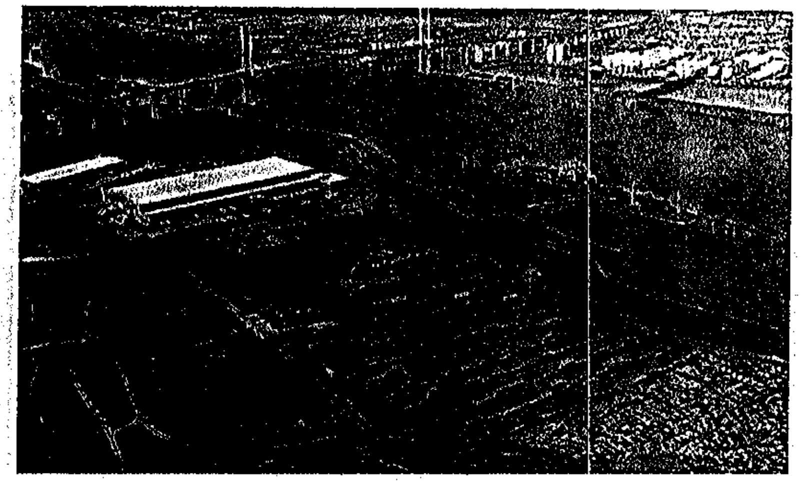
1.2.26 The port of Dover has 8 ro-ro berths handling 67 ships per day on average linking to the continental ports of Calais, Ostend and Zeebrugge. Operations continue for 24 hours per day and there is typically a sailing from Dover to Calais every 30 minutes at peak period during the day.

1.2.27 The berths at Dover have an alongside depth of 5.6 – 8.0m to accommodate the largest vessels. The spring tidal range is 5.9m.

Thames Europort

1.2.28 This is one of the main ro-ro ferry terminals serving London and it is located at Dartford in the Thames Estuary. This terminal exclusively operates freight services such as trucks, trailers (accompanied and unaccompanied) and containers. The only passengers are truck drivers.

1.2.29 The terminal has two 200m long berths with minimum water depths of 10.5m on a tidal range of 6.0m. Dedicated ro-ro vessels service two daily sailings to Vlissingen and three daily sailing to Zeebrugge.



Thames Europort Ro-Ro Terminal at Dartford, London, UK

1.2.30 There are 37 Acres of paved terminal marked out for 1,600 trailer slots and container points. There is also a hazardous cargo area, covered transhipment area and engineering workshop. 24 hours customs and security is provided with computerised trailer tracking and customs clearance system.

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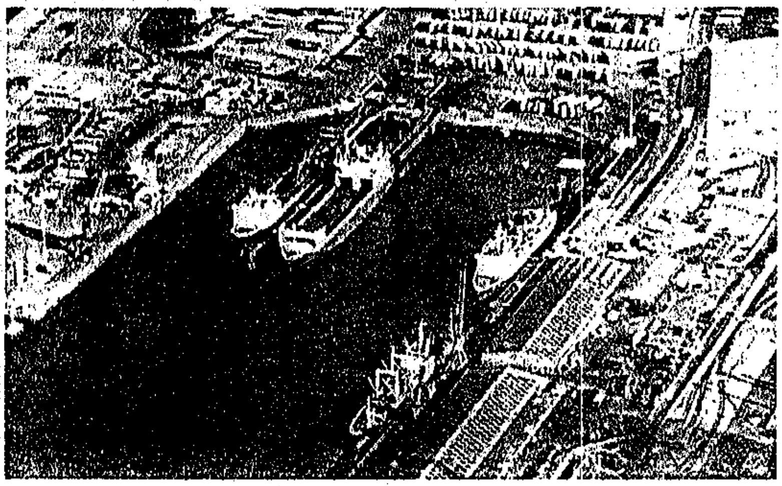
Heysham

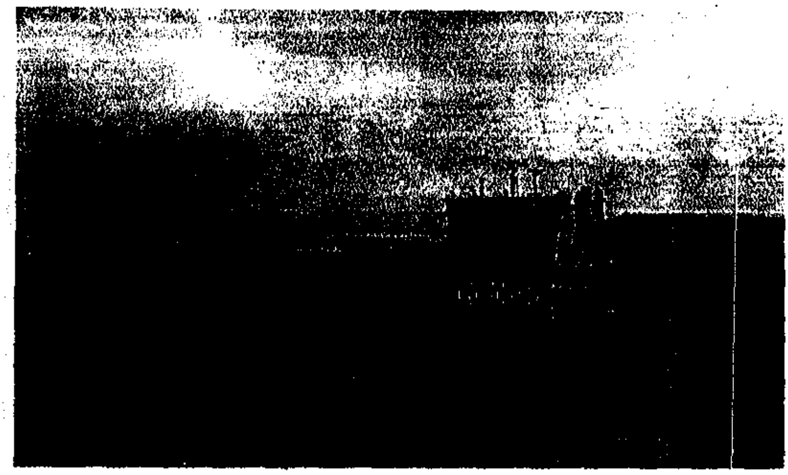
1.2.31 The Port of Heysham is one of the main ferry terminals linking England with Ireland on the fast growing Irish Sea sector. Heysham has become the second largest ro-ro ferry port in the UK A mix of freight, passengers and cars pass through this terminal serviced by 5 ferry lines linking to Belfast, Dublin and Isle of Man. The current annual throughput is 207,000 passengers, 125,000 cars, 260,000 trucks and other units making a total of over 4m tonnes per annum.



Three Ro-Ro Berths at Heysham, UK

1.2.32 Each of the three berths have linkspans of different construction type one utilizing a

ntoon, the second a hoisted truss bridge while the third has an integral bridge and flotation
it. These are designed to accommodate vessels up to 135m long with a minimum water
pth of 5 m on a spring tidal
nge of 8.6 m.



Freight Ro-Ro Vessel on Southampton to Tangier Route

uthampton – Oporto and ngier

new ro-ro ferry service has cently started operation tween Southampton on the uth coast of UK, Operto in rtugal and Tangier in orocco, North Africa. This is a ight only service set up to compete with the alternative of driving over 2,000 km through ance and Spain with two ferry crossings of the English Channel and Straits of Gibraltar.

e benefits of this service are perceived to be:

- Cost – it provides a cheaper alternative to road transport.
- A way of avoiding the weekend truck driving ban in France.
- The ability to carry over height vehicles that would not be permitted on public roads.
- Better security for the freight vehicles.

-Ro in India

ere have been some attempts to introduce ro-ro ferry services to India but as yet no nificant ferry service has been established. A linkspan berth was constructed at Mumbai rt Trust but this has now been removed. Also a linkspan was constructed at Pipavav Port t this collapsed before being used.

ecial heavy cargoes are transported by ro-ro, for example by Larsen and Toubro at Hazira, d some ports in India have a ro-ro ramp which is used from time to time.

1.2.37 The successful operation of a ro-ro ferry service is a specialist activity and needs considerable skill and experience if it is to be efficient. With little or no experience within India it will be necessary to utilise international organisations who have the experience from operating elsewhere in the world. With current cabotage regulations making it impossible for foreign shipping lines to ply domestic Indian routes it will clearly be necessary for a ferry service to be operated on the basis of an Indian and international joint venture.

Ro-Ro in the Gulf of Cambay

1.2.38 The Gulf of Cambay is a difficult location for a ro-ro ferry service to establish itself. The tidal range is considerable making the construction of facilities for all-tide access rather more expensive than for most coastlines. To keep the costs down to reasonable levels it would be possible to construct the berths in marginally shallower water and make use of the higher tide levels. This would mean adopting a tidal, rather than a time based, sailing schedule. However, this is not usually attractive to ferry operators who like to publish a simple timetable because many truck drivers may not understand the complexities of tidal variations.

1.2.39 The marine conditions in the Gulf of Cambay are exposed with little natural protection at deep water location. This in itself makes the port infrastructure necessary for accommodating and serving the vessels unusually high. While it is possible to take steps to minimise these costs, as eluded to later in this report, it should be remembered that the natural conditions are not as conducive as at many other ferry terminals around the world.

1.2.40 Ferry services across the Gulf of Cambay are also at a disadvantage compared with many ferry routes because there is an alternative. Despite the poor roads in the region it is nonetheless quite possible to drive around the head of the Gulf. With a competing ferry service and road route, market forces will determine which is most cost effective and the time factor will be determined, to an extent, by congestion on the road. Ironically as the authorities improve the road system there will be a greater attraction to using the roads rather than the ferry service. If there is not enough traffic using the ferry service it will not remain in operation.

1.2.41 The Authorities are therefore in a position to control the economics of a ferry service across the Gulf of Cambay to a large extent through taxation and the imposition of regulations relating to use of the roads around the Gulf. This is in addition to the factor of any harbour dues or other charges that the ferry operator or users will have to pay.

1.1.42 It is notoriously difficult to predict the utilisation of a ferry service, particularly if it is a new ferry service in an area where no such service has been operated in the past. Any private sector ferry company will need considerable assurances and support from the Authorities if they are to seriously consider setting up a new ro-ro ferry service in the Gulf of Cambay. A private ferry company will study the routes very carefully in an attempt to identify a profitable network. In doing so they are likely to be attracted to the greater potential traffic volumes moving between the cities of Surat and Bhavnagar, ie through the ro-ro terminals at Suvali and Gogha rather than Dahej which presently is at a relatively remote location. If container volumes pick up at Pipavav the possibility of linking Pipavav with Mumbai and even Dahej may become more attractive.

1.3 Overview of Work Carried out in this Study.

1.3.1 We have issued two previous reports (the Progress Report of September 1997 and the Interim Report of April 1998) and conducted the Techno-Economic Study incorporated in the Interim Report. Each report has developed the proposals of the previous report, and this report deals particularly with the details of the development and takes the scheme forward to a stage where construction tenders may be invited.

1.3.2 We have collated information principally from GMB, but also from other sources, and have developed a comprehensive understanding of the ground and marine conditions at each site. We have also obtained information from other sources with regard to possible partnering arrangements and parallel developments such as that at Suvali.

1.3.3 We have held meetings with prospective joint venture partners in order to discuss their requirements in the event that they become involved in sharing the development of these terminals. We believe that a firm commitment is in place in respect of Dahej with Saurashtra Cement Co. and that the terminal at Suvali will be developed in conjunction with Shell's proposed LNG terminal.

1.3.4 The project methodology sets out five tasks comprising the project and progress against these tasks is summarised below. It should be noted that in some respects proposals have been constrained by economic considerations and it has been necessary to modify some of the aspirations of the original enquiry. This has resulted in additional work in revising designs at all three terminals.

Task One - Site Selection

We have considered a number of possible sites at each broad location. These have been evaluated in terms of suitability on operational and constructional grounds, and a preferred location chosen for the development. This task has been completed for the sites at Pipavav/Jafrabad, Gogha and Dahej. At Suvali it is proposed that the ferry terminal should be incorporated within a larger development, and a location has been selected on the basis of the most recent proposals known to us.

In addition, we have considered the types of vessels which would be appropriate to the ferry service in the Gulf and have made enquiries as to the availability of suitable vessels. Certain elements of this task relating to operational aspects are considered under Task 4.

Our studies have shown that some compromise is necessary in respect of the 5m target depth.

Task Two - Development Plan

Planning, both onshore and offshore, is complete in respect of Gogha and Dahej, including, in the latter case, berth facilities for the joint venture partner. Possible partners were identified at Gogha, but interest has lapsed and so design is based on ferry requirements only without precluding development for a joint venture partner.

Detailed design is substantially complete in respect of Gogha and Dahej. In the case of Suvali, details of the proposed overall development have only recently been made available and outline design work has been undertaken; detailed designs have been completed by adopting similar facilities to the other terminals.

Cost estimates have been prepared detailing the various components of the project at each site, and, where appropriate, allowing for phased development commensurate with traffic development; these have been used as the basis for the Techno-Economic study and its later supplement. Drawings have been prepared and are included within this report, Development at Pipavav will be carried out by Gujarat Pipavav Port Ltd and no detailed work has been carried out as part of this study.

Task Three - Techno-Economic Study

This task had been completed as part of the Interim report. Since proposals, and consequently costs, have changed since then as new information has come to light, a supplement to the study has been prepared and is included in the Report.

The Study shows that services from Gogha and Pipavav to Suvali are likely to be most attractive commercially, but that service to Mumbai should also be included. .

Task Four - Ferry Operations

This task has been completed and is incorporated within this report. We have considered safety conditions to be adopted by the ferry operators based on current international safety standards. We have also highlighted points to be considered in preparing the contract to be entered into by the ferry operators and reviewed the operation of the 1952 Customs Act.

Task Five - Supervision of Construction

The design work included within this report is sufficient to allow tenders to be obtained, but construction supervision will not be undertaken until the project receives the go-ahead. Detailed proposals for this task are however contained within this report. We have also shown how training of operational personnel may be achieved by secondment to existing undertakings.

1.3.5 Previous reports have discussed alternative locations and proposals at each site, and these matters are not repeated in detail in this report. However all the data are included in Appendices to this report. Here we discuss the detailed implementation of the preferred options previously identified and develop those designs to a stage allowing tenders to be sought.

1.4 Discussion of Underlying Concepts

1.4.1 In undertaking the planning and development of the project, we have found it necessary to review some of the basic concepts underlying the project and these are discussed below.

1.4.2 Whilst the study has found that a ferry service could operate successfully on a network of routes connecting the terminals under consideration around the Gulf of Cambay, the operation of this ferry service would not provide sufficient income to service the full capital costs of constructing the ferry terminals.

1.4.3 In order to maximise the use of the facilities and spread costs joint venture partners have been sought who would also make use of the new facilities for berthing vessels and handling cargo with direct connection to their own shore facility. However, there is a firm commitment only in respect of Dahej, and expressions of interest in respect of Gogha have lapsed. The nature of the development at Suvali may discourage partnering arrangements, although considerable economic advantage will be gained by developing the terminal along with the LNG port.

1.4.4 The construction required to satisfy the brief's requirement for unrestricted access to berths at the –5m contour is disproportionate to the benefits of use and is unsupportable by the developing ferry operation. This is particularly apparent at Gogha where the deep water, contrary to initial expectations, is some 2km from the shore, requiring a long and expensive approach jetty.

1.4.5 We have therefore proposed that the berths be placed in shallower water allowing operation of tidally constrained service from Gogha; this allows construction of a much shorter approach jetty with berthing facilities closer to the shore. Although less desirable this could be achieved within the present financial limitations and provision would be included for expansion to the unrestrained service by future construction of a longer approach jetty and a new berth in deep water.

1.4.6 The development of the terminals at Suvali and Pipavav (although the latter is outside the scope of this study) is important to the successful operation of a ferry service as is the inclusion of Mumbai in the network of routes.

1.4.7 The amount of good quality, measured oceanographic information that is directly relevant to the terminals is small considering the level of investment that is required for construction, and much of the information has been derived from observations recorded at other locations in the region. We have extrapolated from this information to derive conditions at the terminal sites and have developed designs which will not be unduly sensitive to local conditions should they vary. It would however be prudent to undertake some model studies to enable a refinement of design for various aspects in any case. The cost of these studies is likely to be considerably outweighed by construction cost savings which would arise from the refinement of the designs.

2.0 FERRY TERMINAL FACILITIES-COMMON FEATURES

2.1. Marine Facilities

Layout

2.1.1 The ferry terminals at Gogha, Dahej and Suvali have been designed to facilitate the efficient operation of both roll-on, roll-off (ro-ro) and passenger ferries. A further terminal at Pipavav forms part of the network, but the design of this is not part of this study. A single ferry berth is provided at each site capable of handling all types of ferry vessels, but principally the combined ro-ro and passenger vessels which are expected to be the first vessels to use the terminals. An approach jetty is provided linking the berths to the shore allowing vehicular and pedestrian transfer between the shore terminal and the ferries. The layouts and designs that are shown in this and following chapters take account of the consultants' accumulated experience and in particular draw on the recommendations given in international design manuals and review of work carried out at other terminals as shown in Chapter 1.2

2.1.2 The ferry berths are intended for use by vessels operating on regular ferry services to other terminals around the Gulf of Cambay and further afield, but the designs do not preclude use by other vessels should that be appropriate. However, in order to minimise the initial capital cost attributable to the ferry service, separate berths sharing the approach jetty with the ferry traffic may be provided for use by other shipping lines. At Dahej, where joint venture arrangements have already been identified, an additional berth is provided for the joint venture partner and the approach jetty contains provision for his handling equipment.

2.1.3 Marine conditions in the Gulf make the construction of marine facilities difficult; ferry terminals are made more complex by user requirements of high reliability and a regular timetable. Tidal, current and wave action are all significant and each has an effect on the requirements for marine infrastructure around the Gulf. Tidal and current effects are dominant in the upper Gulf, at Gogha and Dahej, whereas wave action is more significant at Suvali, and to a lesser extent at Pipavav, which are nearer to the entrance of the Gulf. However, the berth at Suvali is now expected to be sited within breakwaters, and wave action at the berth itself is unlikely to be a controlling factor. With few existing facilities, such as protected ship berths, a relatively high level of investment in infrastructure will be required in order to initiate a viable ferry service.

Ro-Ro Berth

2.1.4 Where possible the ro-ro berths are positioned in sufficiently deep water (5m depth at low water) to allow ro-ro vessels to have safe access to and from navigation channels at all states of the tide. However, at Gogha where the deep water is some 2 km from the shore, the cost of the approach jetty would be unsupportable and the terminal is therefore sited in shallower water with the acceptance of some tidal restriction on operation. Nonetheless, the terminal can be extended seaward at some future date. At Dahej, the required depth can be achieved when sufficient dredging takes place.

2.1.5 The berths are aligned at an optimum orientation to resist the prevailing sea generated loading conditions. The most significant in this respect will be current flow because this would be present, albeit at different velocities, for most of the time. It will also be necessary to consider storm wave attack. Since the berths are being constructed in the open sea, a breakwater protected area of sheltered water would be desirable. However financial constraints do not permit this (except at Suvali where shelter is provided as part of a larger development) and a lesser degree of protection is provided. It should be borne in mind, however, that the sea conditions are reasonably calm for much of the year and the additional protection afforded by a breakwater would be of benefit at Gogha and Dahej for only a relatively small proportion of the year; at Suvali the monsoon waves are more restrictive and really a breakwater is essential for year round services.

2.1.6 Each terminal provides a berth for a single ro-ro vessel either alongside a jetty structure or against discrete berthing dolphins. In all cases fenders are being provided to enable berthing to take place in most sea conditions without damaging either the vessel or the berth. Bollards are being provided along the length of the berth for the vessel to tie up and remain safely during loading and unloading operations. The layout of the berth is planned to suit the operational requirements of a wide range of ferry types. However, the requirements of ferry operators vary considerably and the ro-ro facilities are designed to suit the needs of specific vessels where these have already been identified

Linkspan

2.1.7 A link is necessary between the ferry and the fixed shore installation. In essence this is a bridge supported at one end on the fixed jetty structure and at the other on the ferry or some other structure allowing the level to vary with tide and ferry configuration. It is required to provide for a single lane of traffic and be capable of carrying the heaviest vehicles which are expected to use the ferry. The slope of the link will vary according to the state of the tide and the vessel configuration, and the length of the bridge is chosen so that the gradient under normal conditions does not exceed 1:10 . A steeper slope will occur under rarely occurring extreme low water conditions and will generally be acceptable, but it is possible that operations could be suspended for short periods.

2.1.8 In practice, the ferry is not capable of supporting the weight of the bridge and the traffic on it, and the seaward end of the bridge must therefore be supported by other means. Typically the bridge may float on a pontoon or inbuilt buoyancy, or be supported from a fixed gantry with some means of adjusting the level. The bridge itself will be steel to reduce weight and may take any form, but will usually be a truss or box girder.

2.1.9 Fixed support at the seaward end will result in the lightest bridge structure, but this will be at the expense of a complex hoist system for controlling the level of the bridge. In general such a system is only justified in the most intensively used facilities serving vessels without stern ramps, and we have therefore chosen a buoyant system of support. Such as system will require much less maintenance. Such a system has the additional advantage that there is considerable degree of natural level control, and the consequence of any mechanical or electrical failure is much less critical. It is possible to provide support either in the form of a separate pontoon, on which the outer end of the bridge rests, or provide buoyancy tanks within an enlarged structure at the outer end of the bridge itself. We have opted for this latter solution as being the most economic, the weight of the bridge with tank being significantly less than the combined weights of pontoon and simple bridge. The enlarged tank section, which will coincide with the wider section of the bridge needed to serve the ferry will also contain a system of pumps which will be used to control and adjust the level of the bridge to suit individual ferries and tide levels.

2.1.10 For the bridge structure itself, we have selected a box girder design. This is now a standard form of construction, resulting in a light and economical structure. It is particularly suited to the marine environment in that the clean lines allow for easy maintenance. The box girder form allows the width of the bridge to vary, allowing the seaward (ship) end of the link to be wider, providing access across the full width of the ferry; it is designed to support a short ramp from the ship. The buoyancy tank, which is an integral part of the structure, will be of similar construction and will contain a machinery room housing the pumping system.

2.1.11 The inner end of the bridge is supported by a hinge system mounted on a part of the jetty structure. This hinge will allow principally for the rise and fall of the linkspan in response to tidal changes, but will also allow horizontal movement to the extent permitted by the restraining structures at the seaward end. A buffer system between the linkspan and the hinge will absorb impact forces from ship contact. Design of the supports and bearings of the linkspan will be carried out to achieve robust fixity and degrees of freedom where necessary; – good inspection and maintenance will be necessary in use.

2.1.12 The same design is used at Gogha, Dahej and Suvali simplifying spares and maintenance; if necessary, linkspans could be interchanged. The ramp will require a power supply for level adjustment and a backup supply is provided; however the ramp itself is not at risk in the event of power failure.

Passenger Berth

2.1.13 Berths for catamarans or small passenger ferries are provided alongside the main vehicle accesses. There is segregated access for passengers, although in practice it is unlikely that ro-ro vessels and the passenger ferries will berth simultaneously

Approach Jetty and Bund

2.1.14 At Gogha and Dahej, the ferry berths are connected to the shore terminal by a rock bund with concrete armour and an approach jetty; at Gogha these are of some considerable length. The bund will support a two lane approach road with a 7.5m wide carriageway, 1.5m wide pedestrian access and a 1m wide strip for services such as electrical cables, water pipelines and telephone lines etc. The jetty will support similar facilities but is limited to a single lane road to minimise capital costs.

2.1.15 This approach provides access to the ro-ro berth as well as any other berth constructed at the jetty head. Additional provision is made at Dahej for further services, such as conveyors and pipelines, to be installed by the Joint Venture partner.

Utilisation

2.1.16 It is intended that a regular service can be operated on a timetable without undue restriction by tidal conditions. However, because of the need to avoid the high capital costs of long access jetties at Gogha and Dahej the prevailing depth will not be adequate at all states of the tide, and it will be necessary to plan the timetable with this in mind. Although the prevailing weather conditions are such that vessels will be able to operate for most of the year in the upper Gulf it must be recognised that there will be some weather related downtime at all of the terminals. It would simply not be economic to construct the infrastructure to enable operation in all weather or tidal conditions. Downtime will be minimal at Suvali terminal in the lower Gulf as it is constructed within the shelter of the new port development. In the event of the most severe sea conditions operations would cease at all terminals and storm control measures would have to be taken to ensure survivability of the structures. Although we have been advised by the operators of one of the jetties on the Gulf at Dahej that they have experienced no downtime in their first two years of operation, – this may not mean no days of bad weather due to their lower berth utilisation and we think it would be prudent to allow for modest downtime.

2.1.17 The ro-ro berths have been designed to be as versatile as possible, permitting use by a wide range of vessels although the detailed design is be based on specific vessels. This will provide the opportunity for the operation of as many ferry services as possible. In common with most modern ferry terminals the berths will be designed to serve vessels with their own stern ramps. This covers the vast majority of ro-ro vessels currently in operation and will include provision for berthing of single and double door ro-ro vessels. It will not be possible to accommodate vessels without stern ramps without major modifications.

All roadways are designed to support road going trucks, buses and terminal trailer units. Suitable turning areas are provided for vehicles close to the berth with sufficient road space for vehicles to embark and disembark from the vessels. There will also be a setting down and picking up area for passenger buses alongside but clear of the main carriageway.

Safety

2.1.18 The berths and approach jetties are provided with appropriate safety equipment including lifesaving equipment, ladders and safety rails. The roads will be marked in lanes as appropriate and signs will be installed to direct traffic; appropriate controls are installed on the single lane jetties.

2.1.19 Navigation lights are located on the berth to mark its position and suitable ship to shore communications are provided for operational control of vessels at each terminal.

2.1.20 Pedestrian walkways are segregated from vehicle carriageways between the passenger shelter on the jetty and the ferries. The walkway along the approach bund and jetty is marked by a kerb; this walkway is for emergency access only, rather than for general use by the public, and it is the intention that all foot passengers will be bussed to and from the ferry. Safety parapets are provided along the edge of all roadways.

2.1.21 A detailed set of procedures will be prepared for the safe operation of the link between the ferry and the shore.

2.1.22 At all terminals, a fendering system will be incorporated to cater for both normal berthing impacts and abnormal accidental ship impact.

Services

2.1.23 There will be a small operations, maintenance and storage room close to the berth. This room will contain equipment necessary for operation of the link as well as spare parts and emergency equipment.

The electricity supply to the berth will be sufficient for power requirements of the operating equipment as well as flood lighting at the berth and lighting of the approach jetty and a standby generator will be installed on the jetty providing sufficient power for basic lighting and operation of the linkspan. There will be a water supply piped to the berth to enable servicing of the vessel, cleaning and other incidental use. A telephone connection will be installed for direct communication with the shore terminal.

Facilities for reception of wastes from the ferries will be installed adjacent to the berth. A fuel supply will also be installed close to the berth to enable fuelling of vessels from storage tanks on shore.

2.2 Shore Facilities

Standard Guidance

2.2.1 Because of over trafficking on the road network throughout the country, and more particularly in Gujarat, the use of a water surface transport system is now being recognised. This is evident from the proclamation of the new port policy of the state introduced by GMB. As a solution, development of Ro-Ro ferry terminals at various ports for intra and inter state services has been given priority, specifically at Gogha, Dahej and Suvali (Hazira). As this is being developed for the first time in the state and, with no equivalent operation in the whole of India, standard guidelines and norms for planning of onshore facilities are not readily available. The numerous factors for determining the nature and magnitude of facilities depend on the type, size, power, capacity, internal design and facilities of the ferries to be operated, which will only be determined by specific ferry operators. The layout of these shore facilities has therefore been developed on various general considerations, as discussed elsewhere in this report.

2.2.2 The various facilities to be developed on the shore may be grouped in three major sections:

1) Building facilities;
2) Infrastructure (service) facilities;
3) Material storage and handling facilities for joint venture partners.

Building Facilities

2.2.3 The following buildings are provided at each terminal:

i) Passenger terminal building (with embarking and disembarking facilities);
ii) Central administration and canteen building;
iii) Electrical sub-station and switch yard;
iv) Service buildings such as: workshop, fire station, telephone exchange, emergency medical centre, post office, etc;
v) Drivers' shelter house/staff hostel;
vi) Permanent staff quarters;
vii) Other buildings related to functional need of the onshore facilities such as: security cabins, compound wall etc.

Infrastructure (service) Facilities

2.2.4 These are support requirements for buildings with a high functional priority and they are listed below.

i) Roads and parking facilities;
ii) Water supply system;

iii) Storm water disposal system;
iv) Sewage disposal system;
v) Electricity, including emergency power system;
vi) Fuel storage and supply system (not at every terminal);
vii) Telecommunication system including wireless network and PA system;
viii) Postal facility;
ix) Fire protection arrangements.

2.2.5 Certain basic services such as power, water supply, etc. which are sourced from the public supply outside the terminal may need upgrading to satisfy the additional demand imposed by the terminal.

Material Storage and Handling Systems

2.2.6 As well as the ro-ro ferry services other forms of cargo handling may take place at the terminals, notably Dahej. This would result in a need for cargo handling facilities but, as these requirements would be specific to the Joint Venture partners, they are outside the present scope of work. However, the major items that could be required are listed below;

i) Storage facilities such as silos, warehouses, tank farms, etc. depending upon the type of materials to be stored;
ii) Conveyors, transportation or handling system suitable to material, for example mechanical, pneumatic conveyors, or pipeline with supporting structures;
iii) Incoming and outgoing transfer facilities for materials with auto/manual loading system etc;
iv) General facilities such as: buildings, amenities and services.

2.3 Design Criteria

Numeric values of the Design Criteria described below are set out in Appendix E.

General Design Criteria for Marine Facilities

2.3.1 In general Indian seismic requirements and codes, Indian wind codes, and Indian requirements in relation to temperature loadings applicable to highway bridges have been complied with.

2.3.2 Wave and current data have been assessed from existing records and checked by further investigations at site. Design forces and other criteria for the design of marine structures are determined primarily with reference to BS 6349 "Maritime Structures" supplemented by relevant Indian Standards and other relevant literature or test data.

2.3.3 Berthing, mooring and accidental ship impact loadings are determined having regard to the vessels the facility will be required to handle, together with considerations of ship operations, currents, waves etc. Determination of design forces and other criteria, and design of fendering systems is made primarily by reference to BS 6349 "Maritime Structures" supplemented by relevant Indian Standards and other literature or test data.

2.3.4 Vehicular loadings, turning circles and ground clearances as applied to the linkspan, jetty, bund and shore works will cater for the full range of normal road vehicles that would be allowed without special permit on Indian highways. In addition any abnormal road vehicles not covered by the above and specified by GMB will also be catered for. In order to allow for foreign ro-ro traffic and for various configurations of container truck, the UK/European Community 40 tonne gross weight heavy goods vehicle category and terminal roll trailers has also been designed for.

2.3.5 Road pavement construction, parapets and highway specifications and construction details generally comply with Indian Standards and Indian Road Congress specifications, standards and design codes. In the case of concrete vehicular safety fences on the bund, concrete vehicular parapets on the jetty, and steel vehicular parapets on the linkspan, relevant UK standards are followed.

2.3.6 Piling and foundation design are to be carried out in accordance with accepted standard practice, with specific reference to Indian Standards and other references with appropriate. Design is based initially the best estimate of geotechnical conditions and soil desigr parameters from information currently available.

2.3.7 Services are generally carried along a service trench in the bund, and along the side or soffit o the jetty deck. Where necessary provisions will be made to carry pipelines or conveyor belt: for bulk cargo on the bund and alongside the carriageway.

2.3.8 The structural design and construction of the abutment structure, approach span and minor structures on the bund, the approach jetty deck structure and the ship berth deck structure will comply with the appropriate Indian Standards and Indian Roads Congress specifications, standards and design codes.

Approach Bund

2.3.9 The approach bund is designed to incorporate locally available rock where available, having regard to cost, size and specific gravity of the materials. The bund will comprise a sloping armoured facing layer on a secondary armour layer with core material on a filter layer at the base.

Approach Jetty

2.3.10 The whole of the jetty deck is designed to carry vehicular loading. Passenger accommodation is provided as a removable structure supported on this deck allowing flexibility to change the layout of passenger accommodation, vehicle set-down and pick-up areas if modifications are made to the berths at some future date.

2.3.11 Where appropriate, the jetty is also designed for loads from conveyors and other equipment from the joint venture partner.

2.3.12 The piling and deck are designed for a nominal impact force or energy corresponding to slowly drifting floating objects or small craft.

Ferry Berths

2.3.13 The ferry berths are dolphin berths since all access is through the linkspan and no access alongside is required. Dolphins are provided at intervals so that the ferry is securely located and will carry all the loads arising from the berthing and mooring of the ferries.

2.3.14 The dolphins are provided with fenders allowing the ferry to lie alongside at any state of the tide and are also fitted with bollards for mooring.

Ship Berths

2.3.15 Deck loadings on the berthing jetty areas are determined to meet the requirements of the Joint Venture partners who will be operating at the berth. This area will be designed with consideration to the more onerous of the following:-

- Loadings from cranes or other handling plant, cargo storage or cargo handling;
- Loadings arising from vehicular traffic.

2.3.16 The berth deck will be supported on piles which will support deck loadings and carry loads arising from berthing and mooring

Linkspan

2.3.17 The linkspan will be supported at its seaward end by the integral flotation tank and no specific supporting structure will be required. The geometry of the link generally follows British/ISO Standard BS MA 97:1984/ ISO 6812-1983, with further provision for specific ship/ramp combinations that have been identified at the time of design

2.3.18 The link structure is of steel box girder construction utilising longitudinal stiffeners in flange and web plates with an orthotropic plate deck. These are all features critical to the structural efficiency of the link structure. British Standard BS 5400: Part 3: 1982 "Steel, concrete and composite bridges: Part 3 Code of practice for steel bridges" has been used as the principal design code, with specific reference to other codes if appropriate for steel, weld and bolt strengths in the absence of appropriate Indian codes.

Mechanical and Electrical Equipment

2.3.19 Mechanical and electrical equipment will be confined to the pumps and controls used to trim the linkspans and the lighting systems in addition to the basic equipment required to provide the services.

2.3.20 Equipment for the linkspans will be provided as part of the linkspan supply, and will be an integral part of the construction. It is therefore appropriate that this work is specified in the form of a performance specification which will be incorporated into the contract as a contractor designed item.

Layout and Functional Equipment

2.3.21 General layout of ports and harbours will be prepared in accordance with the Indian standard relating to various aspects of water front structures, IS 4651 part V. This covers all functional as well as operational requirements.

Buildings and Shore Facilities

2.3.22 The various structures and buildings required for these facilities may be in steel, RCC, and/or a combination thereof depending upon the functional requirements together with economical considerations. Appropriate provisions for seismic resistance are incorporated. The building systems and facilities proposed for installation inside the buildings will be complementary in every respect.

2.3.23 The majority of buildings and structures will be RCC framed with RCC floors and roofs; this is chosen on the grounds of economy and ease of construction by local contractors. Larger storage sheds have RCC foundations and steel superstructure, with roofing and cladding.

2.3.24 Roads, parking areas and other service structures will also be of RCC, probably using vacuum de-watered concrete, in order to provide maintenance free surface with long durability where possible.

2.3.25 Storage vessels or reservoirs for water supply and fuel, etc are RCC structures, and all related pipelines are ductile iron, cast iron, glass reinforced plastic or mild steel depending on the detailed specification of the liquid.

2.3.26 The networks, layouts and detailed design of surface water drains and foul drainage are designed in accordance with the Central Public Health and Environment Engineering Organisation (CPHEO) manual published by Ministry of Works and Housing, Government of India. All waste water drained from the workshop, fuel storage area, etc is separated and treated to GPCB standards before being discharged.

2.3.27 Ancillary structures such as the perimeter wall are constructed from masonry.

2.4 Design Codes and Standards

2.4.1 All designs conform to the relevant Indian Standards and codes of practice. Where there is no appropriate Indian Code, British Standards (BS) Codes and other international codes of equivalent class have been utilised. The Indian Standards (IS) codes that are in general use for each of the relevant major activities and services are listed below:

- All prestressed and reinforced concrete works are designed and executed in accordance with I.S. 456 1978 and/or its latest amendments and reprints for all buildings and related structures.
- Marine works have been designed in accordance with the additional criteria of the IS and having regard to the recommendations of BS 6349.
- Piled foundations are designed in accordance with the provisions of I.S. code 2911 part I to V 1979 or latest revisions, depending the type of piles are selected in detailed structure design.
- Marine loadings have been assessed in accordance with BS 6349

2.4.2 The following references have been used for planning and sizing of various shore facilities, buildings and services:

(i) Civil Engineering Hand Book - Merrit;

(ii) Design of Marine Facilities - John W Gaythwaite;

(iii) Time saver standards (1996) - USA;

(iv) I S 4651 - Code of practice for planning and design of ports and harbours - layout and functional requirements (Part V).

2.4.3 A full listing of all Codes and Standards used in the project design is included at Appendix F.

2.5 Environmental Considerations

2.5.1 In general, the works proposed and described in this report will have little impact on the environment.

2.5.2 The marine facilities are generally open piled structures and it is not expected that these will have any significant effect on the currents and tidal flows near the ferry terminals. There are already bunds in place at Gogha and Dahej and there is little indication of accretion nearby. Whilst the new bunds could give rise to accretion, there are unlikely to be any significant adverse effects on the foreshore which is principally intertidal flats for which we are not aware of any special environmental sensitivities.

2.5.3 At Gogha, the existing terminal and access bund can not be incorporated in the new development without a significant increase in the length of the approach jetty. The proposed alignment of the approach bund and jetty therefore makes a landfall at the north end of the site, but the detailed arrangement is chosen to avoid interference with the graveyard and temple.

2.5.4 The proposed developments are not expected to have any adverse effects on the local fishing industry

2.5.5 There are no activities at the ferry terminals which would give rise to air pollution. However, the activities of the Joint Venture partners may have the potential for pollution and the potential for pollution should be minimised as far as possible, although this is outside the scope of this study. In particular, the cement terminal at Dahej may have potential dust problems and these will have to be minimised by appropriate selection of the handling plant and implementation of appropriate operating procedures. However, Dahej is already an industrial development zone and the scale of the proposed terminal is insignificant in relation to the existing industrial developments.

2.5.6 Stormwater drainage will generally be discharged to the sea; however on-shore areas likely to suffer oil contamination will be drained separately and the effluent will be passed through an oil separator before discharge. All foul drainage will be treated by septic tank before being discharged to the sea. Facilities for fuel handling on the berths will be drained separately and the effluent will be pumped ashore for treatment

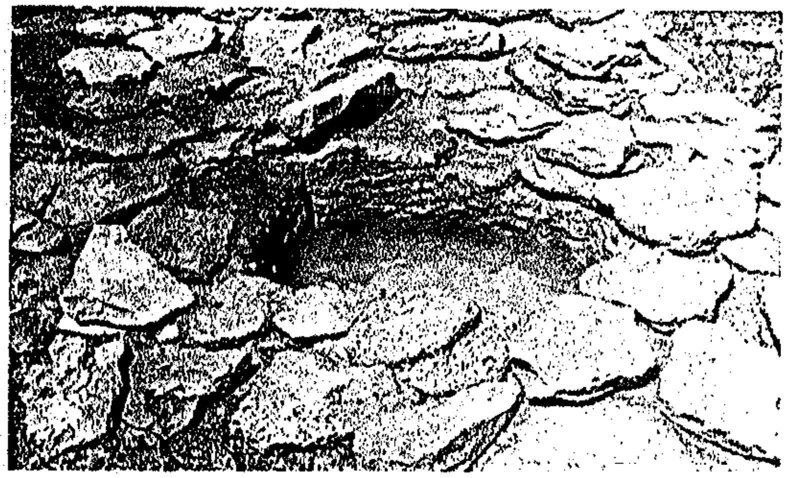
2.5.7 There will be increases in road traffic as the service develops, but although there may be occasional congestion coinciding with ferry movements, the overall effect will be small. Furthermore, traffic will radiate in all directions from the terminals and any congestion will dissipate quickly with distance from the terminal.

2.5.8 We believe that the environmental impacts of the project are small and do not warrant further detailed investigation. However it is possible that an Environmental Impact Assessment will still be required and if this is the case, it should be carried out as soon as possible so that recommendations can be incorporated in the final designs. Such a study is not part of the present brief, but could be incorporated as an additional feature.

3.0 GOGHA TERMINAL

3.1. The Site at Gogha

3.1.1 Gogha lies on the western coast of the Gulf of Cambay where the distance across the Gulf between the shores of Saurashtra and south Gujarat is at about its least. This in itself makes Gogha a logical choice for development of a ferry terminal. Furthermore this location is well protected by the land against the south-westerly monsoon with Piram Island and associated reefs providing some further protection against offshore generated waves from the south.



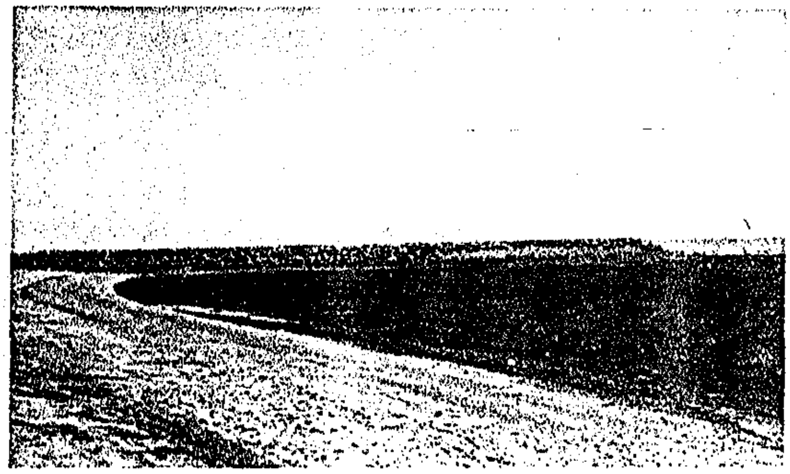
The Seabed at Gogha

3.1.2 The land in this area is generally flat and low lying. Boreholes suggest that the ground is predominately clay overlain by a thin layer of clayey sand, while along the coast to the south, there are some rock outcrops, particularly in the area around Piram Island.

3.1.3 The sea in this area has an exceptionally high tidal range with strong currents, particularly away from the shore in deeper water. Beaches are gently sloping with large muddy areas sometimes lightly covered with vegetation and only covered by water on occasional high tides. Further away from the shore the seabed slopes more steeply thus enabling access to deeper water. Here the silty seabed tends to shift from time to time as a result of the strong current flows.

3.1.4 The small town of Gogha is some 17 kilometres by road from the city of Bhavnagar; it is well connected with the inland districts although the road network is overloaded and there is no rail connection. Electricity, water and other services are available but will have to be improved to sustain any significant development. In particular, water is at present supplied from boreholes, and any development, especially that requiring bunkering of ferries, will need to be supported by piped supplies from Bhavnagar.

3.1.5 Gogha has already been used as base for a hovercraft ferry operation set up by Messrs. Chowgule & Co, Private Ltd of Goa, but this was not successful and has been discontinued. The ferry terminal, constructed in 1985, lies about 1km south of Gogha township, and comprises a terminal building (still in good condition) and a bund (in poor condition) projecting about 150m into the sea. The terminal building has been purchased by GMB and can be used in the initial stages of development until superseded by purpose built facilities.



The Disused ferry Bund at Gogha

3.1.6 There is limited historic hydrographic survey information available for the area, and some of our early proposals were nullified when the information on which they were based was found to be inaccurate; there was. however, sufficient information to enable broad choices to be made as described below. Our latest and detailed proposals are based on a more detailed and specific survey taken in April 1999 which covered the proposed berth area.

3.1.7 A number of boreholes, as shown in Appendix A6, have been sunk on the line of the existing bund and further offshore on the alignment now proposed and these show a seabed of sands and clays. These suggest that adequate bearing exists for piled foundations at reasonable depth. Boreholes undertaken on land (Appendix A7) show that the natural soils are generally suitable for shallow foundations and our designs are based on their use.

3.1.8 General information on the weather and sea conditions has been obtained relating to the Gulf or Bhavnagar, but there is little specific to Gogha, although there is no reason to expect it to be atypical. The monsoon falls in June to September with heavy rainfall, whilst the remainder of the year is dry. Storms occur mainly in the pre- and post-monsoon periods The only wave prediction analysis known to us is that made for the Indo Gulf jetty at Dahej; we have been able to extrapolate from this analysis by comparison of the two sites to provide a wave climate for Gogha. In addition there is anecdotal evidence from skippers of vessels operating out of Bhavnagar that the wave climate is not severe (heights less than 1m) and even suggesting that Gogha is good location for a ferry terminal.

3.1.9 We have current flow measurements made by float tracking at Gogha and these show that currents are small within the 10m contour, generally not exceeding 4 knots.. We have located only a single record of tide levels at Gogha together with the records taken during float tracking and by comparing these to the results of the recording gauge at Bhavnagar, it is possible to use the predictions for Bhavnagar to make predictions for Gogha. These predictions show a tidal range slightly less than that at Bhavnagar, with a Highest Astronomical Tide of 10.94 metres Chart Datum. We have also been able to plot an envelope of maximum and minimum daily levels which shows that there are certain periods when there is consistently deep water and these can be used in the planning of the ferry service. Details are shown in Appendix A5.

3.2 Preferred Location

3.2.1. Three possible locations have been considered for the development of a ferry terminal in the Gogha area (see Drawing No. 97/003/20 in Appendix B2). These are at:

- Saker Creek to the north of Gogha;
- The existing terminal site constructed for a previous ferry project;
- Kuda Point to the south

3.2.2 Saker Creek is very shallow with the seabed typically between 2 and 4 metres above chart datum, which means that extensive areas of this creek dry out at low water. Operation of a ferry service here would be severely constrained by tidal restriction unless extensive dredging were carried out. Without dredging the ferries would only be able to operate at high levels of tide, and this is not considered to be acceptable. The alternative of an extensive capital dredging campaign at this location is unacceptable because of the initial cost and potential requirement for substantial maintenance dredging. In any event there is little room for ferries to manoeuvre in this creek and all such vessel movements would clearly disrupt any other activities in the area. This is not, therefore, a location that is well suited to a regular vehicular and passenger ferry service.

3.2.3 By contrast, the existing terminal site has already been established for ferry operations and land has been made available for terminal use and road access already exists. At the moment the existing bund is too short and will have to be extended significantly in order to reach sufficiently deep water that would be adequate for ferry operation. It is considered that the alternative of a short extension to the bund together with extensive capital dredging should be avoided because of the unpredictable and mobile nature of the seabed. A long approach jetty will be required and this may be costly because of the poor ground conditions. However this is likely to be a reasonable site for a ferry terminal because it offers a partially sheltered location close to the navigation channel that is already used for approach to the Port of Bhavnagar. It appears that operations will be able to continue throughout the year without a great deal of weather disruption.

3.2.4 The third site at Kuda Point offers the benefit of a rock foundation on which to construct an approach bund and jetty which would give access to relatively consistent and stable deep water. However, there are a number of reefs in this area which may make navigation a problem, particularly around Piram Island where it is believed that underwater cliffs combined with fast flowing currents could result in some hazard to shipping. The waters here have not been charted in detail and would require comprehensive surveying before design work could proceed with confidence. A further disadvantage of this site is that there is little land based infrastructure in this area which means that new roads would have to be provided and land would have to be purchased for the terminal site.

3.2.5 The characteristics of each of the alternative locations have been examined and a comparative assessment has been made on the merits of operating ferries at each of these sites; further details of this assessment can be found in Appendix B. This assessment shows a clear advantage for the site at the existing bund, principally on account of good access to deep water, safe navigation conditions, straightforward road access and availability of land and this is therefore the location chosen for the Gogha terminal.

3.3 Proposed Development – Preferred Option

3.3.1 The choice of location defines the general form of the terminal as an offshore berth in deep water linked to the shore by an access jetty. However prior to the development of the preferred option, which is described in detail below, three possible arrangements of the berth were considered in outline; these were a jetty berth, a dolphin berth and a pontoon berth. The pontoon berth could be discounted due to doubts about its suitability in the prevailing sea conditions, and the jetty berth was then selected as being marginally more versatile than the dolphin berth. At the time the early part of this study was undertaken, it was expected that there would be additional facilities for a joint venture partner who would also contribute to the capital costs.

3.3.2 However, no joint venture partner has been identified, so that capital costs are required to be held to minimum values while design may be based solely on ferry requirements. All of these schemes were therefore discarded and a more basic proposal has been prepared which is described in more detail in the following sections. It should be born in mind that the extension to deep water remains a long term proposal.

3.3.3 It should be noted that the initial site selection was made on the basis of an inaccurate chart showing deep water about one kilometre south of its true position and this location suited the desire to utilise the existing bund and shore facilities. Subsequently, the chart was found to be inaccurate and it was necessary to move the berth site to the north, whilst maintaining the jetty landfall at the root of the existing bund; conflicting alignments meant that the bund could not now be incorporated in the new works. In later developments, additional land was obtained and it proved possible to move the jetty landfall some 400m to the north, resulting in a substantial reduction in the length of the jetty.

3.3.4 The correction to the chart not only affected the alignment of the bund and jetty, but showed the deep water much further offshore. Now in order to accommodate vessels at Gogha during all states of the tide it would be necessary to construct a berth at some considerable distance (in excess of 2 km) from the shore. This would require a jetty some 1500m in length constructed at substantial cost and accounting for more than 60% of the total cost of the terminal.

3.3.5 Such costs cannot be supported by the ferry operation, and it was necessary to seek a compromise. We have therefore sited the berth closer inshore, with a correspondingly shorter access jetty, accepting that the berth is not now accessible at all states of the tide without restriction. However, careful timetabling can minimise the effects of this restriction as certain times of the day have reliably deeper water in all tidal conditions (see Appendix A on tidal data) and the full 5m depth is available for some 80% of the time. The access jetty will provide only a single carriageway to minimise costs, but the approach bund will be two lane to assist traffic flow. As noted above, the option to extend the jetty at a later date into deeper water remains.

3.3.6 The ferry berth is aligned with current flow as far as possible in order to make for straightforward berthing and to minimise loadings on mooring lines and fenders. However this alignment does not coincide with the direction of maximum wave loading conditions which means that storm wave conditions may lead to some interference with berthing and cargo handling operations. We have discarded our earlier proposal to provide a small breakwater to protect the berth as being an excessive cost for the small benefit of downtime which might be saved.

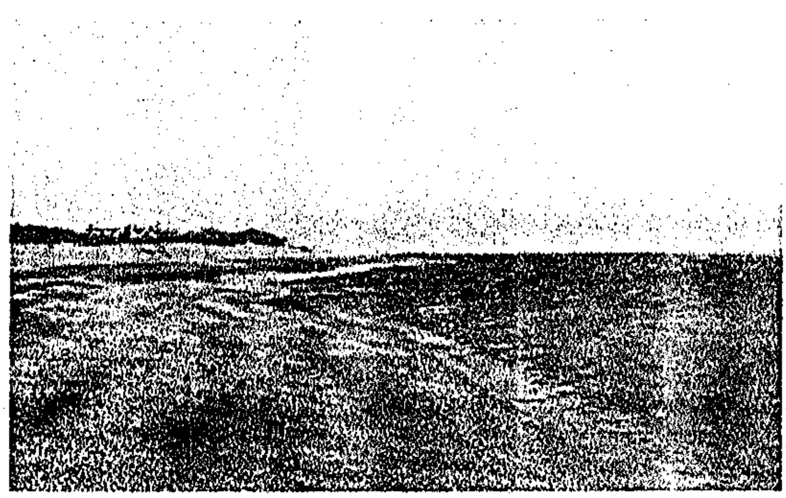
3.3.7 Costs are minimised by the elimination of most of the berthing jetty and the ferry berths against a line of dolphins; these will be substantial structures fitted with fendering systems capable of absorbing the impact of the ferry berthing. The fendering system will take account of the varying sizes of ferries and will allow for differing levels of impact due to tidal variations. The dolphins will also be fitted with mooring bollards and will be linked to each other by walkways allowing access for rope handling.

3.3.8 Circulating space for vehicles and a small waiting area will be provided by a widening of the access jetty adjacent to the berth. This part of the structure will also provide the shore support for the linkspan used to access the ferry. A conventional linkspan is used as described in Chapter 2 and this supersedes our earlier intention to use a simplified structure partly supported on ramp formed as part of the protecting breakwater.

3.3.9 Passengers are accommodated in a shelter adjacent to the ferry berth while transferring between buses to the shore and the ferries. Access to the ferry would be by way of a segregated walkway directly to the ferry.

3.3.10 The shore development is based near the old hovercraft station and takes in additional land. It will provide facilities for reception of foot passengers and vehicular traffic, traffic control and port control. The existing building could be used in the very early stages, but is not well sited for the layout now being proposed and would be superseded by purpose built facilities as soon as the service is established. The layout has been constrained by the graveyard to the south-west and the smashan on the northern shore.

3.3.11 These proposals are shown on Drawing 97/003/77 at the end of this section, and others in Appendix L.



Smasham and Rock Outcrop at Gogha

3.4 Terminal Capacity Requirements

3.4.1 The ferry terminal at Gogha has the dual advantages of being located near to the city of

Bhavnagar with its large population and being at the narrowest point for crossing the Gulf of Cambay. This is a good location from the point of view of attracting potential users of the ferry services.

3.4.2 Ferries from Gogha are likely to service three destinations in the first instance. The link with Suvali and its potential onward connections to the city of Surat is likely to be the most popular of these routes. The longer and more expensive route to Mumbai could also prove to be popular although fewer sailing would be scheduled in the first instance because of the greater journey time. The shorter trip across the Gulf to Dahej could be operated several times a day but the demand is likely to be limited until the industrial zone at Dahej becomes more active.

3.4.3 We have assessed the likely usage of this terminal in relation to cross Gulf ferry services. Connections to other parts of India and international routes should also be encouraged but are not part of this present exercise. Also a significant demand could be generated for container handling on international routes to the Middle East. Although not specifically part of this study provision should be made for container handling in the longer term plans.

3.4.4 The vessels that will use this terminal in the first instance are likely to have a capacity of approximately 90 trucks, 520 Second class passengers and 280 First class passengers. With only one berth available these represent the maximum numbers of users that would have to be loaded onto the departing ferries. Before this can be done a maximum of the same number of users would have to be unloaded from the arriving vessel. While it is normal for most arriving vehicles and passengers to leave the terminal straight away without any significant formality, departing users will have to be checked in and wait to board the vessel. On the basis that there would occasionally be two ferries departing at an interval of two hours we would suggest that the shore terminal should be developed to handle the simultaneous transit of twice the design vessel's capacity waiting for departure together with the capacity of a single vessel arriving. In the first instance the terminal facilities will be designed for 50% of this capacity with a significant provision for expansion as the demand rises. The design should therefore be based on:-

Users categories	Departures	Arrivals
Trucks	90	45
Second Class Passengers	520	260
First Class passengers	280	140

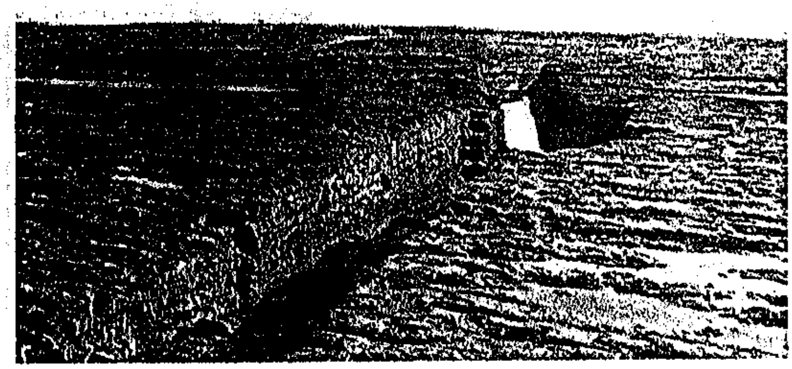
Joint Venture Arrangements

3.5.1 It was hoped that the Gogha terminal could be developed in partnership with a private sector organisation who would develop an offshore supply base with shared use of the jetty. Prospecting for oil in and around the Gulf of Cambay is increasing with these activities currently served from a shore base within the Port of Bhavnagar. This base is adequate for the present requirements but limited water depth gives rise to tidal restriction that would not be acceptable if there is a significant increase in offshore support vessel activity. With a base already established at Bhavnagar it would be logical to provide the improved facilities nearby and Gogha could be a suitable location.

3.5.2 Discussions have been held with one offshore service operator but no commitment has been made. The ferry terminal has therefore been designed as basic facility supportable by the ferry operations alone. However the facility could be used by other vessels as long as that use does not conflict with ferry operations. An offshore service base would require a substantial area of land for its onshore facilities and storage.

3.6 Marine Facilities in Detail

3.6.1 The bund extends to approximately the Low Water mark; due to the relative locations of the berth and shore facilities it is not possible to incorporate the existing bund into the new facility and the new bund therefore starts at the north end of the site. The core of the bund is formed of granular material, selection being based largely on local availability, and this material will be placed by dump trucks working from the shore. The external faces will be protected by concrete armour unitsdesigned to give protection against the worst storms expected. The bund will be of sufficient width to provide a two lane road, pedestrian footway (for emergency use only as foot passengers will normally be bussed to the ferry) and services. The height of the bund is such that the road will be above all normal water and wave levels.



Gogha Rock Outcrop looking to Sea

3.6.2 The access jetty continues the bund and provides the access to deeper water. The jetty will be a piled structure with a concrete deck supported on concrete piled bents at appropriate spacing. Because of the length, it will be necessary to provide strongpoints at intervals to ensure stability, and these will be formed of additional piles similar to those in the main run of the jetty. To minimise costs, the jetty will provide only a single lane road and a pedestrian walkway; guardrails and kerbs will be fitted on both sides. As with the bund, the jetty roadway will be above all normal water levels. Near the main jetty, the access jetty becomes wider, forming an area for traffic circulation and providing a strongpoint for the support of the inner end of the linkspan.

.6.3 The dolphin berth for the ferry will be formed of a number of structures in line providing a defined face against which the ferry can moor. The dolphins will be substantial piled structures designed to resist the forces arising from the berthing of the ferries and also mooring forces arising from the most adverse weather and sea conditions. The dolphins will be fendered on the berthing face and the fenders will be chosen to accommodate the tidal movement of the ferry. The fenders will provide energy absorbing units at high and low levels and these will be linked by vertical facings with low friction coatings allowing the ferry to move (principally vertically) against them without damage to ferry or fender. Light walkways will link the dolphins to facilitate the handling of mooring ropes, and a number of the dolphins will support mooring bollards. The seaward dolphin will be strengthened as this will normally be the ferries' first point of contact.

.6.4 Additional dolphins will control the location of the linkspan which provides access to the ferry. The linkspan itself will be a steel box girder structure providing for a single lane of traffic, with a wider section at the ferry end to facilitate access to the full width of the ferry. At the seaward end the linkspan will be supported on an integral buoyancy tank, whilst the shore end will be supported on the jetty structure. There will be provision to pump water in and out of the buoyancy tank to control the level and trim of the linkspan so that it will connect accurately with the ferry.

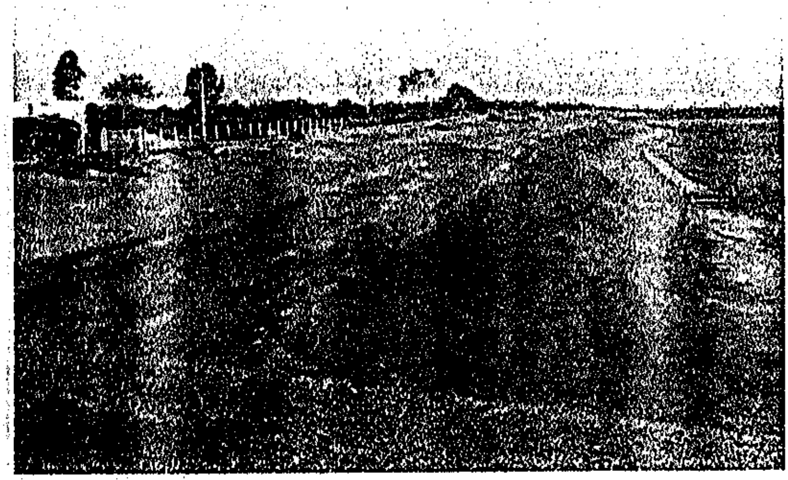
.6.5 A small amount of dredging will be carried out to the north of the berth to provide a turning circle for the ferries. No dredging will be undertaken in the marine approaches and it will be necessary to buoy the approach between the deep water and the berth. Buoys will be used to mark turning points and any significant hazards.

3.7 Shore Facilities in Detail

.7.1 The shore facilities have been planned using the optimum techno-economic approach because this envisages all functional needs coupled with technical standardisation to provide maximum service for a minimum land use. In response to these considerations, the following are provided within the shore facilities:

- Terminal building;
- Administration building;
- Medical facility;
- Fire station;
- Control Tower
- Police and security services;
- Fuel storage and filling station;
- Water supply and storage;
- Electrical supply and sub-station;
- Drainage;
- Refuse disposal service;
- Weighbridge;
- Shelter house and canteen;
- Post Office, telegram and fax services;
- Parking for trucks, cars and buses;
- Workshop for vehicle repairs.

3.7.2 The terminal building has initially been planned for 50 per cent of the capacity of passengers and traffic for departure and arrival at any time, based on the usage calculations at 3.4.4 above. It will initially provide space for ticket sales, waiting space for departing passengers, a reception area for arriving passengers, baggage handling facilities, rest rooms, space for concessions such as snack bar and newsagent, and space for operational requirements (although most of these will be controlled from the administration building).



Gogha Shore Terminal Location

3.7.3 The administration building provides principally office accommodation for terminal control and commercial administration, together with rest rooms and other common facilities. Customs officials are housed in a similar, but separate, building in the same complex. The administration building also supports the control tower which houses the equipment for navigation control.

3.7.4 The shelter house and canteen provides rest facilities for truck drivers. There is dormitory accommodation for some 80 drivers on two floors together with toilet and shower facilities, canteen and social area.

3.7.5 Full infrastructure services are provided. A substation contains switchgear to receive the incoming supply from the grid, and transformers provide the low voltage supplies for distribution around the terminal. Backup generation is provided for critical areas (such as navigation control). Water supply is taken from the main supply, and storage facilities are provided on site to even out demand and provide reserves for fire fighting and in case of mains failure. The storage facilities also provide the large quantities which are required for bunkering of the ferries. A small treatment plant is provided for the improvement of water quality, and the system is pressurised by an elevated reservoir. There is no central drainage treatment plant, and building drainage is treated through individual septic tanks. Drainage of roads and parking areas is generally be discharged direct to the sea, but in sensitive areas, such as the filling station, water is passed through oil and petrol interceptors before discharge.

3.7.6 The medical centre provides waiting and consulting rooms and a small treatment area, together with offices and stores. There is provision for in-patient accommodation.

3.7.7 The fire station provides accommodation for four appliances together with stores and offices. Open space is provided for parking, vehicle washdown, hose drying and a training drill area. There is also provision for the foam storage needed for fighting petrol and oil fires.

3.7.8 Costings have been worked out based on the above planning of the shore facilities using a rule of thumb basis for the immediate requirements. These costings reflect the different levels of facilities within each building.

3.7.9 A further drawing has also been prepared to give an indication of the type of layout that would be required for the shore terminal facilities associated with the ferry port operating with a larger capacity to international standards. This gives an indication of how the shore facilities might look in a few years time (see Drawing No 97/003/29 in Appendix G). It should be noted that this drawing was prepared in the early stage of the study and is based on development of the old hovercraft facility, using the existing causeway and making provision for joint venture facilities. It shows a layout based on currently accepted international practice with a large marshalling area for the trucks which form the principal traffic. There is also a large area for container storage, reflecting a further development of the ro-ro concept. The layout provides for early separation at the entry gate between the freight and passenger traffics, with a dedicated passenger access around the perimeter of the freight area. There is also extensive car parking, acknowledging that car based passengers will begin to find the ferry useful.

3.8 Costings

3.8.1 These costings have been calculated using known prices for similar construction work in the area augmented by international construction costs where necessary and are based on information available at this time and may have to be modified in light of survey and other data received from site in due course The costs in the first phase are summarised in the table below and are based on a jetty length of 400m to reach a water depth of 2m.

Item	Construction Cost Estimate (Rs Crores)
Berthing Jetty	14.16
Approach Jetty	20.99
Linkspan	7.80
Approach Bund	27.95
Transition Slab	0.07
Dolphins	7.09
Dredging	2.00
Navigation Aids	0.05
Passenger Shelter	0.03
On Shore Civil Works	0.87
Terminal Buildings	4.24
On Shore Ancillary Services	0.64
TOTAL	**85.90**

In the second phase additional terminal buildings will be provided involving a further expenditure of Rs Crores 1.54.

More comprehensive details of the costings are set out in Appendix H.

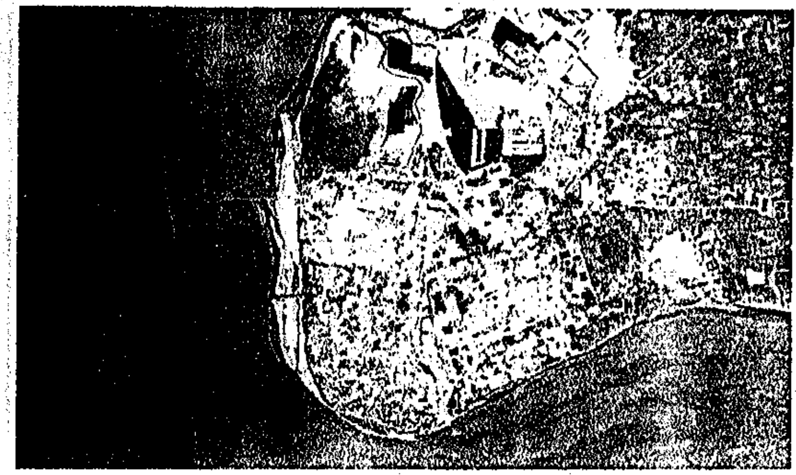
3.8.2 These costs do not include the purchase price for land or fees payable to licensing authorities for permission to construct and operate a ferry terminal at this location.

3.8.3 The costs noted above for the shore terminal are for the facilities required for the ferry services to start operation. Space has been allocated for further expansion to accommodate a full schedule of international services in due course.

4.0 DAHEJ TERMINAL

4.1 The Site at Dahej

4.1.1 Dahej lies on the eastern coast of the Gulf of Cambay ,just to the north of the Narmada River Estuary and almost opposite Gogha. The land, which forms the northern shore of the estuary of the Narmada River, protrudes well into the Gulf which means that a terminal at Dahej would have the clear benefit of the shortest crossing of the Gulf. A terminal on the Gulf coast would be very exposed, but there is shelter within the river estuary.



Satellite Image of Dahej

4.1.2 The land in this area is generally flat and low lying and from the borehole information made available to us it appears that the ground is predominately silty clay. It is known that many of the structures recently constructed in this area have been supported on piled foundations.

4.1.3 The sea in this location has a very similar high tidal range to that at Gogha and currents in the open sea are probably as strong. The beaches to the Gulf are gently sloping for a long way from the shore before changing rapidly to reach much deeper water. By contrast the estuary of the Narmada River is slightly more protected with a lower current flow and generally shallower water.

4.1.4 Dahej itself is a small village and until recently the area surrounding it had been undeveloped. It is some 45km from the district headquarters (Bharuch) to which it is connected by a state highway; improvement of the district network is currently being undertaken. There is limited rail access, but this is currently being redeveloped. Main services are available, and in particular there are substantial water supplies in connection with the industrial developments of the area. The Gujarat Industrial Development Corporation (GIDC) is putting into place an ambitious plan to develop this area into a large industrial zone and a few industrial plants are already under various stages of development.

4.1.5 Although there are jetties on the Gulf and in the river and proposals for a ferry service have been made, there has not been a ferry operation at Dahej. A captive jetty has been constructed on the Gulf for a copper smelter plant, as has a chemical port nearby. A jetty had also previously been constructed in the Narmada River for handling ethylene and other petro-chemical products. GIDC plans to construct roads and other infrastructure in the near future.

4.1.6 A considerable amount of hydrographic information is available for the area although most of it relates to development proposals on the Gulf coast. There is, however, a series of historic surveys which relate to the IPCL jetty (just downstream of the preferred site) and its approach channel which give a clear picture of the river. The proposed terminal area, upriver of the IPCL jetty, is covered by an earlier survey and this provided sufficient information to locate the ferry berth; the location was resurveyed in May 1998 specifically for this project. We have noted that the channel to the IPCL jetty is subject to siltation and requires maintenance dredging showing that the river bed is mobile and suggesting that bed levels may have varied since the surveys were made.

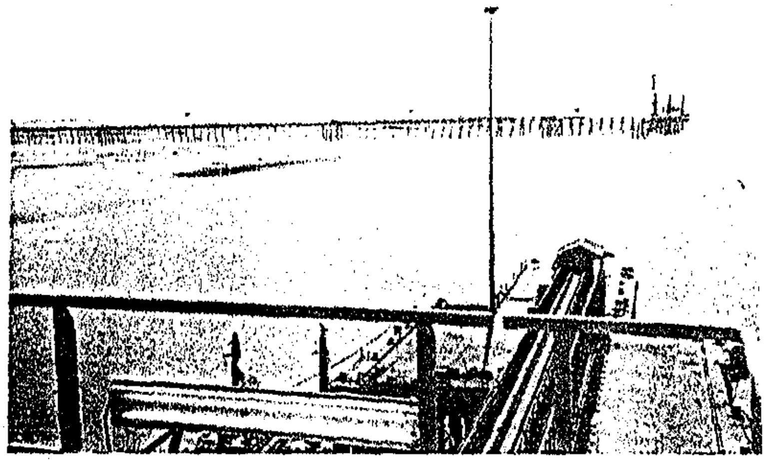
IPCL Jetty at Dahej

4.1.7 In the initial stages of the study, we were given access to the records from the construction of the IPCL jetty which included two boreholes, and it was possible to make general assumptions about the site which is nearly 1 km distant from the IPCL jetty. Subsequently boreholes were made at the designated site, (see Appendix A6), and these confirmed the assumptions made. The boreholes show sand and clay strata underlain by cemented sands which are clearly capable of supporting a piled structure, and this view is supported by the construction undertaken at the IPCL jetty. Boreholes have also been made onshore (Appendix A7) and these show that shallow foundations will generally be adequate.

4.1.8 We have general information on weather conditions in the Gulf, and conditions at Dahej are unlikely to vary significantly from those at Gogha (only 24km away). The area is, however, more exposed to storms from the south west so that wave heights in extreme storms will be significantly greater. We have obtained the findings of the wave model analysis made for the

Indo Gulf jetty in the Gulf and have transposed this information to the present site to provide design wave climate.

4.1.9 Limited tidal records were taken during the float tracking survey, and these, combined with occasional observations at the IPCL jetty suggest that the tide levels will be similar to those at Gogha so that predictions may be made based on the records from Bhavnagar. This allows us to predict the Highest Astronomical Tide as 10.94 metres above Chart Datum and plot an envelope of daily tidal trends which shows that deep water is consistently available in the early morning and in the afternoon. Currents in the river appear to be less severe than those in the open Gulf, but observations made at the IPCL jetty show velocities of up to 6 knots on the ebb tide; similar velocities were shown by the float tracking (Appendix A4).



GCPTL Jetty from Indo-Gulf Jetty at Dahe

4.2 Preferred Location

4.2.1 Two alternative sites have been considered for the development of a ferry terminal in the Dahej area (see Drawing No. 97/003/21 in Appendix B). These are at:-

- Ferry Point, Gulf of Cambay;
- Narmada River.

4.2.2 Ferry Point was originally chosen as the site for a ferry terminal for a previous project in the early 1980's. At that time a short length of approach bund was constructed. In order to complete a suitable berthing facility at this location a considerable extension to the bund would be required to reach an adequate water depth. The bed morphology in this area is such that the water depth increases rapidly some distance offshore where the new berth would be located. Fast flowing cross currents in this area would make navigation difficult. The alternative of constructing a shorter approach together with a large capital dredging campaign is not likely to maintain adequate water depth without continuous dredging. In any event, other jetties are now being planned for the area around Ferry Point as part of a port that will handle commercial cargoes including some hazardous materials. As these plans do not include any protection for the berths, such as breakwaters, there is no advantage in constructing a ferry terminal at this difficult site.

4.2.3 GMB has purchased some land on the northern shore of the estuary to the Narmada River. A much shorter jetty would be required from this site to reach water that would be sufficiently deep for restricted operation of ferries with little or no maintenance dredging at the berth; unrestricted operation (5m depth) would require some dredging. The jetty has, however, been designed for the full depth. There is however a natural bar across the entrance to the river which will have to be dredged in order to maintain sufficient water depth for access at all states of the tide. Indian Petro Chemicals Limited (IPCL) already operate a jetty nearby and it is understood that they have the responsibility to undertake this dredging. Although exposed to the south west, a series of sand banks offer some storm protection to the waters of the Narmada River. Waves are therefore generally less severe at this location than in the Gulf itself. Also the tidal currents are not as great. Whilst the berth site is sheltered, the combination of wave conditions and strong currents at the mouth of the river may make passage through the channel at the bar difficult or impossible at certain times.

4.2.4 The characteristics of each of the alternative locations have been examined and a comparative assessment has been made on the merits of operating ferries at each of these sites; further details of this assessment can be found in Appendix B. This assessment shows a clear advantage for the site in the Narmada River, principally on account of short access to deep water, safe navigation conditions, and availability of land and this is therefore the location chosen for the Dahej terminal.

4.2.5 We have assumed that the channel across the river bar will be maintained by IPCL and will be useable without restriction by the ferry services. In addition we understand that a significant LNG development is proposed at the mouth of the Narmada River and that this development will include major breakwaters which may adversely affect the regime of the river. It is anticipated that Petronet will undertake hydraulic model studies, and GMB should ensure that full consideration is given to the needs of the ferry terminal and its operation.

4.3 Proposed Development - Preferred Option

4.3.1 The choice of location defines the general form of the terminal as an offshore berth in deep water linked to the shore by an access jetty. However prior to the development of the preferred option, which is described in detail below, three possible arrangements of the berth were considered in outline; these were a jetty berth, a dolphin berth and a pontoon berth. These showed the jetty as being most expensive, but as this was outweighed by its flexibility in use and other matters, the jetty berth was then selected as most appropriate. At the time this study was undertaken no joint venture partner had been confirmed.

4.3.2 However, a joint venture partner (Saurashtra Cement) has been since been identified, and the selection of the most appropriate arrangement is confirmed by the need to accommodate both the ferry and the joint venture shipping.

4.3.3 In order to accommodate vessels at Dahej with as little tidal restriction as possible it is necessary to construct a berth some 300m from the shore; however, due to prevailing depths in the river the berth is not accessible to full draft at all states of the tide. In mitigation, careful timetabling can minimise the effects of this restriction as certain times of the day have reliably deeper water in all tidal conditions (see Appendix A on tidal data) and the full 5m depth is available for some 80% of the time. Access from the shore will take the form of a rock bund leading to an approach jetty constructed further seawards to a position that will provide sufficient water depth for the berthing vessels. Costs are controlled by the provision of only a single vehicle lane along the approach jetty; however the approach is wider close to the ferry berth providing circulating space for vehicles and a small waiting area.


Ro-Ro Terminal location at Dahej

4.3.4 A single jetty provides the ferry berth on its inner face and the joint venture berth on the outer face. Each face is protected by a fendering system allowing for vessels to berth against it and move up and down as tidal levels vary. Although the jetty forms the ferry berth, the ferry does not use the jetty deck other than for mooring purposes, and the jetty is normally used exclusively by the joint venture traffic. Thus the jetty provides the platform for handling the joint venture traffic in bulk cement and any other cargo handling should that arise. Access to the ferry is via a linkspan which is supported by an integral buoyancy tank at its outer end; location of linkspan is controlled by dolphins and its attachment to the access jetty at the shore end.

4.3.5 Passengers are accommodated in a shelter adjacent to the ferry berth while transferring between buses to the shore and the ferries. Access to the ferry will be by way of a segregated walkway directly to the ferry. The detailed layout at the junction of the access jetty and main jetty is arranged to minimise conflict between the ferry traffic and the joint venture traffic. This is assisted by confining foot passengers to shuttle busses between the ferry and the shore terminal.

4.3.6 The onshore facilities will provide facilities for reception of foot passengers and vehicular traffic, traffic control and port control. In addition areas of land are set aside for the joint venture partner who will provide his own handling and storage facilities and for other related industrial activities.

4.3.7 These proposals are shown on Drawing 97/003/70 at the end of this section, and others in Appendix L.

4.4 Terminal Capacity Requirements

4.4.1 Although reasonably close to the city of Bharuch, the ferry terminal at Dahej would be at a location remote from the centres of population in an area that is designated for industrial development, most of which has yet to take place. Undoubtedly there is considerable potential for this terminal particularly with respect to freight transport to and from the industrial zone. With the extent of this yet to be defined our initial consideration of throughput volumes relates largely to Dahej's beneficial position at the narrowest point for crossing the Gulf of Cambay. Most of the trucks and passengers will therefore be using the ferry service as part of a longer journey rather than using Dahej as a destination.

4.4.2 Ferries from Dahej are likely to service two destinations in the first instance although in both cases demand is likely to be limited until the industrial zone at Dahej becomes more active. The trip across the Gulf to Gogha could be operated several times a day whereas as the longer trip to Pipavav may be operated on a weekly basis initially.

4.4.3 We have assessed the likely usage of this terminal in relation to cross gulf ferry services. Connections to other parts of India and international routes may also be developed although these are not part of the present exercise. Our assessment of likely usage of the Dahej is set out in the table below for ferry services operating with either one, two or three vessels.

4.4.4 We have made an assessment of the likely number of uses for the Dahej terminal on the same basis as described for Gogha in section 3.4.4. Our findings are that the design for the first phase of shore facilities should be based on:

Users categories	Departures	Arrivals
Trucks	64	40
Second Class Passengers	210	97
Business Class passengers	164	100

4.5 Joint Venture Arrangements

4.5.1 It is anticipated that the Dahej terminal will be developed in partnership with the private sector cement producing organisation Saurashtra Cement. It would use this terminal to import bulk cement to the Dahej area from the factory at Porbander. Shipments would be by small bulk cement carrier with discharge to storage in shore based silos. A dedicated shore terminal will be provided by Saurashtra Cement adjacent to the ferry shore terminal and this would be used for bagging and distribution of cement. The cement terminal will be designed for an annual throughput of some 600,000 tonnes per year but detailed consideration of this is not part of this study.

4.5.2 With bulk cement discharge running simultaneously with passenger and vehicular ferry operations a great deal of care will be required to ensure that there is no interference between these activities. In particular, the cement handling arrangements must be sufficiently pollution free to ensure that the atmospheric conditions are acceptable for people who will be waiting for ferries in reasonably close proximity to this operation. For this reason we think that transfer of the cement to the shore must be by enclosed pipeline and the use of conveyors should not be allowed.

4.5.3 We have met the principals of Saurashtra Cement in Mumbai and they appear to be keen to move this proposal forward and to develop this terminal jointly.

4.5.4 If the Dahej terminal proceeds in joint venture with Saurashtra Cement the following facilities (to be determined by Saurashtra Cement) are likely to be required in addition to the berthing facility provided as part of this study:-

- Safety equipment;
- Unloading facilities for discharge of bulk cement from vessels;
- A pipeline to transport the cement from the jetty end to the shore storage silos;
- Modern dust extraction and pollution control equipment;
- Additional width to the approach road to support the pipeline;
- Lighting to jetty;
- Provision for road access both to highway and to the jetty;
- Offices and workshops;
- Land for storage and parking areas;
- Segregation from public areas with appropriate security arrangements;
- Silos for storage of cement;
- Godown for cement handling activities;
- Bagging plant;
- Truck loading area.

4.5.5 In addition to the facilities to be provided for Saurashtra Cement, provision is made for Bharya Shipyard and some 18 hectares have been allocated to the shipyard to the east of the terminal. The easterly location is chosen to minimise interference between the ferry and shipyard operations since ferries will not have pass in front of the shipyard, and shipyard jetties could be built if required without obstructing the ferry terminal.

4.6 Marine Facilities in Detail

4.6.1 The bund extends to approximately the Low Water mark, beyond which point this form of construction becomes inappropriate. The core of the bund will be formed of granular material, selection being based largely on local availability, and this material will be placed by dump trucks working from the shore. The external faces will be protected by concrete armour units designed to give protection against the worst storms expected. The bund will be of sufficient width to provide a two lane road, pedestrian footway (for emergency use only as foot passengers will normally be bussed to the ferry) and services, together with a space for the cement pipelines. The height of the bund is such that the road will be above all normal water and wave levels.

4.6.2 The access jetty continues the bund and provides the access to deeper water. The jetty will be a piled structure with a concrete deck supported on concrete piled bents at appropriate spacing. Provision is made to support the cement pipelines. To minimise costs, the jetty will provide only a single lane road and a pedestrian walkway; guardrails and kerbs will be fitted on both sides. As with the bund, the jetty roadway will be above all normal water levels. Near the main jetty, the access jetty becomes wider, forming an area for traffic circulation and providing a strongpoint for the support of the inner end of the linkspan.

4.6.3 The main jetty, which forms both the ferry berth and the unloading jetty will be an open structure with a concrete deck supported on piles. The general construction of the jetty is similar to that of the access jetty, but with shorter spans, and is heavier to reflect the loads imposed by the cement handling plant. The piles will support fenders on both sides against which the ferries and cargo ships will berth and moor. Rails and supporting structures will be provided for cement handling plant as required by the joint venture partner.

4.6.4 A linkspan will provide access to the ferry. The linkspan itself will be a steel box girder structure providing for a single lane of traffic, with a wider section at the ferry end to facilitate access to the full width of the ferry. At the seaward end the linkspan is supported on an integral buoyancy tank, whilst the shore end will be supported on the jetty structure. There will be provision to pump water in and out of the buoyancy tank to control the level and trim of the linkspan so that it will connect accurately with the ferry. The position of the linkspan will be controlled by strongpoints within the jetty structure.

4.6.5 A small amount of dredging will be carried out to the east of the berth to provide a turning circle for the ferries, and further dredging will be undertaken in the channel between the terminal and the existing channel serving the IPCL jetty. Dredging of the channel downstream of the IPCL jetty and of the channel across the bar is believed to be the responsibility of IPCL but it is not known if this dredging is presently being actively undertaken. This matter would need to be resolved before contractual commitments are made.

4.6.6 There are already proposals to mark the dredged channel at the river entrance by 14 lit navigation buoys and this proposal should be implemented, with extension as needed beyond the IPCL jetty, before the Dahej terminal is commissioned. Buoys will be used to mark turning points and any significant hazards.

4.6.7 Petronet are planning to start up a substantial port facility for the import of LNG to Dahej. The site that has been selected for this activity is on the Gulf immediately to the north of the Narmada River estuary. It is currently proposed that an offshore breakwater will be constructed in about 20m water depth to give protection to the LNG berth from the prevailing south westerly monsoon. Construction of this marine terminal, especially the breakwater, will have a significant effect on the flow regime in this area and this will inevitably result in a change to the present siltation and accretion levels in this area. The current flows in and around the estuary to the Narmada River are complex with the riverbed and seabed having a tendency for mobility. This will be aggravated by the new proposals. In order to estimate the changes that are likely to result the developers of the LNG terminal will have to conduct a detailed hydraulic model study. In doing this study, consideration should be given to the effect of the new proposals on the other facilities in the area. This should cover jetties presently existing as well as those proposed for the Narmada River estuary including the proposed ro-ro terminal.

<u>Shore Facilities in Detail</u>

The shore facilities have been planned using the optimum techno-economic approach because this envisages all functional needs coupled with technical standardisation to provide maximum service for a minimum land use. This planning has given the functional requirements such as:

- Terminal buildings;
- Administrative block;
- Medical facility;
- Fire station;
- Communication facility;
- Police and security services;
- Fuel storage and filling station;
- Water supply;
- Drainage;
- Refuse disposal service;
- Weighbridge;
- Shelter house;
- Post Office, telegram and fax services;
- Parking for trucks, cars and buses;
- Workshop for vehicle repairs.

The terminal building has initially been planned for 50 per cent of the capacity of passengers and traffic for departure and arrival at any time, based on the usage calculations at 4.4.4 above. It is thus about half the size of that at Gogha. It initially provides space for ticket sales, waiting space for departing passengers, a reception area for arriving passengers, baggage handling facilities, rest rooms, space for concessions such as snack bar and newsagent, and space for operational requirements (although most of these will be controlled from the administration building).

4.7.3 The administration building again is smaller than that at Gogha and provides principally office accommodation for terminal control and commercial administration, together with rest rooms and other common facilities. Customs officials are housed in a similar, but separate, building in the same complex. The administration building also supports the control tower which houses the equipment for navigation control.

4.7.4 The shelter house and canteen provides rest facilities for truck drivers. It is similar to that at Gogha, providing dormitory accommodation for some 80 drivers on two floors together with toilet and shower facilities, canteen and social area.

4.7.5 Full infrastructure services are provided. A substation contains switchgear to receive the incoming supply from the grid, and transformers provide the low voltage supplies for distribution around the terminal. Backup generation is provided for critical areas (such as navigation control). Water supply is taken from the main supply, and storage facilities are provided on site to even out demand and provide reserves for fire fighting and in case of mains failure. The storage facilities also provide the large quantities which are required for bunkering of the ferries. A small treatment plant is provided for the improvement of water quality, and the system is pressurised by an elevated reservoir. There is no central drainage treatment plant, and building drainage is treated through individual septic tanks. Drainage of roads and parking areas is generally be discharged direct to the sea, but in sensitive areas, such as the filling station, water is passed through oil and petrol interceptors before discharge.

4.7.6 The medical centre provides waiting and consulting rooms and a small treatment area, together with offices and stores. There is provision for in-patient accommodation.

4.7.7 The fire station is initially smaller than that at Gogha, providing accommodation for three appliances together with stores and offices. Open space will be provided for parking, vehicle washdown, hose drying and a training drill area. There will also be provision for the foam storage needed for fighting petrol and oil fires. In the later stages of development, it will be the same size as at Gogha.

4.7.8 Costings have been worked out based on the above planning of the shore facilities using a rule of thumb basis for the immediate requirements. These costings reflect the different levels of facilities within each building.

4.7.9 A further drawing has also been prepared to give an indication of the type of layout that would be required for the shore terminal facilities associated with the ferry port operating with a larger capacity to international standards. This gives an indication of how the shore facilities might look in a few years time (see Drawing No 97/003/30 in Appendix G). It should be noted that this drawing was prepared in the early stage of the study and does not fully reflect the land now available and the requirements for joint venture facilities. It shows a layout based on currently accepted international practice with a large marshalling area for the trucks which form the principal traffic. There is also a large area for container storage, reflecting a further development of the ro-ro concept. The layout provides for early separation at the entry gate between the freight and passenger traffics, with a dedicated passenger access around the perimeter of the freight area. There is also extensive car parking, acknowledging that car based passengers will begin to find the ferry useful.

4.8 Costings

4.8.1 These costings have been calculated using known prices for similar construction work in the area augmented by international construction costs where necessary and are based on information available at this time and may have to be modified in light of survey and other data received from site in due course The costs in the first phase are summarised in the table below.

Item	First Phase Construction Cost - Estimate (Rs Crores)
Berthing Jetty	29.21
Approach Jetty	13.73
Linkspan	7.80
Approach Bund	6.26
Transition Slab	0.07
Dolphins	-
Dredging	2.00
Navigation Aids	0.50
Passenger Shelter on Jetty	0.30

On Shore Civil Works	0.80
Terminal Buildings	3.68
On Shore Ancillary Services	0.49
TOTAL	**64.84**

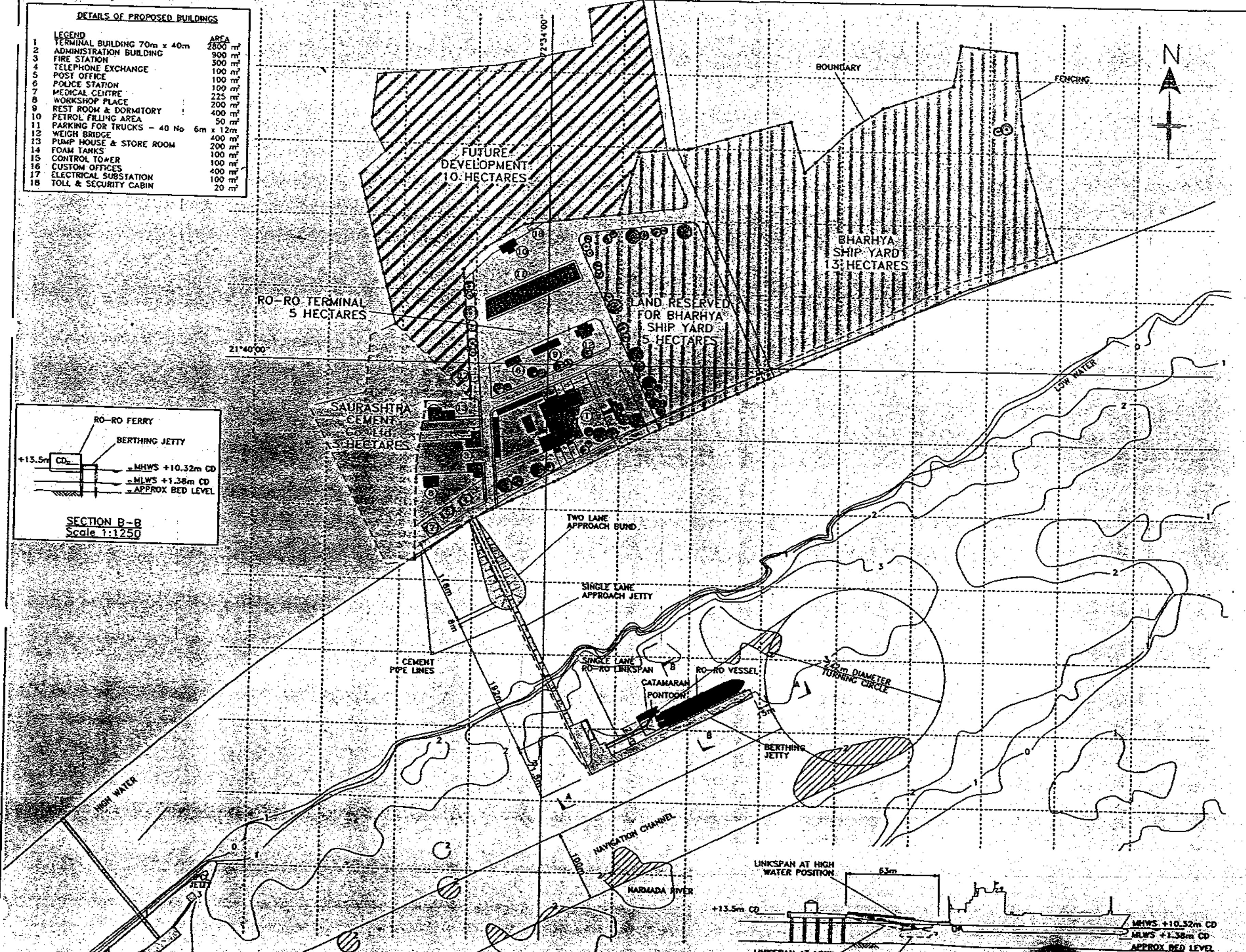
4.8.2 In the second phase additional terminal buildings will be provided involving a furher expenditure of Rs. Crores 0.84

4.8.3 Provision is made within the fendering costs, which includes those required by the ferry, for fendering for the joint venture ship. The fenders for the joint venture ship are not shown on the Drawings as their design is dependent on the type of ship to be used.

4.8.4 These costs do not include the purchase price for land or fees payable to licensing authorities for permission to construct and operate a ferry terminal at this location.

4.8.5 The costs noted above for the shore terminal are for the facilities required for the ferry services to start operation. Space has been allocated for further expansion to accommodate a full schedule of international services in due course.

4.8.6 More comprehensive details of the costings are set out in Appendix B.



NOTES:

1. COPYRIGHT BECKETT RANKINE PARTNERSHIP. THIS DRAWING, DESIGN AND CONCEPT IS CONFIDENTIAL AND MAY NOT BE REPRODUCED, MANUFACTURED OR EXPLOITED IN WHOLE OR PART WITHOUT PRIOR WRITTEN CONSENT.

2. THIS DRAWING IS FOR THE SOLE USE OF THE CLIENT FOR THE PURPOSE SHOWN.

3. DIMENSIONS ARE NOT TO BE SCALED FROM THIS DRAWING.

4. 'HIGH WATER' INDICATES EXTREME HIGH WATER LINE.

5. 'LOW WATER' INDICATES 0m CHART DATUM.

6. SEABED CONTOURS HAVE BEEN TAKEN FROM INS SURVEY 28 APRIL TO 14 MAY 1998 INCLUDING RELATIONSHIP TO LATITUDE AND LONGITUDE.

7. BOUNDARY TO LAND TAKEN FROM TOPOGRAPHIC SURVEY OF PROPOSED TERMINAL SITE AT DAHEJ (JAGESHWAR) AS DRAWN ON RAY CONSULTANTS DRG No RC/GMB/01 DATED 15/12/98. RELATIONSHIP TO LONGITUDE AND LATITUDE NOT PRECISELY KNOWN.

8. LAND CONTOURS ARE SHOWN ON RAY CONSULTANTS DRG No RC/GMB/02 DATED 2/1/99.

9. THE VALUE OF THE BM ON THE SUKHDEV ASHRAM TEMPLE IS 14.32m (JAGESHWAR) WHICH IS 14.32m ABOVE CHART DATUM.

10. THE 100m x 100m GRID IS CENTRED ON LATITUDE 21° 40' 00" N AND LONGITUDE 72° 34' 00" E.

11. AREAS TO BE DREDGED ARE SHOWN THUS:

Reference drawings:

0 50 100 150 200 METRES
Scale 1:2500

0 25 50 75 100 METRES
Scale 1:1250

REV	DATE	DETAILS
E	3/01	NAVIGATION CHANNEL AND DREDGING ADDED
D	3/01	GENERAL REVISION
C	11/00	100m GRID ADDED
B	10/00	LAND AREAS ADDED
A	10/00	NAME OF CEMENT COMPANY ADDED

CLIENT:

GUJARAT MARITIME BOARD

PROJECT: RO–RO FERRY SERVICES IN THE GULF OF CAMBAY

TITLE: DAHEJ FERRY TERMINAL TERMINAL LAYOUT GENERAL ARRANGEMENT

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KASHEC

RAY INFRASTRUCTURE

5.0 SUVALI TERMINAL

5.1 The Site at Suvali

5.1.1 Suvali is on the eastern coast at the entrance to the Gulf of Cambay. Although the Gulf is wide at this location Suvali Point is at the end of an isthmus that protrudes into the sea further than the surrounding land. It is therefore a natural place for consideration for a ferry terminal which would form a principal node in the Gulf network.

5.1.2 The land in this area is flat and low lying. From the borehole information made available to us it appears that the ground is predominately silty clay. Existing structures show that bunds can be constructed across the foreshore.

The Port Site at Suvali looking Seaward

5.1.3 This is an exposed coastline particularly to weather from the south westerly quarter, which is the prevailing direction for the monsoon. The seashore has gently sloping beaches of fine sand and there are muddy banks around the nearby rivers. Considerable offshore generated waves can be encountered in this location. The Tapi River provides sheltered but shallow water within its estuary. There is a considerable tidal range, but it is less than is found in the northern part of the Gulf.

5.1.4 The area around Suvali contains a number of major industrial plants, and so main services are already in existence in the area. Reasonable road access is already in place with direct connections to the nearby city of Surat which provides all commercial facilities and a rail link is planed in conjunction with Hazira Port.

Road Access to Suvali

.1.5 Many of the industrial plants have made their own arrangements for shipping various commodities and so a number of general cargo berths already exist along the banks of the Tapi River and at the river port of Magdalla, about 16km upstream. Although these berths can only handle small vessels, lighters are often used to tranship their cargoes from larger vessels anchored at sea close to Suvali Point. GMB is developing proposals for further general cargo berths in the Tapi River. A major port at Hazira/Suvali Point to handle LNG, other petroleum products and bulk cargoes is now in the advanced planning stage. We are not aware of any previous ferry services in the area.

1.6 Extensive hydrographic surveys have been made in the area, covering principally the Tapi River and the offshore areas north of Suvali point. These show that the Tapi River is generally shallow with a bar at its entrance, whilst the offshore areas are gently shelving with natural deep water at some considerable distance offshore. These surveys also cover the exploration bund constructed by Gujarat State Petroleum Company at Suvali point. It should be noted that some of these surveys are now nearly 20 years old and are unlikely to be accurate except in the most general terms. Our latest layout is based on the proposals made by Shell.


GSPCL Gas Exploration Bund at Suvali

1.7 A number of boreholes have been made in the Tapi River in connection with developments there, and these give a general indication of the prevailing ground conditions. We are not aware of any boreholes made in the offshore areas, although some information should be available from the GSPC exploration activities. It will be necessary to undertake borings at the specific site before construction contracts are let unless information is available from the Shell development.

1.8 There is no specific information on weather conditions, but they are unlikely to vary greatly from those at the other ports in the network. There appear to be no records of wave measurements in the area, but the site is fully exposed to the southwesterly monsoon. A preliminary study for the new port has given design wave parameters for the 100 year return event of 8.8m height and 14.8 second period; this is of course the offshore condition and would be reduced inshore.

5.1.9 No tidal records exist for the area, but the extreme tidal range is believed to be of the order of 7.5 metres. A recent survey shows tidal currents running broadly parallel to the shore with a maximum velocity of 5 knots.

5.2 Preferred Location

5.2.1. Two alternative areas have been considered for the development of a ferry terminal in the Suvali area (see Drawing No. 97/003/23 in Appendix B). These are at:-

- West side of the Tapi River estuary downstream of the Essar site;
- South west side of Suvali Point

5.2.2. The Tapi River estuary is relatively well protected from south westerly storms and does not suffer from severe current flow. It is however a shallow river and the estuary has a natural bar of silt banks that are likely to be constantly shifting. At the moment there is no access channel to the river with sufficiently deep water and this would have to be created in order to make this location a viable proposition. It is likely that training structures would have to be constructed in combination with regular dredging to maintain a viable shipping channel in this area. Reclamation of some land in the area immediately downstream of the Essar industrial site and berth could provide a suitable platform for a berth. Although this berth could be operated in most weather conditions it is unlikely that ferries would be able to enter the Tapi River in severe storms, even if an adequate channel could be maintained.

5.2.3 The Gujarat State Petroleum Company (GSPC) is prospecting for gas in the area around Suvali Point. It has constructed a 1.5km long approach for as a drilling platform. This bund could possibly be made available for use by GMB as the basis of a ferry terminal. However the berth would be some 2km offshore in an exposed location and would probably be unusable during most of the monsoon season. We considered whether it would be possible to support the linkspan by hoists which would allow it to be raised clear of waves. Even if this is technically possible, it closes the service down for perhaps 60 days in the year which we do not believe will be acceptable in a commercial service, the more so as Suvali is a prime destination. We have considered also a protecting breakwater, but the cost is not economically viable. Finally, there are safety implications in the public use of what would remain an oil and gas exploration site, and for all these reasons we have discarded this option.

5.2.4 The assessment was made before the tender to develop a large port (Hazira) in this general location. Now that Shell Petroleum have won this tender they have prepared plans for the new port and tentative provision has been made for ferry facilities to be incorporated within this development. It is likely that breakwaters would be constructed to provide sheltered water allowing the ferry terminal to be used in all weathers. Since making the ro-ro terminal site assessment, Shell's plans have become more definite.

5.2.5 The characteristics of the alternative locations have been examined and a comparative assessment has been made on the merits of operating ferries at each of these sites; further details of this assessment can be found in Appendix B. This assessment shows a clear advantage for a terminal within a larger development at Suvali Point.

5.2.6 This recommendation must then be conditional on the larger port development, but there is no viable location (unless very considerable restrictions are acceptable) which could be developed independently without the unsupportable cost of a breakwater.

5.3. Proposed Development - Preferred Option

5.3.1 We have obtained general information on the proposed development at Hazira, and our specific proposals are based on this information. Broadly we assume shelter within a larger development and access to deep water. Should the overall development change, then our designs may need consequential amendment; however our design is flexible and should be capable of following the natural evolution of proposals without major changes. It is unlikely that there will be marginal wharfage within the new port and so the Suvali terminal will be of the same general form as those at Gogha and Dahej, being an "offshore" berth connected to the onshore facilities by suitable access. We further assume that there will not be joint venture use of the berth since prospective partners will be able to construct their own facilities within the port and the berth will therefore be designed solely on the basis of use by ferries.

5.3.2 We have assumed that deep water will readily accessible within the port area and we have therefore sited the berth in 5m water depth allowing access at all states of the tide. Depending on the specific form of the port construction, adequate depth may be found sufficiently close to the shore to obviate the need for an access jetty, and the linkspan will be supported directly on shore structures. Should this arrangement not be practicable, then a short access bund or jetty will be required similar to those proposed at Gogha and Dahej.

5.3.3 Costs are minimised by the elimination of most of the berthing jetty and the ferry berths against a line of dolphins; these will be substantial structures fitted with fendering systems capable of absorbing the impact of the ferry berthing. The fendering system will take account of the varying sizes of ferries and will allow for differing levels of impact due to tidal variations. The dolphins will also be fitted with mooring bollards and will be linked to each other by walkways allowing access for rope handling.

.3.4 Access to the ferry is via a linkspan, similar to those at the other terminals, which is supported by an integral buoyancy tank at its outer end; location of linkspan is controlled by a dolphin at the outer end and its attachment to the shore at the inner end. Access to the ferry for foot passengers would be by way of a segregated walkway.

.3.5 It is assumed that the general port configuration will provide adequate shelter for the ferry berth in all weather conditions and no further shelter is provided within this proposal.

.3.6 Principal shore facilities are located on reclaimed land close to the berth providing facilities for reception of foot passengers and vehicular traffic, traffic control and administration. However, because of the limited area available, it will be necessary to separate certain functions (such as longer term parking) to a back-up area on shore.

3.7 These proposals are shown on Drawing 97/003/76 at the end of this section, and others in Appendix L.

4 Terminal Capacity

4.1 The ferry terminal at Suvali is near to the city of Surat and is likely to be a major node in the ferry network.

4.2 Ferries from Suvali are likely to service two destinations in the first instance; these are the cross Gulf links with Gogha and Pipavav. There is unlikely to be a demand for a route to Mumbai.

4.3 We have assessed the likely usage of this terminal in relation to cross Gulf ferry services. Connections to other parts of India and international routes should also be encouraged but are arising from the most adverse weather and sea conditions. The dolphins will be fendered on the berthing face and the fenders will be chosen to accommodate the tidal movement of the ferry. The fenders will provide energy absorbing units at high and low levels and these will be linked by vertical facings with low friction coatings allowing the ferry to move (principally vertically) against them without damage to ferry or fender. Light walkways will link the dolphins to facilitate the handling of mooring ropes, and a number of the dolphins will support mooring bollards. The seaward dolphin will be strengthened as this will normally be the ferries' first point of contact.

6.3 An additional dolphin will control the location of the linkspan which provides access to the ferry. The linkspan itself will be a steel box girder structure providing for a single lane of traffic, with a wider section at the ferry end to facilitate access to the full width of the ferry. At the seaward end the linkspan will be supported on an integral buoyancy tank, whilst the shore end will be supported on the jetty structure. There will be provision to pump water in and out of the buoyancy tank to control the level and trim of the linkspan so that it will connect accurately with the ferry.

6.4 It is not expected that any dredging will be required as the ferry berth will be formed within the overall port construction.

7 Shore Facilities in Detail

7.1 The shore facilities have been planned using the optimum techno-economic approach because this envisages all functional needs coupled with technical standardisation to provide maximum service for a minimum land use. This planning has given the functional requirements such as:

- Terminal buildings;
- Administrative block;
- Medical facility;
- Fire station;
- Communication facility;
- Police and security services;
- Fuel storage and filling station;
- Water supply;
- Drainage;
- Refuse disposal service;
- Weighbridge;

- Shelter houses;
- Post Office, telegram and fax services;
- Parking for trucks, cars and buses;
- Workshop for vehicle repairs.

The above listing will provide a self sufficient terminal similar to that provided at Gogha, both in size and scope. It is possible however that certain facilities (for example, fire fighting and medical and the basic infrastructure for services) could be provided from the facilities to be provided for the port as a whole. This would be a matter for discussion between GMB and Shell.

5.7.2 The terminal is designed for the same traffic levels as Gogha, provides the same facilities and uses the same structures wherever possible, so that the details applicable to Gogha (Chapter 3, section 3.7) apply equally here and are not repeated.

5.7.3 It should be noted that the area allocated for the onshore facility, as shown on Drawing 97/003/76, is not large enough to accommodate all facilities; it has been necessary, therefore, to split the onshore facility into two widely separated sections. Such an arrangement is less than ideal, and results in a large part of the staging and marshalling area being at some distance from the terminal.

5.7.4 We note also that the area allocated occupies a large proportion of the area which would normally be allocated as the back-up area to the general cargo berth. Whilst this may not be a problem in the short term, our experience elsewhere suggests that it may be a serious inhibition of any development of the berth, such as might be required for container handling.

5.7.5 We suggest therefore that GMB should explore with Shell whether additional reclamation might be undertaken (for example to the west of the berth), to allow all ro-ro facilities to be brought to a single site and provide for future developments of the main port. Allied to this discussion are safety aspects. As at present arranged, the access road to the ferry terminal passes very close to the LNG terminal, and in the event of an accident at the LNG terminal, this proximity might prevent evacuation of the ferry terminal, and indeed of the cargo and iron ore berths. We think that it would be prudent to discuss this as well with Shell and consider whether alternate access might be made available, or the existing access realigned further away from the LNG terminal.

5.8 Costings

5.8.1 These cost estimates were calculated on the basis that the ferry terminal at Suvali will be constructed within the larger development of the Hazira port. These costings have been calculated using known prices for similar construction work in the area augmented by international construction costs where necessary and are based on information available at this time and may have to be modified in light of survey and other data received from site in due course The costs for Phase 1 are summarised in the table below.

Item	Construction Cost Estimate (Rs Crores)
Piling	0.91
Linkspan	7.50
Bankseat	0.13
Dolphins	6.34
On Shore Civil Words	0.87
Terminal Buildings	4.24
On Shore Ancillary Services	0.64
TOTAL	**20.63**

In the second phase additional terminal buildings will be provided involving a further expenditure of Rs Crores 1.54.

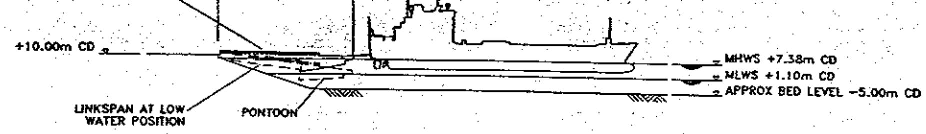
It should be noted that in the above table, the costs of the onshore facilities have been based on the cost analysis for Gogha.

5.8.2 Soil design parameters are not available at sufficient depth in order to allow accurate estimation of piling costs, and so considerable variation in the price of the piling is possible depending on soil conditions found on site. Piling costs make up approximately 70 per cent of berth costs, and the estimates of piling cost included are closer to the higher end of price variability. A Rs 5 crore reduction in the total price of the project would represent the probable lower bound of piling cost variation in respect of the preferred option. Costs of onshore works assume that the reclaimed area will be suitable for shallow foundations as are used at the other sites.

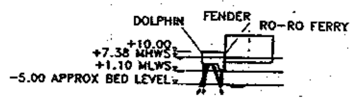
5.8.3 These costs do not include the purchase price for land or fees payable to licensing authorities for permission to construct and operate a ferry terminal at this location nor any fees or royalties to the developers of Hazira port.

5.8.4 The costs noted above for the shore terminal are for the facilities required for the ferry services to start operation. Space has been allocated for further expansion to accommodate a full schedule of international services in due course.

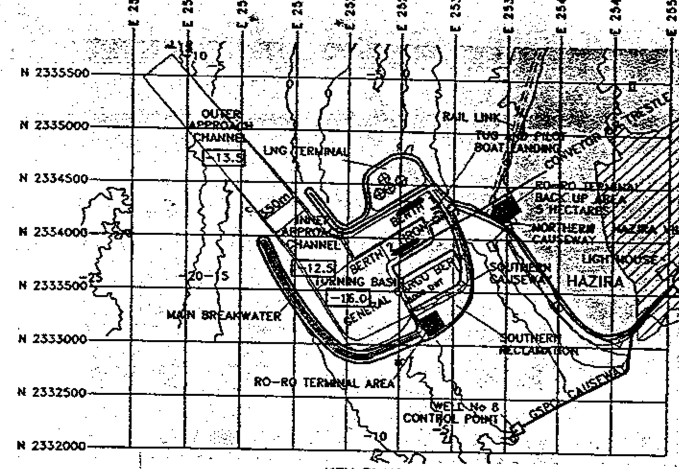
5.8.5 A breakdown of the costings is attached in Appendix B.



SECTION A-A – VESSEL AT MHWS (BERTHING JETTY NOT SHOWN)
Scale 1:1250



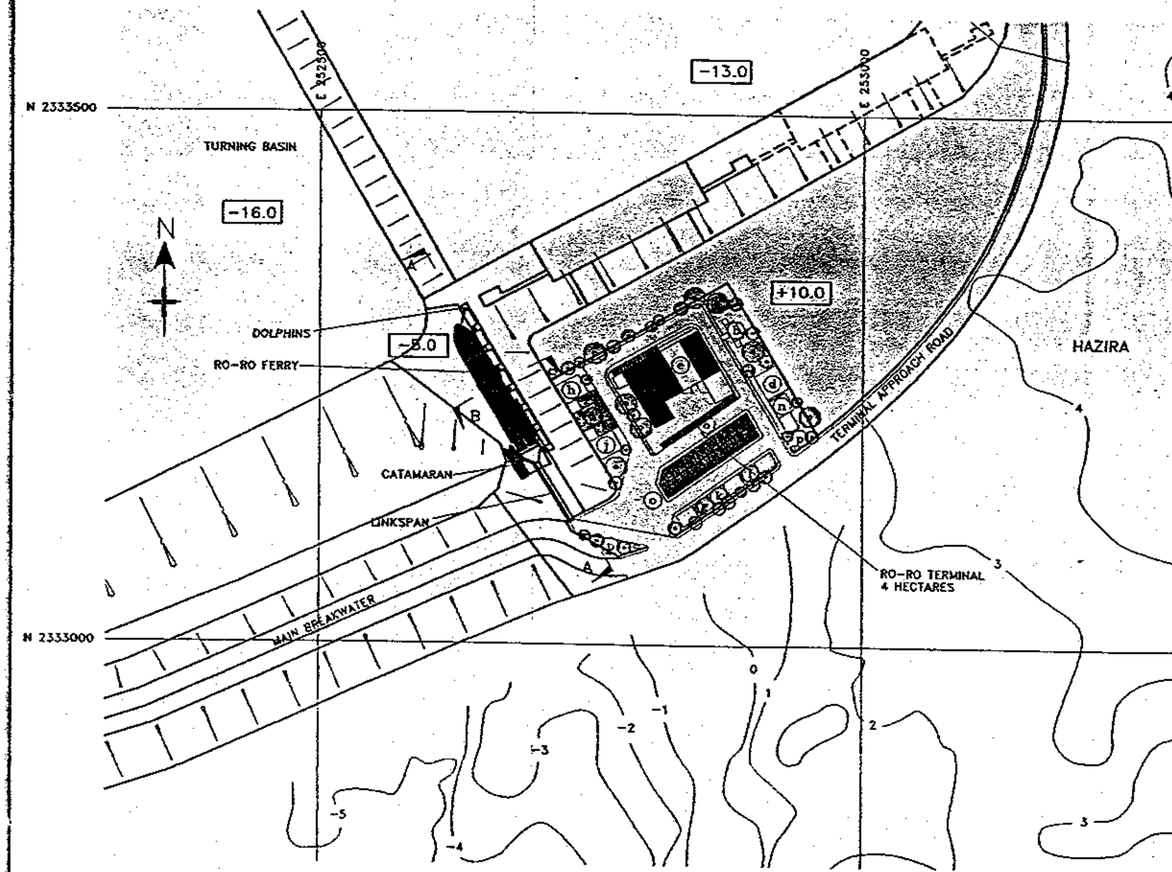
SECTION A-A VESSEL AT MHWS
Scale 1:1250



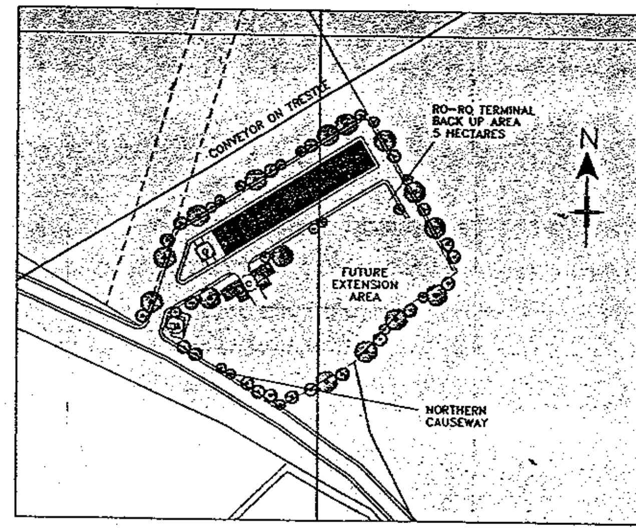
KEY PLAN
Scale 1:25000

DETAILS OF PROPOSED BUILDINGS

LEGEND
- a TERMINAL BUILDING
- b ADMINISTRATION BUILDING
- c FIRE STATION
- d FOAM TANKS
- e CONTROL TOWER
- f CUSTOM OFFICES
- g POLICE STATION
- h TELEPHONE EXCHANGE
- i POST OFFICE
- j MEDICAL FACILITIES
- k SHELTER HOUSE & CANTEEN
- l ELECTRICAL SUBSTATION
- m FILLING STATION
- n WATER PUMP HOUSE
- o PARKING – 7 TRUCKS, 30 CARS PUBLIC, 20 CARS STAFF
- p TOLL & SECURITY CABIN
- q WEIGHBRIDGE



PLAN ON RO-RO BERTH
Scale 1:2500



RO-RO TERMINAL BACK-UP AREA
Scale 1:2500

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Reference drawings:

Scale 1:25000 — 0, 500, 1000, 1500, 2000 METRES
Scale 1:2500 — 0, 50, 100, 150, 200 METRES
Scale 1:1250 — 0, 25, 50, 75, 100 METRES

REV	DATE	DETAILS
B	6/3/01	ENLARGEMENT
A	14/2/01	RO-RO BERTH RESITED

CLIENT:

GUJARAT MARITIME BOARD

PROJECT: RO-RO FERRY SERVICES IN THE GULF OF CAMBAY

TITLE: SUVALI FERRY TERMINAL AT HAZIRA PORT TERMINAL LAYOUT GENERAL ARRANGEMENT

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STATUS	SCALE	DRAWN BY	CHECKED	DATE
PRELIM	AS SHOWN	DWB	RPR	01/01

DRAWING No: 97/003/76 | REV. B

.0 PIPAVAV TERMINAL

.1 The Sites at Pipavav and Jafrabad

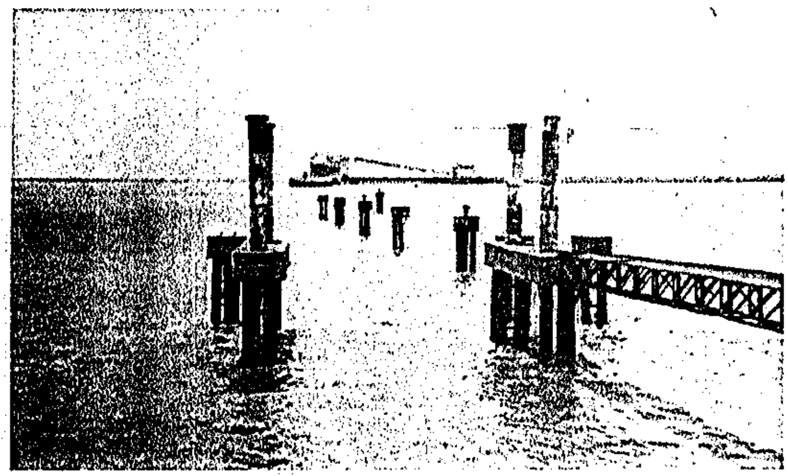
.1.1 Pipavav and Jafrabad are two ports situated about 20km apart on the Saurashtra coast on the western side of the approach to the Gulf of Cambay. They are exposed to the open Gulf, but the land offers some protection from the southwesterly monsoons. Although ferry journeys from these ports will inevitably be lengthy they will be considerably shorter than the alternative of travelling by road and development of a ferry terminal at one of these locations would considerably improve the transportation links with southern Gujarat.

.1.2 This is a rocky coast with hills further inland. There is deep water close to the shore with littoral currents keeping silt away from much of the coastline although there are some inlets that are heavily silted up. This area is directly exposed to the ocean with little protection against offshore generated waves and storms, particularly during the monsoon period, can be disruptive to shipping movements.

1.3 Jafrabad is a small harbour and home to a seasonal fishing fleet. A single jetty is situated in the centre of the harbour and for most of the year cement products are exported from this jetty to the Narmada Cement factory on the eastern shore of the Gulf. A breakwater extending from the western shore of this natural inlet offers protection to the jetty; but has been damaged by storms. The presence of the breakwater may also contribute to the siltation within the harbour which requires constant dredging to keep the berth and turning circle operational. There is only limited road access (through narrow streets in the town) to the south side of the harbour and a bypass would be needed before any development could be considered.

The Breakwater at Jafrabad

1.4 Pipavav Port is located behind a small island, Shial Bet, which offers some useful protection against wave action, particularly during the monsoon period. The port has recently been developed and there are three general cargo berths operational with an LPG terminal under construction. We understand that a new container terminal is being developed now that PSA have joined the project. Land reclamation is also proceeding and it is understood that construction of a ship breaking yard may start shortly. This entire development is in the area protected by Shial Bet and these berths are believed to operate in all weather conditions. However it should be noted that the Larsen and Toubro Cement Works jetty, which is only 600m to the south west of the Pipavav Port jetties, cannot be used during the monsoon period due to wave action, suggesting that the viability of berths is very sensitive to location. The remains of a failed attempt to introduce a ro-ro berth can be seen at the western end of the new jetty construction. The strength of this berth was clearly inadequate and it is understood that it collapsed without being used. Road access is poor but it is understood that proposals are in hand to improve this.



The Failed Ro-Ro Berth at Pipavav

6.1.5 Hydrographic information is available for both ports, although that for Jaffrabad is clearly dependent on the continuation of the maintenance dredging. At Pipavav there is deep water alongside the berths and, since there does not appear to be any requirement for maintenance dredging, it would appear that these depths are stable.

6.1.6 We do not have any borehole information for these sites since detailed construction proposals are outside our terms of reference. However continuing developments show that jetty construction is feasible, and developers will no doubt be able to obtain access to boreholes and construction records relating to the recent developments.

6.1.7 There is little specific weather information for Pipavav and Jaffrabad, the prevailing system being the southwesterly monsoon. We have not found any records of wave activity; as noted above conditions at Pipavav are clearly sensitive to position, and although one source considers that there is too much swell in the monsoon, this is countered by reports of year round activity at the general cargo berths. A study of conditions at Mithivirdi (some 100km further up the coast) has projected a maximum significant wave height of 4m.

6.1.8 We have not obtained detailed tidal records for these ports, where the tidal range will be somewhat less than that at Gogha further up the Gulf. There is similarly little information on currents, but these are likely to be typical of the Gulf conditions at 4 –5 knots. There are no reports of navigational difficulties at either port.

6.2 Preferred Location

6.2.1 Four possible sites have been considered for the development of a ferry terminal in the Jafrabad/Pipavav area (Drawing No. 97/003/22 in Appendix B2. These are at:-

- Jafrabad harbour, western side;
- Jafrabad harbour, eastern side;
- Pipavav Port, western side (previous ro-ro site);
- Pipavav Port, eastern side.

6.2.2 The western side of Jafrabad harbour offers good protection against storms and is particularly well protected against the south westerly monsoon. A new jetty for ferries would have to be constructed from the western shore and the area of dredging near the centre of the harbour would have to be extended to provide sufficient depth of water. Road access to the western side of the harbour is currently restricted with all traffic having to pass through the narrow streets of Jafrabad. A new by-pass would have to be constructed to connect the ferry terminal directly with the main road.

6.2.3 The eastern side of Jafrabad harbour could accommodate a ferry terminal. This would have to be to the north of the existing cement jetty because all areas to the south would be too exposed. Road access to this side of the harbour is good and a connection could be made directly to the terminal. It is generally not desirable to operate ferries in close proximity to industrial plants unless they are controlled by stringent anti-pollution measures. Close attention would have to be given to such measures before a ferry terminal could be developed in this location.

6.2.4 The western end of the jetties at Pipavav port is a reasonable location for constructing a ferry terminal. Although this would be the least well protected area of the port it is only marginally more exposed than the No. 1 berth that is currently in operation. The location of the previously failed ro-ro berth is still available and this could be used to good effect following removal of the wreckage. It is understood that suitable road access can be made available to this berth and an area of land would have to be allocated for a shore terminal.

.2.5 The eastern side of Pipavav Port is well protected against storms and a ro-ro terminal could be constructed here. There would be adequate water depth, safe berthing and easy access. An approach bund would have to be constructed together with a new jetty and dolphins to berth the vessel. This area does however have the disadvantage of being rather too close to the LPG terminal that is currently under construction and this may have adverse safety implications. Furthermore, road access to the berth would have to cross the main gas pipelines. There are also plans for an LNG terminal in this area, although this does not appear to be moving forward at the moment.

2.6 The characteristics of the alternative locations have been examined and a comparative assessment has been made on the merits of operating ferries at each of these sites; further details of this assessment can be found in Appendix B. This assessment shows a clear advantage for the western site at Pipavav where the new berth would be constructed at the general location of the previous ro-ro berth.

2.11 It is understood that if the ferry terminal at Pipavav is to be constructed this would be carried out by Gujarat Pipavav Port Limited which is a joint venture company with GMB. We have not therefore made any detailed proposals for the terminal at this site.

7.0 FERRY OPERATIONS

7.1 Ro-Ro Vessel Types

7.1.1 The sea transportation of cargo by Ro-Ro vessels has become popular in recent years, particularly in Europe where several ports are dedicated to this form of transport. This popularity is driven by the effectiveness and versatility of Ro-Ro operations largely because this form of cargo can be handled quickly and cost effectively. There are several types of Ro-Ro vessels currently in use around the world, many of which have been specially designed for operation on dedicated routes for specific cargoes. In selecting particular vessels for operation on individual routes consideration must be given to the sea conditions on these trading routes as well as protection from storms at the berths and the facilities that will be made available for handling cargo at the shore terminals.

7.1.2 The type and volume of cargo to be carried on the service must also be considered because Ro-Ro vessels can be loaded and operated in a number of different ways. The loading of self drive vehicles, particularly trucks but also cars and buses, is probably the most common form of Ro-Ro operation. Shipping of unaccompanied trailers and containers is also popular. This can be highly efficient for some transport businesses because the roadgoing tractor unit and driver do not go on the ferry and therefore can be deployed on other work during this time. There is, of course, more space available on the vessel for cargo rather than having to carry the dead-weight of the vehicles. One of the most effective way of utilising Ro-Ro vessels is to block stack cargo directly onto the main cargo decks. However this is a specialist operation and cannot readily be mixed with the general carriage of vehicles.

7.1.3 Safety is of paramount importance when operating of Ro-Ro vessels, both while they are at sea and when handling cargo at a berth, and this is considered in detail in the next chapter. A number of accidents in the last few years have highlighted the fact that Ro-Ro vessels are inherently unstable when even a small amount of water infiltrates the main cargo deck. It is essential that no corners are cut in the operation of Ro-Ro ferry services because mistakes in operation that would appear to be small can have devastating repercussions.

7.1.4.1 For a ferry service to be effective it must be able to maintain a regular timetable of operation that can be relied upon by transportation businesses. The ferry services will be in competition with the alternative method of transporting the goods which in this case would mainly be driving on the state and national highways around the head of the Gulf. Haphazard and unreliable departure times would not be a realistic alternative to a road journey even though the sea time might be quicker over the specified route. Efficient operations will also require a quick turnaround in port with fast and efficiently organised unloading and loading of vehicles in order to make the service viable. Regular ferry operations should be exempted from procedures that sometimes delay vessel movements, for example customs control should not cover this operation (unless service embarks from outside India) and the master of the ferry should be able to navigate without additional pilot assistance after he has sailed a specified number of crossings on each of the routes.

7.1.5 We have considered the introduction of Ro-Ro services across and around the Gulf of Cambay centred on new terminals at Gogha, Dahej and Suvali. Also included in this exercise is a terminal at Pipavav, which is also likely to be constructed and the existing Ro-Ro terminal at Mumbai. Ro-Ro services to other ports in India may be introduced in due course as well as international services, for example to the Middle East. For the purpose of this report we have considered that the cross gulf services will commence with combined Ro-Ro and passenger vessels leaving the more specialist vessels to be introduced at a later stage.

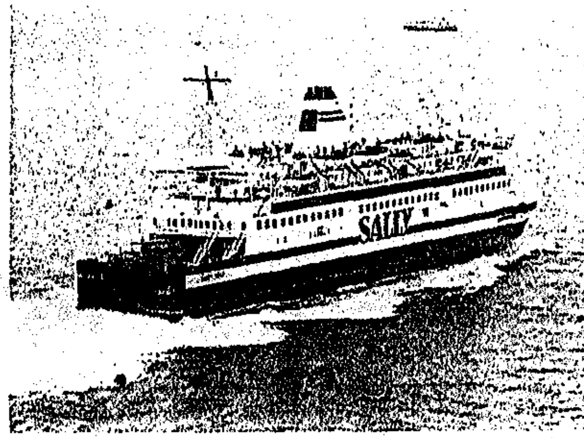
7.1.6 Ro-Ro ferries sailing between the terminals in the Gulf of Cambay must be sufficiently powerful and manoeuvrable for operation in these waters. Vessels with twin propellers and bow thrusters would be preferable. Sea keeping in storm condition is also an important factor particularly for the more exposed routes in the lower Gulf of Cambay and onward to Mumbai where ocean going vessels would be required.

7.1.7 To give examples of vessels that could be used for this Ro-Ro service we have drawn together particulars of a range of vessels that are currently in operation in European waters. Six typical vessels are shown on the following pages. As most of these vessels have been designed for specific routes they have a broad range of dimensions, characteristics, capacities and capabilities. Vessels with conventional stern doors and ramps would be required for this service. Vessels with no on-board ramps or with quarter ramps would not be suitable for this operation. We have only considered conventional vessels at this stage in order to keep the start-up risk to a minimum. Specialist vessels such as fast ferries and vehicle carrying catamarans are normally introduced to routes that have already established a firm demand. The tonnage of the vessels shown may appear to be anomalous due to a change in the measurement system in 1982.

Ro-Ro Ferry 1 - Conventional Passenger and Vehicular vessel

Built in	1981
Length	137.4m
Beam	22.5m
Draft	5.8m
Speed	19.5 Knots
GWT	9120 tonnes
Capacity	75 trucks
	1800 passengers

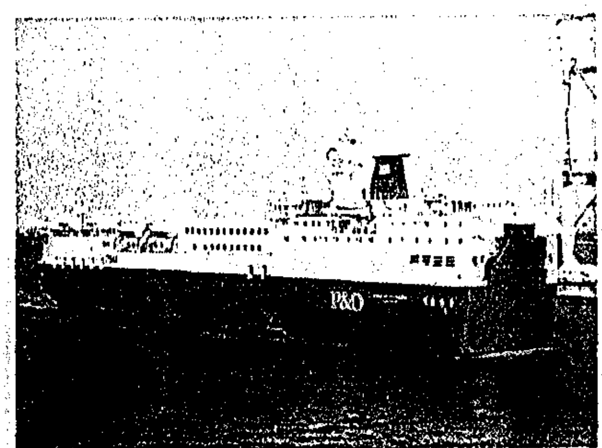
Stern ramp + stern passenger ramp



Ro-Ro Ferry 2 - Conventional Passenger and Vehicular vessel

Built in	1978
Length	151m
Beam	23.6m
Draft	7.3m
Speed	17 Knots
GWT	18732 Tonnes
Capacity	40 trucks
	688 Passengers

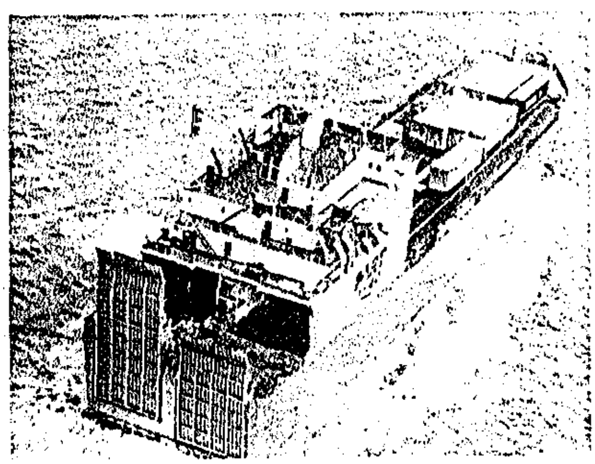
Stern ramp



Ro-Ro Ferry 3 - Conventional Freight vessel

Built in	1984
Length	120m
Beam	15.5m
Draft	5.3m
Speed	15.5 Knots
GWT	8000 Tonnes
Capacity	80 Trucks
	12 Passengers

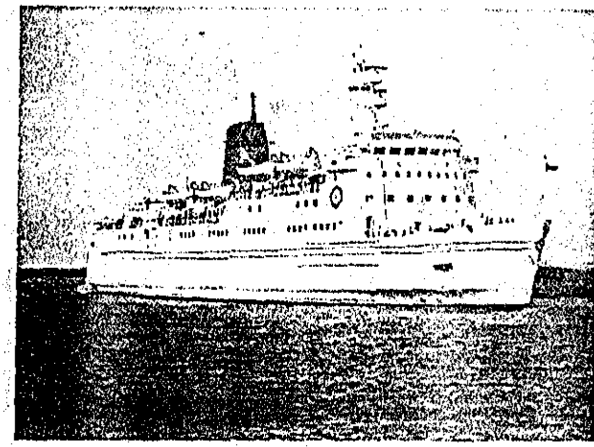
Dual stern ramps



Ro-Ro Ferry 4 - Conventional Passenger and Vehicular vessel

Built in	1975
Length	114.6m
Beam	18.6m
Draft	4.1m
Speed	19.5 Knots
GWT	4649 Tonnes
Capacity	34 Trucks
	1100 Passengers

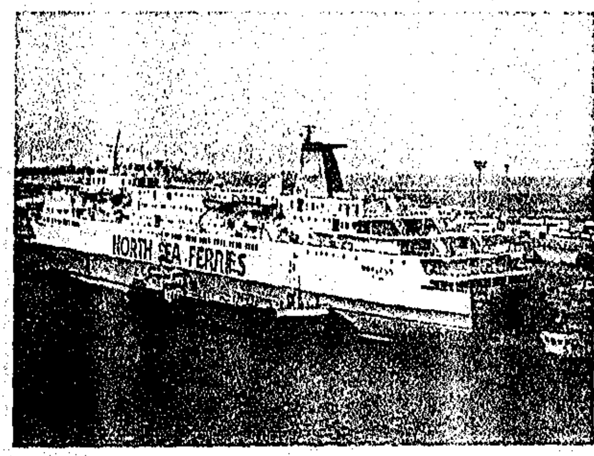
Stern ramp



Ro-Ro Ferry 5 - Conventional Passenger and Vehicular vessel

Built in	1974
Length	153m
Beam	25.2m
Draft	6.2m
Speed	19 Knots
GWT	26290 Tonnes
Capacity	134 Trucks
	881 Passengers

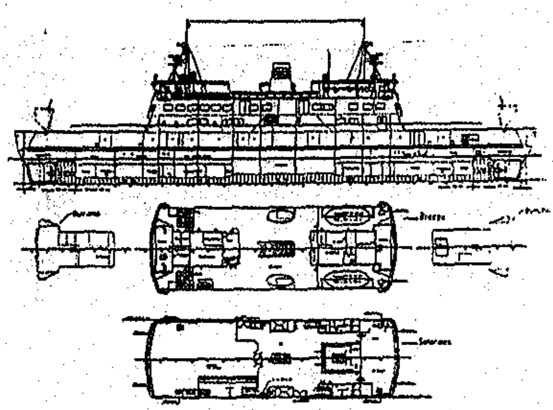
Stern ramp



Ro-Ro Ferry 6 - Double Ended Passenger and Vehicular vessel

Built in	1967
Length	88m
Beam	13.3m
Draft	4.1m
Speed	11.5 Knots
GWT	4000 Tonnes
Capacity	18 Trucks
	450 Passengers

Bow and Stern ramp



7.1.8 Because of the transient nature of many Ro-Ro operations a number of secondhand Ro-Ro vessels are often available on the world market. Recently, the availability of secondhand Ro-Ro vessels has increased because of the new channel tunnel linking UK with Northern France. This has resulted in over capacity on one of the world's most popular Ro-Ro routes, which has led to vessels being shifted to other routes with some being made available for sale. Also Ro-Ro ferry operators are becoming conscious of two separate issues, namely the requirement for faster and safer vessels. By upgrading their fleets with high speed ferries some operators are selling some of their slower vessels. With modern ferries now incorporating more safety features some of the older vessels are also becoming available. Clearly utilisation of older vessels must be considered in the light of the requirements that are necessary to make the operation of these new routes as safe as possible.

7.1.9 A table has been prepared of Ro-Ro vessels that are currently available for purchase to give an indication of the market. This is attached in Appendix D.

7.2 Passenger Ferry Types

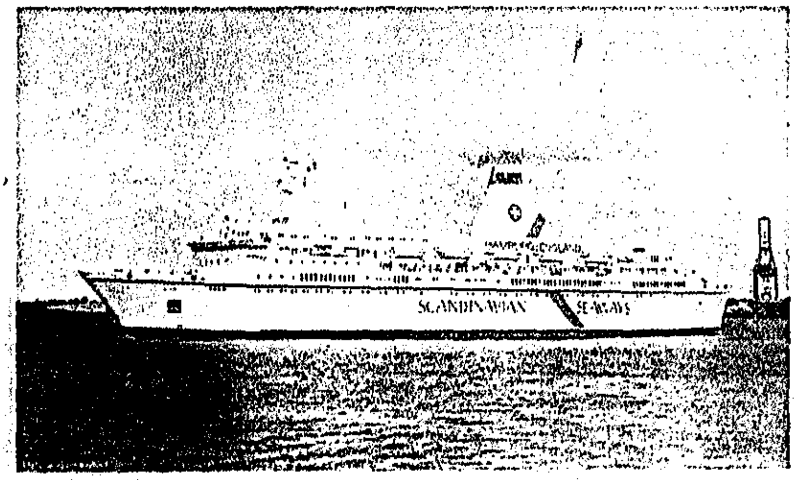
7.2.1 Although priority consideration is being given to the introduction of a combined vehicle and passenger ferry service, designs of the terminals should be prepared with a view to the future commencement of a passenger only ferry service. Catamaran ferries, as referred to in the brief, are one category from a range of vessels that operators would consider when assessing the viability of these routes. It is likely that conventional ferries and other fast ferries would also be considered.

7.2.2 The selection of a vessel for a particular route needs to take a large range of factors into consideration. Route length and sea state are among the more important factors for consideration and they are interrelated. Passengers will tolerate an uncomfortable trip for a short period but most would avoid 1½ to 2 hours of discomfort. Original fast ferry crossings were considered to be practically limited to around one hour duration but recent improvements in ride quality have increased this for larger craft (where passengers may walk around) to near 1½ hours. A rougher route therefore requires a larger craft with better sea keeping qualities.

7.2.3 Although small in capacity compared to conventional ferries fast ferries can transport considerable passenger numbers of account of their high speed and quick turnaround times.

This results in a fast ferry being able to make more return journeys in a day than a conventional ferry. There is however a problem selecting craft for routes that are likely to be rough because the sea state may dictate a large craft which would be expensive resulting in higher fares than for conventional vessels. A detailed assessment would have to be made of the viability of such a operation since there is a high commercial risk in the case of ferry routes that have not previously been tried and tested.

7.2.4 Conventional monohull ferries could be operated in the Gulf of Cambay. Although slower than the more glamorous fast ferries they would more economical to operate which could be an advantage, particularly when setting up a new route. Vessels with good sea keeping ability would be required as well as sufficient power and manoeuvrability to cope with the strong tide. A typically conventional ferry that could be suitable for operation in these waters is shown here.



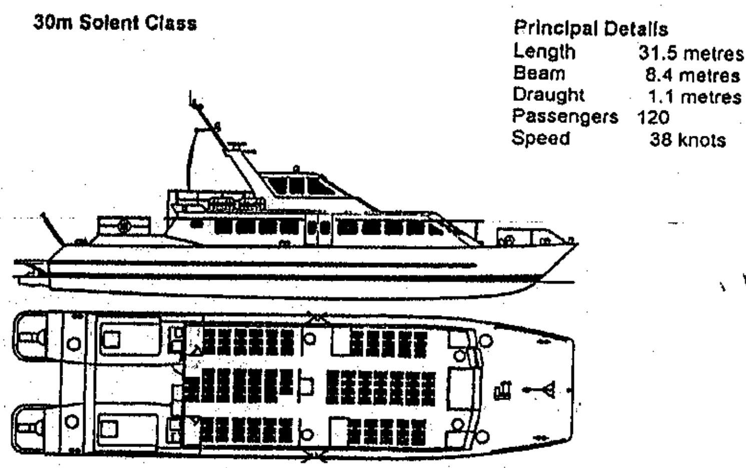
Typical Conventional Ferry

7.2.5 There are eight main designs of fast ferry, these are:

- The standard catamaran
- The small waterplane twin hull catamaran (SWATH)
- The hydrofoil
- Foil assisted catamarans
- Wave piercing catamarans
- Air cushion vehicles (hovercraft)
- Surface effect ships (SES)-combination of air cushion/catamaran
- Fast monohulls

7.2.6 All these designs have one aim in common which is to reduce the energy that the craft expends in wave making (form drag) and therefore reduce the amount of engine power required to push the vessel at high speed.

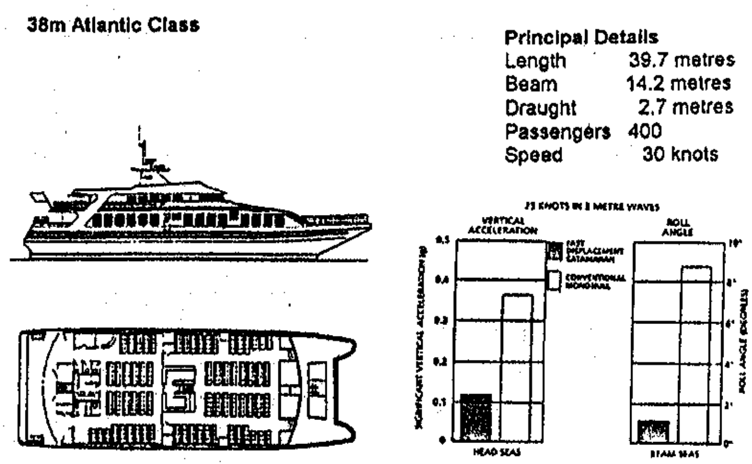
7.2.7 The modern catamaran ferry consists of two long thin hulls powered by two or four engines located within the hulls. While some craft still use conventional propellers the majority are now fitted with a water jet propulsion system. This has the advantages of greatly reduced draft and increased manoeuvrability. Typically a water jet powered catamaran would not require a bow thruster for berthing.



Fast Catamaran Ferry

7.2.8 As a result of the broad beam and high speed of a catamaran ferry it can suffer from an awkward and uncomfortable motion in a sea. The motion is much quicker and jerkier than a conventional ship's roll and this can cause motion sickness. To ameliorate this problem modern craft are frequently fitted with active foil stabilisers or trim tabs. These do improve the ride quality a little but the development of these systems is still at a relatively early stage and much greater improvements can be expected in the future.

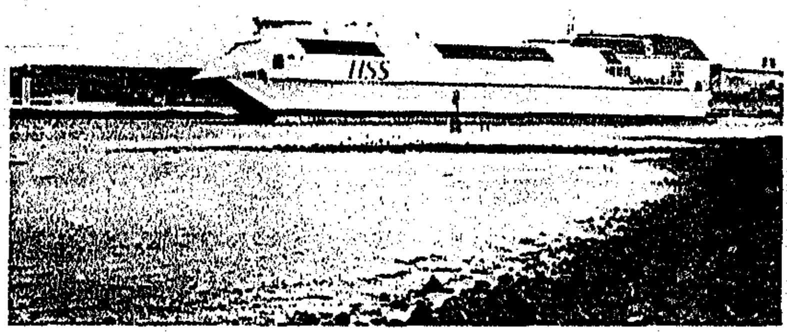
7.2.9 A SWATH vessel is a catamaran with hulls which are very narrow at the waterline but are bulbous at the bottom below the waterline. By reducing the waterplane area of the hulls the vessel becomes much less responsive to the passing of waves since the vessel's buoyancy is concentrated below the water surface. SWATH vessels are normally powered by conventional propellers although waterjets can be fitted. SWATH vessels have the best motion characteristics of all types of vessel and are thus more suitable for routes with larger and longer waves such as are present in the



A Swath Vessel

Lower Gulf of Cambay. SWATH vessels are relatively deep drafted and they are significantly more expensive to build than conventional catamarans, they also require more power for a given speed and payload.

7.2.10 HSS (High Speed Ship) ferries have been introduced on selected services around the UK. These SWATH type vessels carry cars, trucks and passengers at twice the speed of conventional ferries and operate successfully in light and moderate sea conditions.



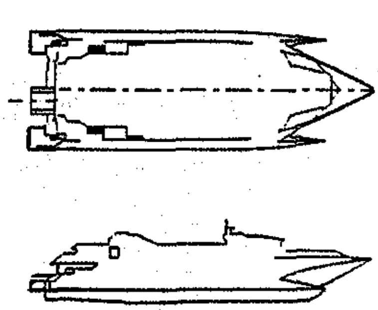
HSS in Service

7.2.11 The hydrofoil is a proven design that has been in use worldwide for over 30 years. Hydrofoils reduce the drag by raising their single hull out of the water on either totally or partly immersed foils. They consequently have the disadvantage of deep draught for their size particularly when they are travelling at slow speed or are at rest. Hydrofoils tend to have higher power demands for a given speed and payload than the more modern catamaran designs, therefore few are built today.

7.2.12 A foil assisted catamaran is a catamaran with foils fitted below the hulls. This results in vessels with deeper draft and greater stability than standard catamarans.

7.2.13 Wave Piercing Catamarans are catamarans with a sharp protruding nose to each hull. The theory is that the nose pierces through an oncoming wave resulting in a more gentle rise of the craft to each wave. The

Incat 74m (shown)



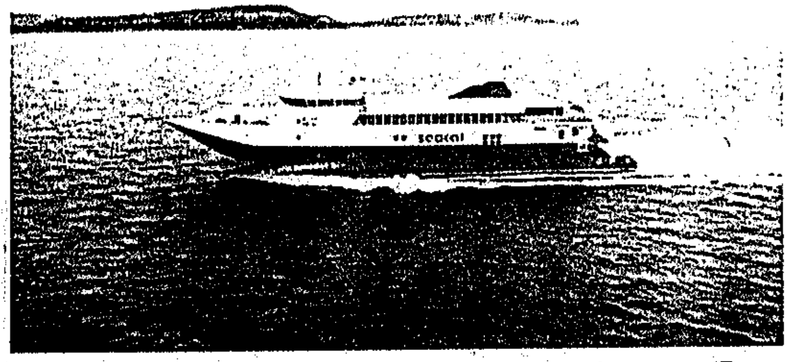
Principal Details

	Car Carrying	Passenger Only
Length	74.2	48.7 metres
Beam	26.0	18.2 metres
Draught	3.0	1.9 metres
Passengers	430	450
Cars	80	-
Speed	35	35 knots

Wave Piercing Catamaran

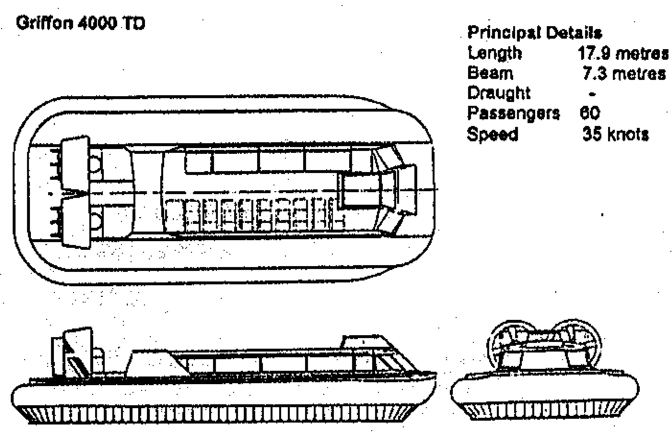
effect appears to work with certain wave heights but the improvement in ride quality is not sufficient to obviate the need for active ride control systems as well. Wave piercing catamarans are usually waterjet powered.

7.1.14 Fast ferries can give rise to unusual wave formations in their wake. Cases have been reported where these long period waves have reached the shore and built up to a single or small number of high waves over a short timescale.



Seacat Car and Passenger Catamaran Ferry

7.2.15 Hovercraft have been proven in service having been tried and tested worldwide since the 1960s. Hovercraft have the unique advantage over all other types of fast craft in being amphibious. They are therefore an excellent vehicle for routes with very shallow water or poor port facilities since they are able to run up a beach and discharge passengers directly to the shore. A previous attempt to run a hovercraft service from Gogha to Suvali was unsuccessful, although this may be a reflection on the commercial viability of the route, especially for passengers only, rather than the suitability of the hovercraft.



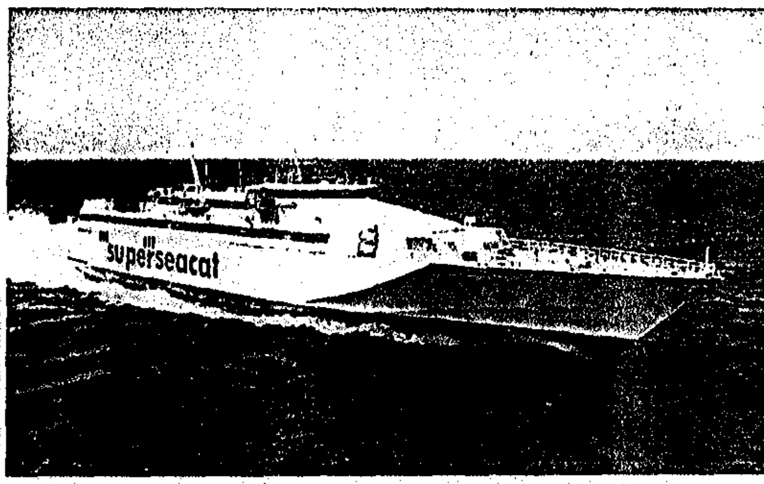
Hovercraft

7.2.16 Early hovercraft designs had high power requirements per passenger carried. Due to technical advances, particularly in skirt design, modern craft are much more economical. Other recent developments have included the use of lightweight diesel engines instead of aero engines giving greater reliability and easier maintenance. Also improvements in airscrew design have made the craft significantly quieter. One remaining disadvantage of hovercraft is the cost of maintenance to the skirt. This can become a significant maintenance burden if the craft regularly travels over an abrasive surface. In general travel should only be over wetted surfaces if skirt life is to be maximised.

7.2.17 Unlike all other craft, hovercraft are not affected by the speed or direction of tidal currents unless operating near their maximum sea state. Hovercraft are however affected by wind speed. Hovercraft can, in their larger sizes such as used by Hoverspeed on the Dover-Calais route, carry cars, but not heavy commercial vehicles.

7.2.18 The SES is a development of the hovercraft with the side skirts replaced by very narrow hulls with flexible skirts only at the bow and stern. Forward power is by conventional water propellers. This modification results in a greatly reduced length of skirt to maintain but at the cost of the loss of amphibious capacity. An SES has a relatively deep draft for its size when at rest and, like standard hovercraft, would be unable to operate in rough sea conditions such as those often encountered in the lower Gulf of Cambay during the monsoon.

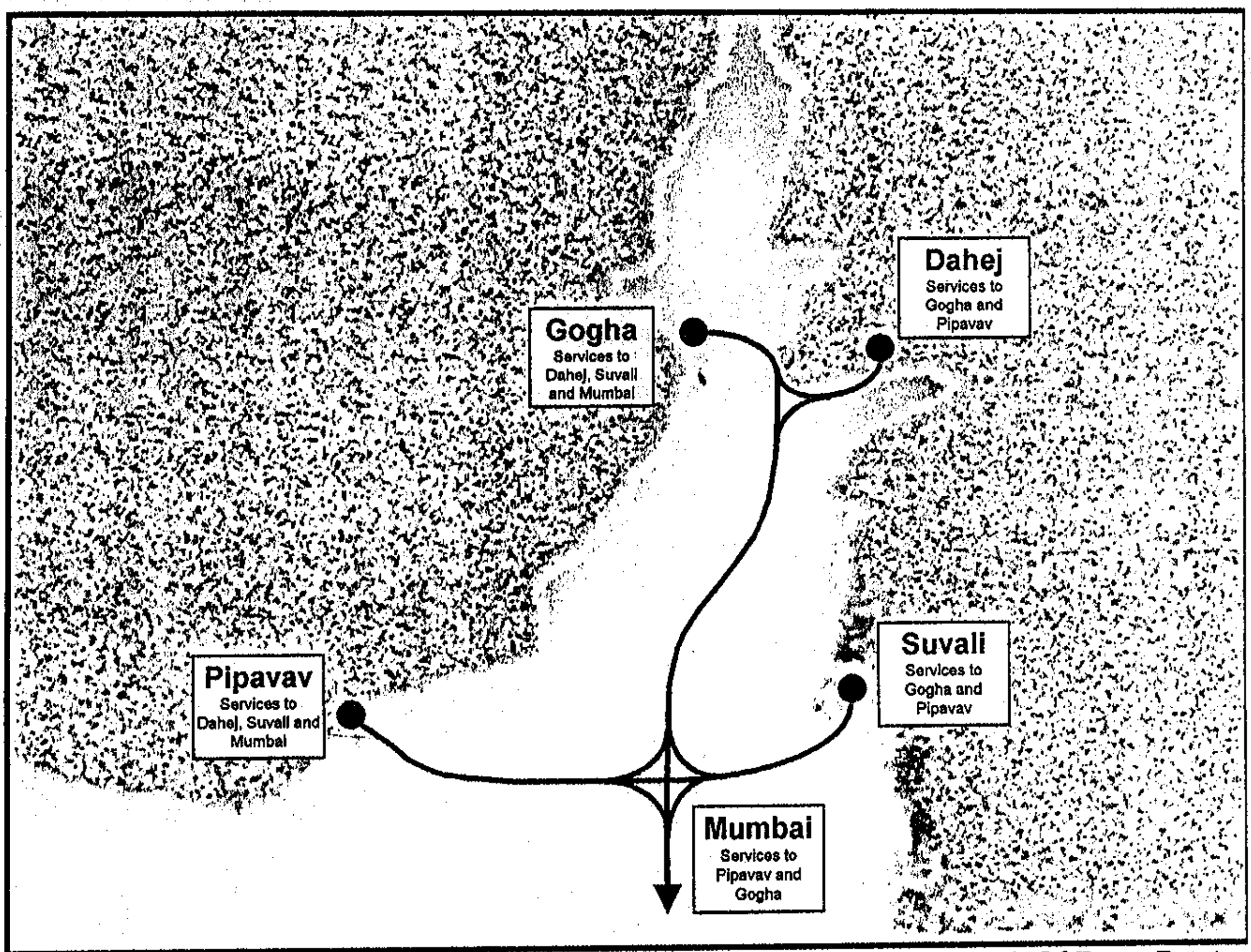
7.2.19 Fast monohulls are long thin conventional vessels with powerful engines. They are used on relatively calm routes particularly in the Mediterranean although a new service has recently started across the English Channel with 'Super Seacat' vessels. However they are not generally suited to rougher routes with long swells on the beam such as occur in the lower Gulf of Cambay.



Super SeaCat

7.3 Ferry Routes

7.3.1 In order to analyse the likely movement of ferry bound vehicles and passengers we have developed a network of ferry routes to link the proposal terminals around the Gulf of Cambay. We have also included Mumbai as a destination and for the purpose of this study we have assumed that the existing Ro-Ro terminal in Mumbai would be fully operational and available for use.



The Proposed Network Of Ferry Routes

7.3.2 Combined vehicle and passenger Ro-Ro vessels have been adopted for the purpose of this study and timetables have been drawn up showing a practical operation for one, two or three vessels. Ferry routes to other parts of India and international routes, particularly to the middle east, will be required to maximise the efficiency of the terminals, but this is beyond the current scope of this study.

7.3.3 The routes that we have examined are:

1. Gogha - Dahej (40km, 1.6 hours)

This is the shortest crossing across the Gulf of Cambay linking the small town of Gogha, which is close to the commercial city of Bhavnagar, and the lightly populated area at Dahej which is being developed as a major industrial site and close to Bharuch. Navigation in the upper Gulf of Cambay is made difficult by the presence of unusually strong currents, which have been reported at between 7 and 8 knots in the area of this ferry route. The water is sufficiently deep for safe navigation throughout this route although care will have to be taken approaching Dahej because navigation will be confined to a dredged channel. It has been reported that the approaches to Bhavnagar are liable to frequent change which means that water depths may be variable in the area around the Gogha terminal. One other possible hazard to navigation is the large and sudden change in current flow with the higher offshore velocities giving way to more tranquil flow as the water depth becomes shallower. In general the wave climate is not severe (heights less than 1m) and wave heights on this route would rarely exceed 2 to 3 metres although, during the monsoon period, there is likely to be a fairly constant sea from the south westerly direction. As this would generally be on the ferry's beam this could give rise to unpleasant rolling motions in ferries on this route. Appreciable periods of downtime at Gogha are expected to be unusual as Gogha is sheltered from the south-westerly waves. At Dahej, the terminal lies in the Narmada River within the confines of a narrow navigable channel. From the Narmada River entrance there is a recognised navigation channel north to the Bharuch Roads. Although most of this route will be tenable throughout the year the approach to Dahej is likely to be difficult in strong south westerly conditions and this may result in some downtime. The extent of this downtime is considered below.

2. Gogha - Suvali (77km 3.2 hours)

This route will form a link between two significant centres of population on opposite sides of the Gulf of Cambay, the city of Bhavnagar on the west coast and the city of Surat on the east. This route involves navigating through the difficult waters to the north of Suvali where there are a number of sand banks visible at low water, with some at a distance of several kilometres from the shore. However, there appears to be plenty of adequate water depth in this area but an easily recognisable channel will have to be clearly defined and marked before the service can start. The stability of this channel will also have to be established because some of the sandbanks are known to be mobile. Currents are less extreme in the Suvali area than around Gogha but the southern part of the Gulf is prone to greater wave activity. This route is likely to be navigable in most conditions but it is possible that sea conditions during the monsoon period will cause some downtime in the approaches to the Suvali terminal; the terminal itself, being inside the harbour, will be unaffected by all but the most extreme conditions.

3. Gogha to Mumbai (400km, 16.5 hours)

This coastal route will connect the city of Bhavnagar, which is one of Gujarat's main trading centres, with India's most important commercial centre of Mumbai. This is a coastal route with a substantial portion of it in exposed offshore waters. The route initially duplicates the Gogha-Suvali route, but thereafter is in open waters exposed, in the monsoon season, to a south-westerly wave climate. Although this may lead to some unpleasant motions on board the ferries it is likely that downtime will not be significant on this route providing the vessels are sufficiently large and stable.

4. Pipavav - Dahej (143km, 5.9 hours)

This route connects the new industrial development at Dahej with the rapidly expanding port of Pipavav which is now becoming the largest port in south Saurashtra. Pipavav is sheltered with easy access to the Grant Channel which forms the main approach to the Gulf of Cambay close to the western shore. As discussed above, conditions at Dahej may be difficult during the south-west monsoon and it is therefore likely that there would be some downtime on this route during the monsoon period.

5. Pipavav - Suvali (122km, 5 hours)

This route will provide a link between the new port at Pipavav on the western approach to the Gulf of Cambay with the city of Surat on the eastern side. From a navigation point of view this is a difficult route because it involves crossing the Malacca banks which are notoriously mobile. For the purpose of this study we have therefore considered the route passing along the recognised Grant Channel and joining a newly formed channel linking Gogha with Suvali, as described in 2 above. In severe weather conditions the wave climate in the Suvali area is likely to give rise to downtime

6. Pipavav - Mumbai (280km, 11.5 hours)

A link will be formed between the fast expanding port of Pipavav in south Saurashtra with India's commercial centre of Mumbai. Although this is a relatively long sea crossing the alternative would be a considerably longer road journey around the western and eastern shores of the Gulf of Cambay This is an entirely offshore route and a course should be set to avoid all the shoals in the entrance to the Gulf of Cambay. Provided ocean going vessels are used there should be little downtime on this route.

7.3.4 We have examined the possible operation of vessels on these routes. From this study we have derived a schedule of trips on the basis of one, two and three Ro-Ro vessels serving the network of five terminals. These schedules are based on a combination of the demand for the ferries between various destinations as well as the practicalities of operations including duration of sailing times. These schedules are attached in Appendix C. Our findings indicate that a weekly schedule of routes could be developed as follows:

Route	Round trips per week		
	1 vessel	2 vessels	3 vessels
Gogha-Dahej	2	4	5
Gogha-Suvali	2	6	8
Gogha-Mumbai	2	3	6
Pipavav-Dahej	1	1	1
Pipavav-Suvali	1	4	6
Pipavav-Mumbai	1	2	2

In order to examine the potential for developing a ferry service between each of the destinations we have also considered each route in isolation, with a single vessel operating a dedicated service on each route. Clearly the shorter routes in the upper reaches of the Gulf would have a more frequent service than the longer distance open sea routes. This would result in the following possible operation for each route:

Route	Trips round per week
Gogha-Dahej	21
Gogha-Suvali	14
Gogha-Mumbai	4
Pipavav-Dahej	7
Pipavav-Suvali	7
Pipavav-Mumbai	5

7.3.5 It should be noted that although we recommend a network including Mumbai, that port does not at present have facilities to serve ro-ro vessels of the type proposed for the service, as the linkspan previously used has been removed. For the purpose of this study, we have assumed that facilities will be made available since the Mumbai routes are important to the success of the service.

7.4 Aids to Navigation

7.4.1 Aids to navigation should define the width and alignment of the shipping channels and any hazards. Effective aids to navigation are vitally important for the safe passage of ferries across the Gulf of Cambay.

7.4.2 The navigator will rely on two main types of aid: -

- on the vessel - charts of the area
- outside the vessel - navigation marks (usually buoys) marking hazards and channels

Although modern electronic equipment will allow very accurate determination of the ship's position, allowing, theoretically, navigation solely by reference to the chart, most navigators will prefer to be guided by visible marks related directly to channels and hazards.

7.4.3 The positions of the existing navigation marks in the Gulf of Cambay covering the sailing routes between Gogha, Dahej and Suvali are shown on Admiraty Chart No 1486 – India – West Coast - Gulf of Khambhat and Approaches

7.4.4 We have noted that the Sutherland Channel is well marked and lit immediately offshore of Suvali. However it will be necessary for ferries to pass to the north of this channel on passage to Gogha and Dahej. A safe navigable channel will have to be defined through these waters marked clearly by navigation buoys.

7.4.5 We have seen a proposal for the provision of 14 lit navigation buoys to mark the dredged channel at the entrance to the Narmada River up to the IPCL jetty. This proposal, or something similar, will have to be implemented before the ferry terminal at Dahej can be commissioned. At Gogha, we recommend that two additional buoys should be provided to mark the general approach to the proposed ferry terminal.

7.4.6 Channel markers should be made conspicuous with light characteristics and radar reflectors that allow them to be easily identified against a background of other lights or in bad visibility. The markers should have a luminous range of not less than 6.5 nautical miles and should remain visible at all times to the pilot. To reduce the possibility of vessels grounding, markers should be located as close as possible to the edges of the approach channels.

7.4.7 Gated pairs of markers are usually preferred by mariners for marking straight channel legs. In critical areas, channel markers should be spaced at longitudinal intervals not greater than one nautical mile as this is the maximum spacing for which a pilot would be happy to maintain control based on his visual perception of the channel as marked by buoys.

7.4.8 The design of the terminals provides a turning area at each for the safe turning of ferries. The boundary should be marked with special yellow markers located at not greater than 45° sectors relative to the centre of the turning area. The markers should have a luminous range of not less than 6.5 nautical miles.

7.4.9 All marks will be fitted with radar reflectors. For these to be effective it is essential that ferry operators ensure that the radar system on each vessel is in good working order at all times.

7.4.10 Lights on aids to navigation should conform with the following: -

- The IALA Maritime Buoyage System
- The IALA Recommendations for the Rhythmic Characters of Lights on Aids to Navigation

7.5 Night Navigation

7.5.1 For the ferry service to operate successfully it is essential that all routes can operate throughout the 24 hour day. Although the waters in and around the Gulf of Cambay are difficult to navigate this can be achieved providing proper safeguards are put in place to ensure safe navigation at all time.

7.5.2 All terminals will have to be properly lit with navigation aids to assist vessels approaching the berths. However, every precaution must be taken to ensure that a mariner cannot be confused as to which is terminal lighting and which is lighting to assist navigation. Warning lights will also be required on structures such as the long approach jetties to indicate their location to passing vessels. Working areas on the jetty and linkspans will have to be lit to internationally recognised standards in order to ensure that safe working can continue throughout the night. On jetties and berths, the minimum average illumination will not be less than 50 lux

7.5.3 The Sutherland Channel is well marked and lit immediately offshore Suvali. However it will be necessary for ferries to pass to the north of this channel on passage to Gogha. A safe navigable channel will have to be defined through these waters marked clearly by navigation buoys with lights showing appropriate characteristics.

7.5.4 Two additional lit buoys should be provided to mark the general approach to Gogha. Further navigation aids may be necessary should future hydrographic surveys show alteration to the channels.

7.5.5 We have seen a proposal for the provision of 14 lit navigation buoys to mark the dredged channel at the entrance to the Narmada River up to the IPCL jetty. This proposal or something similar will have to be implemented before the ferry terminal at Dahej can be commissioned.

7.5.6 A ship carrying dangerous goods requires an additional width allowance for safety when sailing through navigation channels particularly when passing another vessel and there is consequently an increased risk of a ship running aground. We therefore recommend that night-time carriage of dangerous cargoes should only be allowed when there are calm weather and sea conditions. These restrictions should be clearly set out in the Rules of Operation.

7.5.7 Navigation along a restricted channel is much more difficult at night and the risk of accident is proportionately higher. Consequently bends should be avoided as far as possible in the design of navigation channels particularly in the terminal approaches. The risk of grounding is also reduced if the legs between bends are straight and not curved.

7.5.7 GMB must also ensure that the VTS is available at all times for the assistance of mariners. Ideally, port controls should be in operation for 24 hours daily, but where the ferry service is infrequent in the initial stages, any port control must be available to advise on weather conditions and the like before the ferry leaves the previous port. In the case of the longer crossings, this may require a terminal to be open earlier than might otherwise be necessary for the reception of traffic.

7.5.9 Night navigation involves the ferry crews working unnatural hours when their vigilance and reactions to emergencies are likely to be reduced. In some cases, a crew may perform better if it is kept on continuous night duties while in other cases, performance might be improved by the day and night crews alternating their periods of duty on a weekly basis. What shifts the crews should work will need to be the subject of careful planning but vitally important is that the welfare of the night crew is kept at the highest level. For a ferry to operate at night as well as during the day, sufficient crew sleeping quarters must be available to accommodate the off duty crews. This may result in a requirement for larger ferries.

7.6 Downtime

7.6.1 It is inevitable that ports located in exposed locations, such as the Gulf of Cambay will suffer a certain amount of weather related downtime. The prevailing environmental conditions such as wind, waves etc are likely to make each of the sites that we are studying unsafe to use at some times during the year. This part of the study has assessed these conditions with particular emphasis on the annual occurrence of adverse conditions and quantified this as downtime in order to provide an indication of its impact.

There are three components which have to be established in order to calculate the length of downtime experienced at any site:

a. Operational Limit

For each of the various criteria there is a limit above which ferry operations cannot take place. This limit is generally derived from experience of other similar operations and is dependent on the type of vessel, its size and interaction with the prevailing conditions. Operational limits will differ for individual activities such as berthing, cargo handling, navigation etc.

b. Intensity

A record or hindcast of the intensity of the selected criterion has to be prepared in order to establish if the operational limit is passed.

c. Duration

The length of time that the intensity is greater than the operational limit is the time which is potentially lost for ferry operations. For a port operating with a high berth utilization factor all of this time would be lost, whereas for a low utilization factor the potential lost time may or may not coincide with the presence of a vessel and therefore actual lost time.

7.6.2 There are several factors that can cause downtime at ferry terminals and the relevant underlying environmental conditions have been reviewed earlier in this report. These criteria are:

a) Visibility

Weather records for the Gulf of Cambay show that on average there are only 1.7 half days in any year when the visibility is less than 1km. The majority of this time is in the morning with only a minimal effect in the evening. Poor visibility could affect navigation, especially when ferries are crossing shipping lanes, although the extent of this is dependent on the navigation control systems that are used. Manoeuvring on and off the berth would not be delayed except in dense fog and cargo handling would not be delayed at all. Downtime due to lack of visibility is therefore minimal and we have allocated 0.5 day for each port.

b) Current

There are strong currents in the Gulf of Cambay especially at times of spring tide. In extreme conditions this could become a problem when ferries are manoeuvring on and off the berth. The berths would be located to minimize the effect of current and in the absence of specific data on current conditions we have estimated a nominal 1 day of downtime relating to current for each of the terminals at Gogha and Dahej. As the berth at Suvali is within an enclosed harbour, we do not expect downtime due to this cause here. Similarly at Pipavav, there are few currents in the terminal area and downtime may be expected to be minimal

c) Rain

Ro-Ro operation is not as susceptible to disruption by rain as many other types of cargo handling. Although heavy rain may reduce the safe maximum speed of vehicles on the jetty it would only be during severe storms that the rain would be heavy enough to cause delays to the safe use of the terminal. Even at these times it is not expected that the delays would be excessive and therefore no allocation has been made for downtime resulting from rain.

d) Wind

For most of the time the strongest winds are likely to occur at the same time as the highest waves because the wave climate at these sites is principally a result of locally wind generated waves. There will however be occasions when strong winds from a direction that gives some protection against waves could delay cargo and passenger handling. This would be most pronounced at the Gogha terminal where strong cross winds could delay access along the approach jetty and yet the waves would be limited by the protections from Piram Island. We have allocated 2 days of wind related downtime for Gogha. On a similar basis it has been assumed that there would be one additional day of downtime at Dahej due to wind above the time when the terminal would already be closed due to large waves. At Suvali, where the terminal is within the harbour and there is no exposed access jetty, we think that there is unlikely to be any interference with operations. Similarly, at Pipavav, the terminal is sheltered by the land and is likely to have only a short access, so that wind driven downtime is likely to be very small.

A cyclone passing through the immediate vicinity would inevitably cause the terminals to suspend operation. However, cyclones in the Gulf of Cambay are rare and therefore statistically insignificant with respect to annual downtime. The historical distribution of cyclones is such that they would cause a discrete period of downtime at extended intervals rather than a set amount of downtime each year. We have therefore not made any specific allocation for cyclone related downtime.

e) Waves

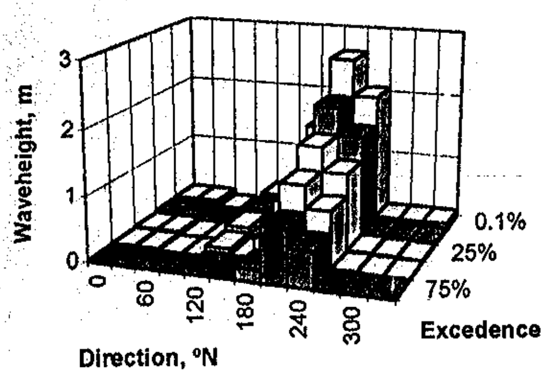
Excessive vessel movement due to waves would be the major environmental cause of halted operations in the area. To establish a basis for assessing the extent of this downtime we have related the expected wave conditions to the type of vessels likely to be operated. Operational limits have been taken from the PIANC report "Criteria for Movements of Moored Ships in Harbours" which gives acceptable movements for specific vessels while berthed and handling cargo. These were related to waveheights through a model study for the Indo Gulf jetty at Dahej.

7.6.3 The distribution of waves was calculated for all directions and hence the probability of an unacceptable wave climate calculated. This was factored as appropriate to give the distribution of downtime from all directions and then totalled over all directions.

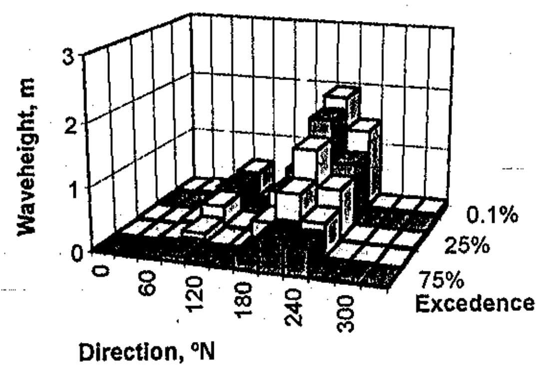
The distribution of wind and hence local waves varies a great deal over the year and has therefore been divided into monsoon and non-monsoon periods for the purpose of downtime calculations.

The wave distributions are shown below.

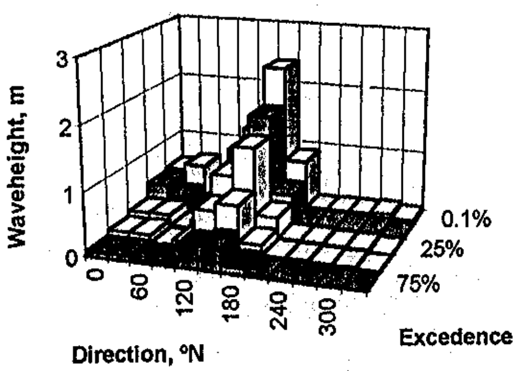
Waveheight Excedence At Dahej During The Monsoon Season



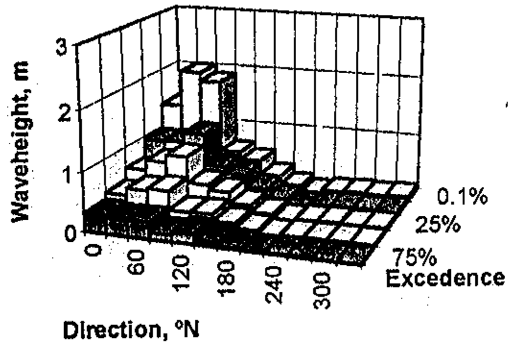
Waveheight Excedence At Dahej Outside The Monsoon Season



Waveheight Excedence At Gogha DuringThe Monsoon Season



Waveheight Excedence At Gogha Outside The Monsoon Season



Our analysis of wave related downtime at both of the sites gives these figures that are presented in the table below.

Site	Monsoon	Non-Monsoon	Total	
Dahej	29.8	1.2	31.0	Days
Gogha	0.1	6.2	6.3	Days
Suvali	Assumed same as Dahej		31.0	Days

7.6.4. Total Downtime

A summation of the estimated average number of days lost to weather related downtime is given in the table below:

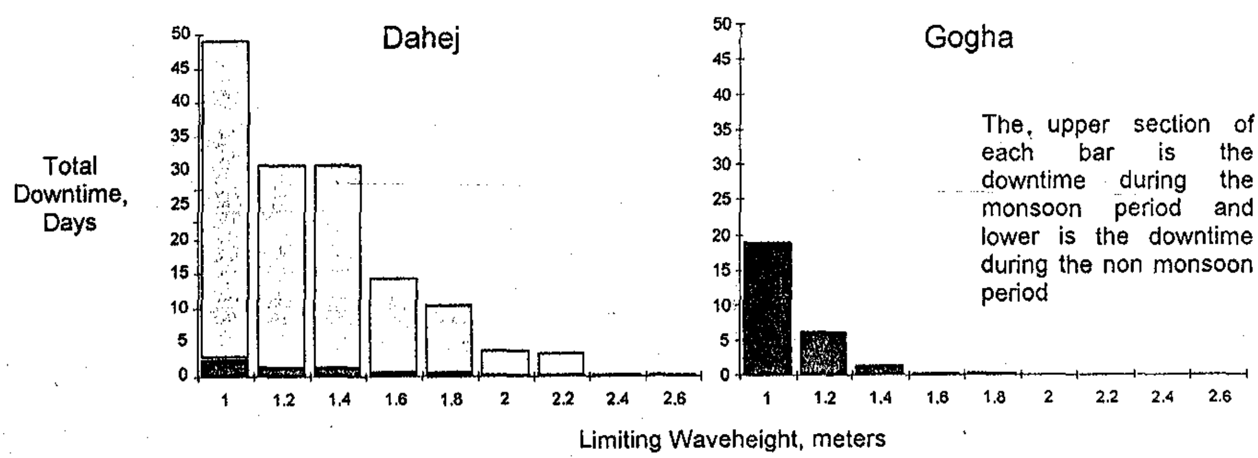
	VISIBILITY	CURRENT	RAIN	WIND	WAVES	TOTAL
GOGHA	0.5	1.0	0.0	9.0	6.3	16.8
DAHEJ	0.5	1.0	0.0	1.0	31.0	33.5
SUVALI	0.5	0.0	0.0	0.0	31.0	31.5
PIPAVAV	0.5	0.0	0.0	0.0	20.0	20.5

It should be noted that although we make allowance for downtime, anecdotal evidence and local experience suggest that disruptions will be less frequent than shown in the tables.

7.6.5 Sensitivity

A sensitivity analysis was carried out in the cases of Gogha and Dahej to give a measure of confidence in the previously calculated downtime figures. It was found that the downtime at each site is extremely sensitive to the limiting significant waveheight chosen (and its corresponding period). The reason for this is that these limiting parameters correspond to the greatest occurrence of waves within the overall spectrum. Therefore the response to a small change in limiting waveheight is a large change in the amount of downtime. Similar conclusions will apply at the other terminals.

Downtime Sensitivity to Limiting Waveheight



For each vessel type and state of loading there is a different response to a given wave climate. This is because the response of a vessel is related to its weight, shape, size and the distribution of mass within the vessel. The period of the incident waves also has a great effect on determining the characteristics of movement of the vessel. We have used a study of vessel characteristics responding to the mean wave period similar to the required wave spectrum. It is therefore likely that these downtime estimates are reasonably accurate. However the sensitivity is such that a detailed analysis would have to be undertaken using the actual types of vessels that will operate on the proposed ferry services. Furthermore it would be prudent to undertake a detailed examination of these conditions using a range of vessels with a view to selecting the vessels with the favourable response.

In order to carry out a more detailed examination of the vessel movements under the present wave spectrum it would be necessary to carry out a model study with specific input of the Ro-Ro vessels to be used in conjunction with the expected wave climate.

7.7 Agreement with Ferry Operator

7.7.1 Before commissioning construction of the terminals, the Board will wish to be sure that a ferry network will be put in place to utilise them. A prospective ferry operator will in turn require assurances in respect of timely availability of the terminals, operating charges, and possibly traffic levels. It will thus be necessary to draw up an agreement between the Board and the ferry operator setting out clear understandings in these matters.

We suggest that an agreement could include:

- Guarantees by both parties in respect of implementation, i.e. GMB to build terminals, the operator to commission ferry fleet.
- Start date
- Terminal charges to be levied by GMB
- Responsibility for terminal operation and management
- Relationship with joint venture operator and responsibilities towards him and obligations from him
- A minimum term and conditions for extension of the term.

- Requirements in respect of ports of call, service levels and fares
- Possible guarantees by GMB or State Government in respect of fares revenue
- Requirements for insurance by the operator
- Any requirements for exclusivity
- Responsibilities (by GMB) in respect of VTS and navigation control in the Gulf
- Provision of navigation aids and services
- Provision for ongoing survey of channels and routes
- Provision for expansion of services on existing network
- Provision for expansion of network
- Guarantee/understanding in respect of Customs Act
- Provision for ferry operator to take on foreign partners (or not)
- Relationship with port owner at Suvali

7.8 Operation of Customs Act

7.8.1 This chapter explores the issues pertaining to the Customs Act and other Statutory Acts which would probably hinder the smooth operation of the proposed water transport services. The exemptions needed from various sections of the Acts are also considered in this section.

7.8.2 At present, several forms and certificates are required to be filled in and deposited with the Customs and Port Authorities by home trade cargo vessels. This system of documentation would affect the smooth flow of loading/unloading of vehicles, which in turn would dissuade the truck operators and other users from using the services. Hence, it is essential that the coastal ro-ro services be exempted from certain sections of the relevant Acts as recommended below.

7.8.3 There are various authorities with powers for the regulation of water transport services in Gujarat and along the coast-line of Gujarat. A list of such authorities is given below :

Central Government

- Directorate General of Shipping
- Ministry of Ports & Fisheries
- Ministry of Surface Transport
- Ministry of Law & Justice

- Customs Department

State and Local Government

- Surat/Bhavnagar Municipal Corporation
- Surat/Bhavnagar Urban Development Authority
- Gujarat Industrial Development Corporation
- Tourism Corporation of Gujarat
- Transport Authorities in Gujarat
- Gujarat Maritime Board
- Kandla Port Trust

7.8.4 Relevant Acts enacted by various ministries pertaining to coastal shipping are given below.

- The Customs Act, 1962
- The Major Port Trusts Act, 1963
- The Merchant Shipping Act, 1958

A view of the above Acts brings to light certain aspects of their operation which would inhibit, or even prevent, the effective operation of ferry services in the Gulf. These shortcomings will have to be overcome by making suitable modifications as highlighted in the following section. The constraints placed by the various Acts and the modifications needed are discussed below.

7.8.5 The Central Government of India set up a high power committee headed by Mr. R.D. Pradhan to study the problems of coastal shipping engendered by the Customs Act and recommend remedial measures. The recommendations made by the committee are presented in Chapter 2 of the committee's report. Based on these recommendations, the Department of Revenue, Ministry of Finance, issued a directive (F>No.450/118/83-CUS IV) dated October 8, 1986, asking the customs collectors to simplify the procedure for port clearance of coastal shipping vessels. We support these recommendations, subject to our further comments below.

7.8.6 It can be noticed from this letter that the coastal cargo ships would still be required to prepare an Export Manifest (which would be accepted as Import Manifest at the destination port). However, we think it unlikely that the truck operators would be willing to take up this extra burden and suggest that the 'Way Bill', which contains details of the number of packages and goods in the truck, should be accepted at the ports of origin and destination instead of the Export Manifest.

7.8.7 In this connection, the following Sections of the Customs Act, 1962 need to be modified so as to reduce, or preferably eliminate, their application to an intra-coastal ferry service.

Section 33 - Unloading and loading of goods at approved place only.

Except with the permission of the proper officer, no imported goods shall be unloaded and no export goods shall be loaded at any place other than a place approved under clause (a) of section 8 for the unloading or loading of such goods.

Section 34 - Goods not to be unloaded or loaded except under supervision of Customs Officer.

Imported goods shall not be unloaded from and the export goods shall not be loaded on, any conveyance except under the supervision of the proper officer.

Provided that the board may, by notifications in the Official Gazette, give general permission and the proper officer may in any particular case give special permission, for any goods or class of goods to be unloaded or loaded without the supervision of the proper officer.

Section 36 - Restrictions on unloading and loading of goods on holidays etc.

No imported goods shall be unloaded from and no export goods shall be loaded on any conveyance on any Sunday or on any holiday observed by the Customs Department or on any other day after the working hours except after giving the prescribed notice and on payment of the prescribed fees, if any.

Provided that no fees shall be levied for the unloading and loading of baggage accompanying a passenger or a member of crew and mail bags.

Section 37 - Power to board conveyances

The proper officer may at any time board any conveyance carrying imported goods or export goods and may remain on such conveyance for such period as he considers necessary.

Section 38 - Power to require production of documents and ask questions

For the purposes of carrying out the provision of this Act the proper officer may require the person-in-charge of any conveyance or animal, carrying imported goods or export goods, to produce the documents and to answer any questions and thereupon such person shall produce such documents and answer such questions.

Section 92 - Entry of coastal goods.

1. The consigner of any coastal goods shall make an entry thereof by presenting to the proper officer a bill of coastal goods in the prescribed form.

2. Every such consignor while presenting a bill of coastal goods shall at the foot thereof, make and subscribe to a declaration as to the truth of the contents of such bill.

Section 93 - Coastal goods not to be loaded until bill relating thereto is passed, etc.

The Master of a vessel shall not permit the loading of any coastal goods on the vessel until a bill relating to such goods presented under Section 92 has been passed by the proper officer and has been delivered to the Master by the consigner.

Section 94 - Clearance of coastal goods at destination.

1. The Master of a vessel carrying any coastal goods shall carry on board the vessel all bills relating to such goods delivered to him under Section 93 and shall immediately on arrival of the vessel at any customs or coastal port deliver to the proper officer of that port all bills relating to the goods which are to be unloaded at that port.

2. Where any coastal goods are unloaded at any port, the proper officer shall permit clearance thereof if he is satisfied that they are entered in a bill of coastal goods delivered to him under-section (a).

Section 95 - Master of a coasting vessel to carry an advice book.

1. The Master of every vessel carrying coastal goods shall be supplied by the customs authorities with a book to be called the advice book.

2. The proper officer at each port of call of such vessel shall make such entries in the advice book, as he deems fit, relating to the goods loaded on the vessel at the port.

3. The Master of every such vessel shall carry the advice book on board the vessel, and shall, on arrival at each port of call, deliver it to the proper officer at that port for this inspection.

Section 96 - Loading and unloading of coastal goods at customs port of coastal port only.

No coastal goods shall be loaded on or unloaded from any vessel at any port other than a customs port or a coastal port appointed under section 7 for the loading or unloading of such goods.

Section 97 - No coasting vessel to leave without written Order

1. The Master of a vessel which has brought or loaded any coastal goods at a customs or coastal port shall not cause or permit the vessel to depart from such port until a written order to that effect has been given by the proper officer.

2. No such order shall be given until.

1. The Master of the vessel has answered the questions put to him under section 38.

1. All charges and penalties due, in respect of the vessel or from the Master thereof, have been paid or the payment secured by such guarantee or deposit of such amount as the proper officer may direct.

2. The Master of the vessel has satisfied the proper officer that no penalty is leviable on him under section 116 or the payment of any penalty that may be levied upon him under that section has been secured by such guarantee or deposit of such amount as the proper officer may direct.

Section 98 - Application of certain provisions of this Act to coastal goods, etc.

1. Section 33, 34 and 36 shall apply to coastal goods as they apply to imported goods or export goods.

2. Section 37 and 38 shall apply to vessels carrying coastal goods as they apply to vessels carrying imported goods or export goods.

3. The Central Government may, by notifications in the Official Gazette, direct that all or any of the other provisions of Chapter VI and the provisions of Section 45 shall apply to coastal goods or vessels carrying coastal goods, subject to such exceptions and modifications as may be specified in the notification.

7.8.8 The Major Port Trusts Act, 1963 insists on compulsory pilotage at all major ports. Certain ferry vessels in the past were exempted from the above Act, provided that the Masters of these vessels were trained and were also licensed by all receiving ports. Such a concession should

also be extended to the proposed ro-ro service, or there should be a clear understanding that the Act does not apply to the ferry ports. Any concession, of course, should not be allowed to detract from the need to ensure that Masters and officers are fully conversant with the routes they will operate on.

7.8.9 In addition special arrangements should be made for ro-ro vessels to be assessed for port dues and light dues on a concessional basis. It should be noted, by reference to the Techno-

Economic Report that setting port dues and charges at an inappropriate level may have an adverse effect on the commercial viability of the service

7.8.10 Under Section 412 of the Merchant Shipping Act, 1958, the power to fix and revise passenger and freight fares lies with the Central Government. However, we have shown in the Techno-Economic report that the ferry operator will need to maximise revenue by setting fares adjusted closely to demand. Whilst we doubt that it will be feasible (or commercially advantageous) to adjust fares daily in response to demand, there are certainly likely to be seasonal adjustments, and adjustments needed to transfer demand between routes. It is also likely that the charging structure will need to be reviewed after the service has been in operation for some time and demand patterns can be assessed with more accuracy. In our analysis we have considered only single fares, but clearly the principal demand will be for return fares, and there will be a need to adjust costs between single and return fares and between long and short term returns. It may also be appropriate to offer season tickets or multiple journey concessions.

7.8.11 In such a dynamic situation, it would be impractical to work with fixed charges, but the government is unlikely to work on a commercial timescale to revise the charges once they are fixed. This would adversely affect the margin of the operators and the viability of the service. Hence, it is recommended that the shipping company should be allowed to revise the freight rates in response to market conditions. It should be noted that these comments apply equally to passenger and vehicle traffic.

) REVIEW OF SAFETY CONSIDERATIONS

I Introduction

.1 Marine conditions in the Gulf of Cambay are some of the most difficult in the world. The area is noted for strong currents, large tidal range and occasional cyclones and the terminal approaches can be particularly hazardous due to the shifting sand banks.

.2 Studies by the Permanent International Association of Navigation Congresses (PIANC) on accidents show that the majority of accidents to vessels occur in the port approaches and that apart from mishaps on board ship, such as machinery failure, weather damage, fire/explosion, etc, the two major causes of accidents are collision and grounding.

.3 In this chapter we identify the safety hazards that are likely to be met by ferries operating in the Gulf of Cambay and the steps that are required by both the ferry operator and the Gujarat Maritime Board to reduce these hazards.

At Sea

.1 The ferry operator is responsible at all times for the safety of his vessels. In this connection, he must take note of all adverse weather and sea conditions which might develop in the Gulf of Cambay and affect ferry services. He must make all necessary adjustments to ferry sailing schedules and services to ensure that at no time is there any risk to the safety of the ferries.

.1 Similarly, the ferry crews must remain in continuous communication with harbour control and other information centres with regard to anticipated weather and sea conditions. The crews must remain constantly alert to take any necessary action to avoid an emergency which might affect the safety of their vessels.

.2 It is the responsibility of the port authority to monitor any changes in the shipping channels such as shoaling and to make this information readily available to all interested parties. However, the ferry operator must ensure that he is kept informed of any changes which might affect ferry routes and satisfy himself that there is no risk to the safety of ferries sailing on these routes.

.3 In view of the varying and changeable conditions (tides, currents, shifting banks etc.) it is essential for ferry crews to have good and up to date knowledge of local conditions. In the early stages it may be necessary for the ferries to carry pilots to obtain this knowledge, but in the longer term officers should be appointed who are suitably qualified with a good knowledge of the local waters.

4 The principal effect of winds is in the generation of wave activity which is considered below. However strong winds will cause erratic handling and will particularly affect navigation in the port approaches and berthing and unberthing and the officers (especially) and crew should be competent to deal with such a situation. The Rules of Operation (see 8.2.10) should clearly set out limiting weather conditions.

5 Strong wave activity does occur in the Gulf of Cambay and can cause a ship to undergo excessive and violent movements which could result in damage to both the vessel and its cargo. It is during these periods that the safety of a ship is usually most at risk and much depends on the type of vessel and the competence of the crew; it will be important for the crew to be fully trained in the safe and secure stowage of cargo. The Rules of Operation should again set out limiting weather conditions and should give guidance as to response when adverse conditions are encountered en route

6 There are strong currents in the Gulf of Cambay, especially during spring tides. However, these are not likely to be a problem for modern ferries in the open sea and in no way affect vessel safety. Care must be taken to remain in a safe position with respect to other vessels when crossing between regions with greatly different currents.

7 Navigation can be adversely affected by poor visibility, particularly where ferries are crossing shipping lanes and need to slow down for safety reasons. However, in the Gulf of Cambay, records show that visibility of less than one kilometre occurs on average only 1.7 half days in any one year. The majority of this time is in the morning with only a minimal effect in the evening. Ferries will be equipped with radar and will be assisted by VTS so that poor visibility is unlikely to affect safety.

8 In the event of extreme bad weather or other emergency situation, the master may decide that it would be unsafe to continue the voyage, or remain at the berth. Instead, he may prefer to hold the ferry in a sheltered area. Suitable areas should therefore be designated along the ferry routes and their positions should take account of:

- Transit speeds and times
- Tidal characteristics
- Currents
- Weather data
- Shelter from prevailing sea conditions
- The suitability of the sea bed for anchoring
- The sufficiency of searoom for a ship to swing at anchor

.9 The berth at Suvali, within a protected harbour, is likely to be the preferred shelter in all but the most adverse conditions.

.10 It should be noted that the best defence against bad weather on the voyage is a comprehensive and reliable weather forecasting and reporting system which will identify times when it would be unwise to leave port.

.11 A VTS is an advisory service for mariners on ships passing through the system. Surveillance of traffic is carried out by the VTS centre with information exchanged between the ships and the centre at prescribed "reporting in" points.. The VTS centre is usually equipped with radar, radio, communicative devices, traffic data processing systems, etc.

.12 The services provided by a VTS include: -

- an exchange of information with vessels on such matters as safety and traffic conditions
- obtaining reports that ships are defective
- the provision of supporting activities such as pilotage, search and rescue, etc.
- giving assistance to vessels in difficult navigational or meteorological circumstances
- warning of obstacles and giving information on alternative routing
- scheduling of vessel movements such as establishment of a one-way traffic system.

.13 Although a ship must remain at all times under the control of the ship's master, none-the less, the VTS centre can require a vessel to conform with certain requirements to ensure safety. These include adhering to speed limits, remaining at anchor and not proceeding beyond a certain point until clearance is given. Investigations by PIANC have shown that the risk of collision and grounding of vessels has been successfully reduced in areas where a VTS has been introduced. We strongly recommend that this system is used in the control of ferry traffic in the Gulf of Cambay..

4 Rules of Operation are set by a port authority for reasons which include improvements in safety. The rules specify such matters as when it is safe for certain classes of vessel to navigate certain areas and what to do in emergency situations. In the difficult conditions in the Gulf of Cambay, an improvement in safety would be achieved by the introduction of a set of Rules of Operation which might include the following or similar depending on the advice of the local pilots;

- All vessels over 50m long should be restricted to sailing along the shipping channels;
- The maximum speed in a shipping channel should be restricted to12 knots;
- Vessels travelling in the same direction along a shipping channel should not be permitted to overtake each other;
- Vessels travelling along a shipping channel should take priority over vessels crossing the shipping channel;
- Limiting weather conditions;
- Special regulations for Suvali (taking account of LNG. terminal).

We consider that the application of a set of Rules of Operation covering the Gulf of Cambay would provide a very powerful tool for use in ensuring the safety of ferry services.

Port Areas

At all times, the safety of each ferry and every person on board is the responsibility of the ferry senior officers. However, ferry movements within the port area will be subject at all times to control by the harbour master.

The harbour master controls all shipping movements in the port and supervises the port control duty managers. The harbour master will have the following duties with regard to ferry management;

- To advise when a ferry can enter/leave the harbour
- To advise when a ferry can berth/unberth
- To instruct a ferry to leave the terminal during an emergency on shore, eg fire
- To instruct a ferry in an unsafe condition to leave the terminal, eg if damaged by ship collision.

The port control duty manager issues instructions concerning berthing and unberthing to the ferries and to the berthing master.

The terminal management should ensure that;

- sufficient port control staff are on duty during berthing/unberthing operations;
- sufficient terminal staff are on duty for the safe handling of ferry mooring ropes, etc;
- the ferry berthing area is in a safe operating condition unobstructed by vehicles, cargo, etc;
- the linkspan is in an appropriate position;
- the bollards are in a safe condition;
- the fendering system is in a safe and satisfactory condition capable of sustaining both normal and abnormal ship impacts.

The ferry senior officers should ensure that;-

- the ferry remains in communication with port control at all times;
- sufficient crew are available at all times on board the ferry for the safe handling of mooring ropes;
- adequate instructions are given to terminal staff handling mooring ropes.

A ferry manoeuvring at the berth is vulnerable to wind, wave or current activity, and for safety reasons, a ferry should not attempt to berth under extremes of these conditions. A ferry already berthed should depart before the onset of abnormal weather, possibly to one of the shelter areas recommended in 8.2.8 above.

Berthing and unberthing operations are unlikely to be affected by poor visibility unless there is dense fog.

The Rules of Operation (8.2.10 above) should make clear limiting conditions.

Loading/Unloading Operations

The Terminal management will be fully responsible for all onshore management. However the terminal staff should consult with ferry crews with regard to all ship loading/unloading operations. Ship to shore telephone points or a mobile radio system should be provided at each berth to facilitate consultation.

Key staff at a ro-ro terminal usually include the following personnel: -

(a) The terminal manager who has overall responsibility for traffic control and shore based personnel.

(b) The berthing master who oversees the operation of the linkspan and the mooring of the ship.

(c) The operator who is a person specifically trained and authorised to operate the linkspan.

3 The terminal staff will carry out the following duties:

(a) The terminal manager should prepare operating instructions, work instructions, training procedures and emergency plans based on information provided by the equipment suppliers. The instructions and plans should take into account the results of risk assessments and should cover collision, structural failure of lifting equipment and extreme environmental conditions. They should also state operational limitations including loading geometry and environmental conditions.

(b) The terminal manager should establish a chain of communication and all persons involved in ship to shore operations should understand the routes for communications, authorisations and reporting incidents.

(c) The terminal manager must keep the ferry senior officers fully informed with regard to the numbers and weights of vehicles and loads to be loaded together with the numbers of passengers.

(d) The operator should be given definite authorisation to operate a particular facility. Before each period of use, he should carry out a routine inspection of the linkspan and complete an inspection report. The operator should check that no damage has occurred to the facility during berthing or unberthing.

(e) When the ship is berthed the operator should only make the various connections to the ship after receiving authorisation from the port control duty manager, who must receive agreement from the ship's master. Authorisation should also be given for disconnection of the ship at the end of use.

(f) While in operation, the operator should monitor the working of the facility and check the warning lights, alarms, etc. In an emergency, a previously prepared emergency plan should be put into operation.

(g) The operator should complete a daily log for the facility, including the recording of any unusual incidents or damages.

The ferry senior officers will at all times be responsible for the safe load arrangement and positioning of all vehicles and loads on board ship. Freight vehicles should remain secured at all times. If not secured, they may shift with serious consequences for the ferry stability.

In port, the ferry senior officers must take particular care when loading or unloading heavy freight vehicles or loads to ensure that the ferry retains stability at all times. They must also ensure that their vessels are not overloaded either with vehicles, goods or passengers. However, the terminal manager must provide sufficient information to ensure that the ferry senior officers are in a position to make responsible assessments.

In the event that overloading with passengers became a problem, it might be found necessary to introduce a system under which every passenger had a boarding card. The number of boarding cards issued for each voyage would correspond with the maximum number of passengers which could be legally carried. This would automatically avoid the risk of carrying excess passengers.

For the safe movement of vehicular traffic between the ferry and the shore, the gradient of the linkspan will not in normal operating conditions exceed 1 in 8 at MLWN. At lower water levels, the gradient of the linkspan may exceed a slope of 1 in 8 and it may be found necessary to suspend loading/unloading operations for a short period at extreme low water levels.

The pedestrian walkway will be segregated from vehicle carriageways along the linkspan between the passenger shelter on the jetty and the ferries. Except in an emergency, terminal staff should ensure that pedestrian traffic is restricted to the walkway.

For safety reasons, the operation of the linkspan should only be undertaken by authorised terminal staff. Each authorised member of staff should be given a detailed set of procedures that should be prepared for the safe operation of the linkspan.

Written instructions on operational limitations should be given to operators and displayed on the facility. These operational limits should relate to loading, environmental conditions such as wind speed, wave heights, tidal extremes, etc. Where possible, this information should be also made available to the ship's master.

Terminal staff will ensure that the following safe load restrictions are applied:-

- Maximum vehicle weight – in accordance with Class A Indian and 40 tonne EC heavy goods vehicle loading.
- Maximum vehicle width - 4m.
- Maximum vehicle height - to be determined in consultation with the ferry operator

To check that the maximum weight restrictions are being observed, a weigh bridge is provided in each terminal where all freight vehicles coming into the terminal can be automatically eighed and issued with a weight certificate. This information would need to be passed on to e ferry loading officer preferably by electronic methods.

enerally, a dangerous cargo is defined as any substance that threatens the safety of people id of facilities by fire, explosion, combustion, toxicity, infection, radioactivity corrosion or ollution. Also, any substance that presents risks during its transport in case of shock, contact th water or air, contact with other dangerous substances. The term also includes an empty ceptacle, portable tank or tank vehicle which has previously been used for the carriage of a ngerous substance, unless such receptacle has been cleaned and dried or has been curely closed.

anning the reception of dangerous goods includes:-

- Taking an inventory of the risks involved ;
- Investigating preventive measures to reduce the risks;
- Investigating the actions to be taken in case of an accident.

e terminal management should not accept dangerous cargo unless special safety cautions are taken which are fully agreed with by the ferry operator Introduction and strict orcement of codes of practice, guidelines and procedures for all parties. These will cover kaging, handling and storage of goods. A common practice is to set safety distances to arate the handling and storage of dangerous goods from other port areas.

deal with on-shore accidents, the terminal infrastructure includes fire hydrants, telephone s, access routes, fire fighting equipment and a medical centre. The terminal management ensure that manpower trained in fire fighting, rescue techniques and first aid is available. A tre for the co-ordination of accident handling will be set up and this will have access to rmation on dangerous substances and other hazards.

safety reasons, all terminal staff and ferry crew members should wear appropriate safety ning. For example, high visibility jackets should be worn by traffic marshals and any staff king with vehicles.

ding/unloading operations should cease for safety reasons when wind or wave conditions se excessive movements at the berth; these conditions are likely to be less than those h require the ferry to leave the berth altogether. The Rules of Operation will give guidance cceptable movements, but in practice it will be necessary to rely on the judgement of the on the berth.

Heavy rain may reduce the safe maximum speed of vehicles on the jetty. During severe storms, rain could be heavy enough to make the deck areas and ramp unsafe for use by vehicles. In such weather conditions, loading and unloading operations should be suspended. Poor visibility is unlikely to affect the loading operation itself, but may prevent the ferry berthing or make use of the access road unsafe.

At the start of each shift or working day, the operator or authorised person should carry out a routine procedure for inspecting the facility, principally the linkspan, to determine whether any part has any visible or obvious defect likely to affect the continued its safe and reliable operation. Additional detailed maintenance procedures should deal with routine checks of, for example, oil and coolant levels

To ensure that the facility may be operated safely and efficiently, it is essential that a maintenance plan is prepared so that the risk of accidents and stoppages is reduced to a minimum. The plan should ensure that the supplier's operating and maintenance instructional manuals are adhered to. The supplier's manuals should recommend that specific tasks are carried out at stated intervals which should not be exceeded.

All repairs or replacement components and consumer materials, such as lubricants, should be in accordance with the manufacturer's recommendations or specifications. To ensure that the facility can be maintained in an efficient and safe condition, consideration should be given to holding stocks of components and consumables.

Maintenance of the ship to shore facilities should preferably be based on a planned preventive maintenance basis This approach includes for shutdowns for planned maintenance and major overhauls and includes replacing parts and making adjustments at pre-planned intervals so that the particular part or adjustment does not fail or deteriorate in the intervening period.

A technical file should be maintained which should include copies of the following;

- details of workstations likely to be occupied by operators,
- instructions for safe putting into service,
- instructions for safe use,
- instructions for safe adjustment,
- training instructions
- drawings and diagrams necessary for checking correct operation
- all instructions with regard to safety.

perating and maintenance manuals should be prepared by a specialist firm for a specific cility and should be supplied for every piece of machinery and lifting equipment including all ructural, mechanical, electrical and control aspects. The manuals should cover the safe arting up, running and closing down of all systems We recommend that the supplier should e required to provide operating and maintenance manuals at the time of commissioning efore the terminal is brought into use. This is to ensure that they are in a suitable form for use terminal staff.

operating log should be kept for each ro-ro facility and completed on a daily or shift basis the operator. The logs should include details of ship arrivals/departures and notes of any usual incidents including ship impacts, excessive movements of the ship and any machinery d equipment defects.

incidents of damage, failure or faulty operation should be recorded in writing and estigated. Operators of facilities should complete daily logs recording any significant currences. Incident reports should be used to plan repairs and to provide feedback into iews of the operating instructions. The operator must receive appropriate training to ensure t he has reached a suitable level of competence and capability. He must be able to carry his duties without risk to himself or to others.

also vitally important that an operator receives regular training in emergency procedures that he is able to respond quickly and safely. Emergencies occur only rarely and can put nse pressure on an operator and can lead to poor decision making unless the operator is perly trained. Simulations of emergencies should be practised on a regular basis to enable operator to become familiar with procedures.

ning should consist of a mixture of theoretical instruction and practical work. The supplier mally provides the majority of the operational training when the facility is being nmissioned.

ropriate training in the maintenance of the various elements of the facility should be vided to the members of the maintenance teams and refresher courses arranged odically. Training course records should be kept so that the competence of individual nbers can be assessed. Authorisation to carry out particular maintenance work should only iven to those who are properly trained.

4.30 The supplier has a very extensive fund of knowledge and experience in the design, manufacture, testing and commissioning of ro-ro facilities which should be made available to staff appointed to operate and maintain the ro-ro terminals. Usually, purchasers require that operators are trained as part of the procurement process in which case, the supplier provides on-the-job training and some class room training on the contents of the operating instructions.

4.31 We strongly recommend that the supplier of any new ro-ro facilities should be contractually obliged to provide a high quality input to a programme of training for all operating and maintenance personnel connected with the ro-ro terminals.

5 Ferry Safety

5.1 Details of accidents to UK registered ro-ro ferries between December 1990 and June 1999 are listed chronologically in Appendix I . These details were collated by the Marine Accident Investigation Board based in Britain.

5.2 In the 181 accidents listed between December 1990 and June 1999, 64 people were injured and 2 were killed. One ferry, the Maersk Yare, was lost in the incident on 27th December 1990. An analysis of the causes of the accidents is given in Table 1.

5.3 A study of the accidents involving UK registered ro-ro ferries indicates that half were causes by collision and contacts. Machinery failures accounted for 18% and stranding and grounding for 18%. Fires and explosions caused 8% of accidents while the remainder were due to heavy weather damage, foundering and flooding.

5.4 An assessment and analysis of the risks which might affect the safety of a ferry is summarised in Table No. 2. This summary is tabulated under the following headings:

- Location - which locates the part of the route being assessed.
- Failure - which identifies the possible failure.
- Cause - which identifies the possible cause of the failure.
- Risk - which records the assessed outcome in terms of risk which could result from the initial effect.
- Mitigation - which gives an initial indication of the basis on which any potential hazards should be addressed.

5.5 From the Ferry Risk Analysis Table, it is apparent that:

- In a number of incidents the ferry could be lost either on a permanent or temporary basis.
- In a number of incidents both the ferry and marine structures could be damaged.
- In nearly all incidents, the risk could best be reduced by the availability of a competent crew.
- In a number of incidents the risk could be reduced by a satisfactory radar and communications system

competence can be greatly improved by regular training in emergency procedures so ew members can respond quickly and safely in a crisis. Emergencies occur only rarely n put intense pressure on the crew and lead to poor decision making unless the crew is y trained. Simulations of emergencies should be practised on a regular basis to enable w to become familiar with procedures.

ematical navigation simulator model is capable of simulating second by second motions ip by solving equations of a ship's manoeuvring motions corresponding to orders from dge including the helm angle, rotational speed of the propeller, etc. With recent ements in computer science and technology, a real time simulator model is now sed as a realistic and essential tool in the training and education of a ship's navigator . However, this type of training is only of value if it is controlled by a very experienced vigator such as a ship's master or a pilot.

ongly recommend that all officers responsible for navigating the ferries should undergo based on the use of Mathematical Navigation Simulation Models.

s of a ferry is frequently due to an accident on board such as an engine failure or fire. er, the loss might be avoided by the action of a competent crew trained to handle encies. At the same time, good communications with port control and VTS could bring services quickly to a stricken vessel and thereby save lives.

t control and the VTS would also warn other shipping and thereby reduce the risk of ship colliding with the stricken vessel.

id stranding or running aground, it is essential that the ferry navigating officer is ed with the latest charts and that he keeps himself informed of any possible changes g the shipping channels. The navigating officer should also be trained to handle any emergencies such as might arise in bad weather. It is also essential that the navigating officer be assisted by a full set of reliable on-board navigation aids.

12 The possibility of a ferry colliding with another vessel is best minimised by constantly checking the on-board radar system for the positions of other ships and by remaining in close contact with port control and VTS regarding other shipping movements.

3 In the event of a near collision situation developing with another vessel, it is essential that the crew has been adequately trained on how to react. Unless they can properly respond, it is possible that the pressures on the crew generated by the emergency can lead to mistakes with disastrous consequences.

4 For safety reasons, all external cargo doors should remain fully closed at all times while a ferry is in motion. The attached Case Study on the mv Herald of Free Enterprise gives an account where this precaution was not properly followed and led to the loss of a ro-ro ferry. Although the direct cause of the accident was that the ferry put to sea with her outer and inner bow doors fully open, the underlying cause was inadequate crew training and lack of clear and adequate procedures.

5 In the event of a ferry sustaining damage following a collision with a fixed structure such as the approach jetty, it is possible that the ferry service could be disrupted while the ferry was repaired. It is also possible that the approach jetty could be severely damaged by the vessel resulting in the disruption of road traffic with possible terminal closure over a limited period.

6 To minimise the possibility of a ferry colliding with the approach jetty or other fixed structures such as jetties, berths, linkspans and breakwater heads, the approach should be planned to minimise the risk of collision should error or accident occur. All structures should be made clearly visible to the ferries by high visibility marking and illumination at night. Training of the crew to deal with emergency situations is also an extremely important factor in reducing the risk of a ferry colliding with a fixed structure.

7 Ferries frequently suffer structural damage due to a failure to maintain loading requirements. This deficiency is best overcome by regular training of the crew in cargo handling particularly of outsize and dangerous loads. Special attention should be given to handling cargo in poor weather conditions. There should be written procedures for all aspects of cargo handling and stowage which would include additional requirements (such as additional lashing) for poor weather conditions.

8 To deal with the difficult marine conditions in the Gulf of Cambay, ferries should always be fully equipped with a set of reliable electronic navigation aids such as satellite positioning, radar, etc. As an illustration of what equipment might be supplied, the navigation aids available on the MS Normandie are listed below. Operating on the English Channel, the MS Normandie is a ferry of 27,000 gross tonnage carrying up to 2,263 passengers, 630 cars and 66 trailers.

Item	**No**
Rasterscan radars	2
Radar antenna/transceiver, S-band	1
Radar antenna/transceiver, X-band	1
ARPA-display and one TM-display interswitched together	1
Harbour radar system with four monitors (2+2) and antennas aft and fore	1
Autopilot	1
Two-axis Doppler log	1
EM log	1
Echo sounders	2
Magnetic compass	1
Wind meter	1
DECCA navigator	1
DGPS navigator	1
Syledis positioning system	1
Radio direction finder	1
VHF-direction finder	1
Draught indicator	1
NAVTEX receiver	1

Certain systems, such as the Decca navigator, will not be appropriate unless the basic network is already in existence. DGPS also requires a shore station at each terminal, but basic GPS is independent of any shore station.

To avoid the possibility of accidents due to ship collision, bad weather, changes in navigation channels, etc., the crew must ensure that they remain in continuous contact with the port control and VTS while at sea. When in harbour, the crew must remain in contact with the harbour master for instructions regarding shipping movements.

21 To reduce the risk of a running aground or colliding with another ship or a fixed structure, a ferry should be as manoeuvrable as possible. The twin screw/single rudder type of ship is characterised by good manoeuvrability at service speeds but poor manoeuvrability at low speeds. In contrast, the twin screw/twin rudder type has good manoeuvrability and control at all speeds and it is this type which we strongly recommend for operations in the Gulf of Cambay.

22 To safeguard against the possibility of a ro-ro ferry sailing with her doors left open, we strongly recommend that ro-ro ferries operating on the Gulf of Cambay should be equipped with door indicator lights. The door indicator lights should be located on the bridge and the entire circuit should be designed on a failsafe basis so that if there should be an electrical failure in any switch circuit, the system would indicate danger. The design of linkspans proposed does not inhibit door closure before the ferry leaves the berth.

23 Due to the flare of the sides of a ro-ro ferry at the stern, it is usually extremely difficult if not impossible the read the aft draught gauge. We strongly recommend that ro-ro ferries operating on the Gulf of Cambay should be fitted with draught gauges at the aft and forward loading positions and on the bridge. The draught gauges should give read-outs of the aft, forward and midship draughts.

4 Closed circuit television has been installed on a number of ro-ro ferries for the following purposes: -

- To monitor the condition of the doors with the intention of keeping the bridge informed.
- To check the vehicle decks for intruders, innocent or otherwise, and check for any movement - of vehicles in a seaway.
- To keep the bridge informed with regard to conditions in the engine room

5 The closed circuit television should monitor the condition of bow doors, inner and outer stern doors and any side doors. The closed circuit television will also give warning of any vehicles which are not properly secured and have shifted. The vehicle decks should be out of bounds during a passage to every person except crew members.

6 We strongly recommend that ro-ro ferries operating on the Gulf of Cambay should be equipped with closed circuit television.

7 In the event of a ship capsizing, the availability of artificial lighting during the hours of darkness is essential as a boost to morale and as an aid to rescue operations. To ensure that lighting is

always available, we recommend that ro-ro ferries are equipped with self contained emergency lighting of which several types are available. Self-contained emergency lighting units should be watertight, that is, when submerged, they should remain alight until the batteries run out. The units should be checked on a regular routine basis.

3 We strongly emphasise the need for the frequent, regular and routine checking of all life saving equipment. In particular, we draw attention to the need for easy access to lifejackets which, because of the rapidity with which a ro-ro vessel can sink, are usually the most used means of escape.

9 In an emergency, it may be necessary to rescue people through side windows. To assist rescue teams, it should preferably be possible to open the side windows from either side.

0 To facilitate escape in an emergency, we strongly recommend that all decks, exits, lifejacket stows and muster stations are labelled prominently.

Special Arrangements at Suvali

The ferry terminal at Suvali is proposed to be sited within a larger development which includes a Liquefied Natural Gas (LNG) terminal. This terminal will load and unload gas tankers, and will provide for onshore storage in large tanks. Safety precautions at this facility are outside the scope of this report, but the presence of the facility has safety implications for the ferry terminal which are considered below.

The major hazards of LNG are due to their highly flammable nature and the very low temperatures at which they are transported. When LNG escapes into the atmosphere, it boils off quickly. The resulting vapour cloud, which is lighter than air, will rise and in light wind conditions, may spread over a considerable distance before reaching non-explosive density.

In a liquefied gas fire, only the vapour burns and not the liquid itself. Thus the major danger is the ignition of the vapour cloud. The flammable vapour can become ignited only when mixed with air in certain proportions. If the ratio of vapour volume to air is less than or more than the specific range for a particular gas, combustion cannot occur. In confined spaces, an ignition of gas vapour can develop into a violent explosion creating forces sufficient to destroy structures.

An explosion-like event known as " flameless explosion" or "rapid phase transition" may occur if very cold liquefied gas strikes water. This is not considered to be a major hazard as the energy release is limited and there is no evidence that fire would result.

When cold liquefied gases are spilt on water, they will rapidly spread and vaporise creating a low dense cloud of flammable vapour. Immediate ignition of the spill will result in an intense short-duration fire. If not immediately ignited, the vapour cloud will travel down-wind until dispersed by becoming heated by the atmosphere which is at a relatively higher temperature.

The proposed Ro-Ro terminal is to be sited some 900m south of the LNG terminal. Although there is no international standard at present available which gives recommendations for the minimum clearance from an LNG terminal to another berth, we consider that a clearance of 900m is reasonable.

Because the prevailing winds are westerly and south westerly during the non-monsoon and monsoon periods respectively, the proposed ro-ro terminal lies generally upwind of the LNG facility and it is unlikely that it will be affected by a vapour cloud developing over the LNG terminal in the event of a leak or spillage.

It is essential that the special risks engendered by the LNG facility are recognised by the ferry and terminal operators, and particular safe practices should be implemented at Suvali in addition to the general safe practice discussed above.

The ferry navigating officers should remain in full communication with the harbour master at all times when approaching or leaving the ro-ro terminal at Suvali. The crew must fully comply with all instructions given by the harbour master and be fully alert to react to an emergency. We anticipate that it is unlikely that the harbour master will permit a ferry to leave or enter the harbour while an LNG carrier is manoeuvring in the turning area or passing through the approach channel, so that the ferry must be prepared to accept disruption to its schedule.

The terminal operator must ensure that the land route to the terminal is very clearly marked and fenced at all times so that no road vehicles can stray into the port zone where the LNG is handled.

The terminal operator must also remain in continual contact with the harbour master to ensure that he is always kept fully informed with regard to the situation at the LNG terminal. The terminal operator should have an emergency plan ready for an immediate evacuation of the ro-ro terminal should an emergency arise at the LNG terminal.

2 The other activities in the main port, handling of general cargo and import of iron ore are unlikely to have any adverse safety implications on the ferry terminal.

Recommendations For Action On Safety

The Port Authority must:

(a) ensure that the harbour master can supply up to date forecasts of weather and sea conditions
(b) ensure that all interested parties are kept informed with regard to changes in local bed topography
(c) ensure that up to date charts are available to all interested parties
(d) ensure that navigation channels, isolated dangers, turning areas, etc are adequately marked with aids to navigation which are lit and equipped with radar reflectors.
(e) ensure that a fully equipped VTS centre is provided
(f) establish a set of Rules of Operation
(g) ensure that ro-ro terminals are manned by competent and well trained staff
(h) ensure that ro-ro terminals are regularly inspected for defects
(i) ensure that ro-ro terminals are properly maintained
(j) establish special rules for Suvali in relation to the LNG terminal

The ferry operator must:

(a) ensure that there is good liaison between shore management and ferries
(b) ensure that there is regular and effective communication between shore and ship
(c) ensure that shore management provides the ferry master with clear instructions for him and his crew
(d) ensure that the ferries are fully equipped and regularly maintained
(e) ensure that ferries are manned by competent and well trained crews
(f) ensure that ferries are of the twin screw/twin rudder type
(g) ensure that ferries are carry a full set of reliable on–board navigation aids
(h) ensure that ferries obey the Rules of Operation
(i) ensure that the ferries conform with any reasonable requirements from the harbour master and VTS

(j) keep in contact with the port authority with regard to changes in the local bed topography affecting navigation channels

(k) ensure that the ferries maintain independent contact with the harbour master, VTS and other information services regarding weather and sea conditions and other shipping movements

TABLE 1

Analysis of Accidents to UK Registered Ro-Ro Ferries between December 1990 and June 1999		
SE OF ACCIDENT	**NO**	**% OF TOTAL**
ions and Contacts	91	50.0
inery	32	18.0
ding and Grounding	31	17.0
and Explosions	14	8.0
y Weather Damage	9	5.0
dering and Flooding	3	1.5
llaneous	1	0.5
	----------	----------
AL	**181**	**100.0**

TABLE 2

Ferry Risk Assessment Analysis Summary Table

ATION	FAILURE	CAUSE	EFFECT	RISK	MITIGATION
n sea	Ferry Sinking	Adverse Weather	Loss of ferry boat	Loss of service	Competent crew
	Ferry Running Aground	Changes	Ferry stranded	Temporary loss of service	Competent crew
oach nel	Ship collision	Adverse weather	Loss of ferry	Loss of service	Competent crew and good communications
	Ferry Running Aground	Inadequate Radar system	Ferry stranded	Temporary Loss of service	Good radar system
pan	Ship/linkspan Collision	Adverse weather	Stricture damage to ferry and linkspan	Temporary loss of service	Competent crew and good communications
	Delayed departure in an emergency	Fire, Adverse weather, explosion etc.	Structural damage to ship	Temporary loss of service	Competent crew and good communications
	Ferry sinking	Non closure of all external doors while ferry in motion	Loss of ferry	Loss of service	Competent crew
	Non observance of linkspan warning system	The linkspan is subject to Excessive loading severe bad weather	Structural damage to ship	Temporary loss of service	Competent crew and good communications
	Unsafe load arrangement on board	Incompetent loading	Structural damage to ship	Temporary loss of service	Competent crew and good communication
	Unsafe loads	Failure to maintain safe load Restrictions	Structural damage to ship	Temporary loss of service	Competent crew and good communication
	Dangerous cargoes	Failure to observe loading requirements	Structural damage to ship	Temporary loss of service	Competent crew and good communications
ach	Ship/structure collision	Ferry sails into jetty	Structural damage to ship and approach jetty	Temporary loss of service	Competent crew and good communications

TECHNO-ECONOMIC STUDY

Introduction

The techno-economic study was initially undertaken in 1998 and presented in the Interim Report with the objective of deriving an indication of the level of tariffs that could be charged to the operators of Ro-Ro ferries sailing between the planned new terminals in the Gulf of Cambay. For the purpose of the study we considered operation of the ferry service as an independent activity quite separate from operation of the shore terminals. We estimated possible revenues that could be generated from users and the likely costs associated with providing suitable vessels and running the service. The difference between these figures gives an indication of operating profits for the ferry service from which tariffs and other charges would have to be paid to cover running costs of the terminals and harbour facilities and make a contribution towards the capital cost of the new infrastructure.

The initial study has now been supplemented with an assessment of the overall viability of ro-ro ferry and catamaran services on the Gogha, Dahej and Suvali network. The initial study is reproduced as sections 9.2 to 9.5 and 9.7 to 9.9 (with small changes and additions) with the supplementary work appearing as section 9.6 (terminal costs) and 9.10 (financial analysis)

This supplementary assessment considers the terminal operating and capital costs, and reassesses the costs of provision of the ferry service. These costs, which are at current (2001) prices, are compared with the revenues generated in the 1998 study which have been updated in line with inflation to 2001 prices

Clearly the findings of the study are greatly dependent on the information available to the team doing the study. We have carefully analysed the available data and utilised it in the most appropriate way. There have been three types of information used during this study.

a. **Raw Data.** This type of information is the evidence on which the assumptions are based, for example charts, borehole logs or weather records.

b. **Assumptions.** These are pieces of information which are influenced only by external factors. For instance we have taken the number of rainy days in an average year to be an assumption because we can not change it although there is an ambiguity as to what this value actually is. We may be able to change our estimate of rainy days as we get better information but the real number will not change over the course of a year. All of our assumptions for this study have been implied from available the raw data.

c. **Variables.** A variable is a piece of information whose value we can change within our analysis. For instance the number of ferries that will operate on any particular route is a variable. We have been able to run the techno-economic model with a range of different values for each of the variables in order to obtain an indication of its optimum value.

General Approach

1 A method has been used to compute likely demand for ferry users by comparing the time taken to travel on existing roads against the prospective time taken for the new ferry routes.

2 Surveys have previously been commissioned relating to the demand for transport from specific regions in Gujarat and from these it has been possible to create origin-destination (O-D) pairs for each region within Gujarat and for the surrounding states. We have used the raw data from the Tata Consulting Services (TCS) study rather than the interpreted results in the TCS report because the previous studies were focused on a quite different set of sea routes that do not directly relate to the specific terminals considered in this study. We have taken the information for the origin-destination survey from the previous studies and analysed it with specific reference to the routes in this study. We have thus derived projections that indicate how many passengers and vehicles currently might wish to travel between destinations that are essentially across the Gulf of Cambay. Passenger numbers are divided into categories of social, tourist and business while vehicles are divided into trucks, buses and cars.

3 This study has a purely theoretical basis because there is no previous experience of a comprehensive modern Ro-Ro ferry service operating in this region. Few direct parallels can be drawn between the Gulf of Cambay and other locations where existing ferry services operate because of the unique combination of marine conditions and geographical usage demands. The volume of potential users has therefore been computed by comparison against other means of transport rather than actual figures from other ferry services. The underlying assumption used in this computation is that the decision by the users between the two methods of transport would be made proportionally to cost and time savings by the chosen mode, with greater emphasis being given to the cost saving.

.4 For the purpose of this study the whole of Gujarat has been split up into small specific areas each concentrated into a single node. Each node therefore represents a city or large town and the surrounding catchment area. If two of these nodes are considered in isolation then the journey joining these nodes can be analysed. Associated with every pair of nodes is a market i.e. the number of users wishing to make this journey. Also associated with each node pair is the cost and time taken for the journey, both by road and subsequently calculated for the ferry.

5 The distance of any one journey (the O-D pair) can be calculated by adding the internodal distances along the route together. These distances have previously been calculated in the traffic study.

6 Using average road speed for each type of vehicle an average journey time has been calculated for each O-D pair. The alternative journey time by appropriate use of a ferry has also been calculated in the same way assuming an average ferry speed and wait at the terminal.

7 For this model average road speeds have been taken as 40 km/h and 20 km/h for A and B roads respectively. The assumed average ferry speed is 18.5 knots. Average waiting time at the ro-ro terminal is assumed to be 1 hour.

3 A proportion of the total market will wish to use the ferry; this proportion will depend on the time and cost savings of the ferry journey. All O-D pairs can be considered in this way, and the total for all O-D pairs over a particular ferry route can be calculated.

9 For this study, it has been assumed that the potential traffic taking the ferry is proportional to the saving, in time and cost, over the whole journey. 100% saving, which is not achievable in practice, would mean that all traffic would use the ferry; a 50% saving would divert only 50% of the total traffic to the ferry. For the assessment of baseline potential, the ferry fare is set at zero.

10 Summing up the process over all relevant O-D pairs has given the initial prediction of the numbers of trips potentially to be taken by ferry if only that one particular ferry route is available.

1 A further case has been worked out with all ferry routes available, in which case all duplicated

journeys have been taken out. This exercise has been done for each route by removing trips taken by all but the quickest route.

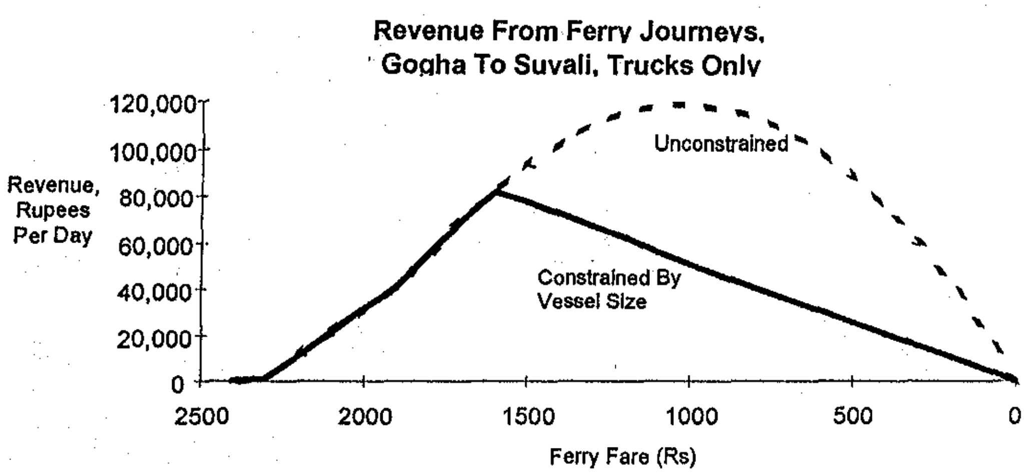
2.12 There are many possible ferry routes connecting the terminals that we have considered, which are at Dahej, Gogha, Suvali, Pipavav and Mumbai. A network comprising the most promising six of these routes has been considered in detail. For the case where all five of the terminals are operating it has been assumed that for some of the time Suvali will not be used because of the unfavourable weather conditions during the monsoon. A further complication is that it is not likely to be efficient to run a single ferry in isolation on each route. A more efficient method of running the network would be to have the ferries covering several terminals each. One, two and three vessels have therefore been considered in turn to cover the network serving these routes. This has given an opportunity of investigating the effects on cost and revenue of operating a different numbers of ferries.

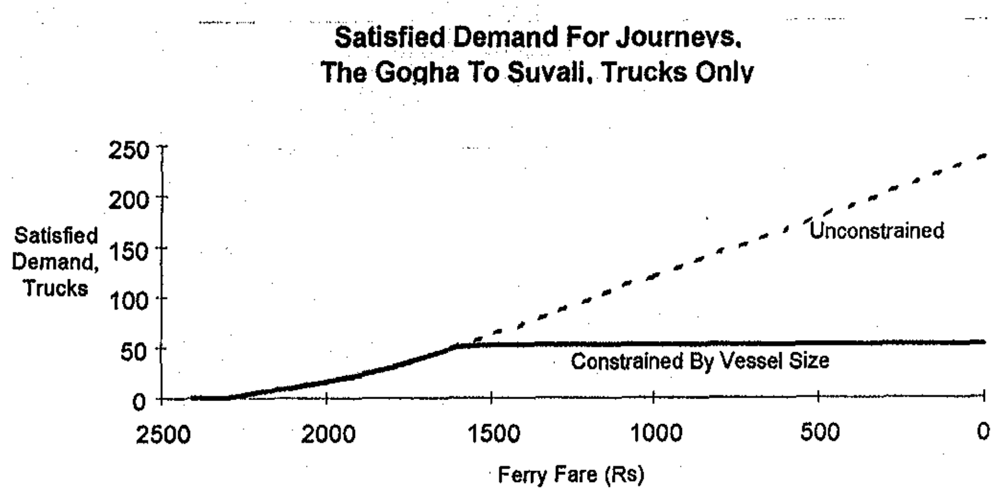
.13 For each scenario there is an almost unlimited combination of fares that can be charged to the different user groups. For the purpose of this study we have chosen to establish a notional level of fares to be charged. This has been done by fixing all other variables and running the computer model with a range of fare values; each notional fare reduces the savings and hence the number of users, as shown in 9.2.9 above. The model thus generates the number of users in each category for each fare value and hence the overall revenue for each fare value. The maximum overall revenue has been identified for each of the routes by comparing the results from each of the computer runs. This has also determined the total projected number of users, based on the assumptions included in the model.

.14 For the entire ferry network connecting the five terminals there is a maximum theoretical revenue. This is an upper bound limited by the demand of the users and the assumptions put into the computer model. The assumptions are described later in this section. The reason why the revenue cannot rise past this maximum level is that there are only a limited number of users who wish to cross the Gulf and there would be an upper limit on the fares that these users would be willing to pay.

.15 This unwillingness to pay above a certain level causes demand to drop off as the fare increases, and this is reflected in the model by reducing the use if the saving is reduced by a higher fare. If the fare is set low and is then increased, there would be a reduction in revenue due to a drop in demand, however this reduction would be more than compensated for by the increase in revenue caused by the higher fare. Once the fares have risen above a certain level any increase in fare is no longer enough to cover the corresponding drop in demand so revenue would fall. This case is referred to in this report as the unconstrained case.

6 A further limit on revenue is the number of users who can be carried by the vessels. This is often the case when the revenue can be raised by reducing the fare, and hence increasing demand. If the increased numbers of users cannot be allocated places in the vessels then the extra revenue would not actually be raised. In fact the overall revenue would go down because of the drop in fares to gain this increase in demand. This is referred to in this report as the constrained case.





Both the constrained and the unconstrained cases are shown above. The first of these shows how revenue reacts to ferry fare. In both cases it can be seen that there is a peak revenue. In the unconstrained case this cannot be improved on within the limits of this particular set of assumptions. This means that the only way to increase revenue in this case is to increase the population or make the existing population more willing to use the ferry service, for example by making the vessels quicker or road travel more expensive or slower.

.18 It can be seen, however, that the revenue from the constrained case can be increased by increasing the capacity of the vessels up until the point is reached when the peaks of the two curves coincide. After this point an increase in vessel capacity will have no effect on revenue and hence the case has become unconstrained.

19 The second of the two diagrams illustrates that even though the revenue drops off with decreasing fare the demand does not. These figures refer to the network of routes connecting the five terminals as a whole. However, exactly the same shape of curve would be observed if the same analysis is applied to a single route.

20 An efficient service could be introduced using one combined passenger and vehicular Ro-Ro vessel (Ro-Pax) serving several terminals (although this would lack flexibility in the event of mechanical breakdown). The schedule for the network of routes that has been developed for services using one, two and three of these Ro-Pax vessels. In considering a network combining more than two shore terminals care has been given to avoid duplication of node-node journeys. This has been achieved by removing duplications when more than one route is present.

21 The previous water transport feasibility study has shown that trucks make up about one third of total road traffic. This figure has been used in the final calculations to find the demand in terms of trucks. O-D pairs were available for vehicles, social, business and tourist passengers and these categories have been computed as summarised on the following pages.

22 Buses have not been considered as ferry traffic because it is not normally economic to transport buses on such long crossings. It is more likely to have a bus terminus at the ferry terminal with other routes connecting with the opposing terminal.

23 Private cars have also not been included because they represent a small proportion of the data available. There would be no statistical justification for treating such a small number.

24 The results of this techno-economic study are based on present (1996) travel patterns and markets for each type of journey. The quite separate issue of the influence of the ferry service

itself cannot be calculated with acceptable accuracy because there is no equivalent precedent, although it is noted that the presence of a ferry service usually attracts users to undertake journeys that would otherwise not have been taken. Forecast of the increase in demand resulting from the introduction of the service has not therefore been attempted. Any such prediction could not be theoretically justified without a large scale consumer survey.

Method of Calculation

A computer model has been prepared to undertake the techno-economic study. This model has taken the input data to make a comparison of the cost and time for equivalent road and sea journeys. The results of this model assess the likely numbers of passengers and vehicles that would make use of this service. Likely fares that could be charged for travelling on the vessels have also been calculated. The level of these fares has then been optimised to give a maximum revenue for the ferry service and the resulting indication of the corresponding number of users. Comparison with running costs has given an indicative operating profit for the ferry company from which a realistic sums could be charged for a contribution to shore and harbour facilities.

A detailed flowchart illustrating the operation of the computer model has been included in Appendix C. The central assumption used in this model is that the proportion of users of the ferry service is equal to the savings made by those users. For example if there is a composite saving of 50% over a journey then 50% of the users wishing to travel between this pair of nodes will use the ferry service, the other 50% will go by road. The composite saving is a combination of time saving and cost saving, offset by the ferry fare, for the journey between a pair of nodes A more detailed example calculation for one node-node pair is shown in Appendix C.

The calculation methods that have been adopted were selected in preference to other possible algorithms because they are relatively straightforward and unambiguous. When projecting reasonably basic data such as that available for this study the underlying assumptions can be critical, with variation having a significant effect on the overall findings. It is therefore appropriate that the calculations have a simplicity corresponding to that of the input data, this also has the benefit of keeping the risk of calculation error to a minimum.

4 Associated with each individual ferry journey there is always some component of road journey needed in order travel between the origin or destination and the respective ferry terminals. This road component has an associated time and cost in itself which is additional to the time waiting or travelling on the ferry. Furthermore, unless the ferry is free, the fares will always reduce the savings. Therefore the total time or cost saving in practice can never be 100%, irrespective of the speed of the vessel. It follows that there will never be 100% take-up of users for any particular ferry journey. This assumption makes sense because some of the journey users would not want to travel by ferry under any circumstance, while some others would prefer to make stops in towns along the way even if it would be cheaper and/or quicker to go by ferry.

5 Justification for this calculation method is also revealed in the output from the analysis which shows a low take-up of ferry places for journeys on the Gogha-Dahej route corresponding to the overall journey between Ahmedabad to central Maharashtra. Clearly the break in this long journey for such a small saving would not encourage many travellers and this is reflected in these figures.

The initial set of calculations has been based on data from the actual surveys carried out in 1996. Subsequent runs of the computer model have been carried out for projections of user demand to give an indication of growth over the next twenty years.

A routine dealing with the effects of the Octroi charge has been introduced into the computer model but its effect is presently set to zero because we only have sketchy information on Octroi rates. Including the Octroi charge would increase road costs, in which case giving it a non-zero value would correspondingly increase demand for ferries. Setting the Octroi universally to zero is therefore conservative for the findings of this study. This is based on the assumption that Octroi or any other taxes would not be charged on the sea crossing.

<u>Information Used For The Study</u>

The raw data that have been used as inputs to the study are described below.

a) Traffic Survey data

This information has been taken from the set of three TCS reports provided to us by GMB.

These reports were commissioned in advance of our study and make an assessment of vehicular and passenger movements around Gujarat based on a survey of traffic covering the whole of Gujarat. This work was particularly founded on the likely demand of users crossing the Gulf of Cambay with its basis being an origin and destination survey undertaken on the road network close to the head of the Gulf. This has given us the basis for derivation of likely demand for the ferry service and possible future increases in that demand.

b) Admiralty Charts

The distances covered by the proposed ferry routes are not direct lines joining the respective two terminals because the ferry would have to avoid shallows and other navigational hazards. These have been estimated from the Admiralty Charts.

c) Node-Node Distance Chart

The distances between nodes have been extracted from the TCS report.

d) Sundry Information Gathered In Gujarat

Information such as bus and taxi fares, estimated travel speeds and other empirical evidence has been collected in the area. Part of this information was used directly as assumptions for the input of the model while some components of this information have been used as the basis for an estimate of other assumptions. For instance the strong currents observed in the area were combined with knowledge of ferry operating parameters to give a lower average ferry speed than would otherwise be used.

2 Assumptions that have been adopted during the course of the study are described below.

a) Choice of routes to make available

This study has considered only routes that sail across the Gulf of Cambay; shore hops along the coast such as Dahej to Suvali were ignored. The justification for this is that the overhead of manoeuvring the vessel in and out of the Narmada river would actually make the journey time much longer than the corresponding road journey. A similar argument stands for the Gogha-Pipavav journey, although the corresponding time differential would be smaller because ship manoeuvring time would be less and the roads are of a lower standard.

b) Time/Cost Weighting

For the comparison between road and sea journeys in the model, and for assessment of usage, the weighting factors between time and cost have been set to 85% cost and 15% time (as illustrated in Appendix E). Generally transport users tend to be more sensitive to cost than time as is clearly demonstrated by the popularity of the cheap ferry journeys across the English Channel which compete successfully with the more expensive and faster rail link.

c) Turnaround time

A two-hour time delay slot has been scheduled at the end of each ferry crossing to allow for deceleration, manoeuvring, berthing, discharging vehicles and passengers, boarding, loading extra cargo, fuel and crew changes. This time has been selected from typical operations of a similar type elsewhere although it is expected that a slightly greater turnaround time would be required until experience is gained in operating vessels on these routes.

In practice the time that each ferry would actually spend at the berth would vary slightly because of the desire to maintain a regular schedule despite the changing conditions, particularly tidal velocities which follow a lunar rather than solar calendar and would move out of phase with the ferry time scale. However turnaround time is not critical to minor variations.

d) Road speed

The speeds of road journeys of different types have been divided into various categories as shown in the table below.

Category	**Speed**	**Method of transport**
Truck	35 km/h	Truck
Social Passenger	40 km/h	Bus
Tourist Passenger	45 km/h	50-50 Bus/Taxi mix
Business Passenger	50 km/h	Taxi

These speeds have been taken from information derived locally. It has been assumed that business travellers would largely travel by taxi and hence these are the fastest of the three passenger groups. It has been assumed that social travellers would use public transport which is slower than travelling by taxi because of the need to stop to pick up other travellers, in addition these would not necessarily be direct routes and depend on the public transport schedules. Tourists have been assumed to use a mixture of the two methods.

e) Road cost

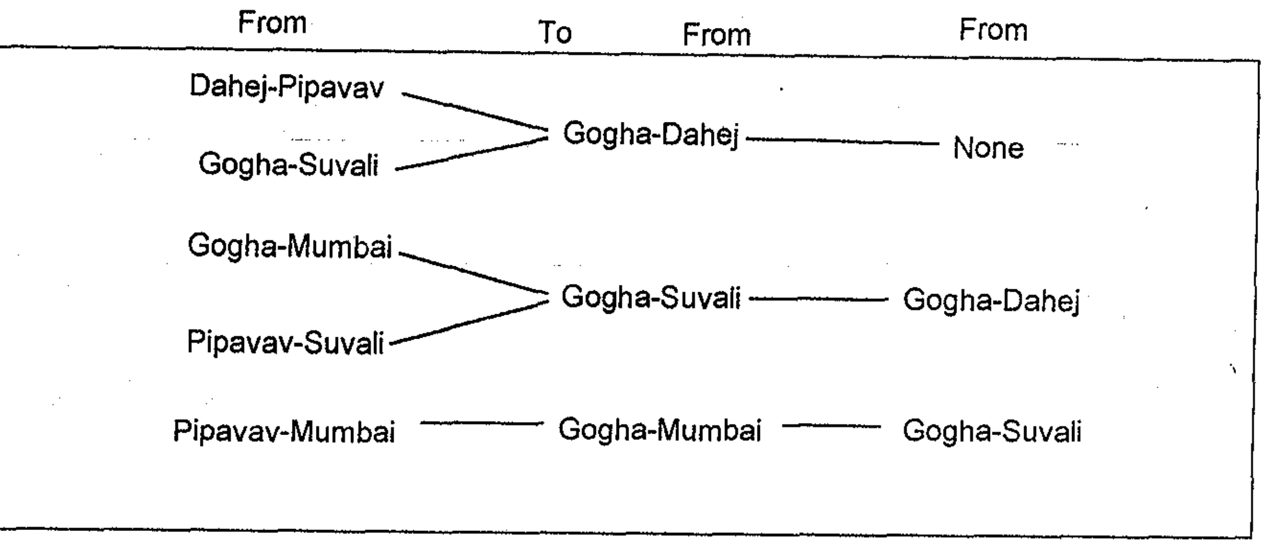
The costs associated with road travel have been derived locally and are presented in the table below. These costs are based on 1998 prices and as they are only used for comparison purposes have not been updated. These figures have been assessed for each type of transportation based on their own associated costs. An average has been taken in the case of taxi costs because of the range of prices relating to quality of vehicle.

Category	Cost per road km travelled
Truck	7 Rupees
Social Passenger	1 Rupee
Tourist Passenger	3 Rupees
Business Passenger	4.5 Rupees

For the purpose of the techno-economic model analysis passenger accommodation has have been grouped into First Class which relates to the TCS category of business class passengers and Second Class which is combination of social and tourist users.

f) Overflow

It has been assumed that when there is excess demand on one of the ferry routes some of this excess would choose to travel by an adjacent shorter ferry route rather than switching to road. A proportion of 15% of this excess has been selected for transfer in the analysis. The hierarchy of routes for overflow transfer are shown below. It should be noted that there is no transfer of overflow from the Gogha-Dahej route as this is already the shortest passage.



g) Truck proportion as a percentage of total vehicles

The TCS report which has been used to provide the raw data for this study was based on a large survey of traffic in Gujarat. One of the conclusions of this survey was that trucks make up approximately two thirds of all vehicles on the roads. Since we discount cars and buses as potential users of the ferries, we have to reduce the overall traffic in the raw data to truck only. We have assumed that the proportion found in the survey has not changed and have selected 67% as the proportion of trucks out of the total volume of traffic.

h) Ferry capacity

Having considered a broad range of possible ferry types we have selected a ferry capacity of 800 passengers and 90 trucks for the study. This has been derived from a study of vessels that are currently operating in similar sea conditions, vessels that are available on the world market and by consideration of likely demand on these routes. At this stage the 'design' vessel can only be an indication of the type of service that could operate because in practice a variety of vessel sizes could be adopted. The number of trucks that each vessel can carry is greater than the officially quoted figures would suggest because the lorries used in India tend to be shorter than the truck-trailer combinations used in Europe on which the quoted figures are generally based.

i) Distances

taken directly from the TCS report. The sea distances have been measured from Admiralty charts on the basis of actual routings that are likely to be sailed between each destination, these therefore includes an allowance for detours around shallows and other dangerous areas.

j) Allocation of costs

The costs of running the ferry depend partially on capital and running costs of the particular ferry chosen and to some extent on other factors that could not be precisely calculated. Other influences are, training costs and escalation of pay for labour and crew, fluctuations in the price of oil, and changing interest rates. All of these change with time and some of which are completely out of the sphere of influence of the ferry operator.

k) Fuel consumption

Fuel consumption has been based on available specifications of suitable vessels currently in use on other routes. Actual consumption could vary dramatically with the particular vessel chosen.

l) Cost allocation over routes

Costs have been allocated between routes on the basis of distance. The decision over cost allocation would be made by the ferry operator so any assumption here is purely arbitrary. It does not, however, affect the overall profitability of the entire service network.

In running the model for the full network of five terminals provision has been made for the four main interrelated variables:

a) The number of ferries

The number of ferries operating on the service is the principal limit to the number of trips that can be made to any one port per week. We have drawn up schedules to consider the operation of one, two and three vessels and have noted that the largest marginal increase in revenue resulted from the introduction of the second vessel. The reason for this is that the distribution of terminals lends itself to two different working regimes, these being the long trips to Mumbai and the short trips in the Gulf of Cambay. While a single vessel could theoretically cover both of these functions it would always have to compromise to some extent between the activities.

b) Choice of routes from those available

For each selected fleet of vessels operating on the network of routes there is an optimum set of sailings, although these can be programmed for different timings. The most efficient way of choosing the routes is to identify the set of crossings for which the excess demand is the lowest over all categories of user. This has been done in conjunction with practical considerations in order to define the optimism number of sailings between each of the destinations.

c) First Class/Second Class passenger split

The proportional split between First and Second class passenger accommodation which has given the largest overall revenue for the ferry network has been chosen.

d) Fares

Fares have been calculated to give the largest possible revenue when the computer model was run for the selected combination of other variables. Each type of fare, i.e. for trucks, First Class passenger and Second Class passenger was set individually for each route. This gives a maximum operating revenue for the ferry network although there will be occasions when this cannot be achieved in practice, for example it would be advisable to set fares at lower levels in the first instance in order to promote ferry use as a realistic alternative to the roads. Also there will be periods when bad whether will cause delays and disruption.

Ferry Operating Costs

The cost of operating a ferry is made up from a number of component parts. We have made an assessment of these costs considering fixed costs charged on a time basis and running costs charged on a distance basis.

a) Capital Costs

The cost to purchase the vessels, whether they are new or second-hand, represents a significant commitment for the ferry operating company. For flexibility of service it has been assumed that two ferries capable of making the longest journey on the network will be used. When the service starts two types of vessel may be used on the network of ferry routes. A ferry that is suitable for the shorter crossings on the northern part of the network would have few overnight berths and more limited facilities than the vessels for the longer crossings. For the routes connecting to Mumbai the ferries would have overnight accommodation. However for the purpose of developing costs as input to this study we have assumed that the network will consist of two of the latter type of ferry each with a current (1998) secondhand cost of Rs 17.25 crore. These figures relate to actual vessels that are currently in operation on a similar routes elsewhere in the world. It should be noted that the secondhand ferry market is dependent on many specific factors and the prices will obviously be different for different vessel specifications and ages. All prices are liable to change depending on market conditions.

b) Charge against equity

We have assumed that the cost of the vessels would be in the form of equity with a further Rs 3.5 crore of equity required for activities associated with start-up of the service. In order to put a reasonable charge against cost in this study we have assumed an 18% annual payment on the reducing total sum over a period of eight years. This gives a total of Rs 38 crores for capital costs.

Capital Costs For Two Vessel Service – 1998 prices	**Lacs Rs**
Total capital costs	3800
Total repayable over 8 years (including charge @ 18%)	6878
Average repayable per year	859.75
Average Daily cost	2.355

Crew Costs

Manning levels have been taken for similar vessels operating elsewhere and related to costs in India. Two crews have been allocated for each vessel to enable round the clock operation. A total of four crews of 20 have therefore been taken for costing purposes to give a total cost of USD 150,000 per month which relates to Rs 2.01 Lacs per day.

There are a number of factors that can affect the cost of crewing the vessels. These include the flag under which the vessel sails, nationality of the crew and whether the officers are licensed for home or foreign trade.

d) Consumables and Maintenance

Consumables such as a oil and lubricants are generally used at a predictable rate and we have adopted a figure of Rs 0.34 lacs per day derived for a vessel similar to those considered in this study. Similarly we have adopted a figure of Rs 0.76 lacs per day for maintenance and repair of the vessels to cover the regular maintenance programme.

e) Fuel

The utilisation of fuel by the vessels has been worked out as a cost for the distance travelled. This has been related to the quantity of fuel and its current price. As vessels consume considerably more fuel when sailing between ports than at the berth different consumption rates of 24 and 2 tonnes per day have been derived for respective activities. The proportion of time at sea during a weekly schedule has been calculated for each network of routes and this has been used to calculate the total fuel consumption.

A cost of Rs 12,000 per tonne has been taken as the current (1998) duty paid price for marine diesel oil. This price is liable to significant fluctuation depending on where and when it is purchased. For example the lower cost of fuel in Dubai could be used to the benefit of international routes. Also there is a significant difference between the bonded price and duty paid price. The price of this fuel is currently maintained at artificial levels although we understand that this will cease in two years time leaving the price to move in line with world market. This will inevitability have a significant effect on fuel costs at that time and to give an indication of recent fluctuations on the world market marine diesel prices have changed by 39

% over a recent 4 month period. Other factors affecting the total fuel costs are the actual fuel comsumption and type of fuel used, both of which are specifically dependent on the type of vessel used and its mechanical condition.

5.2 A total cost has been derived by summing all of the above costs as shown below.

Operating Costs Per Day Per Vessel - 1998 prices	Lacs Rs
Officers and crew costs	1.00
Consumables	0.34
Repair and Maintenance	0.76
Insurance	0.28
Fuel (Full Network)	2.33
Total	4.71
Fuel (No Suvali)	2.21
Total (No Suvali)	4.59

Total Vessel Costs (Two Vessel Service) – 1998 prices	Lacs Rs
Daily cost for operating full network	11.78
Daily costs for operating without Suvali	11.54
Daily costs for suspended operation	7.12

Terminal Operating Costs

Manning

The efficient operation of a ro –ro terminal requires a substantial number of staff. These include:-

- The Management comprising the Port Manager, the Harbour Master, the Operating Superintendent and their deputies;
- The Harbour Master's Staff comprising the port control duty managers, and their assistants;

- The operating staff comprising the Terminal Manager, the Linkspan Operators, Cargo Handling gangs, traffic marshals etc;

- The Accounts Department comprising the Financial Manager and clerical assistants;
- Security Staff comprising the Security Chief and security officers

- Maintenance Engineering Staff comprising the maintenance engineer, his deputy, mechanical, electrical and civil engineers, foremen, fitters, welders, electricians, plumbers, joiners, painters, riggers and their mates and labourers;

- Administration staff comprising administrators, personnel, property managers, their assistants, secretaries and cleaning staff.

2 The total number of staff required to operate each terminal on a three shift basis is estimated as follows: -

	Gogha or Dahej	Suvali or Mumbai or Pipavav
Management	6	4
Harbour Master's Staff	7	-
Operating Staff	25	25
Accounts Staff	7	7
Security Staff	4	4
Maintenance Engineering Staff	15	15
Administration Staff	7	7
TOTAL	**71**	**62**

3 The staffing requirement is less at Suvali, Mumbai and Pipavav than at Gogha or Dahej. This is because a new ro-ro terminal at either Gogha or dahej would require the establishment of a

new Harbour Master's department, while at Suvali, Mumbai and Pipavav, terminals would come under the control of existing Harbour Masters

If the employment cost of each employee is taken as Rs 300,000 per annum including salary and overheads for all staff categories the total annual cost of manning each terminal would be Rs 21,300,000, say US$ 480,000 at Gogha and Dahej. The total annual cost of staffing at Suvali would be Rs 18,600,000, say US$ 410,000.

uel, Utilities and Services

To evaluate the annual cost of providing water, electricity and other services, the following percentages have been applied to the capital/purchase cost as follows: -

Buildings	0.5%
Water supply	0.5%
Street Lighting	0.5%
Linkspan	1.0%

The annual cost of providing fuel, utilities and services at Gogha is therefore as follows: -

Item	Capital/Purchase Price $	Annual Cost %	$
Buildings	987,122	0.5	4,936
Water supply	33,067	0.5	165
Street Lighting	23,245	0.5	116
Linkspan	1,814,186	1.0	18,142
TOTAL			**23,359**

The annual cost of providing fuel, utilities and services at Dahej is estimated as follows: -

Item	Capital/Purchase Price $	Annual Cost %	$
Buildings	855,373	0.5	4,277
Water supply	29,733	0.5	149

Street Lighting	20,898	0.5	105
Linkspan	1,814,186	1.0	18,142
TOTAL			**22,671**

6 For the purpose of financial analysis, we have assumed the same costs at Suvali, Mumbai and Pipavav as at Dahej.

<u>Maintenance</u>

7 To ensure that the ro-ro terminals are kept in an efficient and safe condition, it will be necessary to ensure that money is set aside for annual maintenance. In the first four years of operation, maintenance costs are comparatively low but would then build up as structures and equipment begin to be affected by wear and tear.

8 In the first four years, the maintenance staff might consist only of fitters, electricians and plumbers together with their mates all under the control of a general trades foreman. Their duties would be to deal with breakdowns in the mechanical and electrical equipment as well as the water supply system. In the fourth year, it would be advisable to provide a fully equipped workshop where equipment can be repaired and serviced. The workshops would provide storage space for spare parts and would provide a base for all maintenance staff.

The annual cost of maintaining port structures is about 1% of the capital cost, whilst the annual cost of maintaining mechanical and electrical equipment, including the linkspan, is about 5% of the purchase price.

0 On this basis, the full annual maintenance cost at Gogha from the fifth year onwards is as follows: -

Item	Capital/Purchase Price	Annual Cost	
	$	%	$
Port structures	18,310,779	1	183,108
Linkspan	1,814,186	5	9,070
Street Lighting	23,145	5	116
TOTAL			**192,294**

At Dahej, the full annual maintenance and cost commencing in the fifth year would be as follows: -

Item	Capital/Purchase Price $	Annual %	Cost $
Port structures	16,705,781	1	167,058
Linkspan	1,814,186	5	9,071
Services	20,898	5	104
TOTAL			**176,233**

For the purpose of financial analysis we have assumed that the annual cost of maintenance at Suvali, Mumbai and Pipavav would be the same as at Dahej, and will take a 50% contribution from the JV partner.

<u>Summary of Terminal Operational Costs</u>

A summary of the yearly costs of manning, fuel, utilities and services together with a full year of maintenance are summarised in Table 13 – "Summary of Annual Terminal Operational Costs" shown in Appendix H

<u>Revenue</u>

An attempt has been made to estimate the possible revenue available from this service. Although this has been calculated in a thorough and logical manner the study is based on many assumptions and it should therefore be taken as a guide to the magnitude of possible revenue.

The techno-economic model has been run with the various configurations of vessel and terminal operation levels with overall revenue being calculated during this process. Each stated level is optimised revenue, i.e. it is the revenue available if the fares are tuned to the capacity created by the service configuration in question. The model has been run for several different route configurations and the resulting predicted revenue is shown in the table below for:

- Separate operation of individual routes;
- The full network of five terminals operated by two vessels;
- Four terminals (not Suvali) operated by two vessels.

Route	Total Revenue (Rupees/day) 1998 Figures		
	Individual Routes	Full Network	No Suvali
Gogha-Dahej	1,57,000	72,200	76,631
Gogha-Suvali	9,26,000	7,33,690	0
Gogha-Mumbai	13,10,000	10,37,066	13,60,537
Dahej-Pipavav	50,000	41,089	44,437
Pipavav-Suvali	10,46,000	8,34,262	0
Pipavav-Mumbai	9,62,000	7,50,200	8,97,632
	Total	34,68,507	23,79,237

For the full service there is an optimum revenue associated with each route. In each case the calculations have shown that this revenue is less than for a case when only the individual route is active. However, the cost of running the ferries would spread over the several routes comprising the ferry network, rather than a single route having to support all of the overheads, particularly as the vessels may not be fully utilised.

The terminal at Suvali is likely to be too exposed for safe use at all times during the monsoon season, so an alternative schedule would have to be considered. The revised schedule that we have prepared for the purpose of this study gives overall revenues that are probably as high as could be expected with one of the principal terminals out of use.

A further breakdown of the revenue that could be generated from the full network is shown in the following tables:

One Vessel operating on the full network of five terminals (1998 figures)

Route	Round Trips per week	Users carried per week	% of total using the ferry service	Average single cost by road (Rs)	Single ferry fare (Rs)	Total Revenue (Rs) per week
enue From Trucks						
gha - Dahej	2	360	6.33%	2,121	357	1,28,520
gha - Suvali	2	360	3.93%	2,938	1,855	6,67,800
ha - Mumbai	2	360	2.42%	5,234	3,067	11,04,120
ej - Pipavav	1	150	10.75%	2,377	990	1,48,500
avav - Suvali	1	180	2.93%	3,100	2,184	3,93,120
vav - Mumbai	1	180	1.21%	6,152	4,372	7,86,960
Totals	9	1,590				32,29,020
nue From First Class passengers						
gha - Dahej	2	1,017	8.97%	1,364	201	2,04,417
gha - Suvali	2	1,120	4.51%	1,889	1,184	13,26,080
ha - Mumbai	2	1,120	9.24%	3,365	1,801	20,17,120
ej - Pipavav	1	255	22.12%	1,528	315	80,325
vav - Suvali	1	560	2.98%	1,993	1,690	9,46,400
vav-Mumbai	1	560	4.62%	3,955	2,553	14,29,680
Totals	9	4,632				60,04,022
nue from Second Class passengers						
gha - Dahej	2	1,541	5.55%	606	133	2,04,953
gha - Suvali	2	2,080	3.77%	839	563	11,71,040
ha - Mumbai	2	2,080	6.72%	1,495	1,126	23,42,080
ej - Pipavav	1	398	13.68%	679	206	81,988
vav - Suvali	1	1,040	2.18%	886	1,090	11,33,600
av - Mumbai	1	1,040	3.36%	1,758	1,521	15,81,840
Totals	9	8,179				65,15,501

One Vessel operating between four terminals (not Suvali) (1998 figures)

Route	Round trips per week	Users carried per week	% of total using the ferry service	Average single cost by road (Rs)'	Single ferry fare (Rs)	Total Revenue (Rs) per week
nue From Trucks						
gha - Dahej	1	180	3.17%	2,121	544	97,920
gha - Suvali	0	0		2,938		0
ha - Mumbai	2	360	2.42%	5,234	3,066	11,03,760
ej - Pipavav	2	158	11.32%	2,377	928	1,46,624
vav - Suvali	0	0		3,100		0
av - Mumbai	2	360	2.42%	6,152	4,279	15,40,440
Totals	7	1,058				28,88,744
nue from First Class passengers						
gha - Dahej	1	558	4.93%	1,364	292	1,62,936
gha - Suvali	0	0		1,889		0
na - Mumbai	2	1,120	9.24%	3,365	1,801	20,17,120
ej - Pipavav	2	400	34.64%	1,528	136	54,400
vav - Suvali	0	0		1,993		0
av - Mumbai	2	1,120	9.24%	3,955	1,851	20,73,120
Totals	7	3,198				43,07,576
ue from Second Class passengers						
ha - Dahej	1	1,040	3.74%	606	166	6,30,240
ha - Suvali	0	0		839		0
a - Mumbai	2	2,080	6.72%	1,495	1,126	23,42,080
ej - Pipavav	2	340	11.67%	679	212	72,080
vav - Suvali	0	0		886		0
av - Mumbai	2	1,762	5.69%	1,758	1,059	18,65,958
Totals	7	5,222				49,10,358

Two Vessels operating on the full network of five terminals (1998 figures)

Route	Round trips per week	Users carried per week	% of total using the ferry service	Average single cost by road (Rs)	Single ferry fare (Rs)	Total Revenue (Rs) per week
enue from trucks						
ogha - Dahej	4	355	6.24%	2,121	285	1,01,175
ogha - Suvali	6	910	9.93%	2,938	908	8,26,280
gha - Mumbai	3	540	3.63%	5,234	2,675	14,44,500
hej - Pipavav	1	127	9.12%	2,377	985	1,25,095
avav - Suvali	4	720	11.70%	3,100	1,058	7,61,760
avav - Mumbai	2	360	2.41%	6,152	3,825	13,77,000
Totals	20	3,012				46,35,810
enue from First Class passengers						
ogha - Dahej	4	1,017	8.97%	1,364	201	2,04,417
ogha - Suvali	6	3,359	13.53%	1,889	852	28,61,868
gha - Mumbai	3	1,680	13.86%	3,365	1,632	27,41,760
hej - Pipavav	1	254	21.98%	1,528	317	80,518
avav - Suvali	4	2,240	11.91%	1,993	1,084	24,28,160
vav - Mumbai	2	1,120	9.24%	3,955	1,851	20,73,120
Totals	20	9,670				103,89,843
nue from Second Class passengers						
gha - Dahej	4	1,784	6.42%	606	112	1,99,808
gha - Suvali	6	6,240	11.31%	839	232	14,47,680
ha - Mumbai	3	3,120	10.08%	1,495	985	30,73,200
ej - Pipavav	1	402	13.82%	679	204	82,008
avav - Suvali	4	4,160	8.73%	886	637	26,49,920
vav - Mumbai	2	2,080	6.72%	1,758	866	18,01,280
Totals	20	17,786				92,53,896

Two Vessels operating between four terminals (Not Suvali) (1998 figures)

Route	Round Trips per week	Users carried per week	% of total using the ferry service	Average single cost by road (Rs)	Single ferry fare (Rs)	Total Revenue (Rs) per week
enue from trucks						
gha - Dahej	5	392	6.89%	2,121	324	1,27,008
gha - Suvali	0	0		2,938		0
ha - Mumbai	5	900	6.04%	5,234	2,504	22,53,600
ej - Pipavav	2	150	10.75%	2,377	990	1,48,500
avav - Suvali	0	0		3,100		0
vav - Mumbai	4	720	4.83%	6,152	3,184	22,92,480
Totals	16	2,162				48,21,588
nue from First Class passengers						
gha-Dahej	5	1,012	8.93%	1,364	202	2,04,424
gha-Suvali	0	0		1,889		0
ha-Mumbai	5	2,800	23.11%	3,365	1,294	36,23,200
ej-Pipavav	2	255	22.05%	1,528	316	80,580
avav-Suvali	0	0		1,993		0
vav-Mumbai	4	1,297	10.71%	3,955	1,628	21,11,516
Total	16	5,364				60,19,720
nue from Second Class passengers						
gha-Dahej	5	1,553	5.59%	606	132	2,04,996
gha-Suvali	0	0		839		0
ha-Mumbai	5	5,173	16.71%	1,495	705	36,46,965
ej-Pipavav	2	398	13.68%	679	206	81,988
avav-Suvali	0	0		886		0
vav-Mumbai	4	1,737	5.61%	1,758	1,082	18,79,434
Total	16	8,861				58,13,383

Three Vessels operating on the full network of five terminals (1998 figures)

Route	Round Trips per week	Users carried per week	% of total using the ferry service	Average single cost by road (Rs)	Single ferry fare (Rs)	Total Revenue (Rs) per week
enue from trucks						
ɜogha-Dahej	5	317	5.58%	2,121	324	1,02,708
ɜogha-Suvali	8	821	8.96%	2,938	1,019	8,36,599
ogha-Mumbai	6	1,078	7.24%	5,234	2,338	25,20,364
ahej-Pipavav	1	126	9.07%	2,377	990	1,24,740
pavav-Suvali	6	682	11.08%	3,100	1,120	7,63,840
avav-Mumbai	2	360	2.42%	6,152	3,824	13,76,640
Totals	28	3,384				57,24,891
enue from First Class passengers						
ɜogha-Dahej	5	1,012	8.93%	1,364	202	2,04,424
ɜogha-Suvali	8	4,480	18.04%	1,889	693	31,04,640
ogha-Mumbai	6	3,360	27.73%	3,365	1,125	37,80,000
ahej-Pipavav	1	255	22.12%	1,528	315	80,325
pavav-Suvali	6	3,359	17.86%	1,993	897	30,13,023
avav-Mumbai	2	1,119	9.23%	3,955	1,852	20,72,388
Totals	28	13,585				122,54,800
enue from Second Class passengers						
ɜogha-Dahej	5	1,807	6.50%	606	110	1,98,770
ɜogha-Suvali	8	7,206	13.06%	839	199	14,33,994
ogha-Mumbai	6	6,229	20.12%	1,495	589	36,68,881
ahej-Pipavav	1	372	12.78%	679	211	78,492
pavav-Suvali	6	6,071	12.75%	886	480	29,14,080
avav-Mumbai	2	1,772	5.72%	1,758	1,060	18,78,320
Totals	28	23,457				101,72,537

The revenue figures can be balanced against the costs of operating the ferry service to give an indication of the amount of money that could practically be made available as a payment towards the costs of shore facilities and other requirements. The projected profit has been calculated on the basis of an operation comprising the use of two ferries, one for the longer distance routes and the other for the shorter crossings.

It would be reasonable to consider that the ferry operator could break even with a load factor on the vessels of 60%. This gives the following annual set of figures assuming that the full service is operating for 300 days, the service without the Suvali terminal is operating for 40 days and there is no operation for 25 days.

Revenue for break even		Lacs Rs per year
Full Network Trucks:	300 Days @ 60% Occupancy =	1,192
Full Network 1st Class:	300 Days @ 60% Occupancy =	2,671
Full Network 2nd Class:	300 Days @ 60% Occupancy =	2,379
No Suvali Trucks:	40 Days @ 60% Occupancy =	165
No Suvali 1st Class:	40 Days @ 60% Occupancy =	206
No Suvali 2nd Class:	40 Days @ 60% Occupancy =	199
All Classes	25 Days no operation =	0
	TOTAL REVENUE	6,812

Costs (not including Tariffs etc)		
Full Network	300 Days	3,534
No Suvali	40 Days	462
No operation	25 Days	178
	TOTAL COSTS	4,174
Sum available for tariffs and other costs (Including harbour dues, terminal operating costs etc) on the basis of the set of assumptions outlined above (at 1998 prices)		2,638

Sensitivity

.1 A sensitivity analysis has been carried out for the ferry revenue in the case of the full network with two vessels operating. Most significantly if a different factor were used to determine the proportion of total travellers that would use the ferries, a different set of results would be produced. There is a case for including a multiplier within this factor to make the demand for ferry travel more or less sensitive to price/time. If this were to be inserted then the present assumption would become a multiplier of one in the middle of the sensitivity slope. The bottom of the slope implies that there will never be any demand for the ferry and the top of the slope implies that as soon as any saving at all is made then everyone will take the ferry. Both of these implications are unreasonable. The change in sensitivity at the central position on the slope appears to be shallow enough to make the original factor a valid assumption. The multiplier is therefore shown to be unnecessary.

2 The other assumptions that have been made are associated with lower sensitivities. For most of the assumptions a 10% change in input leads to less than a 1% change in output. As is shown below.

Assumption	**Rank**	**Change for 10% change in assumption value.**
Ferry user factor	1	~10%
Passenger cost/km	2	~7%
Truck cost/km	3	~5%
Vessel capacity, passengers	4	~2%
Cost/time Weighting	5	~1%
First Class/Second Class passenger split	6	~1%
Vessel capacity, trucks	7	<1%
Ferry Speed	8	<1%
Road Speed, all users	9	<1%
Boarding time	10	<¼%

3 The full results of this sensitivity analysis are shown in Appendix ~~E~~ C.

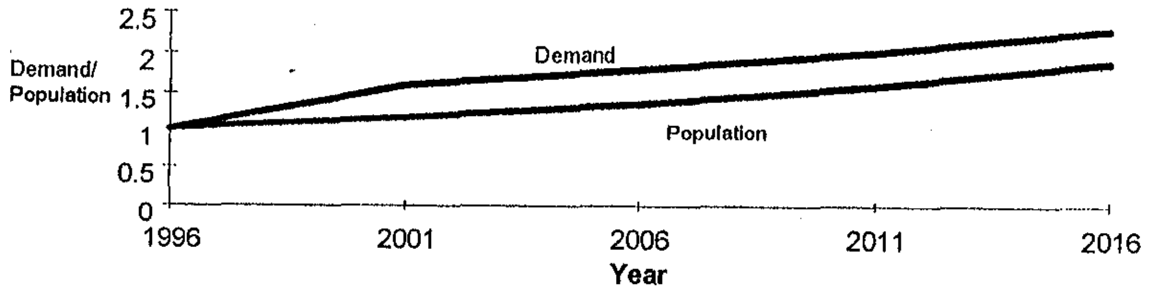
4 A detailed sensitivity analysis has not been carried out for the constituent cost elements. It should however be noted the largest cost element is fuel which can fluctuate considerably. These fluctuations will have a dramatic effect on the profitability of this ferry service.

Future Growth

1 It is extremely difficult to make accurate predictions of expansion in demand for a ferry service that has not even started to operate. As there has not been a fully operational Ro-Ro service in the area against which to monitor the effect of variables on increased demand, many of the critical factors are unknown. An estimate can be made of these variables, such as the expansion of the local population, the level of loyalty to bus companies and the amount of new business opportunities which will be created by the ferry service. However any resulting figures are likely to be sensitive to change in these variables. This problem has manifested itself with the predictions of incorrect user numbers on many transportation projects world wide, some of these have been a serious underestimate whereas others have been seriously over estimated.

2 Future predictions of usage cannot therefore be accurately predicted for the new ferry service around the Gulf of Cambay. However, in order to achieve an indication of possible usage in future years we have made use of the projected user figures from the TCS report. The level of demand predicted by our study differs from the level of demand predicted by the TCS because the choice of routes is different. However, one of the networks in the TCS report covers the same population as our network. It can therefore be assumed that the rate of increase in demand will be similar because the same group of users is involved. The rate of increase in demand follows a path which can be justified. The diagram below shows this increase in potential ferry demand from 1996 levels as well as the predicted increase in population from 1996 levels.

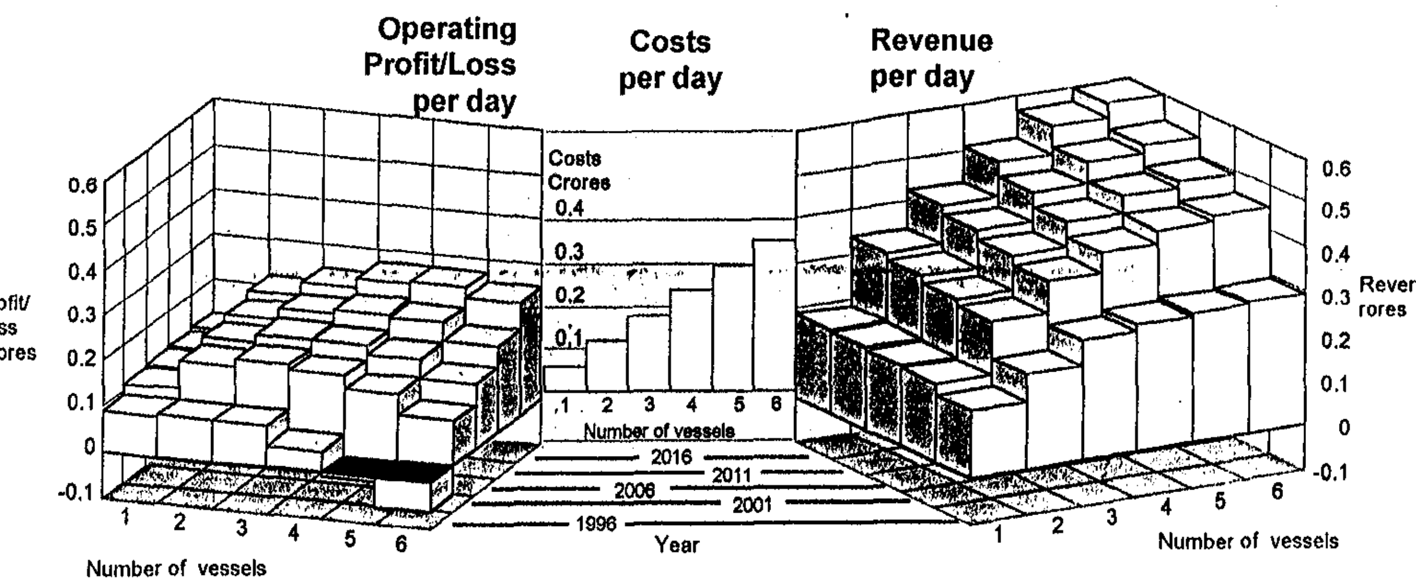
Demand And Population As A Proportion Of 1996 Levels



9.9.3 It can be seen that during the first few years demand for the ferry service would be likely to increase at a higher rate than the population as journeys are created by the very existence of the ferry network. In future years this seems to stabilise and the demand increases in line with population growth. This increase in demand is irrespective of the capacity of the ferries and does not take into account fluctuations in any other factors, such as ferry fare, economic well being of the region, improvement in facilities at the terminal and changes in Octroi charges.

9.9.4 We have applied projections of traffic growth to the proposed network of ferry routes. Because of the increase in user numbers up to six vessels have been considered.

An indicative chart relating revenue, costs and operating profit for a service running at 60% capacity is shown below; costs and revenues relate only to the ferry service and make no allowance for contributions to terminal costs:



Future prediction of operating profit/loss and revenue

.10 Financial Analysis

.10.1 In this section we review the possible revenues and running costs for four routes or combinations of routes and compare these to the projected operating costs (ferry company costs) in order to assess the viability of each route or combination. Although the ferry operating costs take account of the capital costs of the provision of the ferries, we have not included capital costs of the terminals, (State costs). We do this because we have been advised that the State Government considers the venture to have social value, and recognises that imposition of full costs on the service is likely to cripple the venture financially in the start-up phase. It is also necessary to recognise that provision of the ferry operation will be a commercial venture and will not be undertaken at a loss. We look therefore for a surplus on the operating costs of the operation which may be used to contribute to the State's capital costs. We have not allowed for any costs in respect of taxes, inflation or land acquisition.

.10.2 Revenues are those calculated earlier in the report at section 9.7.10 with an appropriate uplift for inflation (18%). The revenues shown there are based on maximised values for each class (i.e. trucks, first class passengers and second class), and we think it unlikely in practice that these can all be maximised simultaneously. We have therefore taken only 80% of the total in the evaluation. We assume 335 operating days per year to allow for downtime and holidays. However we have allowed for the generation of an additional 10% income from sundry items such as rental from the filling station and terminal concessions.

.10.2 We have considered the provision of passenger catamaran services in addition to the main ferry services. In view of the shortness of the sea journey between Gogha and Dahej, it is unlikely that a catamaran service here would be viable whilst sea conditions will not permit operation to Mumbai. However such a service might be attractive on the Gogha-Suvali route and possibly Pipavav-Suvali. It is however difficult to assess the revenue attributable to the catamaran as the revenue predictions are broadly demand led and independent of the service level. Experience shows that such a service will often generate its own traffic by making possible journeys which were hitherto difficult or impossible, and we therefore allow, in Cases 2 and 3, for a revenue increase by removing the 80% cap on revenue. In Case 4, where two ferries are in operation, the cap on revenue is retained as the catamarans provide only a small proportion of the services.

).3 In operating costs we have considered the direct operating costs of the ferry, such as crew costs and fuel costs and allow also for depreciation and maintenance and capital costs. These were considered in detail in section 9.5. Catamaran costs are calculated on a similar basis. In addition we consider the direct running costs of the terminals and these have been assessed in Section 9.6 and are summarised in Table 13 in Appendix H. Where we do not provide the terminals, as at Pipavav and Mumbai, we have assumed that charges will be equivalent to the costs we have assessed at Suvali.

).4 The State's costs at each terminal, assuming that terminal running costs have been met as above, are the financing cost of the construction and the depreciation or replacement cost. We have assessed these as 7% and 5% respectively as shown in Section 9.6. In the case of the full network, we have made notional allowances based on Suvali costs for Pipavav and Mumbai. In practice it is likely that these would appear in the form of port charges in the ferries' operating costs.

.5 We have considered four cases with varying routes or combinations of routes

Case 1	Gogha to Dahej
Case 2	Gogha to Suvali
Case 3	Gogha to Dahej and Suvali
Case 4	Gogha and Pipavav to Dahej, Suvali and Mumbai (the full network)

.6 The tables assume that full revenues will be generated immediately, but allow manning levels to build up to the full costs in year 3 and maintenance costs to build up to normal levels in year 7.

.7 Case 1 revenues and costs are shown in Table 14 in Appendix H. The table shows that projected revenues of some $1,270,000 fall significantly short of operating costs, in Year 1, of $5,129,000. We think it is unlikely that the revenue from a ferry service on this route or sundry income could be significantly increased, certainly by a factor of four or more, and hence we do not consider this route viable in isolation

.8 Case 2 revenues and costs are shown in Table 15. The table shows projected revenues of $9.364,000 and costs of $7,562,000 (Year 1) generating an operating surplus of $1,802,000 in Year 1. It is clear therefore that the service could make a significant contribution to capital servicing and repayment amounting to some 58% of those costs.

9.10.9 Case 3 revenues and costs are shown in Table 16. The increase in projected revenues compared to Case 2 (some 14% based on the assumption that the individual route revenues will still apply) is greater than the increase in costs resulting in an operating surplus of $2,664,000 in Year 1. However, capital costs have been increased by some 50%, and the contribution available for capital servicing falls slightly to 55%.

9.10.10 Case 4 revenues and costs are set out in Table 17 and assume that two ferries and a catamaran service the full network. There is approximately 160% increase in revenue, reflecting the popularity of the service to Mumbai, while costs have not quite doubled; direct operational costs are now less than 50% of revenue. The operating surplus is now substantially greater than the cost of capital servicing, reflecting the potential profitability of the full network.

9.11 Conclusions

9.11.1 Our conclusions from the financial analysis of the viability of the ro-ro ferry services operating across the Gulf of Cambay are as follows:

a) A ferry service on the Gogha-Dahej route would never earn sufficient revenue to enable the capital costs to be paid off.

b) A ferry service on the Gogha-Suvali route could earn sufficient revenue to make a significant contribution to capital and depreciation costs, but is unlikely to cover full capital costs.

c) A ferry service on the Gogha-Dahej-Suvali route could earn sufficient revenue to contribute to capital costs, but returns a slightly smaller proportion of capital servicing costs due to the cost of a third terminal.

d) The analysis shows that the most viable service is the full network providing access, with considerably enhanced revenues, to Mumbai. The operating surplus on the full network appears to be sufficient to service all capital costs and provide surpluses for taxes, profit and further development.

.0 FORM OF CONSTRUCTION

.1 Approach Bund

.1.1 The approach bund will carry the access to a point near the Low Water Mark. This point is selected at each port having regard to the availability of suitable material for construction of the bund and the characteristics of the underlying seabed, and represents the point at which construction of the piled jetty becomes more economic than construction of the bund.

.1.2 The bund is constructed in rock or similar granular material. A relatively finely graded material is used in the core (interior) since this is generally most readily available while larger materials are used in the outer layers. The core and outer layers may be from different sources depending on the availability of material and the Contractor's preferences. Core material will be brought to the site by road and will be tipped directly from lorries onto the seabed. Possible sources have been identified at Gogha, Dahej and Suvali as shown at section 10.7.

1.3 Where the seabed is soft, special measures are taken to minimise the penetration of the core material into the seabed (thus reducing the volume of material required). The special measures will involve the placing of geotextile layers or, where available, careful placing of closely graded rock and stone layers.

1.4 The outer layer, comprising precast concrete units, is chosen to provide resistance to wave attack and requires the individual placing of units. The size of these units is governed by the wave climate, and is reduced in the shallower where wave penetration is controlled by the water depth. Side slopes are chosen to aid stability on the soft materials of the seabed and also to reduce the size of units required for armouring. These shallow slopes will also control runup and overtopping during storms, allowing access in all but the most extreme conditions.

1.5 The form of construction of the bund, coupled with the relatively soft foundation materials, will probably give rise to significant settlements. However these are likely to occur quite quickly, and the construction programme will be arranged to allow the settlement to take place and levels be restored before the road is constructed. AS a further precaution, a settlement allowance is included in the designThe contract arrangements will be drawn up to take account of these settlements.

10.1.6 The width of the bund at the crest is controlled by the requirement for a two lane road, footway and service reserve. At Dahej additional width is provided for the cement company's conveyors

or pipelines. The roadway is formed of concrete block paving placed on suitable underlayers on the core of the bund, and safety barriers are provided on each side. At the seaward end the two lanes combine for access to the single lane access jetty.

10.2 Access Jetty

10.2.1 The access jetty continues from the bund at the Low Water Mark to the berth in deeper water. The jetty is of modular construction and is designed for incremental construction from the shore, although this does not preclude its construction from the sea if required by the Contractor.

10.2.2 The jetty is supported on pairs of piles founded in the bearing strata below the seabed. Vertical piles are used for ease of construction and these are designed to provide lateral stability as well as support to the roadway. The structure is designed for all live loads and weather loading but is not designed against ship impact. Although, in the case of Gogha, the jetty extends some distance offshore, we do not consider it necessary to provide any specific passage for small boats inshore of the ferry berth.

10.2.3 A number of options is available for pile construction and the design is widely drawn to allow conformity with the contractor's preferences. It is likely therefore that piles will be of bored in-situ construction which is well understood by local contractors. This form of construction is flexible, allowing adjustment to take account of varying ground conditions and will produce well constructed piles.

10.2.4 Each pair of piles supports a concrete crosshead which in turn supports the deck structure. The crosshead is designed to allow precast or in-situ construction at the Contractor's option; precast is to be preferred but may require an accuracy of pile installation which cannot be attained under marine conditions.

0.2.5 The superstructure, carrying the single lane roadway, footway and service reserves will be formed of precast concrete units spanning between the crossheads. An insitu deck provide the running surface for the road and kerbs will be formed on either side which will in turn support safety barriers. Space is available for joint venture conveyors or pipelines.

2.6 Similar construction is used at the head of the jetty, which is widened to provide turning areas, space for the passenger shelter and the landward support for the linkspan.

10.3 Berth and Dolphins

10.3.1 The berth is generally defined by a line of dolphins, but at Dahej, where the facility is shared with the cement company, the inner part of the berth is formed by the rear face of the cement unloading jetty.

10.3.2 The dolphins, which are of similar design at each berth, are substantial concrete structures supported on a number of bored cast in-situ concrete piles. The design of the dolphins is such that they will withstand the forces arising from berthing the ferry and they also carry the loads from the ferry moorings.

10.3.3 The dolphin superstructures are substantial concrete structures which link the piles together and provide a bearing face for the fenders which are placed between the ferry and the structure. The top of each superstructure supports a bollard which is used for mooring the ferry and also, at Dahej, for warping the ferry along the berth. Similar dolphins are provided for locating the linkspan pontoon, but these are not fitted with bollards.

10.3.4 The dolphins are linked together at high level by a light bridge providing for pedestrian access. This bridge allows access for mooring parties carrying ropes to bollards and also permits maintenance access to the navigation light on the outer dolphin.

10.3.5 Jetty construction at Dahej is similar to that of the access jetty, being a concrete superstructure supported on concrete piles. Supporting piles are set on a rectangular grid, with two piles across the width of the jetty and piles set at a similar spacing along the length of the jetty. Because of the need to resist forces arising from the berthing and mooring of the bulk cement carriers and the ferries, the piles in the jetty will bemore heavily reinforced than those in the access jetty.

10.3.6 The jetty deck is supported on a grid of beams constructed on the heads of the piles and is designed to support vehicular loads and the loadings from the cement handling plant; if required by the joint venture partner, rails can be provided for cranes and loading/unloading machinery.

10.3.7 Similar fenders are provided at all berths and this will simplify the spares holding and facilitate replacement in the event of damage. Fenders are provided at two levels, linked by a fender panel and this arrangement ensures that fendering is always available for the ferry regardless of the state of the tide.

).4 Linkspan and Vessel Access

).4.1 In order to control costs, very simple linkspans are used and only single lane vehicle access is provided. The same design is provided at each terminal; this will simplify maintenance and spares stockholding. It would also be possible, although unlikely, to move linkspans between terminals.

.4.2 The arrangement is broadly conventional with the linkspan bridge supported at the seaward end by a buoyancy tank which is integrally connected to the bridge structure; the tank is wider than the bridge and acts as the interface with the ferry. One face of the tank is fitted with guides which locate into mating fittings on the dolphins so that the linkspan is securely located at all times. At the shore end, the linkspan is supported on a landing beam which allows the bridge to move up and down with the tide; there is also provision for small lateral movements. The landing beam incorporates fenders which are capable of absorbing the forces which would arise if a ferry strikes the linkspan. The bridge deck surface slopes towards the ferry and is treated with a safety grip wearing surface in the traffic area.

.4.3 The linkspan bridge is an orthotropic steel box girder spanning between the fixed seat on the access jetty and the buoyancy tank. The length of 63m provides generally for a maximum slope of 1 in 10, but at extreme low tide levels this will increase to 1 in 8. The width of 6m provides for generous single lane road and a reserved pedestrian access protected by a continuous crash barrier. The bridge is designed to carry the maximum loads which are allowed on the highway system, together with loads arising from container handling on terminal trailers. The buoyancy tank is a simple rectangular steel box structure, similar in form to the bridge, and is subdivided into separate watertight compartments for safety; a number of these tanks can be filled with water for ballast. Electrically driven pumps are provided within the tank which are arranged to fill or empty the ballast tanks to allow the draught to be varied to suit the deck level of the ferry being serviced. Control of level may be carried out manually by the operator or can be automated by provision of a small preprogrammed computer.

4.4 All parts of the bridge and tank structures will be protected by high quality paint systems which will require relatively little maintenance between overhauls. The tank section will additionally be protected by cathodic protection in the form of sacrificial anodes attached to the structure.

0.5 Shore Facilities

0.5.1 The shore facilities will provide the buildings and infrastructure needed for the efficient operation of the ferry terminal. Specific material storage and cargo handling facilities, as may be required by the joint venture partners are not considered here.

).5.2 Buildings follow a common pattern between the terminals, and where possible similar designs, or common elements are used at each terminal. With the exception of the terminal building, the administration building and the shelter house, buildings are single storey. The main structural form is a reinforced concrete frame with brick or block infill, which will be chosen to complement local forms and make maximum use of local skills and materials. High quality concrete is used for good appearance and to provide durability with minimum maintenance. Buildings will be generally flat roofed with substantial drainage to deal with monsoon rainfall.

).5.3 Shallow raft or strip foundations are used for all smaller buildings and under two storey buildings where adequate ground conditions exist. Where weaker ground is encountered, piled foundations will be used under the larger buildings and piles will also be used to support the elevated water tank.

).5.4 Roads and parking areas are constructed in reinforced concrete on prepared formations, providing a durable and maintenance free surface. Roads and parking areas are laid on slopes which ensure adequate drainage to gullies provided at low points and connected to the main drain runs. In general, surface water is drained direct to the sea, but in areas liable to oil contamination, such as the petrol station and the workshops area, runoff will be passed through oil interceptors before discharge.

).5.5 No provision is made for centralised sewage treatment, and foul drainage from buildings is treated in individual septic tanks adjacent to each building. Septic tanks will be constructed in reinforced concrete and are sized to the demand at each building; treated effluent is discharged to the sea.

).5.6 Service reserves are provided, generally alongside roads, where water and electric services are located. Water pipes will be buried within protective sand enclosures, but all electric power and telecommunication cables are run through cable ducts with access chambers and turning pits at appropriate locations. The water main serves all parts of the site and provides potable water to buildings and a source of water for fire fighting elsewhere, through hydrants sited at intervals around the terminal. The water mains will be ring-mains so that in the event of damage a part can be isolated whilst maintaining supplies elsewhere.

Central substations at each site will receive electricity at high voltage from the public supply through Supply Authority and terminal switchgear. Transformers will provide domestic power for reticulation around the terminal area which will be arranged on the ring main principle. All cabling is placed underground. The substations also contain standby generating sets which will provide power during cuts; the generators will be sized to power essential equipment only (such as that required for navigation) and emergency lighting.

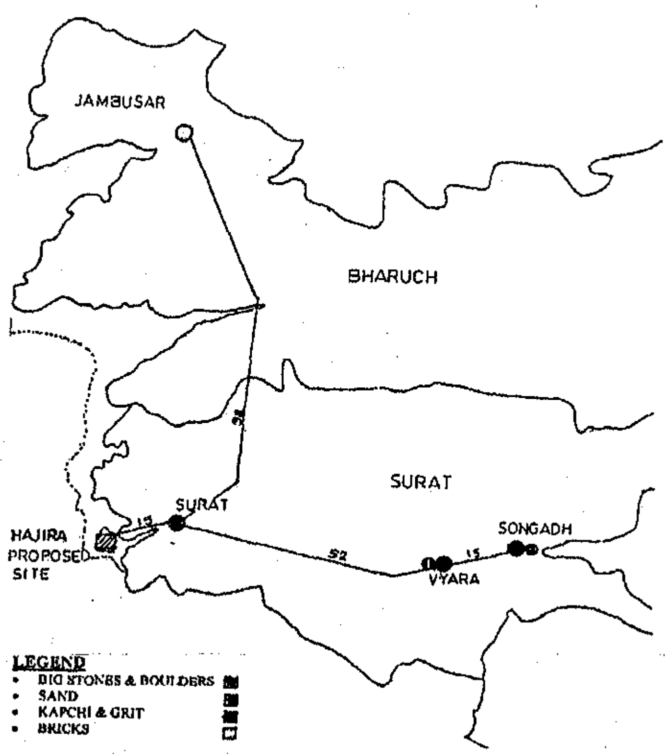
Water supplies are taken from main supplies where possible, and are passed through small treatment plants to improve quality. Because of potential high instantaneous demand for bunkering and fire fighting, substantial reserves, equal to several days' supply are held in underground tanks near the treatment plant, and further supplies are held in an elevated tank which maintains pressure in the event of mains failure. Small pumping sets in the treatment plants will transfer water from the underground tanks to the elevated tank. A simplified system is provided at Suvali where the terminal will be able to rely on the port water supply. The elevated tank will be a reinforced concrete structure, which as noted above, will be supported on a piled foundation.

Workshop facilities are provided at each terminal which will deal with routine maintenance of the terminal plant. The workshops will be equipped also to carry out minor repairs, and it is likely that one (at the ferry company's option) will be equipped to a higher standard to provide support to the ferries.

) Weighbridges are provided at each terminal, sited to permit the weighing of some or all vehicles to the ferry operator's requirements. The weighbridges will be of 20t capacity with provision for this to be upgraded as vehicle weights increase in line with international practice. An operator's cabin is provided at the weighbridge and is linked electronically to the ferry control so that weights are monitored for the ship's manifest and cargo control.

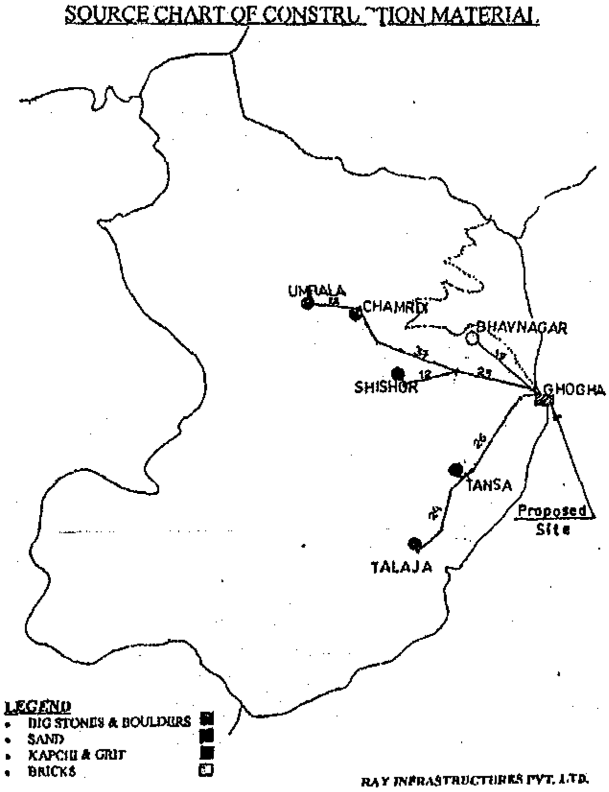
0.6 Sources of Principal Materials

SOURCE CHART OF CONSTRUCTION MATERIAL



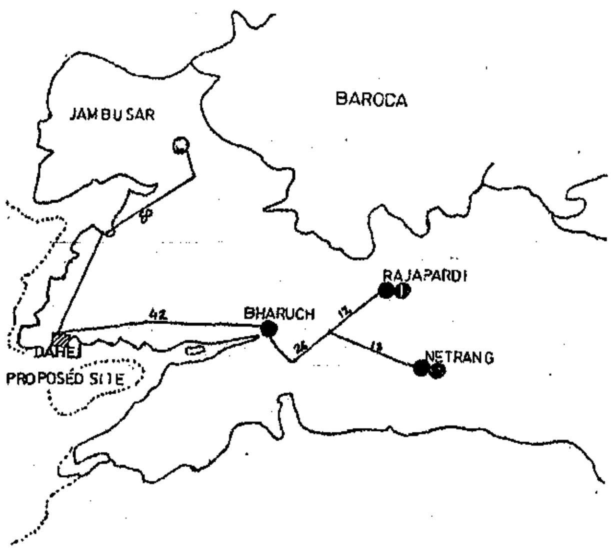
RAY INFRASTRUCTURES PVT. LTD.

SOURCE CHART OF CONSTRUCTION MATERIAL



RAY INFRASTRUCTURES PVT. LTD.

SOURCE CHART OF CONSTRUCTION MATERIAL



LEGEND
- BIG STONES & BOULDERS
- SAND
- KAPCHI & GRIT
- BRICKS

SUPERVISION OF CONSTRUCTION

Introduction

1 The present report deals with the growth of the concept and development of detailed designs for the project. In the sections which follow we show how the project can be brought to fruition.

Tender Process

1 Once the concepts and designs have been approved and finance is in place, it is appropriate to call for tenders for the construction of the ferry terminals. Prior to this, the Consultants will have prepared lists of Contractors who are able to carry out the work and who wish to be considered for the tender lists.

2 It is possible that only a few Indian contractors will have the skills and resources to execute the marine works which are likely to require the use of specialist plant, and even these contractors may wish to associate with specialist international contractors. Conversely, the onshore works are well within the capacity of many local contractors. The terminals are widely separated geographically and we doubt that there will be any benefit in treating them as an entity. We therefore propose to divide the project into marine and on-shore components and to have separate contracts at each terminal. This would not preclude, however, any contractor from tendering for or (subject to capacity) winning more than one contract.

In view of the likely international interest in the offshore works, we propose to use an international form of contract (e.g.FIDIC) for these works with a locally accepted form for onshore works. All contracts will be on a measure-and-value basis.

As an initial stage in the process, we would advertise the project nationally and internationally and invite expressions of interest from qualified contractors. The enquiry would give outlines of the development at each terminal, an outline bill of quantities, a programme and a statement of the resources which the consultants would expect a successful contractor to be able to bring to the project. The consultants would then assess the expressions of interest and shortlist those contractors who appear to have the proper experience and resources and be capable of executing the works competently. Should there be widespread interest, we recommend that the shortlists should be further restricted and a selection made of the best qualified contractors. We have found in the past that a list of perhaps 6 to 10 tenderers will produce the best offers; a long list often discourages those who are best suited, and indiscriminate tendering of course merely serves to increase the overhead of the contracting community as a whole.

.5 Once the decision to go to tender has been taken, tender documents will be issued to all contractors who are on the shortlists and who have recently reconfirmed their interest. A tender period of two to three months will be appropriate.

.6 The tender documents will include a statement of the design parameters (Appendix H) and tenderers will be permitted to propose alternative designs. It will be a requirement of tendering that all tenderers price the Consultants' design in addition to any alternative.

Tender Evaluation

.1 Since all contractors will have been assessed during the preparation of the shortlists, it will not be necessary to check contractors' technical competence again; we suggest, however, that a two stage assessment process be used so that tenders are not evaluated on price alone. Thus we recommend that all technical proposals are carefully scrutinised first, and any that are unsatisfactory or ill thought-out should be discarded at an early stage in the evaluation. Only those offers which are accompanied by a satisfactory technical proposal should be allowed to proceed to the second stage of financial evaluation.

2 Any alternative designs will be checked for general suitability at this stage, and will only be checked in detail if the alternative financial offer is attractive.

The financial evaluation will be concerned principally with the overall cost, but this will be tempered by other considerations such as:

- Rate of cash flow and whether any advance payment is requested
- Overall completion time and the cost/saving of earlier/later completion
- Any reduction if more than one contract is awarded
- Any offer for finance
- Any foreign currency requirements

3 It should be noted that all the contracts are interlinked and there is no benefit, for example, in early completion of the on-shore works unless the marine works are also complete although in this case the converse may not apply and it may be possible to use the marine terminal before

completion of the onshore facilities. Similarly there is unlikely to benefit in the early completion of facilities on one side of the Gulf unless matched by facilities on the other side, and conversely late completion of any contract nullifies timely completion of other contracts.

4 Late completion may also incur penalties in respect of the ferry operation and the need for timely completion must be stressed to tenderers. The construction programme will also need to be considered in conjunction with the programme for the development of the ferry service.

Contract Award

Each contract will be awarded to the contractor whose offer best fulfils GMB aspirations in terms of quality, time and price.

It will be important at this stage for GMB to ensure that any necessary finance is in place and all approvals have been obtained so that construction may start promptly.

Preliminary Construction Programmes

Preliminary construction programmes for the works at Gogha and Dahej are shown on Figs 11.1 and 11.2. These programmes will need to be updated as soon as construction contracts are awarded and detailed programmes have been agreed with contractors.

The construction programmes are very much affected by the southwest monsoon periods which extend from mid June to September each year. During a monsoon period, progress on the off-shore structures would be reduced to virtually nil and work would be confined to on-shore. The contractor's tender would have to include for the cost of disruption to the works over each monsoon period.

At both terminals, the award of the contract would have to be so arranged that the contractor could mobilise on site in readiness for an immediate start on the marine works following a monsoon period. During the mobilisation period, the contractor would set up temporary facilities required to support the construction works. These temporary facilities would include pile fabrication yards, workshops, plant yards, storage facilities, site offices, car parks, welfare accommodation, staff accommodation camp, etc. It would be necessary to ensure that sufficient land would be made available to the contractor immediately following the award of the Contract. At Dahej the contractor would also require access to river berths for the loading of construction materials on to floating plant engaged on the marine works. At Gogha, the contractor may elect to use the existing bund, or may utilise the facilities at Bhavnagar.

5.4 Because two different types of civil engineering are involved, we anticipate that the on-shore and off-shore works would be undertaken by separate contractors. The two contracts would be completed in parallel but separate land areas would be required for each contractor to set up temporary facilities. It would obviously be necessary for the land occupied by the off-shore works contractor to be outside the area allocated to the on-shore works, and this may require temporary leasing of land.

.5 We anticipate that the works at both Gogha and Dahej could be completed within a 25 month contract period.

.6 Construction at Suvali, being of a similar nature, could be completed within a similar timescale; however, progress here is dependent on the overall construction of Hazira Port. If port construction is well advanced by the time the ferry terminal contract starts, it may be possible to work through the monsoon season (or at least suffer less disruption) so that a faster programme may be obtained. There may well be benefits in incorporating the offshore construction at Suvali within the overall port construction contract.

Construction Supervision

.1 The Consultants will supervise all stages of the construction process. In general we will deploy locally based staff, supplemented with visiting inspection from the UK design team for critical phases of the work (principally the marine construction).

.2 It should be noted that the FIDIC and similar forms proposed (see 11.2.3 above) provide for control of the contract by the Resident Engineer under delegated authority from the Consultants, and do not allow for day to day control by the GMB. However the Consultants' and Resident Engineers' authorities are controlled by the contract and exercise of certain powers, usually financial, will be limited in extent or may be subject to the prior approval of the GMB.

.3 It is likely that construction will be carried out simultaneously at all sites and so several teams will be required. Each site supervision team will be led by a Resident Engineer who will head a eam of engineers and checkers; the same team will deal with both marine and on-shore construction. The teams will be supplemented by specialists as necessary to deal with, for example, specialist marine construction or mechanical and electrical works. For consistency, one Resident Engineer will be designated as Chief RE and will be the ultimate authority at all sites.

n addition there will be offsite inspection for items like the linkspan bridges and pontoons vhich will be manufactured by specialist fabricators or shipyards.

'he construction contracts will contain provisions for contractors to provide facilities and upport to the Resident Engineers.

'he Consultants will draw up a Construction Co-ordination Procedure which will provide uidance to the contractors in respect of:

Communication and Correspondence
Review Meetings and Records
Reporting (daily, weekly and monthly)
Programme and Planning
Safety Policy
Quality Management (QM) system
Protocols for inspection and verification of work
Construction Documentation

s-Built Dossier

n important part of the supervision process is the compilation of the As-Built Dossier to form a ecord of the project as actually constructed. Although the project is fully designed there are evitably variations from the design due to unexpected ground conditions, changes made by e contractor to suit his method of working, changes to the design requirements and other asons. There are also other matters not specifically designed, such as foundation levels, hich must be recorded.

e dossier will be compiled by the supervisory team as an ongoing task and will record all anges as they are made. Initially the record will be in the form of marked-up drawings, but hen all changes are to hand, the drawings will be fully revised to reflect all the changes that have occurred. A set of the revised drawings (the 'As Built' drawings) will be provided to GMB for permanent reference

The dossier will also include operating handbooks and instructions for all items of plant and equipment and any other relevant matters.

Photographs will be made to show the progress of the works and sets will be provided to the GMB as the work progresses. At the end of the construction a record set of the completed works will be taken and these, together with all negatives, will be handed over to the GMB.

CONCLUSIONS

1 We have reviewed the data from traffic studies commissioned by the Gujarat Maritime Board (GMB) and examined in particular the potential for routes across the Gulf of Cambay. In parallel with this we have assessed the costs of setting up the ferry service and used this information to project user costs, user savings and hence demand. From these studies we conclude that, given the appropriate tariff structures, there is a substantial demand for ferry services across the Gulf.

2 We have considered individual routes within the scope of the three ports forming part of this study. This review shows that, although the Gogha to Dahej route is the shortest, the traffic potential is also the lowest because the route is easily duplicated by road and potential savings are small. This low traffic potential, and low revenue prospects, means that a service on this route alone will not support the construction cost of the terminals.

We have similarly considered the potential of a single route between Gogha and Suvali. This has a much higher traffic potential as both terminals are near major centres of population and the alternate road distance is much greater; revenue prospects are therefore correspondingly higher. A ferry service on this route may be expected to recover its direct operating costs, and generate sufficient surplus to cover some, though possibly not all, of the terminal construction costs.

In addition to the ferry services between the three ports of the study, we have considered long distance services to Mumbai, and an additional terminal at Pipavav. Although the sea distances are greater on these routes, the potential savings are greater because of the greater distances to the head of the Gulf. If these long distance services are implemented, the increased costs are significantly outweighed by the additional revenue, and such services have the potential to cover all of the construction costs.

The revenue projections show that the terminal at Suvali is a significant revenue generator, especially in the development stages, and this terminal is critical to any development. However, the nature of the coast at Suvali requires that the terminal be built within a protected harbour or breakwater. We doubt that the cost, which would be considerable, of constructing a breakwater, could be supported out of revenues and recommend that this terminal should therefore be developed in conjunction with the LNG terminal at Hazira.

1.6 We have looked at the operation of the Customs Act and other relevant legislation. It is clear that rigorous operation of the provisions of the Customs Act would be a severe constraint on operations where ship turnaround times are measured in hours rather than days. Similarly, Governmental controls on the fare structure would be a considerable restraint on the commercial operation of the ferry company. We believe that these controls must be relaxed in order to interest private sector operators in the project.

1.7 There is little experience of ferry operations on this scale in India, whilst operations in the Gulf are some of the most difficult in the World due to climate and sea conditions which can vary rapidly and dangerously with little notice. We consider, therefore, that it is essential to draw on the experience of international ferry operators, and governmental rules on cabotage may need to be relaxed to allow this international involvement.

.8 Water depths at Dahej are limited but may be improved by dredging which could be undertaken by other operators to obtain access to existing jetties. However, other larger developments are being considered in the open sea off Dahej which will almost certainly have an effect on the regime and depths in the Narmada River. It is essential that the GMB should preserve its position in this respect and ensure that adequate studies are carried out which will minimise adverse effects on the potential ferry terminal site.

.9 We have made designs for the various parts of the terminals based on good practice and the information available at the present time. However, there are occasions where information is limited and designs must therefore be robust to take account of unknowns or possible variations from the limited data available; in these cases it is likely that more economic designs could be developed if more or better information were available. Although there would be cost involved in the acquisition of additional information, it is likely that the savings arising from a more specific design would considerably exceed the acquisition costs.