Acquisition Strategies: Determining the Design Requirements and Managing the Procurement Process for the Next Generation of Patrol Craft for the Saudi Border Guard

By

Mohammed Yahya Alzahrani

A thesis Submitted for the degree of Doctor of Philosophy

Supervised by

Prof. Richard Birmingham

Newcastle University

February 2012

ACKNOWLEDGEMENTS

I am intensely grateful to my supervisors Professor Richard Birmingham the senior supervisor, for this kind co-operating, helpful advice and suggestions generous, guidance and continual encouragement and for carefully reading the initial drafts of this thesis. I am also grateful and thankful to Mr. John Garside, who has supported me especially in the English language as it is not my mother tongue. This great man supported me, when I asked for assistance. I am also grateful and thankful to my colleagues, and staff in the School of Marine Science and Technology of Newcastle University.

I am very grateful and indebted to my family in Saudi Arabia and to my wife and our children who gave me all of their time, help, and patience during my difficult period in undertaken this project.

ABSTRACT

The Saudi Border Guard (SBG) undertakes a major responsibility for securing more than 8000km of the Kingdom borders, which are surrounded by 14 countries; 10 of them with direct land borders, and four which are separated by the Red Sea and the Gulf of Arabia. In addition to the location of Saudi Arabia, and its importance as the largest crude oil producer in the world, it is also the location of the most holy Muslim places of Makkah and al Madina.

All these factors make the responsibilities of the Saudi Border Guard (SBG) to be difficult tasks, especially with the increasing activities of smuggling, illegal immigration, illegal trade, terrorism and piracy. In addition there is the need to protect the territorial in terms of fishing, and leisure and to provide guidance, help, and rescue of people and ships that may be in distress, in Saudi sea waters and in the adjacent international sea transport lines, in both the Red Sea and the Gulf of Arabia.

Obviously the huge number of acts of piracy in recent years, especially off the Somalia coast, may be part of a new era in the Middle East future. Thus for these and other reasons an efficient fleet of SBG vessels must be employed.

There are increasing numbers of people who try to cross the Saudi borders illegally in order to find jobs, to visit the holy places, to engage in illegal trade, or for other purposes. This is especially so owing to the poverty of some of the regional and other countries with high populations (for example the SBG stopped 37,000 people attempting to cross the Saudi borders from Yemen, on the first 20days of Ramadan, 2009, according to the SBG archives), as well as due to regional political conflicts.

Thus there is a need for a strong capability not only in terms of quantity but also in quality of the SBG future fleet.

In this project a survey has been carried out in the form of questionnaire and interviews to SBG members in order to ascertain the degree of the shortfalls in the recent SBG fleet and to provide inputs to proposed specifications for the SBG future fleet. However this expected result of this survey is not completely effectiveness fitness for purpose but help to provide usefully information to the designer in order to define the proposed requirement.

In addition there are considerable navigation difficulties, around the Saudi coasts in both the Red Sea and the Gulf of Arabia. This is especially so along the Red Sea coast, which is considered as being one of the most dangerous of seas for navigation. The Saudi territorial waters along the Red Sea are characterised by extensive coral reefs, which cause considerable difficulties for local navigation, especially for free ranging Coast Guard Vessels.

There are no accurate maps for navigation along the coast of the Red Sea, nor of the random spread of the coral reefs. All of these factors must require the SBG to create a comprehensive plan for the determination excellent ship specifications in order to meet with the SBG mission requirement in the future fleet, and, in addition to make use of newly developed technology for efficiently searching and monitoring the borders.

Geographic political forecasts and new developments in technology must be taken into consideration during the first stage of planning to develop and define the suitable specifications of vessels the future fleet for the SBG. Internal studies within the SBG as well as the studies within SA as a whole must be concentrated in the official members of the SBG and related government officials, with the task to continuously survey and discuss all aspects not only teaching, to achieve the require result, in the way to plan for the next 20 to 30 years of the development and operations of the SBG fleet.

This study looks at the overall acquisition process for the provision of the new craft that will be necessary for the Saudi Border Guard to be able to accomplish its future missions.

This will involve ensuring that the new vessels will be able to effectively and efficiently undertake the many and diverse operational tasks that will face the SBG over the next 20 to 30 years. Given that uncertainties will exist and develop in the foreseeable future, such new vessels must have a degree of flexibility in meeting their operational requirements and be supported by a shore staff organisation that anticipates and responds to technical problems and developments as and when they occur.

Table of contents

Tables of tables

Tables of figures

1 Chapter One: Introduction

1.1 Background

The Saudi Border Guard (SBG) has a major challenge in its mission, which is to secure both the Saudi land borders and their coast. This covers more than 2400km of coast line in both the Red Sea and the Gulf of Arabia. The experience of the SBG in using their vessels to secure the coast is not historically very long. They initially started gradually to operate wooden boats having limited capabilities and facilities using their long acquired regional marine experience to navigate by day and night. These types of wooden boats, built in Egypt and other countries, were built by relatively very simple traditional procedures, and only using their limited experience, and thus not specifically purpose built.

The importance of Saudi Arabia is as leader and guide of the Muslim world and where the most holy Muslim places are, and in having a location which is surrounded by 12 countries. This is as well as Saudi Arabia being the biggest oil producer in the world. These factors all tend to encourage outlaw people, smugglers and migrant others who are looking to find jobs or undertake illegal activities, and are all that, in addition to others factors increase the responsibility of the SBG to secure and control its land and sea borders.

The marine mission of the SBG thus includes the conventional tasks of traffic monitoring, supporting, and undertakeing rescue activities and various legal controls of any local and transiting fishing, sport, commercial and leisure vessels. These and many other important tasks are necessary for securing the contry's borders and which some times require quasi-military operations.

A most important, relatively new challenge for all the border guards in the world is from the threat of terrorism, especially for the Saudi, and where in the marine environment usually they, the terrorists and smugglers, employ modern vessels with high speed and good equipment and performance specifications in order to avoid interception.

Thus, in addition to the provision of good intelligence information, in order to stop the terrorist from reaching their targets, the SBG vessels must be more capable and faster, the crew more proficient, better armed and in enough numbers of vessels to provide adequate sea area coverage at any time, day or night, throughout the year.

The SBG currently have a combattant and balanced fleet that is being used to secure their coasts and the adjacent Saudi economic waters, including relatively their generally high specifications in, such as speed and also adequate navigational and communication systems. Of cource these specifications need to improve in order to cope with new technology and potential future requirements. This fleet consist of several different types, in both sizes and ranges, of vessels. However the relatively short operational experience of the SBG in selecting, on a rational scientific basis, the most suitable vessels for their fleet has resulted in there being some technical and operational problems and deficiences in the current fleet. Normally the SBG fleet practices their tasks in the local coastal areas of the Red Sea and the Gulf of Arabia. The coast of the Red Sea is considered to be one of the most difficult of coasts for navigation all over the world. This is mainly due to the random spread of coral reefs which grow towards the surface and slowly, some less than an inch a year [Heiss 1994] in the north of the Red Sea and in both plotted (surveyed) and plotted developing blocks. Thus the unavailability of modern, up-to date and accurate navigational maps makes the operations in these areas very dangerous, particularly in some areas. These difficulties can be solved by both selecting the best vessel designs including the geometry, hull type, hull material, equipment, etc. and to find solution of the navigational maps within the SBG, or through the other Saudi governments authorities. These and other issues are examined further in this thesis.

The nature of the Red Sea, for example, which is a semi-blocked sea, (i.e. having limited channel to another sea area) with very limited regional rain fall, and which leads to a very high humidity. This is in addition to the very high temperatures which persist for most of the year. There are randomly spreads coral reefs and an unavailability of up-to-date navigational maps of the SA coasts in addition to the impair visibility due to the high humiditity, espcially in the Red Sea. Thus the SBG vessels and the local shipping are facing potentially dangerous navigation tasks almost every day at sea in the regions.

The selection of new vessels for the suitable future fleet to be operated by the SBG for securing their coasts must be supported by rigorous studies carefully taking into mind all of the many factors that effect the formulation of characteristics for the SBG vessel requirements and of the full evolving mission requirements including also the crew requirements.

In support of this project a comprehensive survey, based on interviews and a questionnaire, was undertaken, with many SBG members participating, in order to collect quantitative and qualitative data about the vessels in the current fleet and also for the proposed future fleet that is needed. This includeed a field trip which was carried out in all of the SBG shore stations along both the Red Sea and Gulf of Arabia coasts. The results of this survey clearly indicate many technical, operational and maintenance problems with the current fleet due partly from the inadequate and unsuitable earlier formulation of vessel specifications including hull types, hull material, equipment, range, endurance, and internal and external arrangements, in addition to the adequacies of spaces, volume and speed, etc, .

What the SBG needs to do is to have a very clear understanding of their most likely future operational needs, and of how to formulate such in order to solicit responses and undertake selection from potential designers and builders. Then of how to control and manage the overall acquisition process in an effective and efficient manner becoming of such a prestigious organisation as befits the SBG, in order to acquire the best vessels in service. This is the main purpose of this the study.

Finally in reviewing and discussing the current procedures of the SBG to acquire vessels and from this is how the decision–making process is undertakeen, then to suggest some solutions.

1.2 Some Typical Research Questions

The following are some of the types of questions that were put to members of the SBG and are given here in order to illustrate the work undertaken within this study.

- Do the environments where the SBG undertaken their missions along the Red Sea coast require special types of vessel specifications?

- Are the SBG most current fleet vessel specifications adequate to perform the SBG current and future mission needs?

- What are the SBG member's remarks on the suitability and efficiency of the current fleet?. This coverd a range of qualitative and quantitative factors, eg. sizes, speed, performance, manoeuvring, etc.

- What are the SBG members proposed requirements regarding the future fleet specification?

- What is the future challenge of the SBG in order to secure the coasts?

- What is the best strategy to be adopted for the SBG to be able to achieve the best design of the vessels for the future fleet?

- What is the current procedure followed by the SBG in order to purchase new vessels? And what are the solutions to improve this procedure?

1.3 Aims of the Research:

- The overall aim of this study is to define the process whereby the SBG requirements for the design and acquisition of the various small craft, for its future fleet, to be operated in the Red Sea and the Gulf of Arabia coast regions, can be developed. This will also include vessels that operate out to, and if sometimes necessary beyond, the Kingdom's full legal boundaries.

- The successful completion of this study will aim to establish a rational strategy for developing the future fleet specifications for vessels of the SBG. The development of the actual final specifications themselves will require input from many SBG staff and Saudi government bodies and which the latter may be outside the scope of this study.

- The purposes of the overall study is thus to develop and provide a moderntechnology-based conceptual framework supported by an organisational structure that will enable the SBG to identify and acquire their future fleet of vessels, in both types, capabilities and numbers such that it can effectively and efficiently provide the fruition of the sea based border security required of it by the Kingdom and over the nesr future.

- The assumptions are that the SBG will not themselves actually design (beyond the concept and preliminary stages) or directly commission the building of new vessels, but will have the full range of skills and capabilities necessary to identify their needs, to fully establish the characteristics of vessels to meet the required needs, to evaluate comprehensively proposals that are made to them by vendors who may be subsequently selected and commissioned to provide the vessels and to finally evaluate the delivered vessels in order to ensure that their needs and standards are fully met.

- Thus the nature and composition of a future fleet will be the product of careful study, evaluation and planning by skilled officers, staff and managers of the SBG, using the current fleet as a reference base as and where relevant, and according to some pre-agreed process.

1.4 General Objectives

This means that:

- SBG must have a clear and well thought out methodology and acquisition plan,
- SBG must have officers and shore staff with appropriate levels of experience and expertise in a range of technical and operational areas,
- SBG should be in a position to interface with and effectively monitor the output of the vendors at both pre-and post-selection stages.

It is highly unlikely that the SBG would wish to involve itself in detailed design studies, as distinct from initial provisional putline and concept design studies, in order to enable the SBG to formulate their collective views of the general configuration of potential new construction.

1.5 Specific Objectives of Research:

- To assess the current SBG recent fleet in terms of the stated SBG Mission, and of the crew and operational needs and of the environment requirements,
- To review the past and current procedures of the SBG used to analyse the proposals,
- To convert the above results into conclusions and recommendations for input to future fleet requirements.

1.6 Research Plan

The design of the questionnaire and the approach that was planned for the interviews were heavily based on the researcher's experience as a serving captain in the SBG.

- Collect data on the SBG current fleet
- Collect and analyse data obtained through survey and questionnaires from the SBG members, both officials (officers) and crew members, about the current fleet.
- Collect and analyse data through direct interviews and questionnaires, with SBG members and high ranks, about the forms and characteristics of the future fleet that they consider to be required by SBG.
- Study the navigational aspects and other operational problems of the environments where the fleet operates. Review actual missions and roles currently undertaken.
- Review the current SBG strategy of the process whereby they evaluate the proposals received from potential vendors.
- Study the influence and consequences of geo-political forecasts and new technology developments as well as predicting future challenges for the SBG in maintaining the borders and coasts.

- Evolve a strategy to develop new requirements and to subsequently evaluate the received programme to undertake proposals for the SBG.

The methodology of the research is thus based on several stages:

- Collecting data and information of the SBG responsibilities for securing the Saudi borders. This involves collecting information about the Saudi economic water zones where the SBG undertake their security mission in both the Red Sea and the Gulf of Arabia. This includes the difficulties of navigation and operations in both regions.

- Review of information about the crew requirements, which are many and varied, as necessary in order to perform the tasks of the fleet.

- Collecting information about modern developments in small craft design and of the general design and construction processes that are involved.

1.7 Summary

To achieve the target of this project many questions must be asked in order to find reasonable solutions. The importance of planning to reach this result well is such that good methods of study must be identified. This procedure must have a complete strategy about how to achieve a competent, efficient and well balanced fleet and how the procurement procedure must be formulated.

1.8 Conclusion

The most important aspect in this study is to have not perfect strategy but to have a good flexible plan for forming the future fleet specifications.
The future challange of the SBG to perform their tasks in the Saudi Arabia sea waters and coasts and which needs a good plan including, training an adequate fleet with stronger and faster vessels able to, cope with the coastal zone navigational requirements, the environmental requirements, crew requirements, and new technology.

2 CHAPTER Two: Small Craft Design

2.1 Introduction

By any reasonable definition the majority of the vessels that are currently within the SBG fleet are either small craft or relatively small craft. Classification Societies consider within their rules both small vessels and high speed vessels that tend to be of a modest size.

Given the large length of coasts and quite considerable adjacent sea areas the SBG's mission coverage requirements lead to the need for a fairly large number of vessels having differing capabilities.

In this chapter the general design procedure for small craft of various types is reviewed, albeit very briefly, as the basic principles and procedures are well known to naval architects and designers. This includes the selection of the most appropriate vessel configuration and its form, hull structural arrangement and materials and the propulsive system.

Thus the aim is to put into context the many factors that are of concern in the design of the various vessel types that predominate in the current fleet. However this does not mean that progressively larger, and in some cases faster, vessels may at some time in the near future, and will not find utilisation within the fleet as mission requirements change.

Thus the purpose of the following over-view is to provide a very brief review of some aspects of small craft design, sufficient to put into context the reasons why the SBG operate such craft, to underpin the results from the survey that was undertaken and to provide a background for the review of a suitable acquisition process for new vessels.

Clearly, where appropriate, the rules of the various classification societies could be used in the design of new vessels for the SBG. However some SBG vessels, particularly the high speed in-shore types, are small by reference to such rules and hence the designer will need to undertake, to a high degree, a fully rational approach to new vessel design development. This is particularly so as the development of new small high speed vessels are subject to rapid changes in technology.

The large body of literature in general naval architecture provides much to assist the naval architects and designers and, as such, is well known with quite extensive documentation, text books, etc, and with a wide range of comprehensive computer software being available covering all aspects of design and information for production, etc. This also includes extensive software for many analyses, e.g. ship motions, resistance and propulsion, stability, stress and vibration studies using the finite element method, etc.

Thus there is no need to discuss in any depth the overall subject area. However it is useful to review some aspects of small high speed vessel design in order to illustrate the aspects that will require some special attention by the designer in the search for cost-effective reliable sea-worthy design. The designer must thus pay particular attention to:-

- The optimum configuration,
- The most suitable structural material, and
- The selection of the most effective power and propulsive system.

2.2 Small Craft Definitions

The definition for small craft is ambiguous .[Du Cane, 1951], for example, stated that small craft are those with length up to approximately130 ft (39.6 metres).

Again some definitions can be written as follows [Graham, 1996]:

- less than 45 metres in length,
- below the size covered by merchant shipping acts, and
- a craft of which hull and internal systems can be designed by one person.

In the last few decades the numbers of small craft have increased rapidly, due predominantly to the increase of customer requirements [Du Cane, 1951; Shenoi and Harari, 1993]. In the SBG fleet, there are many different types of small craft including fast patrol boats, fire fighting vessels, tugs, and rescue boats, and with many different ranges of vessel dimensions shapes and sizes, and different performance measures of speed and endurance.

Some specifications of the currently operated vessels in the fleet of the SBG obtained from to the survey results meet with the current SBG requirements and mission requirements, as well as the environments where the fleet operate. However for the SBG to achieve the requirements anticipated in the future fleet specifications there must be an availability of more details in the design of small craft, including an understanding of the types of hulls, materials and naval architecture specific to small craft.

2.3 Small Vessel Naval Architecture.

Small Craft have developed dramatically in the last few decades, not only in terms of their numbers and variety, but also in their technical specification, and performance. High-speed ships are also evolving rapidly: sizes and speeds of fast ferries, carrying passengers and motor vehicles, which would have been undreamed of only a few years ago are now commonplace. Safer, stronger, faster and lighter craft are being developed using advanced materials, including aluminium alloys, and manufacturing technology combined with creative engineering design processes and increases in analyses using computer capabilities. This diversity of more advanced vessels also applies to the vessels that the SBG will have to regularly intercept in the years ahead. Sailing and power yachts have also developed in sophistication, comfort and performance as more and more people seek to experience water-borne leisure activities. The available courses in Naval Architecture and Small Craft Engineering aim to create designers with all the core skills of ship design, construction, operation, and maintenance, along with a particular specialism in the creative and innovative design and engineering of small leisure and commercial vessels, including all forms of sailing and power yachts, fast ferries, hydrofoils, hovercraft and fishing boats.

2.3.1 Hull Configuration and Form

2.3.1.1 Preamble

In this context configuration relates to the possible range from mono-hulled to multi-hulled vessels of various types. Similarly form relates to the geometry of each hull or individual demi-hull in the case of multi-hulled vessels and is influenced by the mode of transit through the water, whether in a simple displacement manner or involving some form of dynamic lift. Thus form relates to the physical shape of the outer surface of the hull, including:-

- bow and stern shapes, and
- mid body shape.

The overall hull shape has a profound influence on :-

- displacement and trim,
- static and dynamic stability,
- resistance,
- motions in a sea state,
- slamming and planing,
- deck wetting, and
- flow into the propeller.

The above have a great influence on :-

- crew comfort,
- propulsive performance (eg.propeller inflow),
- shallow water operations, and
- minimisation of vibration.

It is to be appreciated that the designer and naval architect has a great many tools and techniques available to him, most of them computer based, in the development of a suitable design. Such include advanced surface modelling, comprehensive intact and damaged stability studies, etc.

2.3.2 Main Types of Hulls:

Boats perform in the water based on the physical under-water shape of their hull, and how it behaves when it is in motion through the water. The three typical operating regimes of hull designs are very briefly discussed in the following sections.

2.3.2.1 Displacement Hulls

Displacement hulls (Figure 2-1) transit relatively slowly through the water and they effectively develop no hydrodynamic lift, and thus the boat does not rise out of the water as the speed increases. Small displacement hulls typically have a rounded bottom with a tear drop three-dimensional shape running bow to stern. Such hulls displace an amount of water equal to the weight of the vessel. Displacement hulls are very efficient for most long range cruising vessels. However because of their design, displacement hulls are generally limited in their speed. The determination of the complete hydrostatics of such hull forms is quite straight forwards, as are the associated trim and stability details.

2.3.2.2 Semi-displacement Hulls

Semi-displacement hulls have features of both planing and displacement forms when at normal operating speeds, and both displacement hulls and semi-displacement hulls, of the same dimensions and block coefficients, will displace the same amount of water in the fully stationary condition [Lewis, 1988] . In a semi-displacement form they have a maximum practical hull design speed. Exceeding this speed can result in erratic handling motions and unstable operations. There is not one specific hull design characteristic that differentiates semi-displacement hulls from semi-planing hulls. The greater the hydrodynamic lift and the higher the hull design speed the more likely it will be referred to as a semi-planing hull. Clearly the hydrodynamics lift will balance part of the weight of the vessel and the displaced volume will reduce, with changes to the hydrostatics and trim condition accordingly.

2.3.2.3 Fully Planing Hulls

Planing hulls require a different hull shape and relatively large amounts of power to obtain the forward speed in order to achieve dynamics lift, planing. The underwater section is flat. At speed, a planing hull acts on the water's surface like an inclined plane generating a lifting pressure force as illustrated in Figure 2.2.

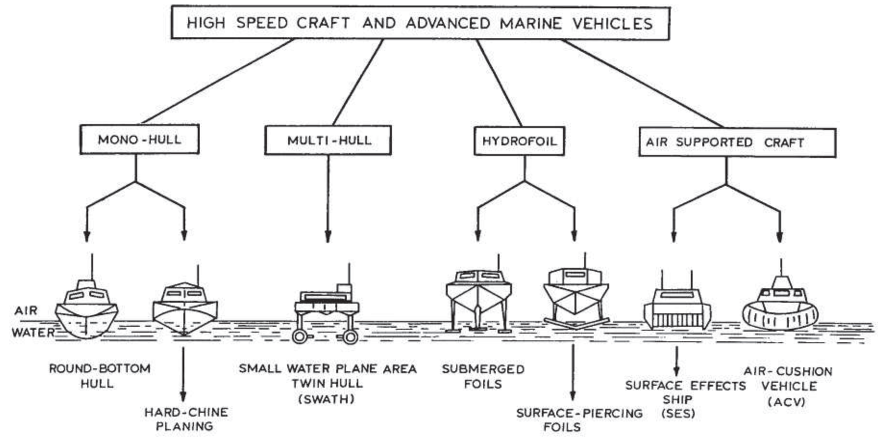


Figure 2-1. Configurations for high speed performance [Lewis, 1988]

So the planing hull is designed to climb towards the surface of the water as power is applied, and hence the speed is increased thus reducing the amount of wetted hull surface and correspondingly reducing the overall friction or drag force and therefore increasing hull speed further. (Actually the friction force per unit area will increase but with wetted area decreasing).

2.3.2.4 Flat Planing Hulls

The Flat/Planing hulls are designed to ride on top of the water, regardless of the weight of the vessel. The flatter the bottom, the easier it is to get on the planes i.e. the condition of fully planing being achieved. Also, relatively less power is needed to attain high speeds with a flatter bottomed hull.

2.3.2.5 A V-bottom Shape

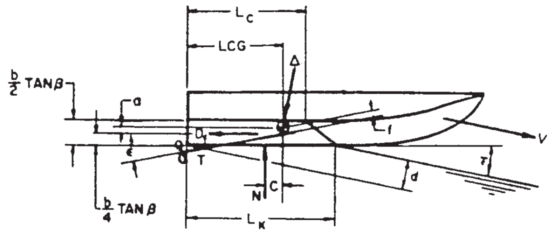
A V-bottom shape is typically selected for better handling in rough water, sometimes there are forms that use a "stepped" hull to give additional lift, as well as reducing planing drag.

2.3.2.6 Types of Small Vessel Hull Forms, General Comments

2.3.2.6.1 Flat-bottom Boats

Due to the large area of the bottom as seen in this type of hull form the vessel is very stable in calm water.

However the flat, broad bow and bottom area create a rough ride particularly in choppy seas. These boats are usually limited to low horsepower motors because they don't handle or manoeuvre well at high speed.



where

T = propeller thrust, lb
Δ_Δ = weight of boat, lb
D_f = viscous component of drag, (assumed as acting parallel to keel line, midway between keel and chine lines), lb
τ = trim angle of keel, deg
LCG = longitudinal distance of center of gravity from transom, measured along keel, ft
CG = center of gravity
ϵ = inclination of thrust line relative to keel, deg
N = resultant of pressure forces acting normal to bottom, lb
a = distance between D_f and CG (measured normal to D_f), ft
f = distance between T and CG (measured normal to shaft line), ft
c = distance between N and CG (measured normal to N), ft
β = deadrise angle, deg
b = beam, ft
L_k = wetted keel length, ft
L_c = wetted chine length (from transom to spray root intersection with chine), ft
V = planing speed, fps
d = draft of keel at transom, ft

Figure 2-2. Forces acting on planing hull system [Savitsky, 1964]

2.3.2.6.2 "V" – Bottom Boats

The "V"-bottom boat is probably the most common hull design. Most manufacturers of boats build today use variations of this form and that is used for many of the smaller vessels. This design offers a good ride in rough water as the pointed bow slices forward through the waves and the "V"-shaped bottom softens the up-and-down movements of the boat. The degree of the angle of the "V" is called the "dead rise."

2.3.2.6.3 Deep-V Hull

"V-hulls" are designed to operate at high speeds and to "cut" through rough water, and which provides a smoother ride than flat-bottomed or round hull boats at the same speed. A vee hull will not have the same level of righting action in beam seas as will a more conventional round hull form.

2.3.2.6.4 Round Bottom Boats

The round-bottom boat has basically a displacement hull and is usually used for dinghies, tenders, and some car-top boats. This boat style is usually easier to manoeuvre at slow speeds than a flat-bottom boat.

2.3.2.6.5 Tri – Hull Bottom Boats

There are many boats that have a distinct modification of the basic “V”-bottom. They are called tri-hulls. This design is more stable than the basic “V”-bottom at rest, but it gives a rougher ride in choppy water because of the increased surface at the bow.

2.3.2.6.6 Tunnel Hulls

Extreme examples of these are catamarans and SWATH vessels, SWATH equates to the small water plane area twin hull. Catamaran Hulls are essentially two deep-v hulls joined by a platform/cockpit deck area SWATH vessels typically have torpedo-like fully submerged demi-hulls. Tunnel hulls are gaining in popularity, as they offer many of the benefits of other hull designs, such as stability, speed, and roominess with few of the drawbacks. They can operate in virtually any seas, and tends to ride better than mono-hull boats, and their advantages are mainly in having a large deck area.

2.3.3 Summary

It is clearly most important to the SBG that great care is taken in selecting the most appropriate hull configuration and form for each of the classes/sizes of vessels that it requires. There needs to be a full consideration of the advantages and disadvantages of each feasible shape in the context of the operational requirements for each class/size. The selected hull types must have the required capacity, speed range, manoeuvring ability, stability, etc. in order to safely and reliably operate in the harsh Red Sea and Gulf of Arabia environments with the associated hazards of randomly distributed coral reefs and clearly implied draught limitations.

So the various types and sizes of patrol boats that are normally used by the SBG should be ones that:

- Adequately perform all the required diverse patrolling operations,
- Operate in all required conditions with minimum level of danger presented to on -board personnel,
- Meet national and international norms for safety at sea and environmental protection, and
- Be designed so that the vessel should be at minimum cost particularly first and through –life costs.

2.3.4 Hull Construction and Material

The SBG require a good service life with the minimum of maintenance, (although the repair any in-service damage is of concern, etc.). This implies a high degree of ease of inspection and of ease of repair, and of compatibility with the environments. To a certain extent the choice of material and structural details will depend upon the overall configuration of the vessel (e.g. whether a mono-hull or multi-hull configuration) and on the fabrication capabilities and skills of the yard that is tasked with the vessels construction.

2.3.4.1 Structural Materials

The structural material alternatives are in two groups, specifically:-

- metallic, and which are either various grades of steel or various aluminium alloys (the latter being ones that are weldable and fully compatible with the marine environment), and
- non-metallic, which are either the traditional woods or the much more modern fibre reinforced plastic based forms, etc.

It is important to note that in many, possibly most, cases, that the completed vessel, consisting of both the hull (or hulls) and the deck structure (including houses, large masts, etc.) may be constructed from a mix of materials, e.g. steel basic hull and aluminium alloy topsides, and full compatibility, at all interfaces must be ensured in the high salinity sea water environment. Hence great care and attention must be given to eliminating the possibility for galvanic corrosion. This will also apply to the installation of equipment, particularly the propulsive system.

As mentioned earlier, maintainability and reparability are most important and this requires ease of, and full confidence in, hull inspection. For hulls constructed from non-metallic material, particularly forms of FRP sandwich construction, this can be quite difficult in some situations, e.g. potential hidden damage cause by repeated slamming and other impact forces.

Also requiring some consideration is the ease of mid-life upgrades and conversions, particularly where propulsive machinery is involved and where new seats and positions of seats are required, etc. This may be difficult in the case of FRP hulls.
Thus the alternatives for hull structure material, as appropriate for relatively small vessels, are:-

- Steel, various grades,
- Aluminium alloys,
- Fibre reinforced plastic compositions, and
- Wood

Each of these materials has its own advantages and disadvantages and must be selected carefully, considering firstly overall performance, structural efficiency and initial cost, but also considering in some detail full through-life aspects and associated costs.
[Savitsky 1985] showed current trends in hull material selection in the boatbuilding industry as in Figure 2-3.

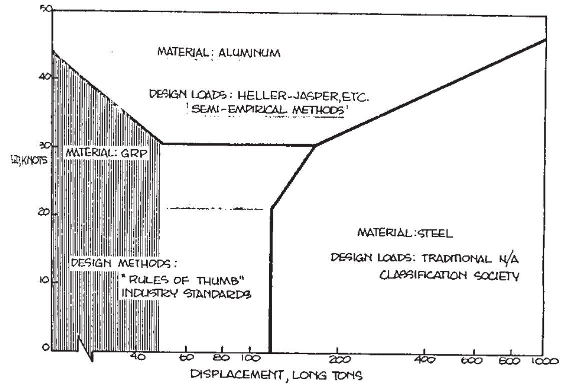


Figure 2-3. Selection of hull structure material trends [Savitsky, 1985].

The following are some points that are relevant to each of the different main structural materials:

- Steel

Usually used for the hull and the main deck of the small vessels because it is cheap, ease of build and repair and has good impact resistance. But the extra weight of the material is often too great a penalty to pay in small fast vessels.

For the larger craft developed for the SBG fleet it provides a good basic reference point for design of alternatives. It also has good data for fatigue life prediction and strength and buckling calculations.

- Aluminium alloys.

Some alloys are both weldable and compatible, to a degree, with the sea water environment. The alloys have a good flexibility for forming into complex shapes and are hence a very good construction material for small craft, fast vessels and for multi-hull configurations. The resulting structures have a good strength-to-weight ratio when carefully designed and both good material data and strength and buckling formulations are readily available to the designer. The fabrication process requires well experienced workmanship, particularly welding, and weld induced stresses and distortions need to be carefully allowed for in design and fabrication.

- Fibre reinforced plastic compositions

A large range of types of fibres are now available, from both simple glass filaments through to very strong, and expensive, more modern material such as carbon and

Kevlar. Both fibres in filament and woven forms are available. Similarly there is a range of plastic/resin compounds available and there must be care in making a selection as toxic fumes can be created in the event of a fibre on board a vessel.

FRP is generally an excellent material for small fast vessels, having a good strength-to-weight ratio, is very good in the marine environment, can be moulded to almost any shape and having an excellent surface finish.

However inspection, maintenance and repair problems require particular attention. As the manufacture of FRP hulls generally requires a mould, and which will add appreciably to the cost, this is perhaps more suitable when several identical hulls are being made in series.

- Wood

This is, of course, an old traditional way of constructing the hulls of vessels and still has many areas of application in the non-military fields. Its only application in the relatively recent military field has been in the construction of counter- sea mine fields for non magnetic purposes.

It is not an effective or efficient material for the construction of modern high performance vessels.

Attribute	aluminium	fibreglass	steel
Survive minor impacts	5	6	1
Survive major impacts	5	3	6
Light weight	5	4	3
Flat shapes	4	3	2
Curved shapes	3	6	2
Joint versus basic strength	4	3	6
Plating resistance	2	3	6
Weather ability	4	5	3
Repair ease	3	2	6

Table 2-1Ranking of small vessels building material.(6= best, 1= worst. [Koelbel, 1995]

Table (2.1) provides an interesting, albeit very simplistic, ranking of small vessel building materials.

2.3.4.2 Structural Topology

Ship structures are composed of:-

- hull shell/envelope,
- bulkheads,
- decks,
- deck houses and superstructure, etc.

Most structural analyses take place either at the overall/global level, (for example by using finite element method based computer programs) or at the panel level, (for example based on using formulae and graphs, for stiffened panels etc.).

As far as the selection of materials is concerned, analyses are typically undertaken at the panel level. The overall ship structure can be considered as being composed of many individual panels, each having boundary conditions that allow for the connectivity with the adjacent panels.

Panel options are:-

- Simple flat plates or curved shell surfaces of constant thickness,
- Flat plate and curved shells created using sandwich members, and/ or
- Discretely stiffened flat plate or curved plate surfaces.

Metallic structures, whether of steel or an aluminium alloy, will typically be of the discretely stiffened flat or curved plate single skin forms. The stiffeners can have one of several cross-sections, ranging from simple flat bar, tee sections through to more complex top-hat sections. The panels may be either uni-directionally or bi-directionally stiffened.

However each design must be considered on its merit, allowing for many aspects including suitability for installation of the propulsive system and other major items of equipments.

Single skin monocoque forms, i.e., having no stiffeners, are structurally inefficient in metal forms, but, however, may be employed in regions of FRP construction and wooden vessels.

Non-metallic structures will typically be of the plain flat panel or curved shell forms of essentially constant thickness or of the sandwich member form where two structural surfaces are separated by, but connected to, some form of core material, member. A further option that has been considered for FRP vessels is the use of a corrugated single skin, and internal bulkheads, etc.

Basically there are four structural topology arrangements that could be applied to small ship design and construction:

- Single skin with some form of stiffeners, typically top hat stiffeners. This is the typical metal material structural topology where essentially flat plate is reinforced with 2-directional stiffener bars,
- Single skin monocoque. A single skin without any stiffener, where the ability to withstand loads depends alone on the skin thickness and shape contributing to self stiffening and strength. This usually leads to a relatively heavy structure,
- Corrugated single skin. This is where the corrugated shape is to replace the necessity for stiffeners. This usually provides one-directional strength while the other direction should be covered by some form of stiffener or framing,
- Sandwich panel. This is basically two skins separated with additional core material of adequate shear capability in the space between the two skins and which produces bi-axial plate bending strength and which replaces the necessity for stiffeners. This could be used in FRP monocoque construction.

[Shenoi and Harari, 1993] gave a comparative assessment on the four structural topologies as shown in table 2.2.

Hull type	Advantages	Disadvantages
Monocoque structure	Easily automated	Very heavy weight
	Low labour cost	High material cost
	Good shock resistance	Survey method need development
	Few secondary bonds below the waterline	Quality control difficult
		Attachment of machinery is difficult
Sandwich structure	High bending stiffness for low weight can be achieved	
	Can be built without mould	Long term durability is not proven
	Secondary bonding can minimize	Special precautions to be taken to protect the core from the fire damage
	Construction and operating cost are lower than conventional structure	
Conventional structure	Properties and response are well known	
	automation possible	Expensive to build
	Survey method need development	Care is needed to provide good impact resistance
	Cost reduced with number of hulls	
	Quality control is easy	
Corrugated structure	Relatively light weight	Lower transverse strength
	Low material and labour cost	Strange appearance
	Automation is possible	Fitting internal structure difficult
		Awkward mould

Table 2-2. Comparative assessment on various structural topologies Fabricated in fibre reinforced plastic (FRP) [Shenoi and Harari, 1993].

2.3.5 Guidance in Selection

Finally, the selection from the potential alternative structural forms for a ship should combine the following considerations and factors:

- Material,
- topology, and
- production processes

The production process is added as it may limit the builder's choice of the other two factors. [Savitsky1985] stated that since most small ships are designed by the builder, selection of structural alternatives at the design stage should be decided based on capability of building resources as well as overall cost effectiveness.

The SBG must consider the topography of the areas of the Red Sea and the Gulf of Arabia where their fleet will operate, due to the coral reefs and sea water condition, particularly the high salinity in addition to the future maintenance and possible repair aspects.

Again there are methods for the design and analyses available for each of these forms of construction and materials, including strength, stiffness, buckling and fatigue (on its equivalent for FRP fabrications).

The main difficulty is in the design and analyses of FRP composite panels. Such panels are also difficult to inspect in-service where damage may occur to the core material and where separation from the faces may also occur, with the result of a loss of strength.

The reliability of FRP members will tend to be less than found in metallic structures and hence a high factor of safety may be considered to be necessary for such structures. This will reduce the efficiency of FRP structures.

2.4 Brief Discussion of Conventional Analyses

All vessels operate either the whole of their sea time in the conventional displacement condition or for a large percentage of their time in the displacement condition. The latter applies in the case of vessels that result to the some form of dynamic lift, either fully or semi-planing for example, as part of their high speed operations.

The design of vessels in the displacement condition is a well documented process and it's supported by a comprehensive range of modern computer based software, and thus does not need any description, beyond general hydrostatics, ship motions in waters, hull and weather deck surface pressures, etc.

The criteria for much of the above can be found in the rules that are circulated by the various classification societies. The factors of vessels must reflect the design of SBG vessels must reflect the sea conditions in which their vessels are required to operate.

2.4.1 Seakeeping in Wave Environments

Seakeeping qualities of intrest and concern include:

- Motion considerations,
- Slams and bow emergence.

Excessive motions are to be avoided if possible. They make for discomfort of both passengers and crew. This tends to make the crew, less efficient and to make some of their tasks difficult, perhaps impossible. Apart from their amplitudes the phasing of motions can have significant effects. Phasing generally creates an area of relatively minimum motion at a location that is about two-thirds of the vessels length from the bow. This becomes a 'desirable' area and in a cruise liner it would be assigned be used for the more important passenger spaces. Speed and powering are also to be considered in waves. A ship experiences greater resistance and the propulsion is working under less favourable conditions. These factors combined, possibly with increased air resistance due to head winds; cause a reduction in speed for a given power. The severity of motions, and the attendant effects on slamming and deck wetness, can usually be alleviated by decreasing the speed and a master may reduce speed voluntarily for this reason on top of other aspects of importance. The concept of ship routing can be used to avoid the worst sea conditions and so suffer less in delay, danger and discomfort and some savings on fuel. Overall savings of the order of 10 to 15 hours have been made in this way on.

This will mainly be of concern to the larger vessels that may be at sea for several days at a time. Although for most of the time an individual vessel will generally operate in either the Red Sea or in the Arabia Gulf and thus will probably have some good knowledge of approaching bad weather, sudden storms may be of indeterminate lengths of time and hence the hours of exposure cannot be predicted. This could be of particular concern for vessels making a transit between the two operational areas. Never-the-less even the smaller vessels could be exposed to sudden squalls that the crew may need to 'ride out' at a low speed and while maintaining a heading into the most severe waves in order to minimise deck wetness.

- Wetness considerations:

The bow motions can cause the vessel to dig into the waves throwing water over the forecastle. At lesser motions spray is caused and is driven over the forward part of the ship. The main factors affecting these phenomena are the relative motion of the bow and wave surface and the freeboard forward. This is exacerbated when the vessel pitches down into the base of a wave.

- Overall seakeeping performance

An overall assessment of seakeeping performance is difficult because of the many different sea conditions a ship may meet and the different responses that may limit the ship's ability to carry out its function. A number of authorities have tried to obtain a single 'figure of merit' but this is difficult. The approach is to take the ship's typical operating pattern and the sea area in which it will be operating over a period long enough to cover all significant activities. From this is it deduced:

- The probability of meeting various sea conditions, using statistics on wave conditions in various areas of the world;
- The ship speed and heading direction in these seas;
- The probability of the ship being in various displacement conditions, deep or light load;
- The ship responses that are likely to be critical for the ship's operations, eg. motion, accelerations and force on the hull girder.

From such considerations the probability of a ship being limited from any cause can be deduced for each set of sea conditions. These combined with the probability of each sea condition being encountered can lead to an overall probability of limitation. The relative merits of different designs can be 'scored' in a number of ways. Amongst those that have been suggested are:

- The percentage of its time that a ship, in a given loading condition, can perform its intended function, in a given season and sea area at a specified speed;
- A generalization of (1) to cover all seasons and/or all speeds for a typical of operation;
- The time a ship needs to make a given passage in calm water compared with that expected under typical weather conditions.

It is really a matter for the designer to establish what is important to an owner and the appropriate classification society and then assess how this might be affected by wind and waves.

Sea keeping Performance of planing ship in seaway can be assessed by analyzing the values of:

- vertical accelerations and impact loads on hull structure,
- pitch motion amplitudes, and
- heave motion amplitude.

2.4.2 Consideration of High Speed Operation

2.4.2.1 Preamble

High speed operations are possible with a range of hull configurations and forms and are not limited necessarily to relatively small short range craft. Indeed some vessels of a medium size and in both mono and multi-hulled forms are either undergoing evaluation or are already in service (e.g. fast ferries, littoral warships etc.) and are allowed for in some of the rules issued by classification societies, eg. DNV. However in the context of this thesis, and in the operational requirements of the SBG, high speed vessels are taken to be ones that have recourse to dynamic lift during the high speed phase of their patrol operations.

High speed operations are possible with a range of hull configurations. However operational requirements, particularly where there are significant draught limitations (due, in the case of SBG's operations, to the presence of submerged coral reefs) tend to prohibit the use of some configurations, e.g. SWATH vessels and hydrofoils, etc. Because some classes of the SBG vessels operate in a mixed cruise fast intercept manner, vessels such as hydrofoils and hovercraft are likely to be impracticable even if/when the vessels are to operate mainly in deep water and with no draught limits. Hovercrafts are also impracticable for general cruising patrols and for many rescue operations, (although they would be excellent for crossing many coral reefs, etc). Similarly wing-in-ground effect vehicles would probably have too many limitations to be of much interest to the SBG, except in special cases.

Thus design tends to focus on hydrodynamic lift hulls, whether of mono- or multi-hulled forms, where high speed is also commensurate with temporarily reduced draught. The smaller in-shore vessels in the SBG thus tend to be of the semi- or fully-planing type and operate in such a mode for a significant portion of their typical patrol time, the rest of the time in the normal displacement condition and during other at-sea activities for purposes of economy and ease of general activities.

Clearly in the high speed mode, the vessels must still be safe and stable, in a range of sea conditions. The crew must be able to maintain full control during high speed maneuvers and be able to maintain a required heading through the waves, subject to limitations as the waves increase in height and, sometimes, period.

In normal operations a typical small patrol vessel will go through many transitions from displacement mode-to semi-planing and through to fully planing, subject to the design of the hull form, available propulsive power and a suitable propulsive system. The crew will be required to use their judgment in matching speed and heading relative to the prevailing sea conditions and will seek to avoid, such as, excessive slamming, propoising, propeller racing and unccomfortable levels of accelerations, etc. High speed maneuvers in wave conditions will also require the crew's full attention.

Given that only a small amount of the average sea time will be in the high speed intercept/chase mode, some things related to crew comfort can be relaxed, however equipment and hull structure must not be subject to forces and accelerations that could degrade, or even damage, them.

The design of the propulsive system, including transmission, must also not be at risk of damage and vibration levels. Thus, again, speed will need to be attenuated according to the wave conditions and the vessel's heading relative to the waves. Fortunately there is a useful body of knowledge to help the designer in considering the above, albeit compared with merchant vessels and more conventional naval vessels specialist knowledge and experience is required for small high speed vessel design.

2.4.3 Operation in Calm Water

2.4.3.1 Planing and Semi-planing

The wetted surface area is defined as the area over which water pressure is exerted, when the vessel is in forward motion and typically is geometrically the bottom area aft of spray root line .Also the wetted surface area reduces and the buoyancy reduces to bring down the total resistance, when the planing hull employs the full dynamic lift caused on the planing bottom surface when the speed rises.

There are two general classes, namely,

- semi-planing, and
- full planing.

All of the above require a careful hydrodynamic design effort; however the slow speed/ zero motion normal displacement mode hydrostatics will be used to derive the initial flotation and stability characteristics. Consideration must also be given to the flow of the water around the vessel and to the minimization of resistance (drag). In addition, the appendages may require fairing in order to reduce their resistance to flow and the propellers must be designed and positioned to provide maximum efficiency and to match the engines to the planing hull.

2.4.3.2 Hydrodynamic Lift

The overall lift on a planing hull consists of two parts:

- The dynamic reaction of the sea water against the moving planing surface, and
- The buoyant lift of submerged part of the wetted surface of the hull, which is essentially the hydrostatic pressure on the hull of the displaced water.

2.4.3.3 Drag Forces

The pressure drag developed by pressure acting on the inclined plane bottom and together with the viscous drag acting on the bottom in both the pressure and spray area ,compose the total hydrodynamic drag of a planing hull, also the viscous drag component will increase if there is a wetted area.

2.4.3.4 Powering Requirements

2.4.3.4.1 Powering and Propulsion System Design

The hull configuration may have been selected to be consistent with the power transmission from the main machinery to the actual propulsor that the designer plans to use. This may be particularly relevant in the case of some of the possible multi-hull configurations and for operation in shallow waters.

A most important aspect to consider in the design of power transmission system, particularly in long mechanical systems, is the avoidance of any form of vibration and shaft whirling, etc.

The quality of the water flow into the propeller or propulsor is also important as is the flow into and through any form of water jet as such may also lead to some form of vibration. These will require considerable expertise on the part of the designer. Supported by several computer based analysis programs that are available.

2.4.3.5 Powering and Propulsion Alternatives

Various powering machinery and propulsion configurations for high speed craft are available and should be carefully selected based on performance requirements and allowing for various operational and maintenance constraints.

Range of available alternatives can be grouped as follows [Fan and Pinchin, 1997]:

- Main source of power:
- Medium or high speed diesel,
- gas turbine,
- Petrol engine (limited to some inshore and harbor duty craft).
- Power transmission to propulsior:
- electrical concept; transformation by generator to electrical energy and use of electric motor to move actual propulsior unit,
- propulsior element,
- Mechanical concept; use of mechanical shafting with or without gearboxes.

Integration with electrical power:

- Power take-off concept by using shaft generator to provide additional (sometimes also as main) electrical energy,
- All electric Ship Concept, where all energy is transferred by cabling to any power device as electrical energy.

Propulsior type:

- water jet,
- screw propeller, either non-cavitating or super-cavitating propeller.

Level of redundancy:

- use of multiple numbers of main source of power,
- use of multiple number of propulsor,
- combination of multiple power source and propulsion,
- Use of multiple compartments for various powering devices.

Combination of those alternatives should be decided upon based on various factors including hull configuration, which should include required performance, operational constraints, availability, maintainability, reliability and other subjective preferences.

2.4.4 Appendage Resistance

The existence of appendages can significantly influence the performance of planing hulls, thus these should be taken into account when predicting the propulsive machinery output power requirement. These appendages drag components may come from:-

- Skews,
- propeller shafts,
- struts and strut boss,
- rudders, and
- appendage interference.

Any other items extendedbelow and beyond the hull shape should also be considered as an appendage

2.4.5 Stability Considerations

2.4.5.1 Criteria and Types of Stability

For small vessels clearly stability and load carrying capacity are two essential aspects of boat design. For clarity it is useful to state the relevant definitions Stability is the ability of a boat to remain upright in the water.when subjected to distrurbancees eg, waves. If the boat does not stay upright in the water, then unsecured deck equipments, for example could move or even fall off and the vessel would become uncomfortable for the crew in the extreme case the vessel could capsize and even roll over. A hull is designed to keep a boat floating and upright when experiencing. The behaviour of the vessel is dependent on the vessels reaction to the disturbance of the waves and may be described as:

- Stable, where the vessel return to the pre disturbance vertical equilibrium,
- Neutral, where the vessel settles into an equilibrium attitude that is different from the original ,i.e. develops a list angle of loll,
- Unstable equilibrium is where the vessel does not reach equilibrium following oscillation about the original equilibrium, and the vessel could capsize.

2.4.5.2 Stability Range and Margin of Stability

Stability range is the maximum displacement from which a system will, in this case a vessel, return to its original equilibrium after the removing of the disturbance.

For a planing craft when turning at high speed, the stability quality is a very important factor for its safety. Stability margin is the restoring energy above the minimum required value that will provide a margin for inaccuracies in predicting the upsetting forces and stability for the small vessel.

Instabilities in a planing draught are depending on:

- Speed,
- Displacement,
- Weight of hull form, and
- Appendage.

Some vessels display the dominant influence of one parameter only but many others display the influences of more than one factor.

Clarily that the effect of hull geometry on stability merits consideration:

2.4.5.3 Dynamic Instabilities

Dynamic instabilities are associated with the speed forward motions however the HSC code appears to be for regular static stability only and completely unconnected with speed.

Non-oscillatory instabilities usually occur at speeds lower than those associated with oscillatory instabilities and are generally found on heavily laden craft travelling at moderately high speeds. These non -oscillating instabilities are typified by a loss in:

- Running trim,
- Progressive heeling. and
- Bow steering.

The start of these instabilities may increase rapidly without any prior warning. [Blount and Codega 1992] defined the general types of dynamic instability associated with planing craft as follows:

- “Chine walking”, which is a dynamic roll oscillation
- “Porpoising”, which is a coupled dynamic pitch-heave oscillation and
- “Corkscrew”, combination of pitch, yaw, roll oscillation

2.4.6 Operation in Wave Conditions

2.4.6.1 Porpoising

Porpoising is a form of self-excited oscillation in a vertical fore and aft plane in a coupled system between heaving and pitching with coupling restoring coefficients having different sign each other.

Also porpoising is defined as combined pitch and heave oscillation motion experienced by planing craft as defined by [Savitsky, 1964]. This behaviour becomes dangerous when the motion is so severe that the hull is thrown out the water and/or digs deep into the water at the bows. Also [Ikeda and Katayama, 2000] present the following results longitudinal instability, called 'proposing,' of a high speed planing craft is associated with the following observations:

- The transverse stability of a craft decreases at high advance speed,
- The stability loss causes a large heel angle at high advanced speed,
- The dependency of the stability loss on the trim angle generates unstable rolling motions induced by pitching motion,
- Proposing of a craft is a self-exciting motion due to the different sign of the coupling restoring coefficients between pitch and heave motions,
- The damping factor plays an important role in order to avoid the occurrence of unstable motions.

2.4.6.2 Slamming Consideration

Sometimes result in dynamic pressures exerted by the water on the ship's hull becoming very large and what is known as slamming occurs. Slamming is also characterized by a sudden change in vertical acceleration followed by a vibration of the ship’s hull girder in its natural bading frequencies. The region of the outer bottom between 10 and 25 per cent of the length from the bow is often the most vulnerable area. However the entire bow plate region can be subject to high transient pressure.

2.4.6.3 General Influences of Hull Configuration and Form

- To allow for displacement condition, ('The displacement condition must have the necessary hydrostatic properties, particularly with regards to the level of trim conditions, as reflected also in the position of the centre of floatation and the calculated position of the centre of gravity, and at least the required amount of freeboard in the working deck regions. With modern computer based tools the naval architects and designers should have the ability to undertake any necessary hull form lines manipulations and modifications in order to be able to undertake these tasks).and
- Minimise motions and deck waters ('The shape and dimensions of the hull form, including hull lines details at the bows, can also be adjusted and analysed with the use of various computer based methods in order to try to minimise the rolling, pitching and heaving motions, etc. in typical operational sea conditions in order to reduce the possibility of taking water over the bows in normal operational seas. This could also result in changing fore-end deck sheer lines and locally increasing the height of the bows. If there is a possibility of taking water over the sides of the vessel, especially when rolling considerably in beam seas, possibly the amount of freeboard would also need to be increased).

2.4.6.4 Mono-and Multi-hull Considerations

- Effects on various, propulsive system,
- Compared with normal naval architecture work relatively complex and require s specialist attention, useful refrences (same),
- Limited software, available,
- Crew safety important, comfort related to limited high speed time, and
- Limited class guidance available.

2.4.7 Comments

Those high speeds vessels can be designed to operate in the semi- and fully-planing modes are clearly certainly achievable, however full attention must be given to:-

- Crew safety and comfort, considering, acceleration levels, impacts and noise, etc.,
- Equipment integrity and operational performance, particularly electronic equipment and the propulsive system, and
- Hull integrity and machinery/equipment seats, considering slamming pressures, acceleration levels, etc.

It is clear that wave impacts, in both severity and frequency, must be a major area of concern in both design and operational practice.
Compared with most traditional naval architectural activities on conventional vessels where there is a considerable amount of well established design methodology and supporting computer software available, the design of vessels which employ hydro-dynamic lift from high forward speed is a relatively specialized subject.

2.4.8 Summary

It is clear that the Naval Architects, designers and draughtsmen within the Saudi Border Guard technical offices have, or can have, available to them a considerable amount and variety of design and analytical methods, of comprehensive computer software packages, etc., covering all aspects of rigorous design development, and from initial concepts through to detailed drawings and plans. This is together with the fairly large volume of guidance that is provided by the many rules and regulations that are promulgated by several authoritative agencies, such as the classification societies, national and international official bodies, and many other such organisations.

Thus the technical staffs who are both familiar with and experienced in using the various methods and whose tasks include, such as, preparing specifications, evaluating proposals undertaking in-house design studies, and planning for operations, inspections, maintenance and possible future mid-life and refit up-grades are well place to efficiently undertake their tasks.

This is particularly so if the technical staff are called upon to prepare outline designs for proposed new vessels. They will be able to develop new designs that are optimum for the needs of the SBG, regarding the specific operational environment, the very detailed tasks that the crews will be required to perform and the culture and style of human factors that are important the the officers and crews.

The above is in addition to the development of efficient and effective designs that will produce vessels that have good handling and maneouvering characteristics, efficiently performing hull forms and propulsive systems, acceptable both first- and inservice running- costs and well arranged for operations, inspection, maintenance, and equipment management and servicing, etc.

For the Naval Architect there is large range of computer software that is available for, such as, hull form development, hydrostatics and hydrodynamics calculations, stability calculations, resistance and propulsion calculations, etc., and that can be used for undertaking design alternative trade-off studies, optimisation against selected criteria, etc. For the structural analysts and production specialists there are many tools and techniques that can be used for the development of efficient hull structures and their most appropriate materials and arrangements for creating a vessel that is best suited for the local operations and environment, and has required inspection and maintenance characteristics. For the designers and draughtmen there are many alternative computer aided design packages for producing detailed drawings and additionally, and of most importance, if the packages include a solid modelling capability then arrangements can be deveoped that facilitate, for example, improved crew mobility around decks and internal spaces, equipAs discussed in an earlier section the Naval Architects and designers will probably embark upon a cyclic process of progressive design development, constantly modifying and adjusting the details of the design until they reach the conclusion of a combination of hull form, structure, compartmentation, arrangement and geometry, materials, propulsive machinery, and outfit and operational equipment, etc. that meets all of their requirements and design targetment access and maintenance, etc.

2.4.9 Conclusion

The tasks and approaches for the Naval Architects and designers should be relatively clear and well defined for them, and they will be well served with much of the currently available methods and computer software, etc.. However this is with the possible exception of situations where they choose to examine relatively innovation configurations for new vessels, for example SWATHS, Catamarans and Trimarans, and of new methods or materials for construction, for example advanced composites and cellular panel forms. Never-the-less even here there there is a relatively considerable amount of design and analysis guidance and methods given in the available literature. However operational and sea area considerations, eg, draught limitations, may limit consideration of such levels of innovation.

Thus the SBG has available to it, or it can readily obtain, a wealth of design guidance and analysis methods, and of information and computer software that is applicable to the design of small boats and vessels of a wide range of types. Hence, given a quite modest amount of additional training, the technical staff of the SBG, that is the naval architects, the designers and the draughtsmen, should be able to readily acquire additional capabilities to complement their already considerable current expertise.

3 CHAPTER Three: Environment Where the SBG Operate their Fleet

3.1 The Red Sea and the Gulf of Arabian

3.1.1 Introduction

The aim of this chapter is to study the environments where the SBG operate their vessels. It is essential to provide to the designer the information about this environment, including the humidity, temperatures, waves, currents, coastal zone hazards, etc.

In this chapter it is also necessary to study about the navigational difficulties especially in the coastal zone where there is random spread coral reefs and charted and un charted lands, and according to the environment requirements, such as the hull material, types, and hull geometry will need to be carefully defined.

It is essential to select the hull material according to environment topography, such as saline and navigational problems. So it is important to provide to the architect and designer in the first stages of planning to the future fleet specification in addition to the survey result and a review of new technology.

From a geographical point of view, the Red Sea is an inlet of the Indian Ocean between Asia and Africa. In the south, the Babb el Mandeb, or also known as of the Gulf of Aden, is the connection sound between the Red Sea and Indian Ocean. In the north, the Red Sea extends around the Sinai Peninsula, Egypt and Saudi Arabia into two major parts:

- North East: The Red Sea extends to the Gulf of Aqaba, also known as the Gulf of Eilat, and
- North West: The Red Sea extends to the Gulf of Suez leading to the Suez Canal which is well known as the vital connection between the Red Sea and the Mediterranean Sea.

The Red Sea is a Global 200 eco-region. Occupying a part of a continuation of the Great Rift Valley, the Red Sea has a surface area of approximately 174,000 square miles (450,000 km²), being around 1,200 miles (1,900 km) long and, at its widest point, over 190 miles (300 km) wide. The maximum depth is reported being around 8,200 feet (2,500 m) in the central median trench and an average depth of 1,640 feet:(500 m). However, there are extensive shallow shelves, noted for their marine life and corals. More than 1,000 invertebrate species and 200 soft and hard corals are inhabitants in the Red Sea and it is the world's most northern tropical sea. This is one reason of why special careful considerations should be taken into account during a vessels design with different lengths or/and draught.

The Red Sea is known as being one of the most saline water bodies in the world that is governed by the effects of the water circulation pattern, resulting from evaporation and wind stress effects. Salinity ranges between 3.6 and 3.8 % making the selection of the hull material even more challenging, and this needs more attention during the design stage to select the type of hull material, including steel grade and composition or aluminium alloy type or Fibre Reinforced Plastic (FRP). This can be achieve through more survey and both inservice and experience.

Since the Red Sea has a unique character, as well as the complex environmental information, it provides on such subjects as rifting, continental drift and sea-floor spreading, and it has been a region of immense significance to scientists. The specific geographical extension for the Red Sea offers outstanding research as it is considered as the greatest contemporary case of a slowly growing ocean [Purser and Bosence, 1998].

The most important coastal and marine environments and resources around Saudi Arabi are widely found in the Red Sea. A huge diversity of coral reef types is present in the Red Sea, with a structural sophistication matchless on the existing maps. The variety of coral, for example, is superior to that seen in the Indian Ocean [Bersga, 1998]. The Red Sea can be considered as one of the most important repositories of marine biodiversity on a global scale.

In this chapter, a very brief hydrographic and an environmental study of the Red Sea are presented. It is also to be noted that the Red Sea contains 379 islands, of different sizes.

The air temperature is normally lowest in the northern part of the Red Sea throughout the year. In the area south of 20°N, the temperature increases rapidly. The rainfall over the Red Sea is extremely low. It is mostly in the form of showers of short duration with dust storms. Surface water currents in the Red Sea are driven partly by the wind and partly by density gradients, which are established by the heating and evaporation that causes salinity levels to rise and fall.

Navigation in the Red Sea is facing many difficulties due to the gradual spread of coral reefs and lack of updated navigational charts. Furthermore, the limited navigational markers present more problems to the shipping in this area. There are also high risk zones for ship navigation within the Red Sea, especially near the ports [Gladstone, 1999]. The importance of the Red Sea increased after the opening of the Suez Canal in 1869. The importance of the Red Sea as an international navigational route thus lies in its role of creating a relatively short and fast route for trade. That means that it has unique importance in terms of both economy and commerce. Another point is that the length of its coast, on the Saudi side, is about 1,190 nautical miles (1914 km), with an average width across the sea of about 180 nautical miles (290 km) (Figure 3.1); this allows for a better control of the area and a reliable defence against any external threat or illegal incursion. There are many ports on both the western and eastern banks of the Saudi Arabia that can be used as naval bases for defence purposes.

3.1.2 Oceanography

The Red Sea is surrounded by desert, semi-desert and arid land. The Red Sea water mass exchanges its water with the Indian Ocean and the Arabian Sea, via the Gulf of Aden. These physical aspects tend to decrease the influence of high salinity caused by evaporation and the cold water in the north and relatively hot water in the south.

Figure 3-1. Saudi Arabia plotical map

3.1.3 Climate

The climate of the Red Sea is the outcome of two distinct monsoon seasons; a southwesterly monsoon and a northeasterly monsoon. Monsoon winds arise due to the degree of difference of heating between the sea and the adjacent land surface areas. The twofold effect of the very high surface temperatures and high salinities make this one of the hottest and saltiest bodies of seawater in the world. During the summer, the average temperature of the Red Sea is about 26°C in the surface water in the north and 30°C in the south, This variation is about 2°C during the winter months with a average temperature of 22°C. The rainfall over the Red Sea and its coasts is extremely low averaging 0.06 m per year; the rain is mostly in the form of showers in short spells, often associated with thunderstorms and occasionally with dust storms. The scarcity of rainfall and with no major inflow source of fresh water into the Red Sea from rivers, etc. result in the excess evaporation is as high as 205 cm per year and a very high salinity results with minimal seasonal variation. The potential effects of global warming are not predictable at this time. The result of the evaporation is to create a high humidity. This effect visual observation and on-boaed equipment, particularly electronic.

3.1.4 Winds

With the exception of the northern part of the Red Sea, which is dominated by persistent north-west winds, the rest of the Red Sea and the Gulf of Aden are subjected to the influence of regular and seasonally reversible winds [Naval Oceanography Command, 1982]. The north-east monsoon is mild and dry, the winds are light to moderate and there is little precipitation since they blow from the land, in contrast to the monsoon that is moist and also much stronger.

The occurrence of the monsoon is related to the great change in pressure that takes place between summer and winter over central Asia. During the winter monsoon and due to continental cooling, a strong atmosphere develops over Asia; the air in the lowest atmospheric layer flows outwards. In January, the high pressure extends from Mongolia to central Europe, and passes over Turkey to Arabia. The atmospheric circulation is reversed as the monsoon blows from the north-east across the Arabian Sea and Gulf of Aden towards central Africa. On the basis of its climate, the Red Sea may be subdivided into three regions [Morcos, 1970].

– Northern Red Sea. The prevailing wind is mainly north/north-west all the year round.

– Southern Red Sea. From May to September, the winds blow from north/north-west in the same direction as in the northern Red Sea. In October, the winds start changing to south/south-east and retain this direction until April. Figure 3.2 gives the climatologic normals of extreme wind in the study area recorded over 30 years.

– Intermediate area. This develops only in the winter months between the north/north-west winds of the northern half and the south/south-east winds of the southern half. The wind speed over the study area throughout the 30 years from 1962–1992 never exceeded 25 m/sec. Applying linear regression between Usea and Uland, an expression is obtained giving

Usea = 2.73 + 1.07 Uland [Abdulrahman 1995]

Where:

Uland= is the measured wind speed over land in the study area (m/sec), and
Usea= is the corrected wind speed over water in the study area (m/sec).

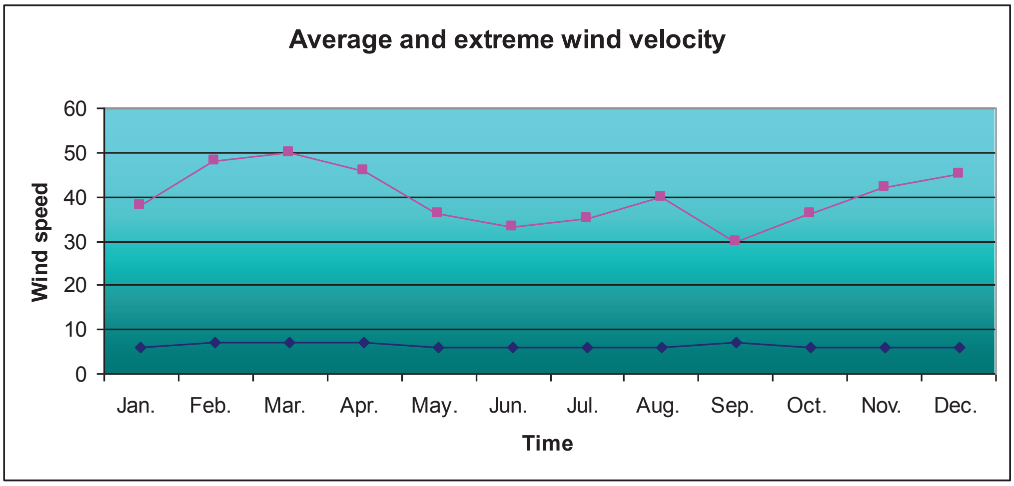


Figure 3-2. Wind speed over 30 years in the Red Sea. MEPA 2005

Such information wull be helpfull during the designing process for the future fleet of the SBG.and can be provided together with other information to the designer in the early stages of design development.

3.1.5 Air Temperature

The lowest air temperatures are normally found in the northern part of the Red Sea all year round. South of latitude 26°N, the temperature increases rapidly. The region south of latitude 18°N and around the shores of the Gulf of Aden are considered to be among the hottest regions of the world [Morcos, 1970]. Figure 3.3 give the monthly average and the extreme air temperatures at a number of stations along the Red Sea.
The Red Sea demonstrates an exceptional condition, namely that south of latitude 20°N, the surface water is cooler throughout the year than the overlying air, which blows off the neighbouring hot deserts. The same condition prevails from March to September in the northern half of the Red Sea and from May to August in the Gulf of Suez [Morcos, 1970].

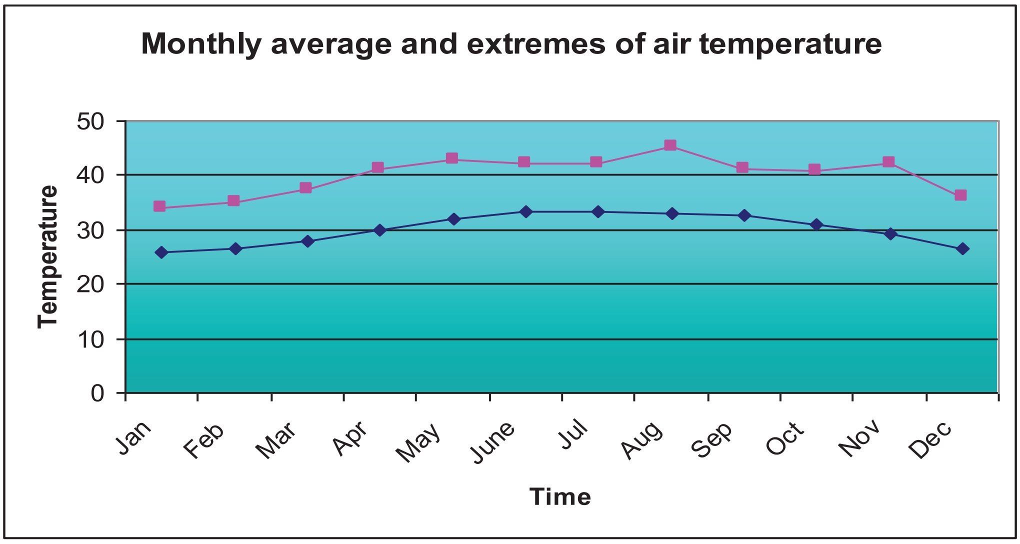


Figure 3-3 Monthly average air temperatures. MEPA 2005

Such information is very important for the designer to be taken in consideration, as such can affect the selection of hull material, crew requirements including, fresh water tank capacity,air conditioning,etc. and mission reqirments.more requirements can be defined and refined through more survey and feed back from the SBG members.

3.1.6 Currents

Surface water currents in the Red Sea are driven partly by wind and by water density gradients, which is established by heating and evaporation [Morcos, 1970]. In summer, water entering the Red Sea through Bab-el-Mandeb drifts northwards on the eastern side. The winds and high temperatures result in evaporation, and this causes salinity to rise from about 38–39% to about 42% at the Gulf of Suez. However, the increasing salinity causes only a small increase in water density and hence vessel displacement.

The main features of the surface current circulation, at least as far the deep waters along the main axis of the sea are concerned, are as follows:

- During the summer months, the north/north-west winds over the entire basin cause a movement of surface water in the south/south-east direction and down the western coast. This average flow is about a quarter of a knot (12 cm/ s) over the northern two thirds of the Red Sea, but south of latitude 16°N it is about twice as strong and reaches a maximum of about 1.25 knots in the Bab-el-Mandeb. At this time of the year, the south-west monsoon moves the surface water of the Gulf of Aden eastwards to the Arabian Sea and these waters are partially replaced by the outflowing water from the Red Sea. From October to May, the drift is reversed. The south-east winds tend to pile up water in the Gulf of Aden and there is a surface flow into the Red Sea reinforced by the south-east wind blowing over the Strait of Bab-el-Mandeb and the southern part of the Red Sea [Morcos, 1970].

- During the transition months in spring and autumn, the current pattern almost everywhere is indefinite. The exception is in the far south in May and early June, when the inflow through the Straits persists until after the north-westerlies have become established.
- In shallow coastal water, the currents are much influenced by the local topography and sometimes by tidal streams, which are themselves much affected by local conditions.
- There are two distinct monsoons, the north-east (October–April) and south-west monsoon (May–September), controlling the weather in the southern half of the Red Sea. In the northern half, the wind blows north-northwest all year. The water surface currents in the northern half are driven partly by these winds and partly by a density gradient. In the northern part of the Red Sea, north of about 19°N, the increase in temperature with decreasing latitude is both well marked and fairly regular. Temperatures are higher on the Arabian than on the African coast. South of about 19°N in the vicinity of the temperature maximum, there is no marked difference in temperature across the sea.

3.1.7 Salinity

The Red Sea is one of the most saline water bodies in the world, due to the combined effects of the water circulation pattern, which result from evaporation and wind stress. Salinity ranges between 3.6 and 3.8 %.

3.1.8 Coral Reefs

The Red Sea is fringed by coral reefs of varying abundance [Cochran, 1983]. Due to the rift-related origin of the Red Sea, the gross reef physiography seems to have been primarily controlled by tectonics rather than by sea level change. However, in relation to this major control, salt diapirism and siliciclastic input are additional factors that may influence the present day morphology and setting of reefs [Dullo, 1998].

Coral reefs in the northern part of Red Sea, the Gulf of Suez and Gulf of Aqaba are mainly of a fringing nature [Bantan, 1999]. Due to the shallow depths in the Gulf of Suez, reefs are transitional from fringing reefs towards barrier reefs, especially along the south-eastern coast near the entrance to the Red Sea [Dullo, 1998].

3.1.9 Coastal Zone

The Red Sea coastal plain in Sudan and Egypt is narrow and is traversed by numerous large wadis (valleys) [Clay et al., 1998]. On the Arabian side, the coastal plains broaden south of latitude (21° N) into the Tehama plain, reaching a width greater than 50 km in Yemen. North of latitude 21° N, the coastal plains are narrower and contain raised terraces that represent older shorelines [Behairy et al., 1992].

The coastal plain within Yemen and Saudi Arabia is mainly an actively alluviating surface that covers most of the earlier tertiary structural trends [Coleman, 1993]. The only significant relief on the plain is provided by salt domes rising about 70 m above sea level at Jizan city, and by small extinct volcanoes 100 to 150 m high, southeast of Jizan city [Blank et al., 1986].

With regard to the tidal range: In general tide ranges between 0.6 m in the north, near the mouth of the Gulf of Suez and 0.9 m in the south near the Gulf of Aden, however it fluctuates between 0.20 and 0.30 m away from these nodal points. The central Red Sea (Jeddah area) is therefore almost tideless, and as such the annual water level changes are more significant. Because of the small tidal range the water during high tide inundates the coastal sabkhas as a thin covering of water up to a few hundred metres in span rather than inundating the sabkhas through a network of channels. However, south of Jeddah in the Shoiaba area the water from the lagoon may cover the adjoining sabkhas as far as 3 km whereas, north of Jeddah in the Al-kharrar area the sabkhas are covered by a thin covering of water as far as 2 km. This creates serious problems for vessels sailing throught these areas.The prevailing north and northeastern winds influence the movement of water in the coastal inlets to the adjacent sabkhas, especially during storms. Winter mean sea level is 0.5 m higher than in summer. Tidal velocities passing through constrictions caused by reefs, sand bars and low islands commonly exceed 1-2 m/s.

3.1.10 Islands

The Red Sea contains 379 islands [El Sayed, 1985]. The largest are Breem, Moleeh, Komran, Teran, Sanafeer, Farsan, Aldoyma, Zaquox, Hanesh Alkobra and Al Soghro, Dahlak, Fatma and Al tair.

Three distinct kinds of island are present in the Red Sea, excluding the many smaller isolated islands related to coral reef formation. At the southern end of the Red Sea, the flat-lying, coral limestone-topped Farasan Bank and Dahlak Archipelagos rise slightly more than 50 m above the sea level. The second type is the volcanic islands located in the southern part of the Red Sea such as Jabal Tair, Zubayr, Zukur and Hanish Islands. Zebargad Island represents the third kind of island. It consists of both mantle and lower crustal metamorphic and igneous rocks. This small island is located on the western shelf of the Red Sea (23° 37′N-36° 12′E). It is triangular in shape, rising about 235 m above sea level [Bonatti et al., 1983].

3.2 Arabian Gulf

The Arabian Gulf, also known as the Persian Gulf in south west Arabian region is an extention of the Indian Ocean located between the Iran and Arabian countries. It is known as the Perisan Gulf historically however the Arabian countries call this gulf the Arabian Gulf.

The Arabian Gulf was a focus of the 1980-1988 Iraq-Iran war, in which each side attacked the others oil tankers. The Arabian Gulf is very important for the international economy because ten millions barrel of oil pass in the Arabian Gulf every day.

The inland area is about 251000 square km, and which is connected to the Gulf of Oman in the east by the Strait of Hormus, the water is overall very shallow with a maximum depth of 90 m and an average depth of 50 m. The countries with access to the Gulf of Arabia are Iran, Oman, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Kawait and Iraq. The SBG is to undertak the challange to protect the Saudi coasts, due to the increasing the smuggling, illegal imergration in addtion to terrorism, and potential regional conflicts.the SBG must use the most developed vessels and equipments in order to control their coasts.

3.3 Summary

In this chapter much information is given which illustrate problems including the enviroment where the SBG operate their fleet including climate, topgraphy, coastal zone and navigational difficulties. The other information of the SBG fleet mission including the sea areas covered, the location and importance of the areas where the SBG practice their duty will give some kind of idea about the future fleet requirements. This information can be helpful for the designer in addition to other information in the next chapters. This will help to provide a clear strategy for the SBG to define the requirements for its future fleet.

It is clear that the Red Sea and the Gulf of Arabia have their own epecial environments and characters including the coral reefs and where there is not an availability of recent navigational maps which causes difficulties in navigation especially in the coastal zones where the SBG operate their fleet. And high temperature and humidity lead to it being necessary to closely define the SBG requirements and crew requirements for the future fleet specifications, including hull material, air conditioning, etc.

3.4 Conclusion

It is very important to study and collect some information about the environments where the SBG operate their fleet. This information is very helpful for the architect and designer in the first stages of the design process. The designer must take in consideration all the available information of the environment where the SBG vessels operate. This information will help to decide the hull material for each part of the Red Sea and Gulf of Arabia, including all the environment factors and in addition of that the survey results, of the mission, SBG and crew requirements. The SBG committee must take consideration the environment requirement, including the different

environment specification along regions the Red Sea which are different from one part of the Red Sea to another. For example the random spread of coral reefs ais more significant in the north of the Red Sea rather than in the south, as well as the saline of the water is more in the south, where the selection of suitable hull material is required. Also the selection of hull geometry in this stage must be taken in consideration according to the area topography.
In this chapter some information about the enviornmants where the SBG practice their mission this information including the wide areas in both the Red Sea and the Gulf of Arabia, temperature, humidity, saline, etc. must be taken in attention during selection of mission and crew requirnments including HVAC, spaces, stores, deck area, etc.
In addition to this information the next step is to have short note about the SBG's history and the stages of its development, in order to well plan for the future fleet specifications and types, which is illustrated in Chapter 4.

So it is necessary to build a strategy to define the requirements for future fleet specifications for the SBG, including environment requirements, the SBG requirements, mission requirment, crew requirements and small craft design requirements.

In Chapter 5 the strategy links all these factors in the methodology of the study. Also in the next chapter short note of the SBG history this will define how the SBG devloped in very short time comparing with other border guard all over the world and the ability of following and becoming familiar with rapid development in all fields .

4 CHAPTER four: Saudi Border Guard (SBG)

4.1 Saudi Border Guard (SBG)

Saudi Arabia (SA) is considered to be the most important country in the Middle East due to its geographical location and national income, as well as the fact that it has the largest stockpile of oil in the world. In addition, SA has the honour of hosting Islamic rituals throughout the year in the Muslim holy cities of Mecca and Medina, which are visited each year by an enormous number of Muslims from all over the world. It is thus the focus of many people wanting to access its borders through both legal and illegal ways. Therefore, it is necessary for the authorities of the Kingdom of Saudi Arabia to pay great attention to protecting and controlling both the country's land and sea borders.

This research focuses only on Saudi Arabia's marine borders, which are roughly 1700 nautical miles (3145 km) in length and stretch along both the east and west coasts. The research will be limited to investigating the maritime requirements of the Saudi Border Guard (SBG) in terms of the characteristics and specifications of the various many vessels the SBG uses to patrol the country's coasts, in particular its long range fast craft.

4.1.1 Geographical Location of the Kingdom of Saudi Arabia

The Kingdom of Saudi Arabia is a recognized geographical region of south west Asia. The country is bordered on the east by the Arabian Gulf stretching 700 nautical miles (1295 km) and on the west by the Red Sea stretching 1000 nautical miles (1850 km). To the south is Yemen, and to the north are Iraq, Syria and Jordan. Its total area is 2.25 million square kelometre and it has a population of 25 million inhabitants. The most important resources are oil and religious tourism.

4.1.2 Main Sea Ports

The most important maritime ports on the Red Sea, from the south to the north, are Jazan, Jeddah, Yanbu and Daba, while on the Arabian Gulf, from the south to the north, they are Ras Tanura and Al Khafji. Dammam in the Gulf of Arabian and Jeddah in the Red Sea and are the most important commercial ports, while Ras Tanura and Al Khafji are the most important ports for oil exports.

4.1.3 Security Strategy

The following are some general observations:

- A number of poor African countries are located to the west of the country. A large number of citizens of these countries enter the Kingdom to perform religious rituals and are attracted by the Kingdom's economical situation, thus they stay on after the rituals are over. This is especially true of those who are uneducated or artisans. Many engage in smuggling by sea.

- Yemen is located to the south of the Kingdom and quite a number of Yemenis are resident in Saudi Arabia. They form the main source of manual labour in the Kingdom.

- Iraq, Syria and Jordan are located to the north of the Kingdom. This region became very hostile after the collapse of the regime of Saddam Hussein in Iraq.

- East of Saudi Arabia is located several friendly Arab countries; however, there has been some very limited tension from time to time due to certain political differences. Iran is also situated to the east of the Kingdom. Its nuclear programmes are causing much concern in the region.

It is clear from the foregoing that the security strategy adopted to guard and monitor the coasts of the Kingdom requires extreme and ongoing caution of all those who might attempt to illegally breach its borders. The SBG's main responsibility is protecting sovereign seas, coasts and beaches and it is also involved in routine security work to protect ports, fight against law-breakers, and guide fishermen and picnickers. Additionally, the SBG provides necessary assistance in the fields of search and rescue of people at peril on seas, and protection of the environment.

4.1.4 International Organizations

Saudi Arabia participates in and contributes significantly to all specialised international organizations concerned with marine, rescue, fishing and communication issues. It also participates in most marine conferences and symposia with official representatives. However, technical and research contributions provided by representatives of the Kingdom are generally very limited.

4.1.5 Marine Education

Despite the presence of several universities in Saudi Arabia, there is no one faculty that specializes in the field of marine studies except for the College of Marine Sciences at the King Abdul Aziz University in Jeddah. It specializes to a great extent in the field of aquatic biology and not in the area of marine engineering nor in the operation and management of ships or shipbuilding. However, there is a military college which trains navy officers for the naval forces. There are also a number of institutes and marine centres for naval forces and the SBG where technical training is provided.

4.1.6 History of the Development of the SBG

The development of the SBG started in the era of the late King Faisal bin Abdul Aziz, passing through three basic stages from 1973 to the present day. These stages are discussed in the following sections.

4.1.6.1 First-Stage

In the first stage the following were attained:

- Establishment of a marine workshop including a slipway of 180 tonnes, a crane of 60 tonnes lift capacity and the building of marine administration centres with facilities and quays in Jeddah in the western region and in Aziziyah (adjacent to Dammam) in the eastern region.

- Establishment of a technical marine institute in Jeddah in the western region.

- A study mission to Pakistan for a number of students with the aim to become naval officers and non-commissioned officers in the SBG.

- Providing nine patrol boats in the 13.7 m category and seventeen patrol boats in the 21.3 m category.

- Providing two boats, named Badr and Yarmouk, in the 28 m category.

- Providing a large number of service boats of the Fisherman and Task Force types, as well as a large number of inflatable rubber boats of the Zodiac type.

- Establishment of a primitive, domestically made slipway in each of the Khafji and Aluga fields. Also, establishment of a very small marine workshop, similar to a car repair workshop rather than a marine workshop.

It is worth mentioning that until 1975 there were only five naval officers in the SBG, and who had been transferred from the Saudi naval forces. The highest ranking of them was a Major and the number of non-commissioned officers (NCOs) in the SBG did not exceed twenty. Those who were in command of these vessels were a group of Saudi civilians with very limited experience and who were not scientifically qualified and who could not sail at night except in very limited situations. Therefore, navy model vessels of the 13.7 m and 21.3 m categories were found to be the most suitable to use due to their capabilities, simplicity of design, and absence of modern communication equipment onboard. There were no quays in the marine regions or sectors extending along the shores except for those at Jeddah and Al Dammam.

4.1.6.2 Secand Stage

- The arrival of 14 marine officers back from their scholarships to work for the SBG.
- An increase in the number of students sent to Pakistan, China and the United Kingdom to qualify as marine officers or officers specializing in different fields.
- Appointment of a large number of technicians and maritime workers to carry out maintenance, repairs, maritime training and the operation of some vessels.

- The establishment of quays, marine workshops and the security of marine cranes in the areas of Alugah and Jazan, and at some other important marine sectors.
- Operation of the marine institute at its maximum capacity after appointing a large number of contracted teachers, trainers, and program and course developers.
- Providing the ship Tabouk, of the 60m category, for practical training.
- Providing 35 boats of the 17m category, 10 in the 15m category and 8 in the 14m fibreglass category. These are medium-range boats of medium-speed whilst being equipped with navigation equipment and modern communication equipment relative to the time when they were built.
- Transfer of 4 fire boats of the 26m category and 2 rescue boats of the 15m category from the Saudi Civil Defence agency to the SBG. These boats were built in the United Kingdom.
- Providing 2 tugboats of the 26m category, an 8m landing vessel, and 2 ferry boats.
- Providing more than 40 jet-boats in the 8m category. However, they completely failed to achieve the lowest speed acceptable and the SBG was forced to change the jets back to ordinary propellers and so did not use them.
- Providing modern marine maps and distributing them to all regions and sectors.
- Co-operation with the Saudi naval forces for the training of officers and non-commissioned officers (NCOs).
- Improving the performance of marine management and development plans for the maintenance of vessels and workshop equipment. Attempting to make available technical documents required for maintenance, repairs and upgrading. Development of the SBG’s requirements for new vessels.
- Supplement of spare parts and raw materials in very large quantities and the development of marine repositories.

This stage was one of the most important stages of development, as achievements were attained very quickly and well developed compared with the previous and subsequent stages. The most prominent were the availability of trained marine officers and NCOs, the security of a large amount of marine transport, establishment of marine workshops and quays, and the operation of the marine institute at its maximum capacity.

4.1.6.3 Third Stage

- Long-range, fast, patrol boats named Salwa and Jubail of the 26m category. Jawf, Tarif, Ha'il and Najran of the 38m category, which were built from high tensile steel (boats from Damen), and veesels 22 m Do-Hirab and Ramin, which were built from aluminium alloy.
- Provision of short-range, high-speed patrol boats (Boston Weller US builder).
- Continuous development of workshop equipment.
- Establishment of more marine workshops, quays and secure marine cranes in most of the marine sectors.
- Development of methods of marine operation (establishment of operation centre and restriction of control of patrols).
- Development of work at sea ports (establishment of marine operation rooms, provision of scrutiny cameras, and increased control over the security of ports).
- Study missions of a large number of marine officers in order to obtain degrees from the United Kingdom, the United States, Pakistan and the Ministry of Defence of Saudi Arabia.
- Development of curricula and practical training for the maritime institute and maritime training centres.
- A rise in the efficiency of maritime officers and NCOs through compulsory further training and practical experience gained from frequent sailing.

- Getting rid of all foreigners who were members of marine transport crews, except in the case of maritime ferries.
- Establishment of a radar network.
- Enabling maritime officers to lead the marine sectors
- Positive representation at all international martime conferences.
- Providing 2 marine cranes, each able to load 300 tonnes, to marine workshops in Jeddah and Dammam.
- The use of computers in all maritime activities.
- Decree permanent orders for the operation, maintenance and management of marine affairs.
- Development and standardization of the cycle of technical documents in all marine areas.
- Gaining experience in all marine disciplines (operation, maintenance, fuelling and leading).

It is clear that these have been a good and systematic process to the evaluation of the maritime arm of the SBG.
The process that have been outlined in chapter eight as a result of this research, together with the creation of technical groups etc, could be seen as a usefull contribution to a future stage 4 greatly facilitating the SBG s development.

4.2 Smuggling as a Potential Threat to the Security of Saudi Arabia

4.2.1 Inroduction

The Kingdom of Saudi Arabia remains an important country in the Gulf, as it is the only one of the three major Gulf countries which is irrevocably committed to the stability and security of the entire Gulf in general, and to Saudi Arabia in particular. This makes Saudi Arabia an attractive target, even more so in a period of oil glut and associated wealth. The Kingdom remains a key producer of oil in the Gulf and amongst the OPEC countries. The importance of Saudi Arabia lies not in its military strength but in its political orientation and economic resources. In recent years, Riyadh has been the world's most active capital in the search for means to dampen the self-destructive fires of conflict and to reinforce the stability of moderates and their ability to resist the pressure and attacks of extremists, revolutionary groups and smugglers.

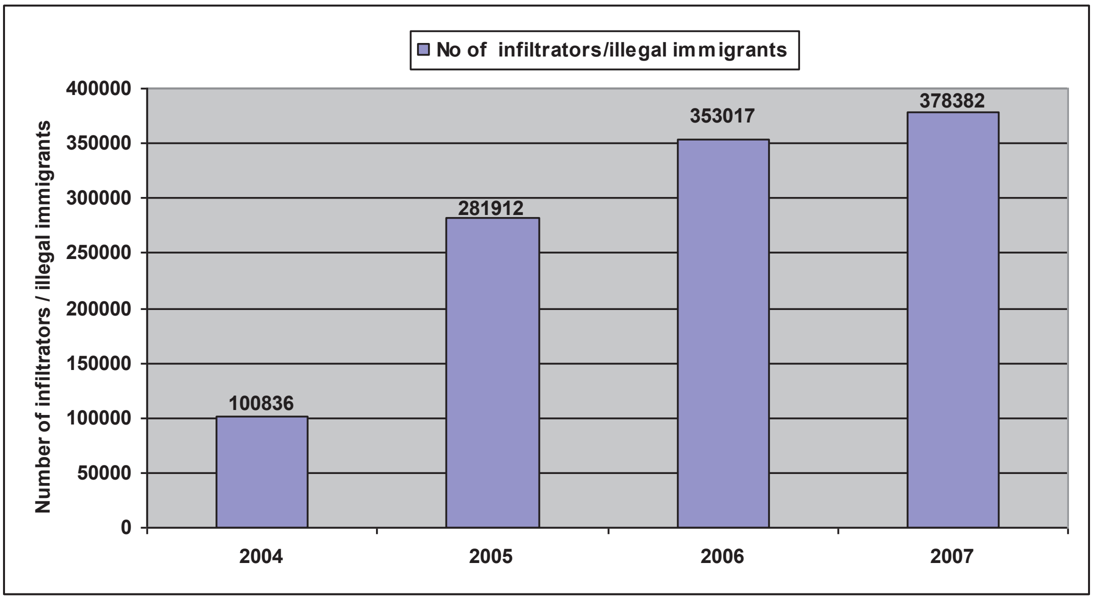
Smuggling can be defined as bringing in or out anything which is needed in desired in the country using unauthorized routes/methods and without paying the taxes and duties imposed by the government. It is an invention of modern times which began when governments started imposing restrictions on the traffic of different commodities needed inside the country. Some time ago, smuggling activity was viewed not just as an extra-legal activity but as a second best option to opening up the economy to an inflow of foreign goods. It has been thought that smuggling reduces distortion in resource allocation and increases consumer surplus. It has also been thought that smuggling does not lead to any loss of revenue because such goods are either placed on a negative list or imports are subject to prohibitive duties. However, all these arguments have been proven to be fallacious.

Smuggling is an activity that affects the Kingdom of Saudi Arabia. It started due to the vested interests of some greedy people. With the passage of time, it has gathered support of the masses because of their interest in earning or desire to buy cheaper items and avoid taxes. Many people are attached to this business, especially people who reside along the borders of the Kingdom. A particular problem is drug abuse, which has started to endanger and threaten the security of the Kingdom.

The Ministry of the Interior of the Kingdom of Saudi Arabia is responsible for controlling smuggling in the Kingdom using the security services. These security services are the Saudi Border Guard, whose mission it is to arrest intercepts and smugglers. Their conduct and responsibilities are mentioned in border security and executive regulations. In addition, customs officers are also involved in controlling smuggling. They work mainly at airports, seaports, and lands borders, checking all cargos and goods to discover if smuggling is taking place. They have good links with the SBG, especially at seaports and land borders. This work of customs officer and other law enforcement agencies is carried out in line with the teachings of Islam and in response to the service requirements of the country.

4.2.2 Smuggling items / Sources – Threat to Saudi

The Kingdom of Saudi Arabia is threatened by the smuggling of various items from different sources. These threats can include:



Year

Figure 4-1. The number of infiltrators / illegal immigrants to the Kingdom of Saudi Arabia from 2004 to 2007 reported (Saudi Border Guard) by land and sea.

4.2.3 Recommendations

Smuggling is considered an epidemic on our society, particularly as it has an obvious impact on the security and economic development of the Kingdom, as identified during the course of this research. It is therefore essential to make some recommendations to those responsible for working for the Saudi Border Guard, in particular to help them eradicate this menace effectively. The following recommendations can be made:

- Officers and enlisted personnel of the Border Guard should be trained in the fields of smuggling and ante- smuggling infiltration, as well as boarding of all types of marine vessels.
- Anti narcotics courses should be scheduled for Border Guard personnel so that they are familiar with the types of narcotics in circulation.
- A facility for recording all anti-smuggling activities and their success rates should be established for recording purposes and for future reference.
- The Border Guard should have an extensive and secret intelligence network covering the villages and cities near to the border.
- Large watchtowers should be installed near the land borders and coasts with powerful night vision and surveillance capabilities (i.e. powerful telescopes and binoculars).
- The SBG must have a strong and highly capable fleet to protect the SA coasts. The specifications of this fleet must be designed to meet all potential future challenges, as smugglers are constantly renewing their techniques and facilities using the latest equipment and technology. The SBG must clearly stay a head of the smugglers in capability, methods and organisation.

4.3 An Overview of the SBG Small Craft

The SBG has several types of small maritime craft to carry out certain tasks assigned to them. They include: -

- Patrol boats of all kinds,
- Fire boats,
- Rescue boats,
- A landing vessel,
- Tugboats,

- Ferry boats,
- Service boats, and
- A training ship.
- A limited number of yachts.

It is well known that patrol boats are the main type of small craft in the SBG fleet, and so the majority of tasks are assigned to them. The rest are mostly of a service type, but have to be available to the SBG in very limited numbers and with appropriate characteristics so as to participate in certain functions of the SBG.

In this section we will shed some light on the patrol boats that are currently used by the SBG so as not to widen the investigation too much. Navy patrol boats are divided into three types, depending on their range: -

- Short-range (<40 nautical miles),
- Medium range (approximately 150 nautical miles),
- Long range (from 150 to 700 nautical miles).

They are also divided according to length, as follows:

- Less than 15 metres,
- Between 15 and 25 metres,
- More than 25 metres.

In terms of hull material, they are either made of steel, aluminium, or fibreglass. The work of the SBG is assigned mainly to short range boats, most of which are made of fibreglass. However, medium range boats are specially designed for particular maritime sectors. Most of them are made of steel; however some are made of fibreglass. Long range boats are assigned to overall marine areas and are supported by some medium and short range boats in some cases, depending on the circumstances of each region.

4.4 Summary

The SBG currently equipped with an insufficient number of vessels that are outdated in the modern era and have limited support in the terms of maintenance, logistics and infrastructure. While the SBG organisation is able to manage all its vessels currently, there is very little capability for the real-time command and control of vessels or incidents once the vessel is at sea. Consequently, the SBG find it difficult to achieve its missions effectively against current threats which are becoming increasingly difficult to confront as the criminals and infiltrator have access to more advanced technology.

The SBG must sets out an ambitious target for the future. There must be new concept of operation calls for far-reaching changes within the SBG that, whilst they will yield great benefits will several years to implement and will require careful management. Changes are required in all the SBG areas such as training, manpower, logistics, management and infrastructure before any of the improved vessels, surveillance and command capabilities are procured.

4.5 Conclusions

In the Kingdom of Saudi Arabia there are comparatively vew illegal activities compared to many other countries in the world. However, smuggling is one activity that does exist in the Kingdom. It started due to the vested interests of greedy people and with the passage of time it has earned the support of the masses because of their interest in earning a livelihood and their desire to buy cheap items and avoid taxes. There are many people who are attracted to this business; especially people based along the borders of the Kingdom. Such people are almost completely dependent on smuggling. The Saudi–Yemen border, in particular, is notorious for drug smuggling. Due to this phenomenon, the size of the illegal economy is growing faster than the legal economy. Apart from causing large fiscal losses to the state, the underground economy distorts the incentive structure and growth of the economic system. This in turn, along with the menace of drug abuse, has started to endanger and threaten the very security of the Kingdom in general, and society in particular. The steps taken by the authorities of the Kingdom have so far been effective. However, as the smuggling business has taken a considerable time to establish itself, so too a considerable time and dedication is required in order to uproot and eliminate this evil.

5 CHAPTER Five: Methods of study

5.1 Introduction

The four main aims of the present study are to research and review information on small craft design, to review information about the Red Sea and other sea areas where the SBG operates a large number of its vessels, to define the SBG's responsibilities and problems in securing the borders, both land and sea and the sea ports of Saudi Arabia, and, finally, to undertake a survey and questionnaire regarding the current vessels . In addition to examine the requirements of the SBG in the future fleet, and then to synthesis the possible strategy of the future fleet precurment as shown in Figure 5.1.

5.1.1 Small Craft Design

Some important up-to-date information about the designing of various types of small craft is required before initial planning, including information on planning to build vessels, the requirement of building, and the purpose of the proposed vessels in terms of mission requirmentsl. Next there is a requirement for an appraisal of current shipyard practices, types of small craft, hull types, hull material design processes, and many details of small craft design including hull geometry, internal and external arrangements, the bridge, masts, propulsion and powering systems, etc.

5.1.2 Red Sea and Arabia Gulf

The Red Sea is considered to be one of the most dangerous of seas for navigation specifically in its coastal areas. Hence all physical information which will affect the design of vessels must be collected from different sources, specifically that about waves, currents, wind, temperatures, humidity and the sea environment topography, including the complex regions of coral reefs and drawn islands.

5.2 Data Collections From SBG Fleet and Serving Members

In order to make the study more successful, collecting data from the field of operations under investigation was seen as being essential, as was subsequently analysing the collected data as this would lead to identifying and defining the existing problems and deficiences and leading to the formulation of the required output from the project. The huge amount of data that was collected from the field, which involved surveying the SBG personnel over more than four months, resulted in achieving the aim of data collection of both the quantitative and qualitative types.

The actual questionnaire in this survey is designed due to the recommendation from SBG members, and my personal experience, in addation to previous survey all over the world. The questionnaire and survey procedure will be explained in detail in Chapter 6 and in this Chapter the process of developing the collection process and the approach taken is discussed.

The first step in order to collect the data as flows:

- Search the previous similar survey;
- Interview with some of the SBG members about their suggestaion about the question must be asked;
- Design the questionnaire and interview questions;
- Finall revise of the questionnaire;
- Define the survey time table;
- Get the agreement from the SBG to carry out the survey;
- Start the survey and solve the facing problems during the survey, including time limitations and achieve accurate answers.

During the field trip that was undertaken, data were collected about the current fleet specifications and of the SBG member's inservice difficulties in operating and maintaining their current vessels and in performing the SBG's mission of securing the borders and coasts of SA. Data was also collected from higher officials and commanders about their envisaged requirements for the future fleet. In addition to this, information was collected about the recent acquisition strategy that has been followed by the SBG in order to obtain new vessels. In order to help to analyse all this assembled data and information, the research then moved on to investigating various parts of the Red Sea and Gulf of Arabia.

5.3 Fieldwork

The fieldwork was undertaken between 15/11/2006 and 15/03/2007, and covered all of the SBG's stations along the coasts of both the Red Sea and the Gulf of Arabia, as well as at the headquarters of the SBG in Riyadh, the capital of Saudi Arabia. The initial starting point was the SBG's marine base in Jeddah, which is the largest marine base of the SBG in the Red Sea. Selection of this location was due to many reasons, the first being the location of the base in the middle of the Red Sea where the main marine workshops and marine stores of the SBG are situated. Secondly, it is at this base that all newly purchased vessels are received and initially trialled and tested. Also, most of the major maintenance work on vessels is carried out at this base.

5.4 Questionnaire About the Recent Fleet

5.4.1 Design and Selection of the Questionnaire

The reason for designing the questionnaire was to collect data from the SBG members, who are either working on board and in offices, in order to analyse these data and to define the shortages in the current fleet and provide input to the future requirements. Selection and designing of this questionnaire according to the SBG official's recommenditions and other survey questionnaire as carried out by many other researchers.

'When the survey was started, and the questionnaire was distributed, it was assumed that it would not, in some cases, receive serious and well thought out answers. However with the careful selection of the most appropriate members of the SBG, both officers and crew ranks, and the spending of a sufficient amount of interview time with each of them, and in trying to justify to them the importance of the survey and of the benefits to the SBG, this hopefully went some way to ensuring that a good percentage of the responses were of good and fair quality.

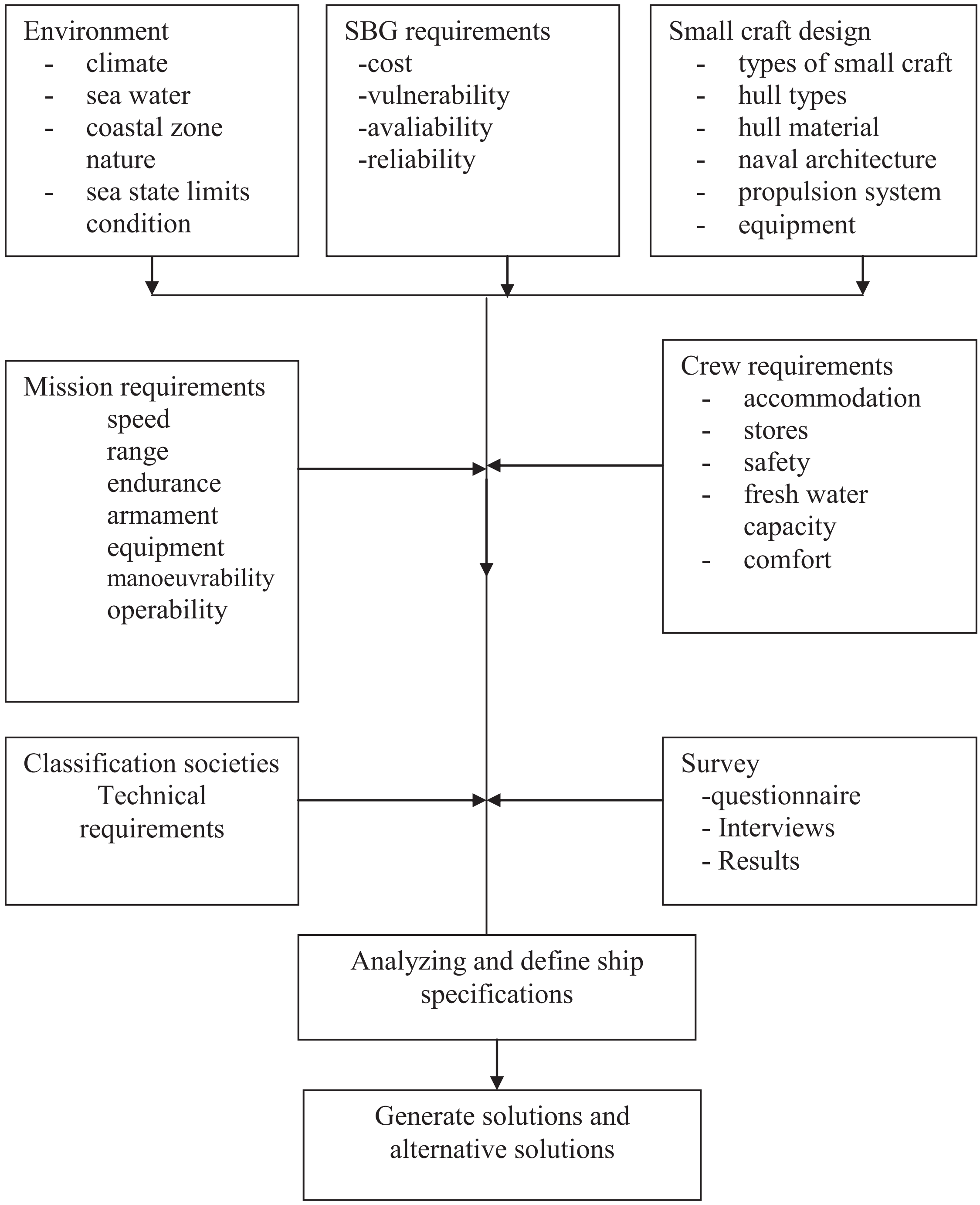


Figure 5-1. Overview of method to determine the requirements in small craft design of the SBG

In this survey the SBG involved devidied into three groups according to the rank and occupations as follows:-

- commanders (those who are working in offices and officers on board, of different occupations including, navigational, engineering and captain of the vessel,
- technicians (working in marine workshops), and
- crews, (including navigation, mechanical, electrical, etc.

The questions distribution to the members according to their jobs,(for example, the technician answer the questions of technical side, etc).

The survey was for all types of patrolling vesels operated by the SBG, with different ranges. And selection of the surved members was according their experience and according the officials and captains of the vessels.

This questionnaire was designed to know about the member's qualifications and level of experience, etc in addition to the data of the current fleet specification and then their responsive answer about these vessels.

The questionnaire consisted of three main parts. The first part was related to general information about vessel lengths and their nominal range, speeds, endurance and crew numbers, etc. The second part parts focussed on specific SBG members who were given a questionnaire to answer asking for data related to their age, education level, level and years of experience, etc. The third part was divided into the following sections:

The first section asked general questions about the satisfactory maintainability, survivability, and operation of the vessels. Theses questions are answered by all the involved members.

The second section asked about the stability, manoeuvrability and mission requirements of vessels, including an overview about the speed and control of their vessels in all circumstances. And these questions are answered by the commanders and crew only.

The third section of the questionnaire asked about crew requirements, in particular accommodation, space, storage, tank capacities, noise levels, internal arrangements, and climate. And these questions are answered by the crews.

The fourth section contained questions about vessel geometry, superstructure, deck height and space, deck area, and handling during operations. And these questions are answered by the crews.

Powering and propulsion systems were investigated in the fifth section, which gathered information about quality, operation and maintenance of the powering and propulsion systems.and these questions, are answered by the technichins and crew.

And finally the required future fleet specification are answered by the the high officials and crew.

5.5 Questionnaire About Future Fleet Characteristics Required by the SBG Members

The second main part of the field trip covered the SBG's assessment according to the member's impressions and experence of its future fleet specifications and requirements in order to enable crews to perform the SBG's tasks and responsibilities efficiently. The questionnaire was designed carefully to obtain from the SBG members their personal opinions about the most suitable vessel specifications for future requirements, and get their answer about the suggested alternaves whether to improve the current fleet specification or the new proposed vessls. The questionnaire was divided into three parts and the same questions were asked in each of the three parts with regards to long, medium, and short range vessel specifications. These parts contained questions about the geometry, missions, and crew requirements for the future fleet. In addition, the members who were asked to answer the questions were grouped according to their personal resposibility, experience and education levels.

The third part of the field trip collected information about the recent procedures followed by the SBG in order to purchase and commission new vessels, including initial planning, asking for proposals, analysing of proposals, selecting the right proposal, supervision during building, and receiving procedures. Finally, as the aim of this study is to define the negative and positive aspects of past and current SBG procedures for securing and analysing received proposals, by investigating the archives of the SBG during the field trip, including the contracts and procurements procedure since 1978 to 2004, and for all the vessels types and sizes.

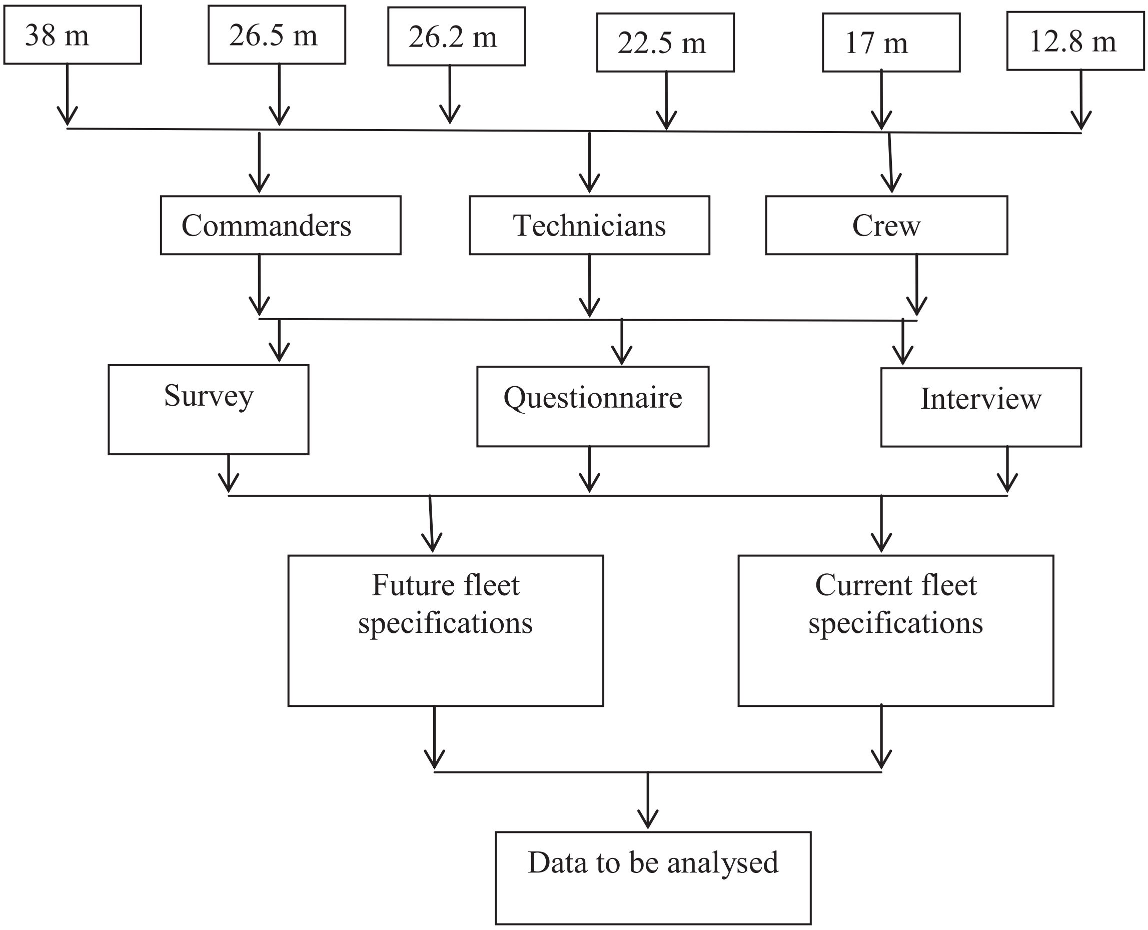


Figure 5-2Data collecting process from the SBG members

5.6 Survey Design Process

The aim of the survey was to collect data and information that would provide valuable input for the preparation of future 'requests for information' and for creating new vessel 'specifications as shown in Figure 5.2.

5.6.1 Objectives of Evaluation of Survey and Questionnaire

The objectives of this study are to compare the future fleet specifications namely long, medium and short vessel length and operation ranges between crews and commanders regarding the several aspects mentioned in Appendix B.

5.6.2 Study Hypothesis

5.6.2.1 The Null Hypothesis

It is assumed that there are no significant differences between commanders and crews regarding their opinions and expectations, according to their levels of technical knowledge and service experience, about the composition of future fleet specifications.

5.6.3 Materials and Methods for Interview Questionnaire

5.6.3.1 Background Considerations

The SBG performs many tasks, among them the patrolling regions of the Red Sea, particularly the Kingdom’s regional and coastal waters. This requires a strategic study of naval vessel and logistics vessel design so that they can meet the requirements of the missions undertaken by the SBG in both the Red Sea and the Gulf of Arabia, where the requirements can significantly vary. This survey was undertaken to obtain an overview of the problems facing the SBG and their valuable opinions and expectations for their future fleet.

5.6.3.2 Study Design

A prospective case control design was used by interview questionnaire survey including two groups of workers. The results can, in general terms be considered in two basic categories, as illustrated in the following figure.

This figure illustrates how the survey methodology developed, first of all and the main point, is how to get the opinion and reflectionss of the current crews about the vessels in the current fleet in order to help to define the potential requirements for the future fleet specifications.

As illustrated in Figure 5.3 the procedure of implication projects these results for new vessels for the SBG. The collected data of both qualitative and quantitative forms from the survey in addition to current fleet general specification and the SBG officials recommended requirements in the future fleet specification, and their analyses results will be given to the designers for the future fleet proposals in the early stage of planning to design.
The designer may use these results to define or redefine requirements of the SBG, itsmission and crew requirements of the future fleet, including hull material, hull geometeric, internal arrangements, deck area, stores, tanks, etc.

The amount of change which will be clear in the field trip results of the current specifications and potential required specification of the future fleet can be judged by the SBG procurement committee.in order to fefine the real future requirements of the future fleet.

5.6.3.3 The SBG Committees (SBGC)

The study was approved by the SBGC. All participants involved in the survey agreed to participate in the research after a full explanation and a comprehensive reading about the rationale of the study were provided to them. All participants were assured that their answers would be kept confidential and that their names would not be shown. All participants were assured that they could withdraw from the study at any time without giving a reason. They were also assured that they had the choice to avoid any question, either partially or completely, without prejudice.

5.6.3.4 Study Methodology for Future Fleet Specifications

An interview questionnaire was also used to collect information from 20 offficals of the SBG, in addition to the other questions that were given to other members in the survey questionaire. The interview questionnaire used in the study is presented in the appendix D .

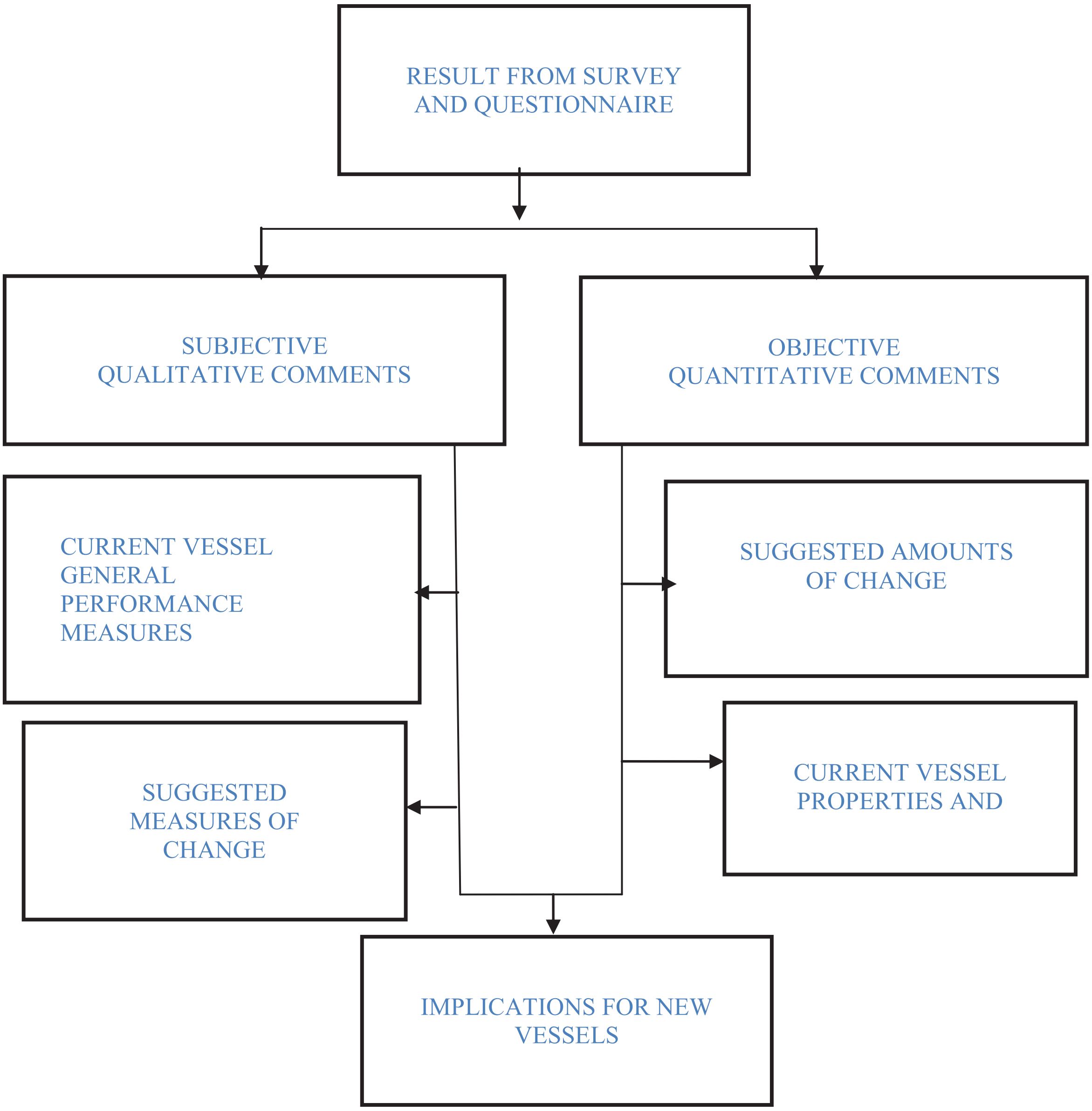


Figure 5-3. Implications process for new vessels for SBG

The interview questionnaire was designed to collect two types of data: personal to be related information and suggested specifications for the future fleet.

Specifications for the future fleet were suggested by 20 commanders each having at least 18 years of experience. They covered the following three vessel operational length ranges according to the SBG current vessels, specifications which are divided into three ranges according to the SBG current practice, these ranges named within the SBG:

- Long range,
- Medium range,
- Short range.

And according to the SBG archives the long range are the vessels of more than 30m in length, however the medium fall between 15 to 29 m in length and the short range is for the vessels of less than 14 m in length.

5.6.3.5 The Methodology of Interview Questionnaire Distribution

The interview questionnaire was distributed in advance to all respondents with a covering letter from the researcher explaining the purpose of the study and any other requirements that were needed. All respondents were interviewed in a calm room where their valuable comments were carefully considered and recorded, these steps were taken to increase the quality of the responses.

5.6.3.6 Power Calculation and the Statistical Analysis of the Study

A relevant estimate was considered to obtain the most accurate responses by selecting the most expert commanders and crews who had achieved a good level of education and experience. All data entry and data analyses were performed using a computerised package (SPSS 17.0, SPSS Inc., Chicago, IL, USA). All data were entered into an SPSS file.

5.7 Summary

In this chapter the details of the method of study was has been summarised including collecting the data from the environment where the SBG operate their fleet, small craft design definitions, and then designing the questionnaire of the survey which carried out with the SBG members and then finally the procedure of analyses the collected data.

In the survey also a wide study of the previous archives of the procurement of the current vessels was made in order to improve and develop these procedures.

5.8 Conclusion

The aims of designing of this method of study was to defined the general aims and objectives of this interview and questionnaire based research, including how the process of research will be undertaken, and how to start and complete the research.

The first step is to define the aims of all this research and then details of all the method items, including the small craft definition and design process, environments where the SBG operate their fleet, survey about the current points of view about the fleet currently operated by the SBG including, the advantages and disadvantages of mission requirements, the SBG requirements including reliability, survivaibility, maintainability, economy operation and performance, etc.

So the main objective of this method finally is to build an strategy for the future SBG requirements in vessels (small craft) design, including the internal arrangements, deck area, stores, etc.

These survey results can be improved by further surveys and research in order to get the best results, and this can done through many processes, including improving the questionnaire, grades of members of the SBG , the qualifications of members , the experience , and repetations of surveyor members.

In the next chapter which is the field trip result which contain the views and observations of the SBG members about the current fleet specifications and their requirement in order to improve the future fleet specifications.

These results can be taken in consideration during the planning for future fleet specifications, including all the requirements for all the factors that influence the designing of the future fleet for the SBG. Finally this method will give complete picture of the most appropriate strategy for the future requirements.

6 CHAPTER Six: Field Trip Results

6.1 Background Considerations

The area of the Red Sea under the control of the Saudi Border Guard (SBG) is very large, estimated at 46000 square nm. If we consider the geographical and climatic nature of the Red Sea coast region we find that the boats that are currently operated by the SBG to achieve its tasks in the Red Sea could benefit from a re-evaluation of their specifications, taking into consideration the local and international situation, current and future trends and of the SBG's mission.

It is necessary to carefully consider the officer and crew experiences of operation and maintenance of the current fleet, in addition to the selection and definition of specifications and dimensions of boats that will be suitable for all tasks, starting from material selection, hull form and dimensions, mission requirements, crew requirements, economic issues, maintenance, and all other factors. The environment of the Red Sea due to the random spread of coral also has to be considered as it makes navigation difficult and hazardous by day and by night. In addition, the Red Sea suffers from high temperatures, high humidity and high salinity which reduce the life expectancy of the vessels. Additionally, international developments and the ease at which smugglers are obtaining increasingly faster boats make protection procedures very difficult to uphold. Therefore, renewing and re-planning the strategic requirements of vessels are increasingly important.

When planning the design of new vessels for the SBG, several investigations are highly desirable due to the vast areas of the Red Sea and the Gulf of Arabia that these vessels must patrol and control. It is possible for almost any type of vessel to work in this environment, but the best boat is one with a long life expectancy and that is suitable for efficiently and economically working in the hard environment of the Red Sea area. A boat that is also economical to crew and operate is more suitable for the SBG's tasks. Obviously the vessels must also have the required performance and on-board equipment capabilities.

When focussing on the SBG's requirements in terms of vessel design, special consideration should be given to the requiremenst of high speed and the ability to manoeuvre in difficult and adverse circumstances. Due to the high speed vessels that are used by the smugglers, the SBG must use faster and stronger vessels in order to protect the coasts of the Saudi Arabia,

Due to the widespread presence of sharp and solid coral reefs the least possible draught is necessary particularly in such littoral operations and employing smaller in-shore vessels. However, reducing the draught will affect both the static and the dynamic stability, the manoeuvrability and anchorage at sea for long periods, as well as the safety and comfort of the crew. The required hull material and many other questions must be taken into consideration at the early stages of planning and design.

6.2 Aim of the This Chapter

The aim of this chapter is to analyse the data which was collected during the field trip of both the current fleet specifications and the requirements of the future fleet. By using suitable software for the analyses, the results can be provided to the SBG procurement committee to help to decide the general requirement and then to the designer which can help to define the geometric, internal arrangement, tanks capacity, mission requirements, etc.

6.3 Materials and Methods for Questionnaire

6.3.1 Study Design

A prospective case control design was used by the questionnaire based survey including three groups of workers and six different sizes of vessels covering the three patrol ranges.

6.3.2 Study Methodology

A questionnaire was used to collect information from 234 officers, crew members and technicians working for the SBG, in addition to the individual interviews with 20 high officials who were working in the headquarters. The questionnaire that was used in the study for the commanders and crews is presented in Appendix D. (Obviously this is a larger number than the 30 interview process)

The overall questionnaire design included two parts:

- Current fleet specifications,
- Future fleet,

The questions were divided into three main categories (namely general ship and personal data for establishing the context of the responses in the actual questionnaire):

- Related currently serving on vessel information,
- Personal information, and
- The questionnaire itself.

The questionnaire and interviews, with the SBG members, are whether to improve the current fleet specification and their suggesttions of improvements, or only improve these requirements in the future design.

6.3.3 Sampling Procedure and Data Collection for all Cases

The study subjects were selected from three important and distinct groups and consisted of commanders, crew members and technicians working for the SBG. Overall, a total of 234 questionnaires were sent out to individual members composed of the three groups (58 questionnaires for each subjected group). All of the selected subjects were currently working in one of the six vessel sizes/lengths (three different operating ranges) with each different specifications and characteristics, namely vessels of 38m, 26.5m, 26m, 22m, 17m and 12m in lengths (13 questionnaires for commanders, 13 for crew members, and 13 for technicians in each vessel category). The study aimed to receive at least 141 responses (i.e. a response rate > 60%). All cases were considered to be controls for each other regarding vessel length (commanders vs. commanders, crews vs. crews and technicians vs. technicians).

6.3.4 The Methodology of Questionnaire Distribution

The questionnaire was sent out to all workers with a covering letter from the researcher giving full details about the study and any other requirements that were needed. A pre-paid reply envelope was sent out with the questionnaires; these steps were taken hopefully in order to increase the number of responses. All subjects also received an information sheet explaining the purpose and scope of the overall study and with a summary protocol. Subjects who did not respond immediately were sent out other related documents so as to increase the chances of improving the response rate.

6.3.5 Statistical Analysis of the Study

A power calculation and an estimate of the expected response rate to the postal questionnaire were used to determine the minimum number of responding subjects needed for the study.

6.3.5.1 Statistical Power Calculation

It was assumed that 75% of cases would respond to the questionnaire. For adequate power, the study would therefore need at least 141 subjects to have responded to the questionnaire so that they could be compared with each other. And as explained in the appendixB there was a reasonable respons from the SBG members.

6.3.5.2 The statistical Analysis of the Questionnaire Results

Statistical analysis is a very important tool for an engineer's evaluation of collected data as it allows the engineer to consider every element that may affect the design. By using statistical analysis we can predict whether the design is probably more likely to be a success or to be a failure. If failure is predicted then one can plan accordingly and take appropriate re-design or rectification actions. Combining deterministic analysis tools, combinatorial possibilities and probabilistic analyses gives the designers the opportunity to utilize their experience and exercise their judgment in the most meaningful way to influence the success of a design activity.

All received data was entered and subsequent data analyses achieved using the computerised package SPSS 15.0 (SPSS Inc., Chicago, IL, USA). Frequencies, descriptions, cross tabulation, McNemar, and Chi squared tests were performed for categorical data, and student's t-tests for ordinal data between subjects of different vessel ranges and/or between workers. In addition, the service time spent working on boats and workers' experience were also counted.

6.4 Results and Conclusions

6.4.1 Long operating Range Vessels for the Future Fleet

There was agreement between commanders and crews regarding the appropriate length of vessels in the long range category of the future fleet, with the average ranging between 40.2m and 65.6m. There were significant differences in opinions regarding the appropriate beam of vessels in the long range category of the future fleet between commanders (mean 11.6 m) and crews (mean 8.3 m); however, both groups of participants agreed that the beam of their vessel should not be less than 8m nor more than 13.5m. These results from the SBG members are according to their impression because there had not been any survey carried out in the past. In order to assist in deciding the length, breadth, drauaght, etc. for the future fleet, the feedback from the current fleet specification is important, in addition to their personal impression about the future fleet specifications.

	The SBG Members												
		1	2	3	4	5	6	7	8	9	10	AV	T AV
L (m)	CO.	50-60	50-70	50-70	40	45-60	60-65	35-45	35-45	40-50	40-60	41.4	40
	CR.	40-50	50-55	45-60	38	40	35-40	30-40	30-40	40-60	38	38.6	
B (m)	CO.	8-12	8	10-14	8-10	12	12	7-11	12	10	10	9.55	9.27
	CR.	7-9	8-10	6	10	10	8-12	8-10	10	10	8	9	
S (kts)	CO.	40-60	45	40-55	40-60	40	50	55	40-60	40-6-	40-60	48.75	47.2
	CR.	50	50	45	40-50	45-50	38	45-50	45-60	40	45	45.8	
R (NM)	CO.	2000	2500	2500	2500	3000	3000	3500	1800	2000	2000	2480	2365
	CR.	2500	3000	3000	1500	2000	2000	2500	2000	2000	2000	2250	
H M	CO.	S C	S C	S C	S C	S C	S C	S C	S C	S C	S C		S C
	CR.	S C	S C	S C	S C	S C	S C	S C	S C	S C	S C		
C N	CO.	20-35	30	20-25	25-40	25-45	25-35	35	35	35-45	30	32	33.1
	CR.	20-30	25-40	20-40	30-40	30-40	35	40	40	30-40	30-40	34.25	

L: length B: breadth m: metre kts: S: speed R: range HM: hull material CO: commanders
CR: crews AV: average NM: nautical miles C N: Crew number SC: Steel compositions TAV:total average

Table 6-1The SBG' members their general requirement of the long range future fleet

There was agreement between commanders and crews regarding the appropriate draught of vessels in the long range category of the future fleet that it should meet society rules, but should not be less than 1.9m nor more than 3m. There was also agreement between commanders and crews regarding the maximum speed of vessels in the long range category of the future fleet, with the suggested maximum average ranging between 45.6 knots and 49.8 knots. Moreover, there was a broad agreement between commanders and crews regarding the number of crew members working on board a long range vessel in that there should be between 20-37 .

These personal impressions about the future fleet are according to their experience, in the SBG mission operations and environmental requirements where these vessels will operate.

Although the majority of commanders believed that the endurance of vessels in the long range category of the future fleet should be for at least 30 days and up to 38 days, 50% of crew members suggested that 20 days was enough, while the other 50% were in agreement with the commanders. There was agreement between commanders and crews regarding the normal operating range of vessels of the future fleet (long range) category with averages of 3575 and 3265 nautical miles respectively.

The huge area which is covered by the SBG fleet, which leads to the need to increase the endurance and range, such requirements lead to the need to, carefully define the internal arrengements, with adequate tanks capacities, etc.

There was an agreement between commanders and crews regarding the use of a steel alloy as the suitable hull material for vessels in the future fleet (long range), and 20% of the crew members suggested a high strength steel. There was also agreement between commanders and a crew that a diesel or diesel-electric propulsion type of engine should be is used with a pod propulsion system. Moreover, there was agreement between commanders and crews about crew accommodation requirements of vessels in the future fleet (long range) category in that the space provided should be sufficient for the crew as well as spare capacity for any persons who may be rescued. Other standard spaces for similar length military ships should also be in place.

There was agreement between commanders and crews that the bridge dimensions of vessels in the future fleet (long range) category should be within the limits of military bridge requirements and normal ship standards, allowing sufficient space for commanders and other operating crew members to move safely inside the bridge. There was also agreement between commanders and crews that the superstructures of vessels in the future fleet (long range) category should be made of an aluminium alloy or any other strong material that is adequately resistant to on-board fires. Moreover, there was agreement between commanders and crews that the superstructure height of vessels in the future fleet (long range) category should be within the standard set for military vessels of the same length. A medium superstructure height above the deck of 3.8m will allow crews to see over a wide sea area. Although the bridge must be higher, commanders and crews agreed that the superstructure height must not affect vessel stability.

Due to the hot weather conditions of the seas surrounding Saudi Arabia, there was agreement between commanders and crews regarding the need for more fresh water storage capacity than is currently usual. This should match the number of crew and the vessel's endurance. So, the increased fresh water tank capacity and its location must be sufficient for the endurance and there must also be distillation of sea water facilities to replenish the tanks.

There was agreement between commanders and crews on the fuel tank capacity and that their storage location in vessels of the future fleet (long range) category must be away from flammable and hot areas. There was also agreement between commanders and crews that vessels in the future fleet (long range) category should be faster and stronger in order to allow them to attack enemy vessels or to be able to follow these vessels in the open sea. This would also help with rescue operations of ships in distress in the open sea. The strategy of the SBG must comply with future security requirements of coastal as well as open sea areas (i.e. it must cover the whole of the Red Sea coast region, amounting to more than 2000km from south to north, without re-supply).

6.4.2 Medium Operating Range Vessels for the Future Fleet

There was agreement between commanders and crews regarding the suitable length of vessels in the medium range category of the future fleet, with the average ranging between 23.75m and 38m. There were significant differences, however, in opinions regarding the appropriate beam of vessels in the medium range category of the future fleet between the commanders (mean 5.75 m) and crews (mean 6 m); however, both groups of workers agreed that the beam of their vessel should not be less than 5.85m nor more than 8m.

		The SBG Members											
		1	2	3	4	5	6	7	8	9	10	AV	TAV
L	CO.	20-30	15-30	20-40	20-40	30	25	20	20	15-25	20-30	23.75	
(m)	CR.	20-40	17-30	20-30	25-30	20-30	35	35	30	25	2O	27.1	25.4
B	CO.	6	5-6	6-8	6-8	5-7	5	4-5	4-5	4-7	6	5.75	
(m)	CR.	5-7	5-6	5-6	6	6	6	7-8	6	5-7	4-6	6	5.85
S	CO.	50	45	50	50	50-60	50-60	55	55	45	45	50.5	
(kts)	CR.	45	40-45	45	50	50	55	50	50	45	45	48.25	49.3
R	CO.	1000	1500	1800	1800	1500	1200	800	800	1000	1300	1270	
(nm)	CR.	1800	1500	2000	2000	1000	800	700	1000	1000	1000	1280	1275
H M	CO.	ALM	ALM	SC	SC	ALM	ALM	ALM	ALM	ALM	SC		
	CR.	SC	ALM	ALM	ALM	SC	ALM	ALM	ALM	FIBER	FIBER		
CN	CO.	6-22	5-20	6-22	6-15	6-22	8-25	8-25	25	25	20	16.3	
	CR.	6-20	6-18	8-20	12-22	6-18	25	23	20	25	20	18.1	17.2

L: length B: breadth m: metre kts: S: speed R: range HM: hull material CO: commanders CR: crews AV: average NM: nautical miles C N: Crew number SC: Steel compositions TAV: total average

Table 6-2The SBG members' requirement of the future medium range fleet

There was agreement between commanders and crews regarding the appropriate draught of vessels in the medium range category of the future fleet that it should meet classification society's rules, but should not be less than 0.75m nor more than 1.90m. There was also agreement between commanders and crews regarding the speed of vessels in the medium range category of the future fleet, with the suggested maximumaverage ranging between 45 knots and 60 knots. Moreover, there was agreement between commanders and crews regarding the number of crew members working on board a medium range vessel in that there should be between 10-25 .

The vessels within this range normally operate in sea waters close to the coast where the requirement of low draught is nessary due to the local navigational difficulties. As well the high speed is required also because most of SBG tasks within this range are due to the, rescue operations, vessel and cargo inspections, etc.

Although the majority of commanders believed that the endurance of vessels in the medium range category of the future fleet should be for at least 700 nm and up to 2000 nm, however 90% of crew members suggested that 3 days or 1280 nm was enough, 10% mentioned more days and upto 2000 nm, 80% agreed with the maximum endurance suggested by the commanders of 1270 nm. There was agreement between commanders and crews regarding the operating range of vessels in the future fleet (medium range) category, with averages of 1275 nm. That means there is complate agreement between the members about the operating range of the vessels in this range (medium), and this may be due to the area of sea water area covered by these vessels in each sector of the Red Sea and Gulf of Arabia, which is more than 1000 nm patrol length of both sector.

There was agreement between commanders and crews regarding the use of steel or aluminium alloy, or any other strong metal as hull materials of vessels in the future fleet (medium range category), and 70% of crew members and 30% of commanders suggested the use of high strenght steel. There was also agreement between commanders and crews that a propulsion type of engine should be used with a normal propulsion system. Moreover, there was agreement between commanders and crews about crew accommodation requirements of vessels in the future fleet (medium range category) in that the space provided should be sufficient for the crew as well as spare capacity for any persons who may be rescued.

Of course some special questions were answered only by the responding members according to their specific occupation, for example, hull material type, propulsive type, etc.

There was agreement between commanders and crews that the bridge dimensions of vessels in the future fleet (medium range category) should be within the standard set for military vessels, allowing sufficient space for the crew to move easily and safely inside the bridge. There was also agreement between commanders and crews that the superstructure materials used for vessels in the future fleet (medium range category) should be aluminium alloy or any other strong material adequately resistant to on-board fires. Moreover, there was agreement between commanders and crews that the superstructure height of vessels in the future fleet (medium range category) should be within the standard set for military vessels of the same length. A medium superstructure height of 3.8 m (the same as in the long range vessels) can give crews a maximum overall sea viewing area. Although the bridge must be higher, the commanders and crew members agreed that the superstructure height must not affect the vessel's stability.

Due to the hot weather conditions of the seas surrounding Saudi Arabia, there was agreement between commanders and crews regarding the need for more fresh water storage capacity than is usual. This should match the number of crew and the vessel's maximum endurance. So, the fresh water tank capacity and its location must be sufficient for the endurance and there must also be facilities for the distillation of sea water.

There was agreement between commanders and crews on the fuel tank capacity and that their storage location in vessels of the future fleet (medium range category) must be away from flammable and hot areas. The SBG's vessels operate in approximately one third of the area of the Red Sea, and so the capacities of fuel and water tanks, stores and accommodation must meet the maximum requirements of the missions being undertaken. If used in the north of the Red Sea the hull material of vessels must be strong due to the presence of coral reefs and shallow water as this may lead to a high potential for damage to the side and bottom regions. In the south of the Red Sea, fibreglass is best because the water there is very saline. Aluminium alloy is also good in this case. There was agreement between commanders and crews about other requirements of vessels in the future fleet (medium range category), such as they should be faster and stronger to meet the future challenges of terrorism and allow for an increase in the number of people who enter the sea for fishing, leisure and picnicking.

6.4.3 Short Operating Range Vessels for the Future Fleet

There was agreement between commanders and crews regarding the appropriate length of vessels in the short range category of the future fleet, with the average of less than 15m. There were similarities in the opinions regarding the appropriate beam of vessels in the short range category of the future fleet between commanders (mean 3.15m) and crew members (mean 2.9m). Both groups of workers agreed that the beam of vessels should not be less than 2m and not more than 4.5m.

There was agreement between commanders and crews regarding the appropriate draught of vessels in the short range category of the future fleet that it should meet society rules, but should not be less than 0.5m and no more than 0.75m. There was also agreement between the commanders and crews regarding the maximum speed of vessels in the short range types of the future fleet, with the average value ranging between 40 knots and 60 knots. Moreover, there was agreement between crews and commanders regarding the number of crew members working on board short range vessels in that it should be between 2 and 7.

		The SBG Members											
		1	2	3	4	5	6	7	8	9	10	AV	TAV
L	CO	7-16	11-19	7-16	8-15	7-16	7-16	7-20	7-20	20	18	13.75	12.6
(m)	CR.	10-20	8-15	10-15	8-16	10-20	15	17	15	12	10	11.5	
B	CO	3	2	4	3.5	2.5	3	3.5	3	4	3	3.15	3.025
(m)	CR.	4	3	3	3	3.5	3	2	2.5	2	3	2.9	
S	CO	40	50	40	45	45	50	55	60	60	55	50	51.75
(kts)	CR.	50	50	45	50	45	55	55	60	60	65	53.5	
R (h)	CO	8	12	24	12	12	14	20	24	12	24	15	15
	CR.	6	12	12	10	12	15	20	20	24	12	14	
H M	CO	FRP	FRP	FRP	FRP	FRP	FRP	FRP	FRP	FRP	FRP		
	CR.	FRP	FRP	FRP	FRP	FRP	FRP	FRP	FRP	FRP	FRP		
CN	CO	3-6	4-8	3-6	3-6	3-6	3-5	3-7	3-7	4-6	3-6	5	5
	CR.	3-6	3-6	2-6	4.8	3-7	2.5	3.6	4-6	4-6	3-6	5	
L: length B: breadth m: metre kts: S: speed R: range HM: hull material CO: commander CR: crew AV: average h : hour													

Table 6-3the short range future fleet requirement of the SBG' members

Although the majority of commanders believed that the maximum endurance of vessels in the short range type of the future fleet should be at least 15 h and up to 24 h, 60% of the crew members suggested that 12 h was sufficient. There was agreement between commanders and crews regarding the range of vessels for the future fleet (short range category), with averages of 150 and 300 nm respectively.

There was agreement between commanders and crews regarding the use of fibre reinforced plastic as the suitable hull material for vessels in the future fleet (short range category). There was also agreement between commanders and crews that the propulsion system used for vessels in the future fleet (short range category) should be both of the outboard type and inboard.

Selection of a structurally adequate material (normally some forms of FRP composite construction), which can protect the hull from grounding by coral reefs, shallow waters, and resulting in some forms of damage of the vessel bottom is essential.

Normally these vessels operate very close to the coast and are normally only used for one day patrols; thus, their general facilities must meet these requirements. There was an agreement between crews and commanders that crew accommodation of vessels in the future fleet (short range category) must be sufficient enough for the crew as well as for people who they may be called upon to rescue. Also, other standard spaces similar to military ships of the same length should be provided, taking into consideration spaces required for emergency and rescue operations.

There was agreement between commanders and crews about the bridge dimensions of vessels in the future fleet (short range category) in that they should be within the limits of military bridge requirements and ship standards. The higher the bridge the better as it allows the crew to observe a larger sea area. There was also agreement between commanders and crews that the superstructure materials used for vessels in the future fleet (short range category) should be fibreglass. Moreover, there was agreement between commanders and crews that the superstructure height of vessels in the future fleet (short range category) should be meet the standards of military vessels of the same lengt. Although they stated that the bridge should be as high as possible, the commanders and crews agreed that the superstructure height must not affect the vessel's stability.

Due to the hot weather conditions of the seas surrounding Saudi Arabia there was agreement between commanders and crews regarding the need for more fresh water storage. Thiurrent practise should match the number of crew and the vessel's maximum endurance. So, the fresh water tank capacity must be sufficient for the endurance. There was also agreement between commanders and crews that the fuel tank capacity and location onboard vessels of the future fleet (short range category) must be sufficient for the range. These types of vessels operate very close to the coast so the draught must be the lowest possible, they must be able to reach high speeds, and they must have a strong fibreglass hull. There was agreement between commanders and crews about other requirements of vessels in the future fleet (short range category), such as they should be faster and stronger and with less draught in order to help to avoid accidents and grounding.

6.5 Overall Summary of Results and Conclusions on the SBG Current Fleet Survey

6.5.1 Summary of Results

More details of this survy

Of the overall 234 questionnaires which were sent to the potential participant population who are working in the Saudi Border Guard (SBG), 201 responded (85.9%). However, only 180/234 (76.9%) are included in the analysis results due to high number of incomplete answers or missing the response to a few questions (more than 20%) from some participants.

One hundred and eighty responders (76.9%), who answered 80% of the questions or more, were included in the analysis (inclusion criteria). These involved the commanders, the crews and the technicians (60 off of each). Six types, by length, of vessels were included in this survey, these are 38, 26.5, 26, 22, 17 and 12 metres in length. The inclusion criteria considered the need to acquire ten questionnaire result sets for each of the commanders, crews and technicians in each of the six vessel types.

Table 6.1 shows the distribution of the questionnaires sent to the selected 234 individuals in the six vessel types, together with those who responded initially and those who were considered in the final response rate and who were included in the subsequent analysis. All participants in this survey were males.

6.5.2 General Information

Of the 180 individuals participated in this questionnaire survey, and finally used for analyses, 60 of each group of commanders, crews and technicians were included.

Of the 180 responders to the questionnaire survey analyses, 10 (5.6%) were in the age band 18-24 years, 67 (37.2%) in the age band 25-34 years old, 78 (43.3%) in the age band 35-49 years old and 25 (13.9%) older than 50 yearsTable 6.1 shows that the majority of commanders and technicians were in the older age groups (≥ 35 years old). This is to be expected in that both commanders and technicians need to be well experienced in order to accomplish their tasks adequately. Clearly the experienced responders will be able to recognise and understand the aims of this research. This age experience related term was not valid for crews where the majority were in the younger age group (≤ 34 years old). These differences regarding age between commanders, technicians and crews are statistically significant (Pearson Chi-Square, $p < 0.001$). The service experience of the members, in addition to their qualifications, is very important, in order to provide reasonable answers. Figure 6.1 illustrate the age distribution.

<table>
<tr><td>NUMBER OF THE INDIVIDUALS WHO WERE SENT THE QUESTIONNAIRE (SBG WORKERS)</td><td colspan="2">234 QUESTIONNAIRES (Q)
39Q IN EACH VESSEL TYPE (6 LENGTH TYPES)
13Q FOR EACH OF COMMANDERS, CREWS AND TECHNICIANS</td></tr>
<tr><td>Initial Response Rate</td><td colspan="2">201/234: 85.9%
35q in vessel 38metre (m), 33q in v 26.5m, 32q in v 26m, 34q in v 22m, 34q in v 17m and 33q in v 12m.</td></tr>
<tr><td rowspan="2">Number of excluded questionnaires</td><td rowspan="2">21
questionnaires</td><td>9q: incomplete answers and missing questions (more than 20%): 3q in v 26.5m, 2q in v 26m and 1q for each of the remaining four types.</td></tr>
<tr><td>12q: excluded randomly to have equal comparison: 4q in v 38m, 3q in v 22m, 3q in v17m and 2q in v 12m.</td></tr>
<tr><td>Final Response Rate</td><td colspan="2">180/234: 76.9%</td></tr>
<tr><td>Distribution of the Final Response Rate</td><td colspan="2">30 questionnaires in each vessel type (30/39: 76.9%)

10 questionnaires for each of commanders, crews and technicians in each vessel type: 10/13 (76.9%)</td></tr>
</table>

Table 6-4Shows the distribution of number of individuals who were sent the questionnaire survey (Saudi Border Guard workers: **SBG**) and those who responded in each type of vessel of the commanders, crews and technicians.

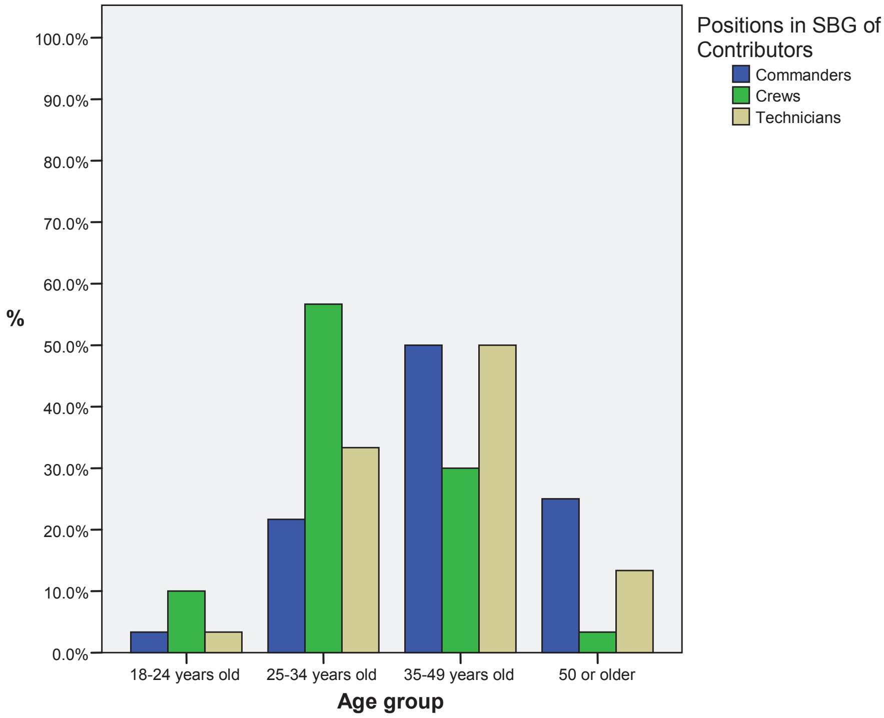


Figure 6-1. Tthe percentage distribution of commanders, technicians and crews who responded to the questionnaire survey according to their age group.

The maximum level of education in all of the participants who responded to the questionnaire survey, and taken for the analyses, is shown in Figure 6.2 In the commanders group, all but one had at least a degree of Bachelor of Science (BSc). These were similarly noted in the technicians group but not in the crew group where the vast majority had either a diploma or had completed high school (Figure 6.2). Clearly the personnel with the higher academic attainment levels and experience levels will be the more likely to provide relevant data to meet the aims of this research. That is to say that their responses will be based upon sound assessments.The differences in the level of education between commanders, technicians and crews are statistically significant (Pearson Chi-Square, $p < 0.001$). Table 6.2 summarise the collected dat.

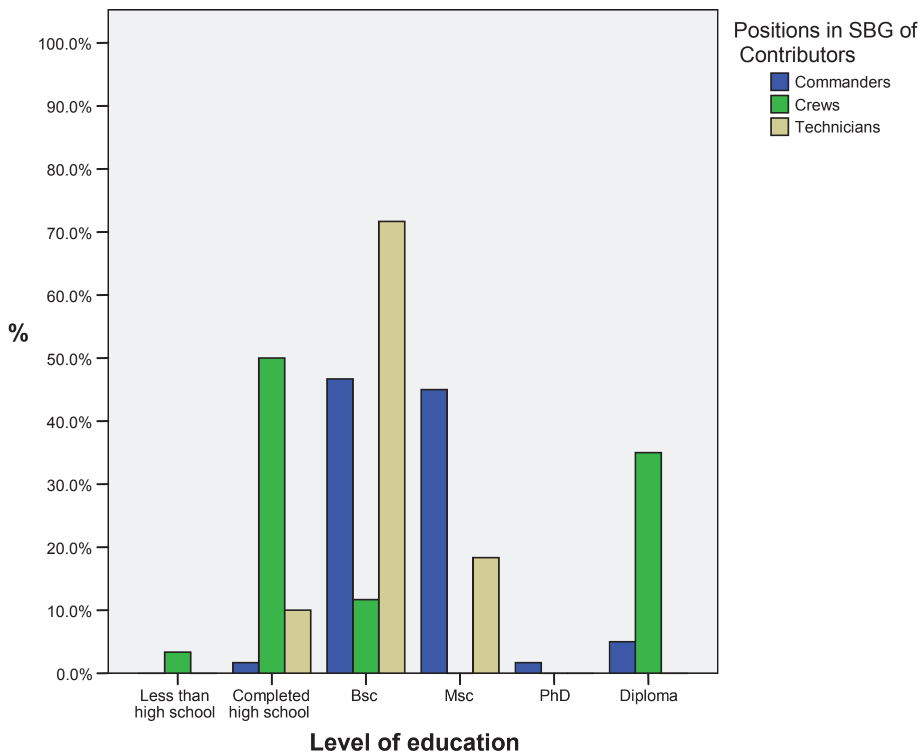


Figure 6-2. The level of education achieved (%) in commanders, technicians and crews who responded to the questionnaire survey.

All commanders who responded to the questionnaire currently occupied commanding roles as related to below. The majority of technicians work in marine engineering (63.3%), others in hull fitting (26.7%) and the remaining in mechanical services (10%). The crew members were working as boat commanders, navigation, mechanical, hull fitting and other services such as deck officer Table 6.3, The vast majority of commanders work in offices (59/60: 89.3%) and only one currently worked on-board a vessel. However, 58 out of 60 (96.7%) of the crew members were currently working on-board and the remaining two crew members worked in an office and in a workshop respectively. All technicians but two had their job in workshops on shore. The remaining two technicians worked as a commanding officer and in an office respectively.

TYPE OF SUBJECT	OCCUPATION						TOTAL
	Commanding (N) (%)	Navigation (N) (%)	Mechanical (N) (%)	Marine engineering (N) (%)	Hull fitting (N) (%)	Other (N) (%)	
Commanders	(60) (100.0)	(0) (.0)	(0) (.0)	(0) (.0)	(0) (.0)	(0) (.0)	60
Crew	(6) (10.0)	(25) (41.7)	(12) (20.0)	(0) (.0)	(1) 1.7	(16) (26.7)	60
Technician	(0) (.0)	(0) (.0)	(6) (10.0)	(38) (63.3)	(16) (26.7)	(0) (.0)	60
Total	(66) (36.7)	(25) (13.9)	(18) (10.0)	(38) (21.1)	(17) (9.4)	(16) (8.9)	180

Table 6-5. Number and the percentages of responders to questionnaire survey regarding their occupation

The overall results of the field trip study for all of the six lengths fleet vessels in the SBG fleet are given Appendix B.

6.6 Analyses Result of the SBG Current Fleet

Summary of results for all vessels is given in Table 6.4 which provides the compliled results from the analyses that have been made for each of the six vessel lengths.

These answers of the SBG members are only according their personal views and impressions and their experience working on board and management.
According the six length categories of the current fleet, a rank out of six is given to the answers of the members according to their answers of the different question of the different vessels sizes.
All the different vessels operated currently by the SBG, were involved in this survey, the general specification of these vessels are illustrated in the appendix C. These results clearly show that some vessels assumed aspect ranks that are different within the vessel, and some vessel's rank is satisfy in general for most of the answers.
Table 6.4 clearly shows that the 26 m is the best and 26.5 m is the worst and the SBG's committee must revise the specifications of the two boats in order to define the required future fleet specifications.

Overall summary for the six vessel types	NO	Questions included for all worker responders	38 metre	26.5 metre	26 metre	22 metre	17 metre	12 metre
General questions	1	Overall satisfaction of the vessel	2	6	3	5	1	3
	2	Economically operation of the vessel	4	6	1	3	5	1
	3	Survivability of the vessel	2	5	3	4	6	1
	4	Maintainability of the vessel	3	5	2	4	6	1
	5	Feeling about the maintenance cost of the vessel	4	6	1	3	5	2
	6	The feeling about the comparison between this vessel and other vessels	2	6	1	4	5	3
Mission requirements	7	Speed of the vessel	1	5	2	4	6	3
	8	Sailing of the vessel in the open sea	1	3	2	4	3	6
	9	Sailing of the vessel close to the coast	5	5	4	6	3	2
Crew requirements	10	Spaces of the accommodations	1	6	2	4	3	5
	11	Spaces of the bridge	2	6	1	5	3	4
	12	Spaces of the main deck	1	6	1	5	3	4
	13	Spaces of the stores	2	6	1	5	3	3
	14	Fresh water tanks capacity	1	5	2	4	3	5
	15	Fuel tank capacity	1	6	4	3	5	2
	16	Quality of the hull material (general rate)	2	6	1	4	5	3
	17	Geometry of the hull	1	6	2	5	3	3
	18	Superstructure height	4	6	1	3	2	4
	19	Draught of the vessel	1	6	2	4	5	3

Table 6-6. Overall comparison of all the recent SBG fleet specifications (1 is the best and 6 is the worst)

6.7 Discussion of Field Trip Results

6.7.1 Introduction

This result in aadition to the future fleet requiremnets which in section 6.4, the current and future SBG concept of operation in Appendix A must be taken in concideration during the Saudi Border Guard Development Commettee (SBGDC) final discution of the future requirements.

It is clear from the final results of the survey and the questionnaire responses covering both the current fleet characteristics and the preferred future fleet specification requirements, upon which will depend the future fleet of the SBG and its missions due to expected future, political and technology forecasts, that there is a need to define the right and most effective requirements and the most effective vessel characteristics. In this section, the three operating range categories of vessel having six sets of dimensions associated with length, that is the long, medium and short operating ranges, will be compared and discussed, taking into consideration the levels of experience and occupations of the SBG members who contributed to the survey (commanders, crews, and technicians). The results of this section will contribute to the first stage of decision making about the evolving SBG future fleet specifications, before other important factors are considered, including political and new technology forecasting, and the results of other internal studies.

6.7.2 Long Operating Range Vessels

The current long range fleet, crewed by the SBG members, consists of vessels of lengths of typicallly more than 30m. However, the average proposed length of this class of vessel for the future fleet is between 40.2m and 65.6m. In the author's experience based opinion, this is a reasonable length for the future fleet because this size is more economical in terms of crew numbers, maintenance, docking facilities and fuel consumption than for vessels of more than 70m in length.

The beam of current vessels in the SBG fleet is 8m. However, the SBG members (commanders, crews and technicians) recommend on increased beam to around 11.1m. The author also suggests the provision of a wide deck area; as such wide spaces will be more helpful during rescue missions, as well as for the requirements of other missions associated with the vessel's tasks and general crew activities.

However, the requirements of the relevant classification societies must be taken in consideration during the process of defining the required specifications in this matter. The implications of such an increase in beam will need to be fully examined in all stability and resistance calculations, etc.

The draught of the veseels in the current fleet is approximately 1.9m, and the same is anticipated for the future fleet. However, the classification society's rules may require more than this draught according to the shape and general geometry of the vessel's hull. In the author's opinion, this draught or more will not be an important issue because the long range vessels will perform their SBG tasks in the more central areas of both the Red Sea and the Gulf of Arabia, meaning they will always be away from the coast with its shallow water hazards and in the open sea.

The combinations of hull shape, deck beam and vessel draught will required studies to ensure the required level of stability,

The maximum speed of the current vessels in the SBG fleet is 38 knots. However, the maximum speed suggested by the SBG members for the future fleet is 47.7 knots and this is the average of the member's suggestions. Again it is to be appreciated that averaged numeric values obtained from the study should not be taken as absolute values but as being indicative of the preferred and recommended trends and possible magnitude of the trends. In my opinion the speeds of all ranges of vessel involved in the future fleet of the SBG is a very important issue, in particular because of the high speed vessels that are normally used by people engaged in illegal immigration, smuggling and terrorism. On other hand, some constraints may affect and tend to limit the speed performance that is possible (for example the displacement, hull types, and powering and propulsion systems). But in general maximum speed is very necessary of the future fleet of the SBG, in order to be faster and stronger than the vessels used by the others in order to protect the coasts and make the people in the Saudi economic waters safer. Some of the members require higher speeds, but some of those who require the speed of this range in the average of the current fleet.

Typical vessels of this type in the current SBG fleet have a crew of 20. However, the SBG members suggested that the average crew number should be 28. However the higher the crew number the higher are the operational costs. Conversely the smaller the number of crew the more they must be trained and be able to use new complex technology for controlling and monitoring purposes. These are issues that require further consideration.

According to the vessel's range and endurance more crew are required for the follows reasons:

- The rescue requirements,
- Mission requirements, and
- Crew duty requirements.

For the current long range fleet the general endurance is for several days sailing. However, the SBG members who responded to the questionnaire and interviews recommend 34 days as being the average sea time to be aimed at for future operations. In the author's opinion, a greater number of days at sea means that there will be more requirements of the crew in terms of facilities, including fresh water, fuel tank capacity, stores and leisure facilities. This is particularly true in conditions of very high humidity and hot weather. The environment in which the SBG fleet operates usually experiences very hot and humid weather and which thus increases the fresh water consumption of the crew in terms of drinking, washing, cooking and ritual purification before praying. This is in addition to the increased food storage and fuel tank capacity that larger vessels require and that are sufficient for the scheduled number of days at sea.

These types of vessels operated to meet by the SBG missions, is require more endurance and range, due to the long coasts on both the Red Sea and Gulf of Arabia, and when the vessel require to cover this sea areas, in order to protect the coasts and economical water of Saudi Arabia, need more range including the special requirements of mission and crew.

The maximum operating range of current long range vessels is typically 1700 nautical miles. However, the maximum range required by the SBG members is more than 3000 nautical miles. This range is very important due to the vast sea areas off the SA coasts and the adjacent areas of both the Red Sea and the Gulf of Arabia, which are more than 3000 km in coast length. This is especially important because long range vessels are normally located to patrol in the mid regions of the Red Sea and the Gulf of Arabia.

The majority of answers given by the SBG members about hull material stated that the best hull materials are the alloys of steel, which provide high strength and which the hull material is used for the 38m vessels of the current fleet and considered to be very good by the crew members.

The propulsion system used for the current fleet's long range vessels is of the conventional diesel engine propulsion system, and which has a hollow 10m length transmission shaft. The SBG members are satisfied with this type of propulsion system. However, in the author's opinion, more recently developed propulsion types should be used, which provides for both excellent manoeuvring and ease of control.

The surveyed members were satisfied about the accommodation facilities found on the some of the current vessels. However, they recommend that more attention is given to determining the crew requirements for the future fleet in terms of rest area location, size of spaces, noise level, lighting, and ventilation air conditions. This issue may be covered briefly in the first stages of determining the requirements of the future SBG fleet, taking into consideration the environments where the vessels will operate, their range, their endurance, and the special religious requirements of the SBG crew, such as privacy.

Most of the members were satisfied about the current bridge spaces and heights found in this category of vessel length, as well as the material that is used for the deck house structure, however they recommend that for the future fleet that a more spacious bridge is provided in order to enable the crew to move more easily during both normal and emergency operations. This will also allow for new and additional equipment to be installed in the future. In addition, the height of the bridge above the deck area must be of military height to enable the crew to see areas around the vessel further into the distance, and a strong superstructure made of an aluminium alloy should be used, as found in many semi-military vessels.

In this current vessel range the fresh water tank capacity is not sufficient compared to the number of the crew and the vessel's maximum endurance. This quantity of fresh water is no where near sufficient for drinking, cooking, washing, showering and performing ritual purification before prayer five times a day and especially when the very hot weather and high humidity are combined. Thus, it is strongly recommended that the fresh water capacity of the future fleet be increased so that it is of sufficient quantity for use by the crew as well as providing for any rescued people. Clearly the provision of on-board de-salination equipment will help to re-dress the situation.

6.7.3 Medium Operating Range Vessels

The length recommended by the SBG participations for the future medium range fleet is between 23.5m and 38m. However, the medium range vessel length of the current fleet is up to 26m. In the author's opinion, future vessels in this range must be between 20m and 35m, and this is a very wide range and the most appropriate will depend on the sea areas where these vessels are expected to operate and the relative importance of the particular locations and the associated sea environments.

The vessel beam suggested by the surveyed members for this class range is between 5.5m and 8 m. However, the average beam of the current fleet is between 4.5m and 6m. In the author's opinion, in addition to the SBG's final decision the classification society will also finally decide on the most suitable beam for the future fleet in this range, and this will depend on other geometrics and specifications of the vessel. It is considered that the maximum beam would allow for more space on the main deck and more internal space.

In this class range, the draught of the current vessels is between 1m and 2m. The proposed draught, as recommended by the SBG members, is between 0.75m and 1.9m. Thus, the figures are quite close to each other. However, reduced draught in this range is recommended in order to avoid possible grounding due to unexpected coral reefs, etc.

The average speed of the vessels in the current fleet in the medium range category is 30 knots. However, the SBG members suggested 44 knots. This size range normally deals with a lot of similar sized vessels, such as those used by fisherman, merchants, smugglers, terrorists, and illegal traders. Many of them use relatively high speed craft. So, it is necessary that the SBGvessels in this range can reach sufficiently high speeds so that they can undertake the required interception tasks of the SBG especially where most of the SBG tasks are within this category.

The number of crew per vessel in the current fleet is between 5 and 11. However, the recommended number of crew per vessel for the future fleet is between 10 and 20. This is because of the suggested increase in operational range for this class of vessels.

Using newly developed equipment for searching, communications and navigation, as well as having a well trained crew, may reduce the number of crew members needed and such will increase the overall efficiency of the missions that the vessels undertake.

The average operational range of the current vessels in this category of the SBG's fleet is up to 500 nautical miles. However, the surveyed members of the SBG asked that this be increased to more than 2000 nautical miles. This substantially longer range would require more capacity in terms of fresh water and fuel tanks, more space and storage, and more crew. All this depends on the lengths of the vessels within this class.

Some of the hull material that is used in the current fleet is not appreciated by the members, especially steel hulls. They prefer aluminium alloy, however they mention that this type of hull material must be used in a safe environment where there are no coral reefs or plotted blocks, for example in the southern area of the Red Sea. Also, they prefer fibreglass hulls, but only in vessels of less than 20m in length. A suitable steel alloy, which is strong and anti-corrosive, is also appreciated by them. In the author's opinion, these recommendations although somewhat conflicting, must be taken into consideration during planning for the specifications of the SBG's future fleet.

The SBG members who answered the questionnaire and also those who attended the interviews recommended strongly the use of newly developed technology for the propulsion systems of the future fleet. In the author's opinion, using new types of propulsion systems will provide the possibility of achieving good performance and give more manoeuvrability and controllability of the vessels.

The crew requirements, according to the answers given by the SBG members, are regarding habitability (including less noise, increased internal accommodation, and improved lighting and internal air temperature and ventilation control), a good location for the accommodation, increased storage space, and both sufficient space on the main deck and in the bridge. These recommendations must be studied in more detail and a more in-depth survey of all crew members must be carried out in the first stages of planning in order to determine the final requirements for the SBG's future fleet. In the author's opinion, having more suitable and improved facilities for the crew will increase their efficiency and make it easier for them to perform the SBG's tasks of controlling and guarding the Kingdom's borders.

The members also mention that the superstructure may be made of either steel or aluminium alloy. However, the hull material must be strong, which is the case now with the current fleet. In the author's opinion this is correct, but the alloy must be strong as these vessels are military or semi-military in nature as the operations can be quite arduous. The materials of the joint between the hull and the superstructure must use new technological processes and materials in order to avoid corrosion and rust.

The members recommend more capacity for fresh water, according to the number of crew members and mission range and maximum endurance. This is in response to the high temperatures and humidity that is often experienced, and which leads to maximum consumption of fresh water by the crew.

6.7.4 Short Operating Range Vessels

The surveyed members of the SBG recommend that the vessels in the future fleet, of the short range type, be between 10m and 20m in length. However, this range in the current fleet is between 7m and 12m, and typically capable of reaching speeds up to 50 knots. The majority of the SBG fleet is below the suggested length range and 90% of all vessels in the current SBG fleet are below 10m in length. Most of them are very old and need replacing because their maintenance burden is increasing gradually. The hull material of these vessels is fibreglass and they have out-boarded engines and a very low draught. There is a need to be able to easily remove and replace engines when required, and to avoid grounding. Normally, these types of vessels operate very close to the coastline where many reefs are located, and most of the SBG's tasks are carried out in these areas by these vessels.

The crew requirements for accommodation and storage on board vessels below 12m length are important, but not at the same level as in the case of the long and medium range vessels. Normally, patrol periods in this type of vessel are for less than 24 hours and they cover a range of around 70 nautical miles.

6.8 General Comments

The results from the questionnaire and survey are really extrapolations for new replacement vessels based upon the commander's and crew's experiences of the current vessels and of their views of the improved characteristics that they would wish to see in future vessels. Thus such makes no implicit consideration of changse and developments in the operational demands that may be put on the SBG in the future nor of technology changes and developments that may have an impact on vessels, their form, design and equipment, and in their mode of operation,

These comments above are not meant to suggest that the questionnaire and survey results are questionable-indeed just the opposite. Predictions for future vessel characteristics can be approached from various directions in order to bound the most probable needs.

6.9 Summary

The field trip was carried out in order to collect data and information that was relevant to the preparation of future fleet new vessel specifications and it was undertaken, through the use of both interviews and a questionaire, with members of the SBG. The archives of the SBG regarding earlier procurement contracts were also accessed, and all of the collected data was analysed and the results illustrated that special and careful consideration must be given to future specifications for new vessels for the SBG's future fleet.

The environment where the SBG fleet operates also needs to be given full consideration during the pre-contract stages and also during the reception of a new proposal, due to the random spread of the coral reefs, in addition to both the crew and the mission requirements.

The three suggested types of vessels, in terms of their range categories, which are long, medium and short ranges, become of considerable importance and can be passed to the Procurement Committee in order to prepare a Request For Proposal, RFP. In addition the overall concept of operations needs to be revised and clarified in order to define the requirements for the future fleet."

6.10 Conclusions

The current SBG specifications and the suggested specifications for the future fleet of vessels for the SBG for all three operational ranges are not necessary perfect for carrying out the many SBG tasks that are necessary for securing the Kingdom's borders. However, more internal technical studies within the SBG, as well as local specialist interaction and interface studies are needed. In addition, geopolitical and technology forecasts are needed to move closely define the SBG and its future mission requirements. Also, the use of newly developed technology for area surveillance and searching which costs less and is faster and safer should be adopted, for example small helicopters, mini- unmanned aerial vehicles (UAV), etc.

The SBG must plan for the next 20 years, involving all departments, administrations and experienced and serving members of the SBG. This plan must include technical training of committees and engineers in all fields, including naval architects, mechanical engineers, maintenance technicians, navigation officers, and members and officials who go to sea. In addition to the responsibilities of the SBG to protect the coast, undertake rescue and firefighting, etc, the future fleet vessels must be able to carry out all of these duties, instead of having many different types of more limited capability specialised vessels and this will reduce the cost, operating cost, crew numbers, number of the vessels, etc.

Carry out more and continuos surveys within the SBG and local field is required in order to improve the future fleet specification in order to have a better overall fleet performance.

7 CHAPTER Seven: The SBG Procurement Procedures Current and Proposed

7.1 Introduction

The aim of this chapter is to study the SBG procurements procedure during the previous period, in order to define the problems and generate solutions in this chapter as well as in the next chapter which Chapter eight. The study procedures are as follws:

- Revise all the contracts and including the contract procedures,
- Compare these contracts and procedure with each other and define these procedures,
- Nogatiate these procedure with the SBG members in order to define the problems, and
- Generate some recommandations and solusions.

The following should be seen in the context of the three stages over a period of years of the initial development of the SBG, as reviewed in an earlier chapter, and as culminating in the current position in what has been a progressive evolutionary process.

There is an established system for ensuring that government purchases are made in accordance with Royal Decree. It has procedures and controls. The system states that there must be: -

- Identification of the accurate specifications of the items to be purchased, whether this be for a marine craft vessel with many different features, for a piece of wood, or for a water pipe,
- A general call to potential suppliers or promulgated through official newspapers and publications,
- An absence of any kind of monopoly,
- Selection based on achieving products meeting the required specifications at the lowest price,

- Adoption of a stringent procedure for selection of the best offer, through committees and various measures, and by the approval of state officials. It may, in some cases, need the approval of the primary commissioner.

Clearly the above are the basic adjectives of all procurement process. however the SBG, being a relatively new organisation, has not yet developed a cohesive scientific approach to formulating its needs, as a reflected in the promulgated technical specifications, and of undertaking the subsequent stages in the new vessel acquisition process in a similar regerons manner.

There is no doubt that this system preserves equality and fairness between suppliers and avoids monopoly and the potential for improper manipulation. It also saves the state funds due to the transparency and accuracy of the procedures. However, it is impossible to apply the model in the case of purchasing complex marine vessels composed of many components because it is often difficult, if not impossible, for delegates of the SBG to establish accurate and comprehensive technical specifications. It is possible to review the stages and procedures to be followed for purchase of a vessel by understanding the positives and negatives of the actions of the various committees that are formed for this purpose.

The following points illustrate the current position.

7.1.1 The Technical Committee Responsible for Deciding the Specifications of the Vessel to be Purchased

The so-called technical specifications of a vessel are, for the SBG, a metaphoric designation. It is better that they are called requirements of the SBG to provide a vessel. The issued technical specifications can perhaps best be seen as wish lists based upon the opinions of the SBG members having same operational experience and extrapolations from current in-service vessels.

Until now there are no technical committees in the SBG which can formulate in a scientific manner, complete technical specifications for any vessel.

It is possible to consult with specialized consultants in order to develop complete technical specifications, but the high cost of this and subsequent laboratory tests of the number of vessels needed, as well as the uncertainty of obtaining the consent of senior officials of the SBG with regards to the results of these specifications, generally prevents the use of a this approach.

Looking at the way in which the requirements of the SBG are currently prepared, having been developed significantly during the last phase of the organisations development, we find that this method is generally inaccurate and unscientific.

For example there is no careful postulation of future operational needs or of the evaluation of alternative approaches to undertaking the missions for which the SBG is tasked. The SBG needs to adopt a more pro-active approach and less a reactive one. It results in requests for the best requirements from all sides despite the fact that technical committees know that what is required may be impossible to achieve and there is often no form of trade-off process. For example, high speed cannot be achieved when displacement caused by the type of construction material, abundance of equipment, high capacity water and fuel tanks, etc, is not appropriate to the length of the vessel. The size of the vessel etc, also affects the number of the crew who are needed to operate the vessel. This is significant as, in the Kingdom, crew have to have space for entertainment and privacy.

Most of the time the main features of vessels are imposed by the senior leadership, who may not be fully conversant with marine specifications or experts and whose requirements may not be capable of being matched practically or in a cost-effective manner. Top officials can often be influenced by field visits to other countries, to exhibitions, or during discussions on acquisition with neighbouring countries, the SBG and naval forces. This is in addition to the possible influence of some manufacturing equipment companies on the SBG officials through their commercial advertising and sales methods.

Serious mistakes can occur when writing in detail the requirements of the SBG or even when tenders are awarded for a new purchase. The same situation has happened in relation to the purchasing of tugboats and ferries for entry into the fleet, and which were ordered only once without any previous experience of operating such vessel type and with no means to engage expert people having knowledge able to consultant such craft.

In this case the SBG can only learn through their subsequent experiences in using the acquired vessels, (assuming that they have good feed-back) and the successful vendor will have received a contract that may be particularly advantageous to them.

Whatever efforts are made by technical committees in developing the requirements of the SBG for new vessels, they are often incapable of making sure that they obtain the best results in accordance with the requirements and needs. This is because of the ability of some shipyards to obscure same technical aspects during discussions on their offers or upon actual deliver of a vessel. There are also some companies that may ignore some of the key operational or maintenance elements in the requirement in order to achieve a secondary requirement to satisfy officials. In this manner they may be taking advantage of the relative lack of technical expertise of the Saudi technical committee.

7.1.2 Technical Committee for the Study of Submitted Company Offers

The work of the Technical Committee for studying the company offers that has been received follows the work of another committee which is refer to as the 'opening of proposals committee'. Usually this initial committee is chaired by a senior member of the SBG and is composed of staff from the financial, marine and technical teams. Its only task is to physically open as received proposals in the presence of representatives from all of the bidding companies and then to prepare all documentation, such as the minutes which record the names of the bidding companies and their prices. The duration of implementation, the terms of payment and some precautions and conditions which may be written in company offers are also recorded. This approach clearly ensures that there is no possibility of any subsequent tampering with documents, this committee submits a report to the chief executive of the SBG who will study it and transfer it to the technical committee whose task is to study the various company offers. They may ask for a repeat of the tender if prices are judged to be too high or they find any administrative errors or incomplete documentation. The Technical Committee then studies the proposed offers carefully, checks the degree of conformity with the previously issued requirements of the SBG, and then submits a technical report listing the bidding companies according to their quote and technical ability. They will recommend one of the offers after preparing comparative tables that show the degree of conformance with items in the as-issued key specifications of the SBG.they may, however, decide that no proposal satisfies the SBG requirements

The Technical Committee undertakes its study, referred to earlier, in the as following manner:

- Considering the achievement of all the main and maximum requirements of the vessel which are needed by the SBG,
- Verifying the experience of the manufacturing company relevant to the proposed vessel,
- Verifying the conformity to mandatory administrative conditions, in terms of payments, bank warranties and other administrative and legal requirements of the Saudi system of purchasing,
- Writing a technical report that shows the views of the committee on each offer from technical, financial and administrative points of view. It is important to highlight clearly and concisely the points of superiority and weakness of each offer,
- Preparing tables that compares the offers between the companies, summarizing the report referred to in the preceding paragraph, and ranking the companies submissions based salely on price,
- Nominating the most acceptable offer that complies with the specifications of the SBG,
- Inviting the nominated company, after gaining approval from the Director-General of the SBG, in order to lift administrative or legal restrictions, if there are any, discussion of the negative observations, if there are any, of the Technical Committee with regards to the company's offer in order to avoid or minimise them, and clarification of points that may have potentially different interpretations,
- Passing the technical report and comparison tables to the Director-General for him to then pass them onto the Decision Committee which is composed of the

Deputy Director General, the Director of Maritime Affairs, the Director of Financial Administration, the Director of Contracts and Tenders Administration, and a financial representative. Its function is to review the procedures and reports in order to confirm the validity of the nomination. It has the right to accept or reject the opinions and recommendation of the Technical Committee.

It is clear from what has been described above that the procedure is complex and formalised. However, it ensures impartiality, equality and justice between competing firms. It is certainly in the interests of the SBG if the product that is being purchased has simple and easy to determine and follow specifications. However, when purchasing a vessel of some size and complexity there are some problems and shortcomings in the overall process that may arise, preventing the selection of the best and most cost-effective offer. These include:

- The inability to meet the main requirements by any means and for any reason. This completely prevents the Technical Committee from selecting the best most efficacious offer. For example, if the submitted offer is excellent and well designed in many ways, but the required speed is not met by, say, one knot, then the offer will not be accepted. Also, in some cases, the need for an increase of one or two knots in order to reach the required speed may increase the price of the vessel by 20% owing to additional installed power. (This may not be a rational cost-effective approach.),

- The impossibility to differentiate between companies and their proposals in the field in terms of their relative levels of expertise and the demonstrable quality of their products. This is against the principle of giving companies equal opportunity to compete and to be fairly evaluated. A simple domestic example of this is when buying a car and considering the brand name only and not being concerned with the main characteristics such as size, engine capacity and luxury elements. The Technical Committee may analyse offers for, say for example, Mercedes equipmented cars that have the same specifications, without considering where they were manufactured. A car manufactured in a third-world country may be completely different in terms of quality and reliability compared to one produced in a developed country,

- Comparing the technical intricacies and sophistication of elements of complex designs of competing offers has no fixed process other than by looking at certain key requirements such as speed, draught, material of the hull and the upper deck structure (without considering the ability to achieve the hull strength requirements), as well as the presence of navigation and communications equipment and air-conditioning etc. Other than this, the comparison often depends on the general attitude and technical ability of the individual committee members, which can differ from the views of engineers depending on their particular interest and specialization. In many cases, selection may be made according to the guidance of the executive members or a dominant influence of one of the members of the committee on the others. The existence of pressure from persons outside the Technical Committee structure to select one of the competing companies can also not be ruled out as there many are others factors involved. In other word, the formal consensus view of the technical Committee may not have been arrived at in a wholly scientific manner,

- If a company re-writes or re-expresses the requirements of the SBG in their offer and includes, for example, a very simple diagram which suggests that it fulfils all of the requirements of the SBG theoretically, if it has the lowest price of the ones submitted the committee may be obliged to select this offer despite the limited information presented,

- The Technical Committee itself cannot assess the anticipated performance of the builder of the proposed vessel in terms of build quality, accuracy in assembling, or consistency and comatibility between the components of the vessel, of all which are directly related to the value of the vessel, its reliability and probable life span, performance and ease of maintenance.

- Some companies include full consideration of all of the requirements of the SBG in their offer in order to win the tender, even though they know that it is not, or may not be, possible to fulfil all of them, intending or providing some technical justification later on in order to explain why they cannot achieve all the requirements. The committee is often obliged to accept the vessel even though it has not achieved what was originally promised, or appeared to be promised in the offer due to an acceptance of the status quo, external pressures and even financial penalties. Technical challenges regarding deficiencies do not appear to be possible in retrospect,

- The Technical Committee originally responsible for the study of offers cannot itself make an inventory of all of the components of a vessel with all details sufficient to find out their quality and availability in the market, along with their suitability for hard and demanding maritime work. This makes a significant difference between a company maintaining its reputation and a company trying to reduce the cost of building by any means possible.

The engineering drawings may sometimes confuse or even mislead members of the Technical Committee due to the quality of the drawings and certain incorrect dimensions, and which many show a very different reality after completion.

The possible resolution of the above deficiencies is discussed in the following chapter.

7.1.3 Technical Committee for the Supervision of Vessel Construction

After a contract has been completed and signed, the building yard identified and a construction schedule established, some oversight of the vessel at various stages during construction and out fitting is clearly of benefit to the SBG. However the following illustrates the current position:

- There is no technical committee in the SBG that supervises the building of vessels from the beginning to the end,

- The SBG depends on the selected classification society as and where relevant for technical supervision of the detail design and construction of vessels, and for attendance at commissioning and sea tests. Contracts include a clause stating that the constructing company will pay the costs of this supervision. In the author's opinion, the absence of the eventual owner, that is, the SBG, during construction and outfit and leaving a classification society to supervise the work on its own is not acceptable because same degree of leniency or collusion between shipbuilders and supervisors may take place,

- During the construction period, one or more SBG representatives are sent to the construction site for very limited periods in order to determine the extent of progress in terms of implementation of the contract. They submit a report which includes the observations of the representatives and their views on the current quality of work. However, a lack of continuous observation and a lack of experience of the SBG representatives can lead to obscured weaknesses and possible rectification work in the finished product, unless the building company has a very good reputation.

It is clear from what has been mentioned above that there is no real supervision or observation of the work at the shipbuilders, and therefore certainty about the quality of work and the possibility of modifying the design e.g. To facilitate inspection and maintenance, when unforeseen problems develop during the early stages is not possible. This is discussed in the following chapter.

The formation of a small committee to attend sea tests and to be provided with a degree of practical training for the operation of the vessel at the vessel's place of construction is necessary. This is same times done but the experience of the committee is generally not enough.

7.1.4 The Reception Committee

When a newly built vessel is delivered to the SBG, it is clearly necessary to be examined to see if it is in full compliance with the full details in the contract before the SBG becomes its owner. The following points summarise the current posion:

- The vessel is shipped to Saudi Arabia usually after payment of 90% of the value of the vessel together with all relevant financial, administrative and technical certificates, including the classification society's testimony,

- Upon the arrival of the vessel in the Kingdom of Saudi Arabia, the building company prepares the vessel for operation and sailing. An expanded Technical Committee is then formed to take over the vessel. Among its members there are usually one or two members from the technical committees that originally prepared the requirements of the SBG and studied the offers. However, the majority are operational marine staff,

- All of the components of the vessel and the documented method operation of equipment are inspected. They must be identical to that which the company originally offered and were written into the formal contract,

- Following the completion of trials by the Reception Committee, the results of the sea trials will be noted showing all negative aspects. Many problems between the company and the Reception Committee can occur if there are any negative findings, regardless of what was recorded in the contract and as and where the general requirements of the SBG that were found to be difficult to meet,

- The company generally deals with identified operating problems in order to reach a satisfactory outcome. However, negative observations of the design including lack of performance or selection of materials can only be solved through negotiation between the company and senior officials of the SBG. It is worth mentioning that sometimes in the past very poor vessels have been received but that have had to be taken out of service after a very short period of time.

7.1.5 Conclusions

The following points are the general conclusions that have been reached following a review of the current practices,

- Significant and substantial progress on maritime issues has been made by the SBG since its inspection through constant developments and a rising of the efficiency of officers and maritime personnel, as well as by a rising of the efficiency of the vessels that have entered into service and the progressive developments of field, administrative, and technical work,

- There is great difficulty in following a developed systematic scientific method for the evolution and design of vessels to be provided for the SBG by the SBG technical committee throughout the overall specification-acquisition process,

- There are complex administrative and technical problems in the way of purchasing the best possible and most cost-effective vessels,

- There is a need to conduct extensive research of previously provided vessels in order to identify actual shortcomings and to determine methods to address them in the future in an attempt to provide the best vessels for future service.

The overall plan proposed below gives a detailed research based procedure, considering actual realities and using, in the author's own point of view, processes for determining the best way to provide vessels, in the future, that meet the required and projected future tasks and to consider environmental, operational, maintenance, and reliability issues, taking into account economic factors, local potentiality and surrounding circumstances.

7.2 The proposed Method for Securing Maritime Vessels for the Saudi Border Guard

Any method used by the SBG to secure maritime vessels that enables them to achieve their objectives is restricted by several factors. These include:

- Compliance with rules related to governmental purchases,
- Financial budgets,
- The absence of a strong professional body that is able to anticipate needs, to design and modify designs or to conduct a range of necessary tests,
- Inability to secure a large number of any type of marine vessels (middle or long range) in a limited time,
- Inability to design and to construct small to medium size fast naval vessels in the Kingdom of Saudi Arabia, including naval/military vessels,
- Rapid changes in technical and technology, which do not allow the acquisition of in-house expertise,
- Significant and effective developments in order to be able to protect against those who transgress the law, which means there is a requirement for quicker and better development in SBG capabilities,

- Achievement of speed, strength, surveillance crew comfort and communication are key factors that need to be considered in the design of patrol boats,
- The high cost of naval operations against military operations, in addition to the poor results that are sometimes achieved through maritime operations.

We can conclude that any method that might be proposed in order to secure the freedom of the SBG to obtain maritime efficient and effective vessels will not be free from negative aspects. Some aspects of abuse of regulations and practice are still challenging.

From the previous study, it can be concluded that the best method will include the following factors:

- Democracy in decision-making,
- Transparency and simplicity in undertaking activities and making decisions during the procurement process ,
- An emphasis on learning from previous experience in the field of design and construction, which are the most important elements of the greatest interest,
- Development of the practical and comprehensive technical skills in the marine field should depend on an integrated system which helps others and connects the various sides quickly in order to perform the required tasks. Secrecy and intelligence should be the most important issue, rather than relying on the SBG vessels only,
- Development of non-marine work is worthwhile in order to reduce ground operations where costs are very high,
- Saving of time and effort,
- A serious attempt to consider economic factors, including insurance, employment and maintenance,
-
- An attempt to increase well-being factors and consideration of marine customs and past experience when determining the requirements of the crews,
- An increase of the facilities available in each sector of each region for the maintenance and repair of marine vessels, particularly with regard to maintenance and repair of underwater structure,

- The development of style and performance of naval operations in accordance with the circumstances of each sector on the one hand, and the link between all naval operations on the other so as to achieve the lowest possible overall cost.

The proposed method can be summarised as follows:

- The operations management of all marine areas need to confirm the requirements of the navy to His Excellency the Director General of the Border Guard. This should take place in an appropriate manner so as to identify the requirements for naval operations and to identify the most important key characteristics of the vessels to be acquired,
- Compilation of all the applications is considered by the General Department for Operations, the Directorate General of Maritime Affairs, and the Department of Finance and Public Administration of Contracts and Tenders,
- Arrangement of a long term plan of action over, say, a ten year period. This will secure what other parties have agreed (second item),
- Specialists assigned to the Directorate-General for Maritime Affairs are entitled to study and define the main characteristics of the agreed vessels. The basic requirements should be obtainable, taking into account the many functions of the vehicle, the area of sea covered, the nature of the sea's condition, the topography, weather conditions, facilities available to border guards, and external workshops. A suitable crew is responsible for operating the vessel and is selected according to their levels of education and experience. The crew should have the right to amend the main characteristics proposed in light of their functional and technical expertise, the budget, and future plans,
- Consent of the concerned parties (as in the second item) related to the study of the technical committee is always taken. This is important to develop the requirements of border guards,
- Serious and practical research into all aspects of the navy is to be considered within the key characteristics that have been agreed and built before at the dockyard with long-lasting experience in this area,
- A technical committee is expected to inspect a number of vessels and conduct a field survey to determine the pros and cons of each product and to recommend where and how improvements could be made.

- A clear identification of the construction costs of each mode of operation, as well as maintenance costs,
- Re-examination of the requirements of the SBG and revision of details when necessary,
- Invite a number of reputable companies with expertis that have already built similar vessels and fulfilled the survey team's criteria.
- To complete the rest of the regular updating procedures to secure the required vessel,
- To appoint a technically qualified official who is a representative of the DBG for permanent presence throughout the period of construction. This should ensure an experienced individual oversees implementation of the contract, and quality of construction with a separate holding company taking responsibility for any error in the design, implementation or selection of materials,
- The contract should include all operational plans and equipment catalogues for the SBG to consider. This should include details of maintenance requirements, and procedures, requirements and procedures repairs and major devices, as well as specifications of materials used in construction. The information should enable Border Guards to carry out any reforms, rectifications and developments,
- The contract should include planned maintenance instructions and details for its implementation.

First Stage

In order to clarify and illustrate the above items it is necessary to have a comprehensive over-view of the full life cycle of a given vessel, from the initial assessment of potential operational needs through to the eventual entry into service of a new design.

This over-view is developed and presented in the following chapter, in a form that is particularly applicable to the larger vessel in the SBG fleet where their complexity requires a quite detailed and scientific approach in order to yield an efficient solution.

1- If the vessels will operate as rescue boats the following issues must also be considered in addition to those items listed above:
    - Rescue equipment, including medical requirements;

  - High speed craft;
  - Space for rescued people;
  - Emergency rescue equipments.

2- For firefighting vessels the following issues must also be considered in addition to those items listed above:
  - Firefighting equipment and related facilities;
  - Equipments for vessel controllability during fire fighting.

3- If the vessels are to be used as landing craft the following issues must also be considered in addition to those items listed above:
  - The strength of the bottom shell plates;
  - Design of the hull so that it withstands environment topology;
  - Store capacity for fuel, fresh water, arms, etc.

4- If the vessel has been procured for training SBG members the following issues must also be considered in addition to those items listed under number 2:
  - Training facilities for training members in communication and use of navigation equipment, etc;
  - Space for training;
  - Education regarding safety equipment.

Second Stage

In this stage a great deal of work must be undertaken, including:

- Undertaking out a survey with SBG members,
- Getting feedback about the current SBG fleet‘s achievements,
- Investigating previous studies in this field,
- Internal studies into the SBG, including:
  - Previous work on the past operational history of each part of the Red Sea and the Gulf of Arabia,
  - The current regional situation of each part of the Red Sea and the Gulf of Arabia,
  - The expected future challenges of each part of the Red Sea and the Gulf of Arabia,
  - Changes in domestic, regional and international political conflicts in the surrounding geographic region,

- Expected increases in the various types of vessels that sail in SA national sea waters over the next years (for example, ferries, yachts, fishing vessels, sports vessels, pleasure vessels, trading vessels, etc.),
- Types of vessels expected to sail in SA national waters including vessels carrying dangerous material (for example, gas carriers, explosive and chemical carriers, etc.),
- Vessels that may be used by terrorists or people smugglers, etc.

Third Stage

The third stage, which is the final and most important stage, is the developments of a framework for identifying the problems and real requirements of the SBG in terms of the future fleet specifications and other recommendations. The following issues must be studied for this:

- Newly developed technology in the fields of marine security and monitoring;
- Future technology in all aspect in the marine fields;
- Future domestic, regional, and international political forecasts;
- Future challenges to securing the Kingdom borders and sea ports during any unexpected and unanticipated future political situation;
- The location and importance of SA in the Islamic world due to the presence in the country of the two Muslim holy cities of Makkah and Madinah, and the fact that it is a large oil producer. It is located among many poor countries, leading to big challenges to securing its 8500km coasts and borders. These issues must be considered carefully during any future planning of fleet specifications;
- Innovation in terms of thinking and planning for a future fleet must be embraced;
- The largest challenge is receiving and evaluating many proposals about different types of technology related to hull design and new vessel technology, etc.

The final stage is that the SBG committee and members must understand that innovation in securing borders and coasts, and border technology is unlimited. This simple procedure for procuring future vessels for SBG specific tasks involves various stages that not only analyse real requirements, but also consider future technological developments, and regional and international political forecasts.

7.3 The SBG Proposed Future Patrol Capability Request for Proposal (RFP)

7.3.1 Introduction

The purpose of the Request for Proposal (RFP) is to solicit bids that will enable the Kingdom of Saudi Arabia (KSA) Border Guard (SBG) to evaluate Bidder qualifications and experience in order to award a contract to provide maritime patrolling capability in the maritime Area of Responsibility (AOR).

In addition, the information presented in the Bidder's response to the SBG' RFP shall convey to the SBG that the Bidder:

- Understands the BG mission, organization, and challenges,
- Has experience in leading a robust and complex program,
- Is capable of integrating and providing unique and comprehensive solutions to the required capabilities and needs of the SBG.

The SBG must encourage creativity and unique solution concepts in all responses.

7.3.2 Applicable Law

This RFP must be in accordance with the laws and regulations of the Kingdom of Saudi Arabia (KSA), including: "Government Tenders and Procurement Law" and "Implementing Regulations of Government Tender and Procurement Law".

7.3.3 Background and Objectives of the SBG Future Procurement Process

The General Directorate of the Border Guard is one directorate within the minestry of Interior (MOI), and is responsible for monitoring and protecting the land and sea borders of the KSA. The SBG's responsibilities also include monitoring and protecting key national assets including sea ports, harbours (and their approaches), desalination facilities, power plants, petroleum production and distribution operations, land border crossing points and other critical infrastructure within the SBG Area of Responsibility (AOR).

Some immediate threats the SBG faces, include increased infiltration and smuggling through both land and maritime borders. The SBG' Development Committee (DC) must provide the BG with the tools and processes needed to deter, detect, classify, identify, respond and resolve smuggling, infiltration and terrorism activities that pose a threat to the KSA.

With the ever-increasing complexity of national security threats and emerging technologies, the SBG recognizes that a major acquisition effort is required to achieve sustainable mission success. The DC must provide a comprehensive modernization and development effort to implement state-of-the-art technologies and systems that work seamlessly with improved modern processes and human factors to maximize the effectiveness of the force and the security of the KSA.

7.3.4 The SBGDC Strategic Objectives

The BGDC has three Strategic Objectives, supported by guiding principles as follows:-

- Increase the efficiency and operational effectiveness of the SBG.
- Modernize the supporting infrastructure using industry-leading technologies to improve SBG capabilities to perform its mission.
- Increase the human and resource management capability of the SBG.

7.3.4.1 System to Solution Approach

KSA border security requires an enhanced and secure infrastructure, continuous surveillance, actionable intelligence, and responsive interdiction. Effectively combining these elements requires integrating assets at the border and linking them to all activities involved in cross-border travel and transport, including investigations and the detention and removal of unlawful persons.

7.3.4.2 System of Integrated Solutions

The security of the KSA borders requires the integration of solutions, new and existing, to meet the required capabilities of the SBG'DC system of solutions vision. Individual, stand-alone solutions will not meet the integrated needs of the SBGDC.

7.3.4.3 Focus on Human Capital Development and Supporting Infrastructure

Ongoing personnel training, human resources, and physical infrastructure needs to be in place to properly support any newly acquired technologies. Properly trained and motivated personnel, combined with supporting logistics, are key elements of long term Capability development and sustainment.

7.3.4.4 Total System Solution Approach

A Total Systems Solution approach will deliver fully operable capabilities, including all required training, equipment, personnel factors, information, data, doctrine, organizational considerations, infrastructure, logistics, maintenance, and interoperability.

In support of these Objectives and Guiding principles the BGDC has the responsibility for the alignment of strategy, people, process, and technology to fully develop the SBG organization into a 21st century security force capable of delivering comprehensive border protection. The modernization and integration of command, control, communications, computers, intelligence, surveillance, reconnaissance (C4ISR), telecommunications, information technology (IT), organizational development (OD), and training, as well as air, land and sea capabilities and infrastructure, is the means to create an effective and efficient border protection system. This integration and modernization effort will be accomplished through successful acquisitions that will provide SBG every advantage in proactively securing the KSA borders to:

- Deny illegal entry of people and contraband into the KSA,
- Provide front-line staff the best possible environment to effectively deter, detect, identify, classify, respond to, and resolve border security situations,
- Balance the need for efficient border crossing processes to encourage economic growth, while also ensuring that threats are countered before they impact the country, thereby protecting the citizens and legitimate residents of the KSA.

7.3.5 Overview of Developments to Date

As part of the modernization effort, the BGDC must establish the Systems Integration Engineer (SIE) project. The SIE is responsible for delivering full capabilities across Core Domains, and for providing Systems Engineering, Integration and Project Support across all (Core and Operational) Domains.

These Domains include the following:

- Core Domains:
    - Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR),
    - Telecommunications (Telecom),
    - Information technology (IT),
    - Organizational Development (OD), and
    - Training.
- Operational Domains:
    - Land,
    - Maritime, and
    - Air.

The SIE must has a direct role providing Core Domain solutions, and shall have a Systems Engineering, Integration and Project Management support role to ensure that the Operational Domains (and associated capabilities) integrate with the other Core Domain systems.

Figure 1-2, The Role of the SIE in the BGDP, describes the relationship between the SIE and the BGDP.

7.3.6 Core Domain CONOPS

The Core Domain Concept of Operations (CONOPS) as shown in Figure 7.2 describes the employment of the Core Domains of C4ISR, IT, Telecommunications, Organizational Development and Training. The Core Domain CONOPS also provides a sufficient description of the operational environment, to understand how capabilities in the Operational Domains of Land, Maritime and Air are likely to be employed.

This overview of the Core Domain CONOPS is provided to add context for the Bidders in proposing their solution. Most missions require some aspect of deter, detect, identify, classify, response and resolution of threats to the Kingdom's borders, or protection of the safety and welfare of its people, infrastructure and environment at the borders. Key success factors are situational awareness across the border areas, as well as the ability to transmit and assess information, make and execute decisions quickly and effectively, and to coordinate with other stakeholders. This requires a robust telecommunications infrastructure, state-of the-art IT systems, effective organizational and process design, and well trained and motivated people. The Core Domain CONOPS results from prioritized missions in each region, optimized by effective employment of specific SBG assets. The Core Domain CONOPS has been developed utilizing a process of identifying the SBG's strategic goals refined to measurable and required capabilities, which are enabled by specific assets and doctrine.

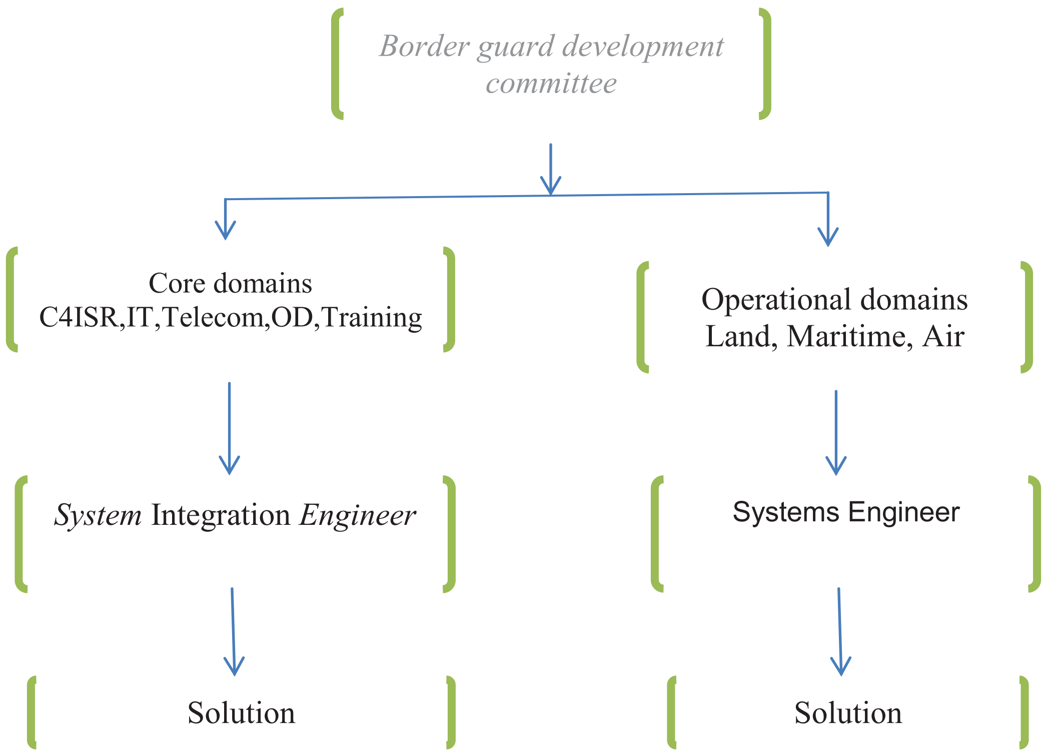


Figure 7-1the Role of the SIE in the BGDC

The Saudi Border Guard Maritime – Offshore and Coastal Patrol CONOPS is summarized in this Chapter and can be found in its entirety at Appendix A.

The assets that support the required capabilities proposed in the SBG'RFP will be found in Section 7.4 of this document.

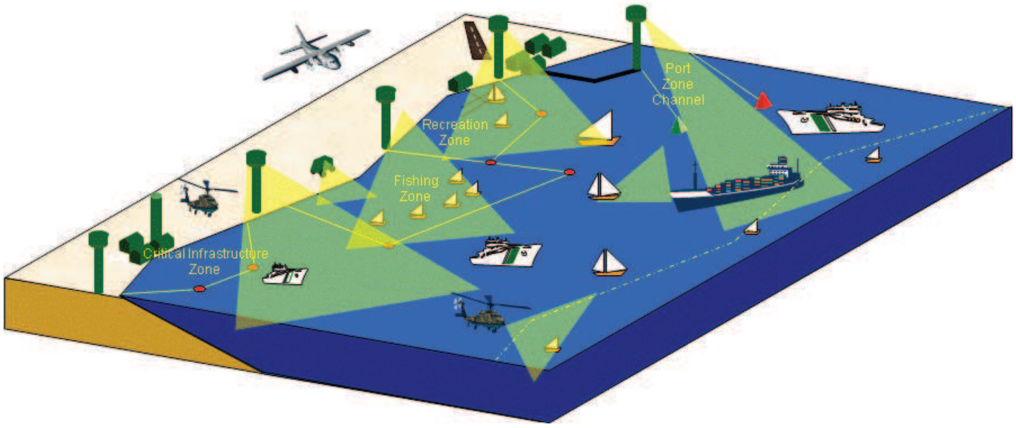


Figure 7-2 SBG Mritime Domain CONOPS

7.4 Functional and Technical Requirements

7.4.1 Defining the Opportunity

7.4.1.1 The Future Missions Reuirement

The SBG seeks a fully integrated, multi-purpose solution that builds Maritime Patrol capabilities within the Border Guard Maritime Domain. The SBGDC must seek the acquisition of four capabilities:

- Capability 1 – Offshore Patrol Boats (OPB),
- Capability 2 – High Speed Interceptor (HSI),
- Capability 3 – Utility Boat (UB),
- Capability 4 – Command & Control Boat (C2B).

Each of these solutions must be a total Capability approach that is able to sustain the full lifecycle support of the solution. As such, the vendor for the solicitation would work as a solution provider under the BGDC and work in conjunction with the SIE, as shown in Figure 7.1. The vendor shall also be responsible for integrating its solution with all other ongoing Minestry of Interior (MOI) programs.

The vendor must additionally responsible for Systems Engineering, Integration and Project Support, for their individual solution. This shall include support services for program management, training, equipment, personnel, information, doctrine, organizational considerations, infrastructure, logistics, and interoperability.

Also the vendor must work in a spirit of partnership with the BGDC to provide business and technical advice, insight and incidental work products that help assure the success of the Program.

7.4.1.2 Maritime Domain Concept of Operation

The complete Saudi Border Guard Maritime – Offshore and Coastal Patrol CONOPS is at Appendix A.

The Maritime Domain employs a defense in depth approach using an integrated system of fixed and mobile resources. This is a modular approach with mutual support and leveraging of all resources. The designed mix of various resources counters the environmental and geographic extremes and the capacity of the threats to adapt tactics to overcome defenses.

The C4ISR system provides situational awareness for the Regional and Sector commanders, in addition to the deployed assets, such as patrol boats. The standard procedure is to employ surveillance resources to systematically reduce the percentage (number) of unknown contacts in order to focus the more limited interdiction and response resources effectively. The hierarchy is as follows:

- Intelligence to establish the baseline of expected activity,
- Reports and data feeds from outposts and cooperating agencies and organizations,
- Automatic Identification System (AIS) to identify reporting vessels (all vessels over 300 tonnes, as well as other mandatory and voluntary compliance vessels),
- Radio Direction Finding (RDF) for Line of Bearing (LOB) or location of transmitting vessel,
- Positional, course and speed, and behavioral factors to provisionally classify targets (temporarily eliminate certain contacts from the population that will require immediate positive classification and identification),
- Fixed and mobile systems to obtain positive classification,
- Mobile systems (with some Capability from fixed systems) to obtain positive identification,

- Mobile assets to interdict and resolve potential threats.

The Command Centre has direct and secure communications with the response stations as each of the outposts has the ability to transition from primary patrol mission to primary response missions. The command centre also has direct and secure communication with all vehicles, vessels and aircraft that are on-station and on-alert. The command centre uses the composite large screen display and other key sources of information from the integrated C4ISR system to make the decisions on vehicle, vessel, and aircraft positioning and tasking.

The SIE must include a significant effort to develop a SBG CONOPS. The Maritime CONOPS described here is a subset of the overall SBG CONOPS.

7.4.1.3 OPB, HSI, UB, and C2B Capabilities

The OPB must be multi-mission capable platform operable from SBG shore stations, primarily used for extended offshore missions. The HSI will be used for nearer to shore missions on a daily basis. The SBG will employ the UB to conduct island searches and augment transport capability. The C2B will provide a suitable platform for senior personnel to exercise command and control within the SBG Maritime area of responsibility.

The SBG must deploy these assets primarily in support of six mission areas:

- Critical Infrastructure Protection (CIP): Supports port security, the security of offshore and near shore drilling platforms,
- Enforcement of Laws and Treaties (LE): Includes illegal drug trafficking, human trafficking, smuggling of weapons and contraband, enforcement of territorial water boundaries, etc,
- Search and Rescue (SAR): Includes recovery of persons and material from the water, transfer of personnel between vessels, towing of disabled vessels, transferring personnel to and from helicopters, providing on-board medical assistance as well as limited fire fighting capability,
- Support Defense Operations: If necessary, the patrol boats shall be capable of cooperating with the Royal Saudi Navy vessels as well as international vessels. This could include interdicting foreign hostile vessels, disabling hostile targets, conducting patrols and enforcing security zones both inside and outside of the territorial waters of Saudi Arabia,

- Recreational Boat Safety and Lifesaving: In recreational areas along both coasts, the patrol craft shall be capable of monitoring boat safety, conducting vessel boarding and inspections, rescuing distressed persons, and enforcing safety and security zones,
- Marine Environmental Protection: The boats shall support and coordinate with other KSA and international agencies by acting as Command and Control Centres as part of incident response and resolution, typically being the first responders to incidents within the KSA Maritime AOR.

The OPB will likely be deployed for more than 3 days at a time. It will serve primarily as the offshore platform, capable of performing the LE, SAR, and CIP missions within the BG Maritime AOR.

The HSI will be deployed for periods of approximately 12 hours. It will serve primarily as a first response for each of the mission areas and will be expected to receive orders and tasking under the same Command and Control systems being deployed throughout the Saudi Border Guard.

The UB will be deployed for periods not to exceed 36 hours. It will serve primarily as a first response for the island search mission and may also be used for the emergency movement of people and materiel in support of missions.
The C2B will be typically deployed for more than 3 days at a time. It will serve primarily as the offshore command & control platform, capable of both performing and directing the LE, SAR, and CIP missions within the SBG Maritime AOR.

7.4.1.4 Requirements Breakdown Structure and Maritime Domain Capabilities

The Requirements Breakdown Structure (RBS) provides a structured map of Maritime Domain Capabilities and Assets must be provided by the SBGDC. The structure for the RBS begins with Capabilities (e.g., Offshore Patrol Capability). Each Capability consists of two parts—Assets (e.g., Offshore Patrol Boat) and Asset Support. Asset Support includes all of Full Capability Integration (FCI) elements, as described in Section 7.4 of this Chapter. For each Asset, the RBS then progresses through several Asset Components (e.g., General, Hull and Structure, etc.).

For the purposes of the SBG' RFP, the term "Asset," shall be synonymous with the term "boat" or "vessel" and shall herein be used to reference individual units to be delivered. Each Asset is comprised of several Asset Components to be delivered in accordance with this Chapter and the next Chapter. References to "Asset Components" or "Components" shall be considered integral parts or elements of each Asset or for the entire fleet according to context. The term "Capability" shall be used to refer to the fleet of all delivered Assets in addition to delivery of the all support required by the FCI elements.

7.4.2 Capabilities

The following sections contain high-level descriptions of Capabilities 1 – 4 as depicted in the RBS above.
The Beaufort wind scale, and the corresponding World Meteorological Organization's (WMO) classification of wind force and appearance of wind effects (Sea State) and which already disussed in Chapter three for the Red Sea, shall govern the weather conditions as they pertain to the Capabilities in the SBG'RFP.

7.4.2.1 Capability 1: Offshore Patrol Capability

The KSA requires an Offshore Patrol Capability for the Border Guard in support of the BG Maritime Offshore and Coastal Patrol CONOPS (Appendix A). These vessels shall conduct (at minimum) 3 day patrols in the Offshore AORs, primarily in support of CIP, LE, and SAR operations.

The OPB shall be classed by an internationally recognized classification society for services within the Gulf of Arabian and the Red Sea, and comply with all applicable standards published by the International Maritime Organization. The vessels must anticipate operating for a maximum hours per year over their service lives.

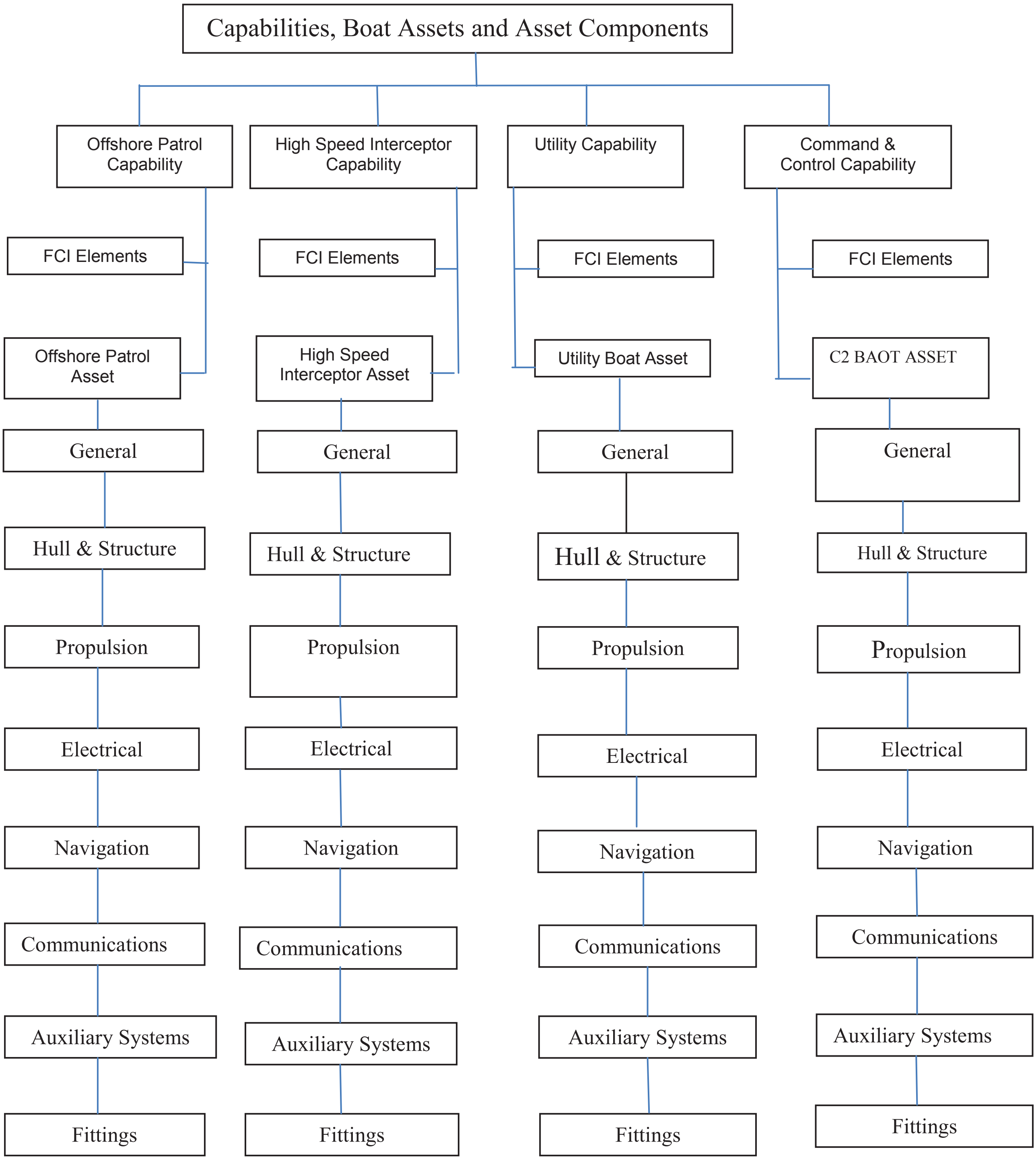


Figure 7-3Capabilities, Boat Assets and Asset Components

Force (Sea State)	Wind (Kts)	WMO Classification	Appearance of Wind Effects on the Water
0	< 1	Calm	Sea surface smooth and mirror-like.
1	1-3	Light Air	Scaly ripples, no foam crests.
2	4-6	Light Breeze	Small wavelets, crests glassy, no breaking.
3	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps.
4	11-16	Moderate Breeze	Small waves 1-4 ft., becoming longer, numerous whitecaps.
5	17-21	Fresh Breeze	Moderate waves 4-8 ft. taking longer form, many whitecaps, some spray.
6	22-27	Strong Breeze	Larger waves 8-13 ft., whitecaps common, more spray.
7	28-33	Near Gale	Sea heaps up, waves 13-20 ft., white foam streaks of breakers.
8	34-40	Gale	Moderately high (13-20 ft.) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks.
9	41-47	Strong Gale	High waves (20 ft.), sea begins to roll, dense streaks of foam, spray may reduce visibility.
10	48-55	Storm	Very high waves (20-30 ft.) with overhanging crests, sea white with densely blown foam, heavy rolling, and lowered visibility.
11	56-63	Violent Storm	Exceptionally high (30-45 ft.) waves, foam patches cover sea, visibility more reduced.
12	64+	Hurricane	Air filled with foam, waves over 45 ft., sea completely white with driving spray, visibility greatly reduced.

Table 7-1 Beaufort Wind Scale and Corresponding Sea States

(Source: http://www.spc.noaa.gov/faq/tornado/beaufort.html)

The SBG shall seek the vendor who provide a highly reliable, efficient, and easily serviceable propulsion system capable of achieving and demonstrating all required performance characteristics while meeting all stated international standards and regulations. According to the interviews with the SBG members which already disussed in Chapter six, the SBG prefers a propulsion system consisting of twin marine diesel engines, shafts and submerged propellers, but is willing to consider other propulsion systems that achieve the capabilities laid out in the future SBG' RFP.

The vendor shall provide an asset that meets the broad performance requirements of the SBG.

The OPB shall have an objective according to the survy and CONOPS a length of 45m. Actual length of the vessel may be less than 45m or more and will be dependent on the bidder demonstrating that their proposed vessel can meet all functional requirements and achieve the stated missions. The OPB shall have a cruising speed of 25 kts at sea state 3 at full load, and maximum continuous speed in excess of 35 kts in sea state 3 at full load. Range will be (at a minimum) 1500 nautical miles at the cruising speed.

The OPB shall have a deployable boat capable of conducting boarding operations, island search, interdiction, fisheries enforcement, and SAR operations. The deployable boat shall have minimum capacity of 6 personnel with weapons and equipment for boarding operations.

The OPB vessels shall be outfitted with one forward-mounted camera, stabilized and remotely operated from the bridge. The vessel shall be outfitted with two machine gun mounting points to be located port and starboard, to accommodate either .50 caliber or 7.62mm machine guns or similar gun machine.

7.4.2.2 Capability 2: High Speed Interceptor

The SBG requires the Intercept Capability in support of the SBG Maritime Offshore and Coastal Patrol CONOPS. These vessels will primarily operate in Coastal AORs on shorter duration missions (up to 12 hours), providing quick reaction to approaching threats and emergency situations.

The HSI shall be classed by an internationally recognized classification society for services within the Gulf of Arabian and the Red Sea. It shall comply with all applicable standards published by the International Maritime Organization. The expected service life of hull, deck, structure, and enclosures shall be not less than 10 years before requiring major overhaul.

The HSI shall be less than 15m in overall length according to the survy result in Chapter six and CONOPS in appendix A. It shall have a cruising speed not less than 25 kts at full load in sea state 3, and a maximum speed not less than 55 kts at sea state 3. Its range shall be a minimum of 200 nm at cruising speed.

The SBG currently operates interceptors up to 12 m with outboards and inboard propulsion systems. The SBG will consider other propulsion systems that meet the functional capabilities of the future SBG'RFP; however, the SBG prefers not to adopt vessels with surface drive propulsion systems according to the SBG members experience in operation and maintenance.

The hull shall be a V hull design, and an enclosed, air conditioned cabin due to the crew requirement which mentioned earlier Chapters. The HSI shall have a crew of up to four, and minimum capacity of eight persons.

The HSI shall have a navigation system including, at a minimum, radar, chart plotter, DGPS, depth sounder, compass, and AIS, and shall have suitable gun machine.

7.4.2.3 Capability 3: Utility Capability

The SBG requires the Utility Capability in support of the BG Maritime Offshore and Coastal Patrol CONOPS. These vessels will primarily operate in Coastal AORs on missions up to 36 hours, allowing the SBG to search islands and augment transport of supplies and personnel to and from remote BG maritime posts.

The vessel shall be classed by an internationally recognized classification society for services within the Arabian Gulf and the Red Sea. It shall comply with all applicable standards published by the International Maritime Organization. The expected service life of hull, deck, console, and enclosures shall be not less than 12 years before requiring major overhaul.

The UB shall be constructed of high-grade marine aluminium or steel. The UB shall be less than 15m in overall length, with an objective length of 12 meters. The keel shall be sufficiently protected to enable repeated safe beaching without damage to the hull.

The UB shall have a self-bailing open deck space, with a bow load ramp with power winch to accommodate All Terrain Vehicles (ATVs), small trucks and with room for excess equipment. The minimum cargo carrying capacity shall be more than 5,000 kg. It shall include tie downs and anchoring points included along the deck for securing vehicles and cargo.

The UB shall have a cruising speed not less than 12 knots in sea state 3 conditions at full load, and a maximum speed of 30 kts in sea state 3. Operational range shall be a minimum of more than150 nm at cruising speed. Vessel shall have a cabin with overnight sleeping accommodations for a crew of four (including water closet, refrigerator, stove, and sink). Vessel shall have fly-bridge with overhead cover and seating for the crew.

Air conditioning, appliances, tools and equipment shall be capable of being run off a separate, on-board generator.

The navigation system shall include, at a minimum, a radar, chart plotter, DGPS, depth sounder, compass, and AIS.

7.4.2.4 Capability 4: Command & Control Boat Capability

The SBG requires an Offshore Command & Control Capability in support of the SBG Maritime Offshore operations. These vessels shall conduct (at minimum) 3 day patrols in the Offshore AORs, primarily to provide command & control in support of CIP, LE, and SAR operations.

The C2B shall be classed by an internationally recognized classification society for services within the Gulf of Arabian and the Red Sea, and comply with all applicable standards published by the International Maritime Organization. The vessels are anticipated to operate for a maximuim hours per year over their service lives.

The C2B shall be employed mainly in a command & control capacity for senior members of the SBG, and augment the OPB fleet capacity.

The C2B must have similar functional requirements as the OPB, with specific differences in specification.

The C2B shall have, in addition to the crew, accommodations for the very important persons (VIPs), and more additional senior guests, and enough escort personnel (security, aides, etc.). The vessel shall have wider ingress and egress, doorways, and hatches, appropriate for VIPs and senior personnel. The vessel shall have additional staterooms, mess, and galley to accommodate VIPs and associated personnel.

The C2B shall be equipped with a command & control information centre, in addition to the surveillance suite identified for the OPBs, a highly reliable, efficient, and easily serviceable propulsion system is required and capable of achieving and demonstrating all required performance characteristics while meeting all stated international standards and regulations. The SBG prefers a propulsion system consisting of twin marine diesel engines, shafts and submerged propellers.

The SBGDC shall provide an asset that meets the broad performance requirements of the SBG.

The C2B shall have an objective maximum length of 60m. Actual length of the vessel may be less than 60m and will be dependent on the Bidder demonstrating that their proposed vessel can meet all functional requirements and achieve the stated missions.

The C2B shall have a cruising speed of 15 kts at sea state 3 at full load, and maximum continuous speed in excess of 25 kts in sea state 3 at full load. Range will be (at a minimum) 1500 nautical miles at the cruising speed.

The C2B shall have some deployable boats capable of supporting routine operations and to provide a tender capability for transportation of personnel. The deployable boat shall have minimum capacity of 10 personnel with weapons and equipment.

The C2B vessel shall be outfitted with one forward-mounted camera, stabilized and remotely operated from the bridge. The vessel shall be outfitted with two machine gun mounting points to be located port and starboard.

The SBG' members are interested in the ability of this vessel to accommodate helicopter landing operations, for operations support transport of personnel to and from the vessel.

To allow helicopter operations, the vessel shall include all appropriate lighting, firefighting, and safety equipment.

7.4.3 Capability Systems Engineering

The SBGDC shall provide system engineering and technical management for integrating engineering tasks for the provided Capability (Offshore Patrol, High Speed Interceptor, Utility, and Command & Control). As part of the system engineering effort the vendor shall provide boats that meet all of the requirements. The planned integration of systems shall be identified throughout the construction process.

7.4.3.1 Traceability of Requirements

The SBGDC shall develop, implement and maintain a Requirements Traceability Plan to ensure the contract requirements are met. The traceability plan shall show the flow of requirements down and outward across hierarchical levels and into the Assets. The plan shall demonstrate the completeness in meeting contract requirements. The plan shall show that each requirement has been addressed at an appropriate level.

The traceability plan shall include a Requirements Traceability Matrix that maps contract requirements to the vendor's products. The intent is to demonstrate that all contract requirements are mapped to Assets and their features and characteristics. This matrix shall be updated throughout the life of the construction and shall reflect approved changes as they occur.

7.4.3.2 System Engineering Management Plan

For the OPB and C2B Capabilities, the SBGDC shall prepare with the vendor to provide a System Engineering Management Plan (SEMP). The SEMP shall provide the vendor’s integrated approach for construction, systems integration, testing, delivery, logistics, and life cycle support planning for the Capability. The SEMP shall define the vendor’s plan for conducting and managing a fully integrated, total program effort. The SEMP shall identify systems engineering task descriptions.

7.4.3.3 Configuration Management

The SBGDC must insure that the vendor shall develop, implement, and maintain a vendor's Configuration Management Plan (CMP) for establishing and maintaining configuration, identifying configuration items, maintaining configuration control, conducting functional configuration audits as appropriate, and maintaining configuration status accounting.

7.4.3.4 Verification, Test and Trials

The SBGDC shall demonstrate that the vessel’s performance and capability meet all SBG requirements. Demonstration/Verification shall occur in two steps. The first step is ensuring that the allocated baseline meets requirements of the specification. The second step, final acceptance of the Capability, will be based on Tests and Trials.

The SBGDC shall develop the test plan and procedures for final acceptance based on the technical specifications of the Capability. Acceptance criteria for Tests and Trials will be based on system and equipment performance requirements established in the contract requirements as well as those identified in the Specification. The SBGDC shall develop, implement and maintain an Integrated Verification Plan (IVP). The IVP shall:

- Ensure all products and deliverables meet the requirements of the SBG’ RFP,
- Determine compliance with subsystem and lower level requirements,

- Provide a logical time sequence of component, subsystem and system level tests and simulations, and
- Identify specific inspection procedure or test procedure.

The SBGDC shall be responsible for conducting all equipment, component and system testing.

All test procedures shall be in accordance with component and original equipment manufacturers' recommended practices, and shall not violate component and equipment installation practices, operating procedures, and manufacturers' warranty. Testing and trials shall be in accordance with the governing classification society. The Verification, Test, and Trials described here have been developed for the OPB and the C2B, as they are the more complex assets. This process also applies to the HSI and UB.

7.4.4 Full Capability Integration

Full Capability Integration (FCI) includes the entire set of resources and activities (attributes) required to deploy, operate and maintain a Capability. This includes: training; Equipment and tools; Personnel; Information and Data; Doctrine; organizational considerations; Infrastructure; Logistics and Maintenance and Interoperability.

7.4.4.1 Training

The Training element includes all knowledge related activities required to prepare SBG personnel for optimal performance in existing, enhanced, or new roles resulting from the delivery of the new Capability. The SBGDC shall develop a comprehensive training program for operation, maintenance, and support personnel. The training program shall encompass the types of boat(s) crew positions, maintenance, and support personnel on the boat(s). The SBGDC shall ensure that the training program provides the essential job skills/knowledge so the Saudi Border Guard crew and support personnel can adequately, safely, and effectively operate, maintain, and support all the equipment and systems on the boat(s). The SBGDC shall be responsible to provide the following:

- Document, provide, and present the means to identify and develop SBG needed skills,
- Develop a training needs analysis that is Capability focused and identifies the collective and individual training requirements of the new Capability, including crew and maintenance requirements,
- Develop pre and post Training evaluations and post evaluation follow-up activities to measure effectiveness and impact of training, and
- Pre-Training assessment. Each training course or workshop shall include a pretraining test for the purposes of allowing BGDC to baseline and evaluate the initial impact and effectiveness of the training program on the skills, knowledge, and abilities of training program participants.

The SBGDC is responsible for developing a comprehensive training plan and supporting documentation (e.g. curricula, individual development plans) that addresses the full scope of the SBG training needs with relation to the capabilities provided. The SBGDC shall also develop management support of planning, requirements, acquisition, and other management functions.

7.4.4.2 Equipment and Tools

The Equipment element includes all physical elements required to enable all SBG capabilities that are not covered in “Infrastructure” below. The BGDC ensure that, the provision of platforms, systems, and physical items required to outfit or equip individuals, groups, or organizations affiliated with the SBG requirments. This includes, but is not limited to, the following:

- Deployable and non-deployable items,
- Operational and non-operational items,
- Information Technology,
- Support Equipment and Systems,
- Tools, parts, spares, supplies, and calibration apparatus,
- Hardware and software, and
- Commercial off-the-shelf (COTS) components.

The SBGDC shall address, for each Capability, the linkages with other systems, both current and planned for future implementation.

The SBGDC must be responsible for the development of an Equipment Management Plan that addresses the full scope of the equipment management process. The SBGDC also shall provide management support of planning, requirements, acquisition, and other project related functions.

7.4.4.3 Personnel and Capacity Building

The Personnel element refers to the individual members of the SBG community. The SBGDC must be responsible to provide the following:

- To ensure that the SBG has the right people with the right training and skills, at the right place at the right time,
- establish Integrated Product Teams responsible for formulating both individual and collective personnel solutions to support the capabilities,
- Provide qualified staff in adequate numbers to support the scope of SBG tasks across the entire Capability life cycle, and
- Define changes to aptitude and staffing requirements resulting from the new Capability and how they may impact recruiting and manning targets.
-

The SBGDC shall developed management support of planning, requirements, acquisition, and other SBG management related functions.

7.4.4.4 Information and Data

The Information element refers to all data, knowledge and documentation in any format or media needed by the SBG. There must be a comprehensive information and data management system across each Capability. The details of these system processes must be documented in an Information Management Plan. The SBGDC shall establish, manage and support processes designed to gather and handle data, information and knowledge related to the operational use and support of the provided capabilities. The BGDC must provide the following:

- Establish and maintain a comprehensive information and data management competency across all phases of the Capability development,

- Provide identification, capture, security, compliance, storage, accessibility and availability of data, information and knowledge requirements, and
- Establish the policy, procedures and processes that will be used to check, distribute, update, and manage the configuration of, the technical information necessary to construct the Capability.

The SBGDC shall ensure that the vendor provides drawings, data and associated lists:

- Lines Plan,
- Curves of Form,
- General Arrangement Drawings,
- System Drawings,
- Hull Offsets and Body Plan, and
- Construction Drawings.

Construction drawings are necessary for use, repair, modification and maintenance of the boat meeting requirements of the Specification. Drawings prepared by vendor shall completely specify and/or depict performance ratings, dimensions, tolerance data, equipment characteristics, functional diagrams, mechanical and electrical connections, physical characteristics including form, finish, and weight, details of material identification, inspection, test, and evaluation criteria, calibration information, and other quality control data as applicable to use, repair, modify and maintain the boat, including all information necessary to reproduce any part unique to the boat or otherwise not generally commercially available, including, but not limited, to propulsion shafts, struts, rudders and similar special components. Vendor shall provide construction and as-built drawings depicting the boat(s) that are necessary for use, repair, modification and maintenance of the boat. These drawings shall depict the boat in a manner so as to make the functionality of systems easily evident and shall depict all components of the boat including but not limited to:

- Arrangements of equipment, machinery, outfit and joinery,
- Hull molded shape with tables of offsets and other dimensions required to fully define the hull geometry (i.e. hull lines or equivalent),
- Molded shape of any deckhouses, cuddies, and deck lockers, etc,

- Structural components of the hull, superstructure, deckhouse, cuddy and any lockers or other components including all plating; supporting structure, such as longitudinal, transverses, and engine girders; bulkheads, and decks, foundations, brackets and minor elements such as clips, headers, or other details. These drawings shall include welding symbols.
- Joiner components and details, including the, type, location and mounting of hinges, hooks, fasteners and other minor components,
- Schematics and arrangements of piping, HVAC and mechanical systems and their components including unique parts. Arrangements of piping and other components may depict a single system completely or all systems in a major space at the vendor's option,
- One-line electrical diagram,
- Electrical and electronic schematics, arrangements and cableways,
- Drawings depicting unique electrical components and their internal connections such as switchboards.

The SBGDC must ensure that the vendor provide a Master Equipment List (MEL). The Master Equipment List (MEL) shall document the functional, allocated and product baselines for the Capability.

The vendor shall provide a full set of technical manuals, to support operation and maintenance of the entire class of boat(s). Technical Manuals shall describe the as-built configuration and corresponding systems, software and equipment of the boats. The SBGDC must ensure that the vendor delivers the following System Manuals:

- Boat Information Book (BIB),
- Engineer's Operating Manual,
- Electronics System Operating Manual,
- Navigation System Operating Manual, and
- Computer Hardware and Software Manuals.
-

The vendor shall prepare and deliver the following other Technical Manuals and data:

- Hull Mechanical and Electrical (HM&E) Equipment Manuals,
- Equipment Technical Manuals,

- Electronic Equipment Manuals,
- Stability and Seakeeping Documentation,
- Stability Analysis,
- Stability and Loading Instruction
- Owner's Manuals, and
- Vendor's Manuals.

7.4.4.5 Doctrine and Concept

The Doctrine element includes all user procedures, processes and instructions needed by the SBGDC to fulfill all vendor responsibilities and SBG functions. The vendor shall establish the following:

- Development of concepts (expression of the Capability) that are used to accomplish modernization, and doctrine (expressions of the principles by which SBG resources guide their actions and which stipulates how activities are conducted), and
- Required tactics, techniques and standard operating procedures necessary to achieve an effective level of operation lifecycle activities across all capabilities proposed.

The SBGDC must ensure that the vendor provides management support of planning, requirements, acquisition, and other project management related functions. The vendor shall be required to integrate and interoperate its proposed Doctrine and Concept solution with that established by the BGDC.

7.4.4.6 Organizational Considerations

The Organizational element includes all activities required to successfully prepare for and execute change, and to operate in the changed environment. The BGDC shall define, establish, fortify and sustain an operationally viable organizational structure and new business processes that support the mission of each capability, including, but not limited to:

- Definition of workforce structures,
- Definition of SBG departments,
- Inclusion of contractor provided support, where applicable, and

- Identification of any significant alterations to steady state manpower requirements for each Capability proposed.

The SBGDC shall provide a comprehensive Change Management Plan to ensure organizational readiness to adapt new solutions and doctrine. The vendor shall provide management support of planning, requirements, acquisition, and other project management related functions. The SBGDC shall ensure that the vendor integrate and interoperate its proposed Organizational Considerations solution with that established by the BGDC.

7.4.4.7 Infrastructure

The SBGDC shall demonstrate the requirements of each Capability in terms of its effects on infrastructure, including:

- Entrance profiles,
- Jetties & docking,
- Maintenance facilities and equipment,
- Lift requirements,
- Storage facilities,
- Security while docked or in port, and
- Shore power utilities.

The SBGDC shall define what additional infrastructure will be required to be developed for the maintenance and operation of each Capability.

7.4.4.8 Logistics and Maintenance

The Logistics element refers to all activities needed to sustain the readiness and availability of the SBG capabilities. The SBGDC shall institute, or the vendor must support in instituting, management, monitoring and reporting on all aspects of Integrated Logistics Support (ILS) operations dealing with:

- The development, acquisition, storage, transport, distribution, maintenance, evacuation and disposition of materie,
- Supply chain management of required parts and support equipment,
- The transport of personnel and equipment,

- The acquisition, construction, maintenance, operation, and disposition of facilities, and
- Maintenance of assets, directly or through training of SBG personnel.

The SBGDC must ensure that the vendor shall be supportability, maintainability and availability to deliver interoperable total systems capability. The vendor shall establish processes and procedures to manage its relationships with stakeholders to deliver an interoperable (total systems) capability to include provisions for supportability and interoperability. The vendor shall capture logistics support processes and procedures in an Integrated Logistics Support Plan. The vendor shall provide management support of planning, requirements, acquisition, and other project management related functions. The vendor responsibility is to support the BGDC in the development and maintenance of the Integrated Logistics Support to ensure the integration and interoperability of the proposed capability.

The Saudi Border Guard maintenance concept has three levels: organizational, intermediate, and depot. Organizational maintenance involves routine tasks, such as inspection, lubrication, and assembly of minor parts that are typically performed by a vessel's crew. Maintenance beyond the capability or capacity of a vessel's crew is performed at SBG intermediate maintenance facilities and consists of short-term, time-critical projects. Depot-level maintenance, traditionally done in shipyards, requires high levels of skills and equipment beyond the capability or capacity of ships' crews and intermediate personnel and facilities.

The vendor shall develop, implement and maintain a Reliability, Maintainability, and Availability (RM&A) Plan that establishes procedures and processes and identifies life cycle support. The plan shall address the following areas as a minimum:

- A procedure for evaluating risks associated with achieving required RM&A levels for the boat,
- A system for evaluating and trading off RM&A performance with boat performance, mission performance, and Life Cycle Costs,
- Identification of reliability of mission critical items (those items that require special attention because of complexity, advanced state-of-the-art, including

stateof- the-art integration of state-of-the-market subsystems, or whose failure will result in serious degrading effects on boat safety, readiness, mission performance and success, or maintenance/logistic support), and

- Identification of mission critical single point failures and the steps taken to avoid them.

The RM&A Plan shall focus upon measurable benefits (metrics) to the BGDC, such as total Mean Time between Failures (MTBF), Mean Time between Mission Critical Failures (MTBMCF), Mean Time to Repair (MTTR), and Mean Logistics Delay Time (MLDT).

The vendor shall identify to the BGDC those alternatives that provide the maximum cost benefit to the SBG over the boat’s life cycle, considering standardization and other external factors. The vendor shall use an iterative approach to optimize the incorporation, accessibility, and maintainability of systems and equipment throughout the construction of the boat.

The vendor shall develop a Provisioning Parts List (PPL) containing the end item, component or assembly and all support items which can be disassembled, reassembled, or replaced, and which, when combined, constitute the end item, component or assembly.

The vendor shall provide the initial spares (repairable items) and repair parts that are required to support and maintain the Capability for more than 3 years after completion of the one year guarantee period, for all levels of maintenance. The vendor shall guarantee the availability of all repair parts for a period of not less than 10 years after delivery of the vessels.

The SBGDC must ensure that the vendor identify operations, maintenance tasks and schedules required for the Capability and all of its installed major systems/equipment items to: identify logistic support resource requirements for each task; identify mission critical logistic support resource requirements; identify support requirements which exceed established requirements, or constraints; and provide source data for preparation of required documents (technical manuals, training programs, manpower

and personnel lists, etc.). As part of FCI, the mandatory and optional O&S periods include these requirements. Section 3 further describes the O&S requirements.
The vendor shall be required to integrate and interoperate its proposed Logistics and Maintenance solution with that established by the BGDC.

7.4.4.9 Interoperability

The Interoperability element refers to the activities and results associated with ensuring all of the components of the SBG work together to create effective capabilities. The SBGDC must ensure that interoperability, providing for the ability of systems and infrastructure components, to aid, protect, complement, sustain, develop, test, train, and operate within the on-going BGDC initiatives to achieve its required functional, technical, performance and operational capabilities. This includes setting and executing standards, procedures, or requirements. The SBGDC shall affect these results through management support of planning, requirements, and acquisition. The vendor shall be required to integrate its proposed Interoperability solution with that established by the BGDC.

7.5 Summary

The many aspects of vessel acquisition, and of subsequent operations and maintenance, are reflected in detail in the above text and with a rigorous 'through-life' focus on how to effectively and efficiently manage and utilise a fleet of vessels of various functional types and sizes. This also illustrates the integration of an operational fleet with the broader national aspects of over-arching communication, control and command integration in order to attain total combined systems benefits.

All aspects of acquisition, design, manufacture, operation, and maintenance, etc. must be considered in the development of an efficient fleet and in its operational effectiveness. There are various ways of measuring effectiveness and efficiency and each requires a comprehensive breadth of data and information, etc., and the full professional involvement of all officers, crew and technical support staff and an organisational culture that is correspondingly focussed.

A considerable amount of data, information, service records and applied expertise is required to be collected, analysed and developed such that all aspects through-out a vessel's life are fully understood. Through this the through-life care and maintenance can be assured leading to improved vessel availability following from corresponding improvements in reliability and maintainability.

Also by keeping comprehensive records, including full service operations and maintenance activities, the SBG will be greatly assisted in the preparation of the specifications for new vessels in the future.

7.6 Conclusions

The long history of the Border Guard of the Kingdom of Saudi Arabia has lead to its current approaches for the acquisition and operation of new vessels for its fleet and that are necessary for ensuring the safety, security and integrity of the water-bourne routes into and around the Kingdom.

The practices that are currently followed reflect the various checks and balances, operational experiences and the preferred style of top-down control, etc. that have evolved during its long history.

However great increases in the sophistication and complexities of modern vessels and in their machinery and equipment, and in the similar changes in the current and future traffic, both legal and illegal, through Saudi waters, leads to the supposition that changes in both equipment and practices, including the embodiment of modern data and communications technology, would be greatly beneficial.

This section proposes major developments in acquisition, integration and organisational aspects that will enable the SBG to meet its challenges in the near future in an effective and efficient manner. It also should lead to a fully modern capability that will enhance the prestige of the Kingdom.

8 CHAPTER Eight: Synthesis of the Overall Process for the Acquisition of New Vessels for the SBG

8.1 Introduction

The process of acquisition of a new vessel for the SBG can range from simply purchasing one on an ad-hoc basis, similar to one that is currently in-service, through to undertaking a relatively lengthy but wholly rationalised process of systematic analysis and evaluation. This chapter looks into the latter of these two extremes. The process involves many inter-related activities, some implicit and others more organised and explicit. A great deal depends on the abilities of the SBG staff that are tasked with acquisition of new vessels. This chapter is more relevant to the larger vessel types operated by the SBG.

In Chapter seven the current procedures for the purchasing of vessels for the Saudi Border Guard, SBG, were discussed. Although significant progress has been made over the years since the initial evolution of the SBG, the procedures has been refined and developed in a somewhat ad-hoc manner, reflecting sound experience and professional/commercial judgement, but not in a structured and formalised manner that reflects the long term developing needs of the SBG.

The SBG will undoubtedly continue to grow in the years ahead, as both greater and new demands are placed upon it. It thus seems to be an appropriate moment in time in which to examine, in the broadest possible detail, the overall through-life vessel acquisition and employment process in order to postulate how the SBG can develop to meet the challenges of the next century.

8.2 The Acquisition Process

The overall acquisition process can be considered to span the time from the initial identification of a need for a new vessel to the point at which the vessel enters into service. This overall process can include many activities and stages, all of which contribute, in one way or another, to ensuring that when the new vessel enters into service it is the most suitable vessel; one that will give many years of good service and not to be found lacking in the ability to perform tasks, including any new ones, that it is called upon to undertake.

There is no formal description of the acquisition process that reflects the particular needs of a coast guard type of organisation. However, there have been, over the years, descriptions of loosely similar acquisition processes for military vessels which offer a general template. Figure 8.1 shows a proposed form that links all the possible activities in the overall acquisition process.

The acquisition process includes the formulation of the specification for the new vessel which will eventually be procured. If vendors respond to the SBG's request for a proposal, submitting tenders, they will become involved if their bid is found to successfully meet the specification. The overall acquisition process is illustrated, in conceptual form, in Figure 8.1

Although there exists several organisations around the world (excluding military navies) there is no single collectively recognised formal process for the acquisition of new vessels for organisations such as the SBG. There are several large organisations, such as the US. Coast Guard, which have quite wide ranging sea and environment area responsibilities.

There are other coastal water operators that face quite demanding challenges, such as the Canadian and Russia authorities. There are also a large number of organisations, of relatively modest size, that have very specialised functions, such as the UK, Royal National Lifeboat Institute. Many of these organisations maintain a core body of experienced and qualified staff to oversee the through-life operations and development of their vessels. These core staffs are usually tasked with ensuring that their organisation has vessels that meet current and anticipated future operational demands.

The acquisition approaches followed by these organisations are not generally published in any detail; however they can be gleaned from their patterns of behaviour, etc., over many years combined with a general understanding of how they operate.

Figure 8.1 is thus not taken from any available specific source material but has been synthesised from many observations (together with some limited extrapolation and interpretation) in order to provide a notional overview of the entire future needs to the new vessel commissioning process.

It is thus suggested, as a result of the studies made within this thesis, that it could be used by the SBG as a template for the development of its future organisational structure.

Thus the purpose and intent of the various boxes in Figure 8-1, and as discussed in the following pages, is to touch-upon all of the activities, no matter how peripheral, that are involved, or potentially involved in the acquisition of new vessels for the SBG.

The following sub-section numbers are to be identified with the corresponding box numbers in the chart.

8.2.1 Overview of the Chart

Some of the 'activity' boxes in the chart given in Figure 8.1 are implicit rather than explicit. Some activities are very subjective and it is difficult, if not impossible, to put any form of numerical value on them. Obviously, there may be some, if not many, iterations within the overall process and unforeseen developments may occur that require changes, particularly with regards to earlier decisions, etc. Therefore, having some kind of a systemic development plan will help to ensure that decisions are made in a rational manner and will help to minimise, or hopefully eliminate, the possibility of an unsuitable, ill-equipped vessel entering into service. The various activities presented in Figure 8.1 need some explanation and discussion in order to clarify their purpose and intent.

8.3 Geopolitical Issues

The only prediction that one can make about the future, with a reasonable degree of certainty, is that it will be a time of uncertainty and thus one need to expect/anticipate and be prepared for the unexpected.

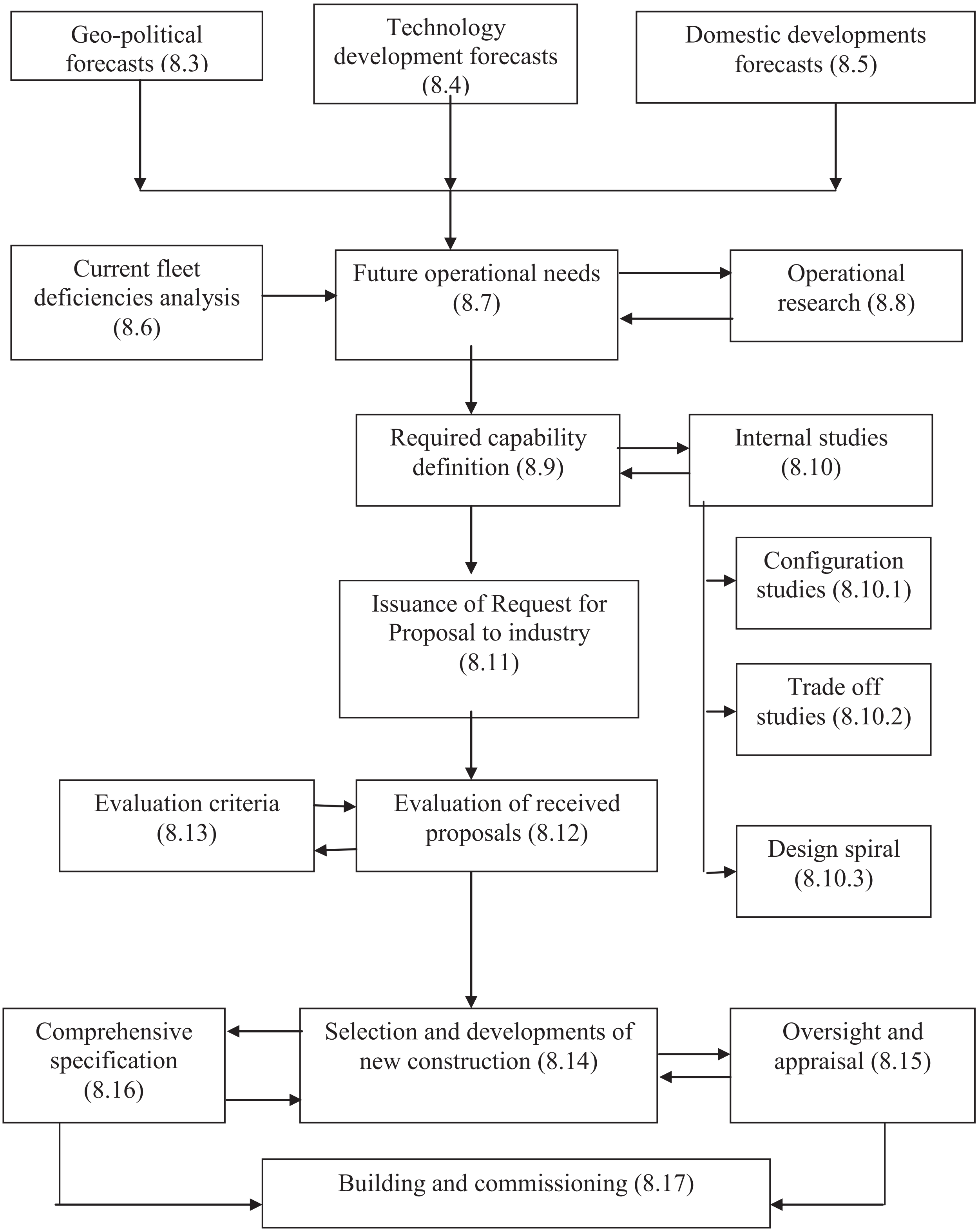


Figure 8-1Conceptual overview of the possible organization and planning process for the SBG future fleet specifications.

This is one lesson of history. Thus, the SBG is obliged to plan for the future and make the best possible predictions of its requirements, allowing for unforeseen situations that may develop, whether physical, moral or practical. Disasters, whether natural or the result of human action and/or inaction, are always possible (such as earthquakes, pollution, global warming, flooding, etc). As a result, it is prudent to propose vessels, specifically the larger vessels that are designed to permit a degree of progressive enhancement in the years ahead.

The quality of interactions with neighbouring countries may be considered as uncertain. For instance, there may be the unfortunate emergence of regimes that have a degree of hostility towards Saudi Arabia. As a result, the SBG may need to develop a more militaristic stance than it currently holds, for example to combat pirates, aggressive smugglers, aggressors using ‘swarming’ approaches, etc. Thus, the SBG must get input from others when formulating its future fleet plans. They should consider:

- Internal issues within Saudi Arabia (SA), such as expenditures,
- Relationships with countries sharing the same sea areas of the Red Sea and the Gulf of Arabia,
- Larger international obligations and treaties with regards to trade routes, safety at sea, etc.

The status of the SBG vis-à-vis other government agencies with regards to financial limitations on resources both men and material.

The relationship between the SBG, the Saudi navy, the police, and the kingdoms other armed forces.

8.3.1 Changes and Developments in Water Bourne Traffic

Such political changes are influenced by :-

- Commerce,
- Trade,
- Pilgrims,
- Tourists,
- Exploitation of the sea, and,
- Exploitation of sea-bed resources.

The rapid increase in local and international trade, which comes mostly via the sea, as well as the arrival of millions of pilgrims and tourists who come to visit the Muslim holy sites in Saudi Arabia, means that a strong fleet is required, not only in terms of vessel numbers, but also in terms of vessel specifications. This is in order to protect the country's borders and provide rescue and help services that may be needed by people and vessels who find themselves in trouble in the sea.

8.3.2 Changes in Vessel Types, Sizes, etc.

A gradual change in commercial vessel sizes and complexity can be anticipated, including:-

- Ferries and cruise ships,
- Gas carriers,
- Small vessels for pleasure, fishing sports, etc.

Over the last few decades there has been an increase in the size and number of different vessels, in addition to advancements in vessel specifications, as a result of newly developed technology. The monitoring of these vessels will require increased attention from the SBG, particularly large vessels carrying a greater number of passengers and vessels carrying hazardous cargoes e.g. LNG, LPG, chemical/petroleum carriers, crude oil, etc. Smaller vessels can be used by terrorists to attack civilians and onshore constructions beside the coastline. Smugglers tend to use either mundane imnocuous types of vessels, e.g. fishing vessels or to use modern very high speed craft in order to evade being caught. So, in order to protect Saudi Arabia, its people and its constructions from terrorism, the acquisition of newly developed technology, including vessels and sensors, must be considered by the SBG. Higher speed and multihull vessels will also need to be considered, although these fall under technical developments.

Many geopolitical issues influence the overall changes that occur in the economy of the whole region as well as the movement of goods and people. Thus, to undertake this work input from local politicians, economists and industrialists is required. The views of the Saudi Navy will also be important, as they may wish to see increased support, co-operation and communication with the SBG. This work, albeit tenuous, may help to illustrate the environment in which the SBG may need to operate in the years ahead.

8.4 Technology Developments Forecasts

It is important that the SBG are kept fully aware, through continuous studies of worldwide developments in state-of-the-art design, construction and equipment of vessels. By maintaining such awareness the SBG will be able to ensure that all vendor proposals for new vessels reflect these developments and associated improvements.

8.4.1 Technological Development Forecasts

Regarding future SBG vessels, anticipated developments that should be considered include:-

- Hull design shape and arrangement,
- Construction material,(both metallic and non-metallic)
- Power plants,
- Machinery and equipment,
- Operational equipment,
- Shore based interfaces.

Considerable changes are continuously taking place in each o tthese areas, particularly the latter two where the collection and sharing of data, in all forms, is of extreme value and importance.

8.4.2 Vessels Entering Saudi Arabian Sea Areas

Such vessels can vary in terms of:-

- The type of vessel and its cargo,
- Size, speed, and configurations,
- Equipment used by the vessel,
- Selection of transit routes.

Aspects and developments in new vessels to be aware of and which will be of interest to the SBG include:-

- Multi-hulls, new materials, construction methods, hull stress monitoring, vibration detection, fast planing and slam control, etc.,

- Machinery, propulsion systems/thrust vectoring for steering, improved reliability and maintainability trends, monitoring equipment, etc. ,
- Power generation and storage, fuel cells, fresh water generation, fire fighting equipment, monitoring equipment, etc.

However specifications must meet the requirements of the SBG, its missions and its personnel, in addition to the environments where its vessels operate.

Obviously merchant/commercial/pleasure and working craft will experience design changes as the years go by and such changes may result in changes required in the capabilities of the SBG craft that will be tracking and monitoring them. Changes in vessel design may cause additional problems for the SBG in the case of accidents, on-board fires, pollution implications, etc.

Clearly any development in the design and construction technology of these vessels will be of some considerable interest to the SBG for their proposed new vessel designs. This will particularly apply to the levels of equipment, including for navigation and communications. Trends in the development of these vessels, particularly in their size and speed, will also be most important as such will put similar demands on the capabilities of the SBG fleet.

8.4.3 Equipment Development

This is possibly the area of greatest significance for future developments, and includes:

- Ship-mounted, optical, infra-red, and electronic sensors,
- Ship operated unattended aerial vehicles (mini-size),
- Communication equipment,
- Data processing/display equipment and condition monitoring equipment,
- Ship to shore interfaces for 'network centric' operations,
- Position finding equipment, navigation equipment and radars.

In the military field in recent years significant developments have taken place in the areas of intelligence gathering, surveillance, exchanging information in real-time, threat recognition and evaluation, etc., and much of this will eventually become available to the SBG for the consideration in integrated network operations, both within the SBG and at the national level.

8.4.4 Needs and Demands

The SBG will need to plan for the future in order to:-

- Avoid early obsolescence,
- Plan for continuous enhancement,
- Plan for future service life extension needs,
- Avoid being unequipped for future operational demands.

Developments that relate to hull and machinery condition monitoring, together with the maintenance of comprehensive operational needs and scheduled maintenance, are the most important. Acting in a cost effective manner will help to ensure that any new construction will avoid early obsolescence. Having state-of-the-art vessels will help the SBG to fully meet its goals as effectively as possible.

8.5 Domestic Development Forecasts

This is clearly a relatively tenuous area and one in which most deliberations will be implicit, rather than explicit, activities. However, the SBG does not exist in a manner that is totally unaffected by Saudi domestic developments, and the staff at the SBG's headquarters, who are responsible for the acquisition of new vessels, have to consider several aspects.

These can include:-

- National projections and integrated policy,
- Availability of funds and future manning levels,
- Commitment to training,
- Commitment to sharing marine related infrastructure,
- Development of offshore projects,
- Interactions with other Saudi national services which will always be important and, including:

- Navy, air-force, helicopters, police,
- Part traffic planning and management,
- Shore based radar and communications,
- Development of national ‘network centric’ processes for controlling coordination, commands, communication and intelligence (C&I), and integrated sea-level-air surveillance systems,
- Increased use of college/university output,
- Overall contingency and general disaster planning,
- Social/religious/commercial/industrial developments that may affect ports and trade routes, share related installations, and create new areas that will lead to increased marine activity,

Any intention to develop design, manufacturing and maintenance capabilities relevant to the SBG fleet and its equipment.

8.6 Current Fleet Deficiencies

Current fleet deficiencies, if it is found there are any, can be considered to fall into two categories, namely:

- The overall and detailed performance of current vessels in the context of their current operational roles,
- The projected performance of the current vessels in relation to anticipated new demands that maybe placed on them in the near future.

An exhaustive survey has been undertaken by the author in the form of a series of interviews and a questionnaire. This involved collecting, collating and evaluating the views of a considerable number of officers and crewmembers that currently serve with the SBG.

The results of the survey are given in Chapter 6, and in the appendix B, the information that was collected includes both subjective and objective views. The latter are useful because quantitative data can be produced from them, potentially to provide input to future new design.

The second of the categories mentioned above is a task that still needs to be undertaken. It is considered to be extremely important in that benchmark measures can be developed against which proposed new designs can be compared.

8.7 Future Operational Needs

A group of highly experienced officers need to review, in some considerable detail, all of the input that they are presented with from all earlier activities in order to assess future operational needs. It is reasonable to assume that there will be considerable conflict between the received input items which become barriers to choice and selection.

It will not be useful to go into detail in reviewing the intricacies of this activity; however, it is reasonable to assume that some form of trade-off, cost-benefit and cost-effectiveness studies, involving a study of a range of alternatives may be of value in reaching a clear statement of future operational needs. If there are serious difficulties in reaching a consensus of views on operational needs then it may be necessary to undertake further operational research as discussed later.

It should be appreciated that establishing an understanding of future operational needs is not the same as defining the required capabilities of individual classes of vessels, but more in the form of the overall composition of the future SBG fleet.

Future challenges facing the SBG in securing the coasts include the traditional threats of illegal fishing, smuggling and illegal immigration, as well as the developing threat of terrorism, which is potentially the most dangerous. Thus, the SBG must be very careful when defining its various missions because depending upon the type of mission the specific patrol boats used must have particular characteristics and equipment, taking into account other potential rescue and general support issues.

Smugglers normally use small, high speed boats for trafficking illegal goods, drugs, or passengers. They often use firearms when intercepted, and try to run from the SBG's boats to the open sea or to the rugged hazardous coastal waters. They prefer not to use heavier boats due to a lack of manoeuvrability. Thus, the SBG must consider not only its fleet specifications and the protection of its vessels from enemy fire, but also the performance and number of its opponent's vessels.

Terrorists may use fishing and sports boats for their movements, or may even attack large merchant ships or chemical and gas carriers. They are a real and serious potential threat to civilians, as well as to very important installations and constructions near the coastline. They may also attack navy vessels or the SBG's vessels. In addition to using intelligence information which defines their targets, the SBG must use new technology including such as Unmanned Aerial Vehicles (UAV s) either operating from the SBG vessels or from the land, (the former influencing the vessels design, electro/ optical /infra-red sensors and satellites to track and monitor the coasts and prevent terrorists from attacking by sea. Terrorists must be stopped at a distance far away from their potential targets, which means that SBG activities must involve long range vessels with maximum endurance.

There are two different types of SBG activities in coastal areas: conventional activities, which require vessels for inspection, support and rescue etc, and security and counter-terrorist activities which need semi-military vessels that are strong, fast and with modern equipment for communication and navigation, as well as stabilised weapons and advanced all-weather day and night sensors.

The responsibility of the SBG, which is to secure more than 2400 km of coastline, is not an easy task. Not only are its fleet specifications very important, but also the size and composition of its fleet. Vessel radar, due to hideouts of infiltrators being located on islands, often cannot detect targets, so securing the coastline and waterways requires constant surveillance by coastal radar and various electro-optical and direct visual means, and also frequent patrolling and possible data-links with airborne sensor platforms. Thus, some vessels in the SBG fleet have to be designed with minimal draught in order to allow operations in shallow coastal waters, especially since there is a random spread of coral reefs in the mid and northern areas of the Red Sea.

According to the type and location of the SBG's missions, different sizes and types of vessel will be needed. The facilities, endurance and range capabilities of short range and service boats ranging from 8 to 20m in length are used for operations close to the coastline. The lowest possible draught is preferred with high speed because fishing and sports boats are used mostly close to the coastline. The hull material often best for this type of vessel is some form of modern fibre reinforced plastic in either simple laminate or composite laminate faced core form due to ease of maintenance and its strength.

Given a well thought-out and extensive over-view of possible future operational needs there will still be a level of uncertainty about many aspects, possibly expressed in terms of probabilities, etc.

There will also be levels of priority assigned, either rationally, arbitrarily or politically motivated to various situations. For example incidents that would probably rarely occur and would be relatively expensive in order to be able to develop the means to respond to would be given low priority in the context of future needs. However incidents that are projected to frequently occur would be given high priority regardless of the probable expense involved in developing a response to.

There will likely be a considerable spectrum of such situations. However there will be the possibility of newly emerging technology enabling the SBG to devise approaches to cost-effective solutions.

8.8 Operational Research

Operational research is a relatively new, but mature, science that first began to develop in a recognisable form over 70 years ago. One of its early applications was in the military equipment and operations fields, and it has been employed in several other areas since. The extent of its application need not be highly detailed. It should match the complexity of the potential needs and reflect the degree of uncertainty that may exist. It is clearly not the same as market research.

It is important to establish the breadth of, and uncertainties within, perceived operational needs, and to examine the various possible reactive strategies. This may include various tools and techniques, such as:

- War gaming,
- Simulation,
- Statistical analysis of operations.

Clearly, the scope of the study will relate to the size and importance of the individual classes of vessels that will possibly be developed. The larger and more complex the vessel the more will be the value of an operational research type of study. However, it may be of particular benefit to do some level of operational research in order to establish the factors that are of significance to the total fleet of vessels, its composition and the number of vessels in each class or category, as well as the various levels of coordinated operation, etc. The following section attempts to touch upon the various factors and aspects that can be involved in operational research studies.

8.8.1 Operational Research Studies

1) Probability of transiting/intruder/suspect vessel detection allowing for:

- All weather conditions, day and night.
- Effects of humidity, rain, sea condition, etc.
- Size of target vessel, length, height above waterline, shape of vessel, orientation (e.g. bow on, stern on, and full profile) and colour.
- Visual detection with and without navigation lights.
- Use of passive and active infrared equipment.
- Use of radar and radio direction finding.
- Use of search lights.
- Use of sound detection equipment.
- Use of electronic surveillance equipment.
- Use of active and passive sonar.
- Confidence levels.
- Crew training.
- Effects of equipment improvements.
- Potential benefits of network centric aids involving ship-to-ship and ship-to-shore data collection, etc.
- Use of the SBG coordinated intelligence and navigation aids.
- Detection of other floating objects, persons in the sea, life rafts, lost objects and containers, results of accidents, etc.

2) Influence of patrol duration:

- Performance of on- patrol time relative to overall departure and return to port time.
- Considerations of various areas of operation, including in-shore.
- Effects of sea and weather conditions.
- Benefits of extra fuel and provisions.

Effects of vessel performance and habitability on crew performance over time.

3) Influence of speed:

- Time out to patrol station,
- Area covered patrolling,
- Requirements of interception,
- Requirements of pursuit,
- Benefits of different hull forms and multi hulls, (e.g. catamaran, trimaran, etc)
- Effects of slamming and spray on crew, vessels and equipment in various sea conditions,
- Effects of sea and weather condition,
- Influence on hull machinery and equipments reliability.

4) Examination of various patrol/search patterns in order to look for illegal vessels with associated levels of probability of detection and interception, etc.

5) Advantages of advanced 'intelligence' and anticipation of regular/legal traffic and vessel detection by other sources (e.g. land-based radar, airborne radar, etc.), including predictions of regular/legal traffic with associated ship and port data.

6) Traffic/vessel tracking systems, reporting systems and integration with port estimated time of arrival, ETA, scheduling. Integration with port security systems could result in the advantages of fitting temporary tracking devices to intercepted vessels (note - port security starts at the territorial sea boundaries, that is, as soon as vessels enter into Saudi sea regions).

The above could have some influence on the nature, size and composition of the future SBG fleet. The development of the future SBG fleet must be compatible with other in-country developments, such as a national 'network centric' air and sea recording, traffic pattern and central system. A network centric system could be:

- A centralised, real-time, continuously updated data base of all air and sea traffic, fused together from all sources including intelligence operations,
- Comprehensive and with a degree of future position predictive capability for all vessels.

Full vessel descriptions with data, including name, owner, registered class type of vessel, dimension cargo, deadweight, etc., and with some form of qualification to enable SBG craft to be able to plan and prioritise interceptions, and, if required, board and inspect vessels (this is then used to update the overall data base on land in real-time).

SBG vessel operations could be fully integrated with the system and providing input to the system but with their commanders being given some flexibility for individual judgements.

Operational research will continue into internal studies, as discussed in Sections 8.10 in order to continuously refine and develop ideas and goals.

8.9 Required Capability Definitions

This is the stage that comes immediately before the preparation of the actual specification that will be formally issued to national and international companies for their response. At this stage the SBG will have established its future operational needs in terms of the general characteristics and detailed capabilities of each vessel class that is to become an integrated part of their future fleet. However, the SBG will need to have a clear picture of that which is technically achievable and, of particular importance, that which is cost-effective. It would thus be most prudent for the SBG to undertake some limited internal studies, which are discussed in the following sections. Internal studies will enable the SBG to clarify its ideas, rationalise its expectations and anticipate how potential vendors may respond in terms of technicality, quality, efficiency and integrity of any submitted design efforts.

As an outline functional design for a particular craft begins to evolve within the SBG offices, the SBG will be able to fine tune its identification of required capabilities and hence refine subsequent formal specifications. Indeed, the overall process leading to this point in the overall acquisition process may be reiterated several times and various earlier activities may be revisited and their results re-validated. This process of adjustment and refinement is almost inevitable and will apply mainly to the larger vessels in the future fleet.

At the end of this stage, the SBG will have carefully defined and evaluated the capabilities that they require each class of vessel to have and the required attributes of form, configuration, arrangements, construction and outfit, and the technical aspects of the specifications would have begun to emerge. At this stage are added mandatory performance demonstrations, legal and financial aspects, as well as the usual guarantees and commercial clauses, etc.

8.10 Internal Design Studies

As discussed earlier, the SBG staffs that have undertaken the operational research studies will most probably be the team that is the most suitable to subsequently undertake general internal studies into the general forms and characteristics of potential vessels for the future fleet.

Figure 8.2 illustrates the general scope of this activity. It can be assumed that it is undertaken by a relatively small group of highly skilled and experienced naval architects, marine engineers, systems engineers, and persons with good operational experience in the SBG. It would be reasonable to assume that, for purposes of continuity and overall effectiveness, the members of the group will include persons who were deeply involved in the earlier operational research studies. The level of detailed efforts at this stage need not be high, but sufficient in order to ensure that the general characteristics required of new vessels for the SBG are clearly developed and progressively refined.

Such studies will also enable this group of engineers to subsequently contribute to the preparation of exacting new build specifications and to provide specialists who can help with the process of evaluating designs that are proposed by vendors who respond to the issued Requested for Proposal (RFP).

The presumption behind this is that a central core of experienced engineering staff will be created within the SBG. This core staff will need to have an in-depth involvement with many, if not all /most, of the acquisition steps notionally reviewed within this chapter.

It will clearly be a major new commitment by the SBG and could become a Centre of Engineering Excellence within Saudi Arabia (SA). This will thus be similar to that within the US Coast Guard and to that within military organisations such as the UK Royal Navy and the US Navy. This centre of excellence could be shared with the Saudi Navy.

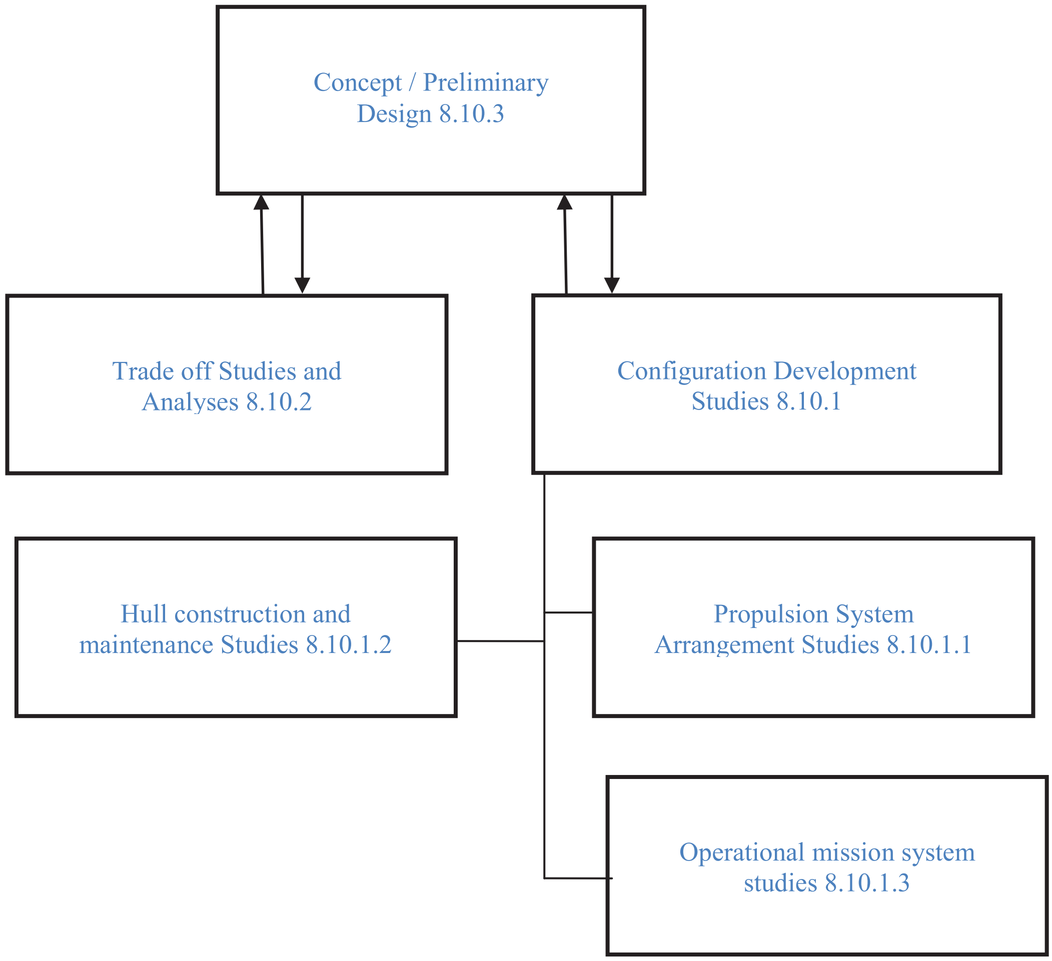


Figure 8-2. Outline of Possible Internal studies within the SBG

Figure 8.2 is a simplified representation of the general multi-disciplinary activities that will need to be undertaken in order to develop one or more general arrangement designs that could meet postulated requirements, etc. These designs will enable to the SBG to anticipate aspects of any design and associated costs of proposals that are submitted to them by potential vendors that elect to respond to the RFP that the SBG issues.

These internal designs could be used to provide a comparative benchmark level. Some similar organisations in other countries undertake tasks of this nature.

The ranges of studies that may be undertaken at this stage will include the following:

8.10.1 Configuration Studies

Such studies could include:-

- General hull configuration, mono-hull and multi-hull alternatives,
- Hull envelope evolution for both displacement and planing conditions allowing for motions, slamming, spray, manoeuvring, etc. ,
- Bow and stern arrangements development,
- Upper deck and topside structure,
- Internal decks and bulkheads,
- Assignment of spaces and compartments.

8.10.1.1 Propulsive System Arrangement Studies

Such studies could include:-

- Basic engine / prime mover,
- Type and location of propeller system,
- Power transmission system,
- Engine management and control system,
- Power take-off system,
- Installation and maintenance studies,
- Repair /removal and replacement studies.

8.10.1.2 Hull Construction and Maintenance Studies

Such studies will include:-

- The influence of the earlier studies on general configuration,
- The requirement for the SBG shore staff to be able to inspect, maintain, and if necessary repair damaged,
- The durability of the hull material and the associated form of construction,
- Hull structure material.

There are two groups of potential hull material:

- Metallic: Steel of different grades and aluminium of various alloys; for each there is suitable form of construction, type of protective treatment, consideration of in-service inspection and maintainability and builder's maintainability issues.
- Non-metallic: issues are a composition of conventional fibres, new fibre groups, resin material, and also form of laminate construction and manufacture.

Innovative materials and structural forms, particularly for the non-metallics, must have carefully thought-out inspection and repair schemes for a full spectrum of damage scenarios. Typical damage possibilities can include beaching, hull to hull contact with other vessels or contact with any shore facilities. Other reasons for damage might be weapon damage, accidentally dropped heavy objects (e.g. during equipment repositioning) or equipment seating failure.

Contingencies for future service-life development and extension programmes are for equipment and machinery. Advanced materials, particularly non-metallics, and methods of construction need to be carefully considered for initial cost, potential through-life cost, and problems of inspection maintenance by the SBG or by the original manufacturer.

Some form of statistical study allowing for the probability of various costs occurring on a fleet basis (e.g. number of vessels of the same type operating for the required number of operational years) may lead to an optimum material and configurations that are not technically the immediate best.

8.10.1.3 Operational/Mission System Studies

Such studies will include:-

- General operation of the vessel, speed and overall performance, navigation equipment, communication, engine/machinery control and gauges, general automation, general gauges and alarms, search light, rescue equipment, etc.
- Mission system and equipment includes:
    - Specialist communications,
    - 2- Specialist radar equipment,
    - Specialist surveillance equipment:
        - Optical,
        - Cameras,
        - Infrared,
        - Electronic and radio.

Network centric equipment for ship to shore and ship to ship coordination

Possible light weapons

8.10.1.4 Commentary

The various in-house internal studies will make the SBG better able to clarify its requirements because for example, it will have examined all possible alternatives of various propulsive systems, and such as multi-hulls verses conventional mono-hulls. Also, undertaking such studies helps from both a cost-effectiveness and cost-benefit perspective.

Obviously, the SBG will need to have a clear understanding of what is technically achievable within the budget that has been allocated and will have to be able to argue a good technical and through-life cost based case if it thinks that it would be advantageous for this budget to be increased.

It is better to do this before proposals are received from any potential vendors and it will enhance the status of the SBG if vendors recognise that the SBG has a level of expertise that will enable them to evaluate and question the efficacy of their submitted proposals.

It is reasonable to assume that the successful vendor who is awarded a contract to produce a new design will be required to produce both comprehensive drawings and attendant analyses in order to verify how fit for purpose their design is (e.g. adequate fatigue life, reliabilty, etc.). The internal studies group at the SBG should be the best able to evaluate and pass judgement on these submitted drawings, documents and analyses.

The group that undertakes all the various internal studies will require a range of modern up-to-date computer software in order for them to be able to create both outline/preliminary designs and undertake a spectrum of analyses. For example:-

In support of configuration studies:-

- General naval architectural analyses,
- General hydrodynamic hull resistance investigations,
- Powering studies,
- General ship motions and slamming,
- Initial weight estimates.

In support of propulsion system studies:-

- Power transmission efficiency,
- Vibration aspects,
- Propeller operating behaviour.

In support of operational/maintenance system software control help with:

- Electrical power documents,
- Batteries/storage,
- Electrical interference,
- Systems efficiency studies,
- Bilge/fire fighting, pumping studies,
- HVAC calculations.

8.10.2 Trade Off Studies

A major part of any studies at this stage must include 'trade-off' studies, starting with predictions about future operational scenarios. The 'trade-offs will involve, for example:

- Future fleet numbers,
- Future mix of vessels,
- Crewing requirements,
- Future basing of vessel,
- Speed and endurance parameters,
- Levels of sensor capabilities,
- Levels of equipment performance,
- Effects of network centric operations,
- Ship-shore-air influences,
- Contingency allowances.

The future mix of vessels, for example, will include various numbers of such types and sizes of vessels, e.g. large numbers of small unsophisticated vessels to small numbers of large complex sophisticated vessels, etc. This will clearly be related to the speed and endurance of the vessels.

Fleet to shore coordinated network-centric operations will clearly have a significant influence, particularly where coordinated data collection and sharing, intelligence assessments and ship-shore-air assets are well integrated. This is a significant development in recent years in the military field and offers a significant improvement in overall operational efficiency.

In this context studies need also involve vessel/system availability, reliability and maintainability considerations. For example less reliable vessels will need to be traded-off against increased numbers in order to compensate to provide the required levels of continues patrol coverage, etc.

Clearly trade-off studies become a complex activity but, however, should enable the SBG to develop an optimum fleet.

This should/could lead to agreement of new vessel requirements. There will also be two factors relevant to the nature of the SBG:

- To see and to be seen,
- To see and to act if required.

Purely in-house studies that are very preliminary can be undertaken in order to provide sufficient graphics/drawings/data, etc. to clarify the results of earlier considerations and to make comparisons with current in-service vessels.

8.10.2.1 Design Spiral

The design spiral Figure 8.3 is really just a graphic representation of the normal iterative process of developing design. Starting with a general initial assessment of all aspects, using approximate methods, progressing through stages of progressive refinement and more accurate calculations of all aspects, using improved mathematical models and methods, and eliminating alternatives by 'trade-off'. A refined level of design is finally achieved and upon this a very detailed study of all aspects can then be focussed, including final performance and cost estimates, etc.

At the early stages of the design spiral, several alternatives can be developed and considered together, sufficiently detailed to enable operational studies to be undertaken together with cost-effectiveness and cost-benefit studies in a search for the best design.

The SBG, with its fleet, shore staff and associated technical departments, can thus develop a baseline design for each required class/size of vessel which can then form a standard of comparison for judging any vendor's proposed design. Such baseline designs can also be used to 'sharpen-up' the RFP that is released to the industry for companies to respond to.

The SBG will assume that responding vendors have the relevant expertise that will enable them to produce efficient state-of-the-art designs. However, the SBG must itself be seen to be very knowledgeable. By developing the same baseline designs the

SBG will be in a position to fully design vessels in the future and thus increase their country's technological expertis

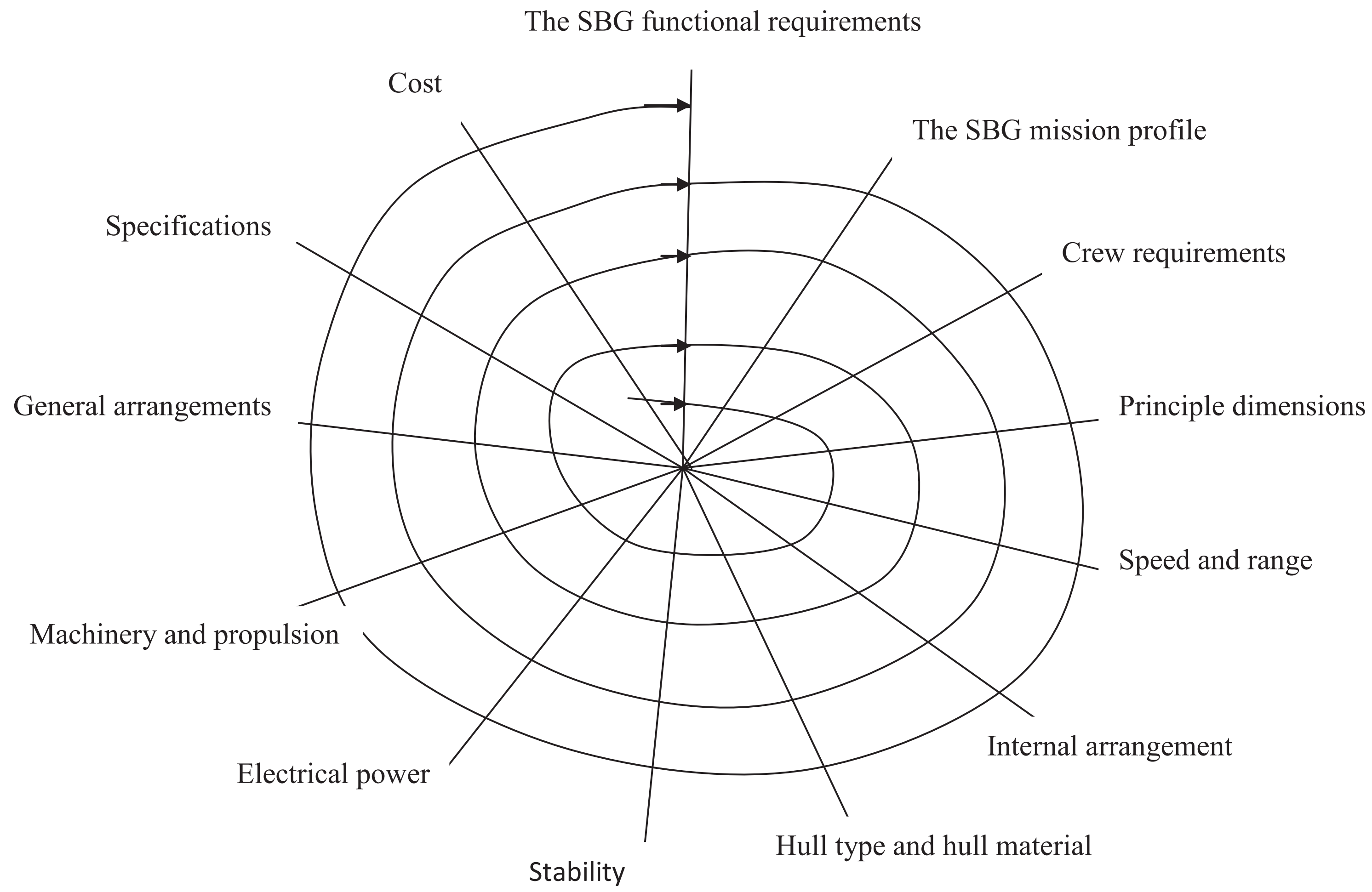


Figure 8-3. Design spiral for the SBG future vessels.

8.10.3 Outline Design

This task forms the first approaches of configuration design development leading to the next level of definition where the installation of machinery and equipments can be reviewed, as to can the human factors, ergonomics, aspects can be examined.

Operational requirements, crew and equipment, can thus be studied in some detail at this stage.

The first step is to estimate space, volume and positioning requirements, including safe locations to store arms which must be away from hot machinery and fuel tanks, as well as the engine room. It is very important to also take into consideration the storage of crew equipment that is sufficient enough to last for the vessels maximum endurance period, as well as accommodation spaces and locations, because to get the best out of the crew they must be able to get suitable rest and relaxation.

Calculating deck and deckhouse space is important for the SBG because during search and rescue operations, especially with the increase in passenger ferries, their sizes and numbers (in particular pilgrim and tourist ships), there is an increased requirement for more deck space and general deck safety and for rescue equipment.

The internal volume and general arrangement of the SBG fleet must meet the requirements of SBG missions and crews in terms of space and location of engine rooms, volumes of storage rooms, and supply of fuel and fresh water. Bridge spaces and height must be sufficient enough for control and navigation equipment, as well as for crew movement.

Clearly a main requirement, for a quasi-civilian crew, is the adequacy and comfort of the various work and off-duty spaces. This is especially important in the hot and humid environments in which these vessels operate. The volumetric capacity of some of the vessels, and of deck areas, will also be important in order to make provisions for persons who may have been rescued in an emergency situation. Modern warship designs are often planned to reflect current and future volumetric demands.

In some design environments this may be referred to as sketch design in which major features of form and arrangements are infered rather than expressed in detail form (e.g., in UK. MOD (N) environments). One of the purposes of this tentative design stage is to provide a starting point for the generally iterative series of analyses-redesign-reanalysis stages that the design spiral represents and in which the level of definition of the vessel progressively improves and enlarges, etc.

Clearly the arrangements of bridge deck and of the equipment on masts can be given full attention at this stage. This will be of most important with regards to the positioning of sophisticated surveillance and communications equipment.

At the early stage of preparing an initial outline, the design and general arrangement can follow that of previous similar vessels designs and such can also be used to estimate various component and structural weights, as well as powering requirements and arrangements. Figure 8.4 illustrates how the design typically develops from preliminary to a final level at which sufficient information information is available for manufacture, etc.

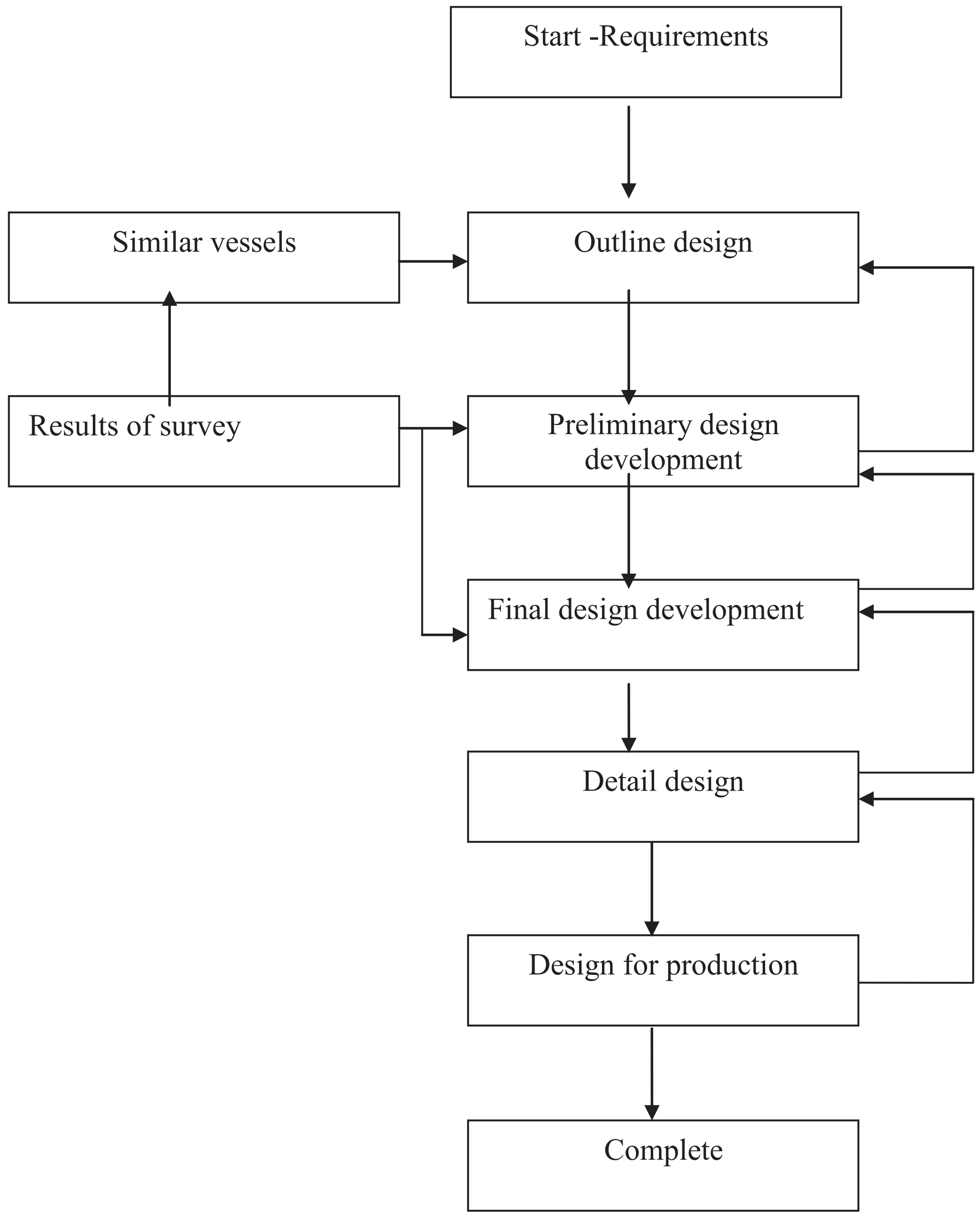


Figure 8-4. Operational requirements crews and equipments.- Full design process for future fleet

The preliminary design development process tends to involve considerable computer aided design definition and associated analysis programs and facilities of which there are many that are commercially available and well employed an a world-wide manner.

The hull surface definition and internal arrangement of bulkheads, decks, compartments, machinery/equipment spaces and tanks, etc. leads to the ability to examine areas and volumes/capacities for comparison with target required values.

Given calculations of hydrostatics and initial weight distribution estimates, assessments of trim stability (both intact and damaged) can be made, together with powering estimates. Processes of re-sizing, hull shape refinement, re-positioning of decks and compartment boundaries, etc., becomes inevitable and then followed by new estimates of hull and system weights and powering, etc, and progresses around the design spiral until a convergence is reached with a design that has all of the required capabilities, characteristics and performance attributes, and at a level detail in which there is confidence.

The preliminary design process may be applied to several competing alternative designs until one is final selected for final/ deep design development which are mainly a continuation of the above integrative process and to extend to include statutory requirements, machinery studies, equipment integration, hull scantlings design and integrity checks, etc.

Again both computers aided design software and computer based analysis systems will be employed for a wide range of development activities, eg.determination of hydrodynamic forces, hull strength calculations, structure and mechanical systems vibration studies, etc.

For the larger vessels being developed for the SBG this may involve support from experienced specialists, classification societies, etc.

The detailed design stage will attend to the myriad of small details, including structural joints and brackets, seats for machinery, shafts and equipment, plumbing and piping systems, many out-fit details, etc. This will involve both geometric items and the close specification of fabrication standards, material specifications, particular manufacturing processes, finishing and painting details, etc.

The design for production stage will define the breakdown of all aspects of the vessel into assemblies and units, etc., and the associated details, that will need to be allowed for in the actual construction of the vessel.

8.10.4 Speed Requirements

The growing popularity of using boats for sport and leisure is rapidly increasing the market for very high speed boats. These types of vessels, when used by outlaws, smugglers and terrorists, can be seen as a serious threat to securing coasts. Speed is thus a very important factor for the fleet operated by the SBG. Modern, fast boats can travel at 50 knots and above using various propulsion methods such as water-jet and optimised propulsion systems. Some of these propulsion methods offer very high speed, but at low speed they often lack manoeuvrability. Thus, the SBG requires high speed vessels which can travel at 50 knots and above, but due to the environment where these vessels operate, especially the Red Sea coast, there are navigation difficulties and the SBG have no experience in operating such high speed vessels. Some border guards and navies of other nations and in similar environments, which already have experience in engaging this type of speed, have started to use vessels that can reach speeds greater than 50 knots. They include Indonesia and India. Interestingly, the design of these vessels have improved manoeuvrability provided by a combination of different types of propulsion methods and modern technology of sensors and weapons (International Online Defence Magazine, 28/11/2004).

Fast attack boats needed for the future fleet of the SBG must be designed to operate in difficult littoral waters and should have both high speed and also good manoeuvrability in order to perform during their SBG missions in the best way possible. According to the interviews with SBG members, the SBG's future fleet requires vessels of different sizes that can reach very high speeds, which is a challenge facing the SBG's securing the coasts.

8.10.5 SBG Requirements in Vessel Design in Terms of Human Factors

Figure 8.5 illustrates the human factors issues that have to be considered.

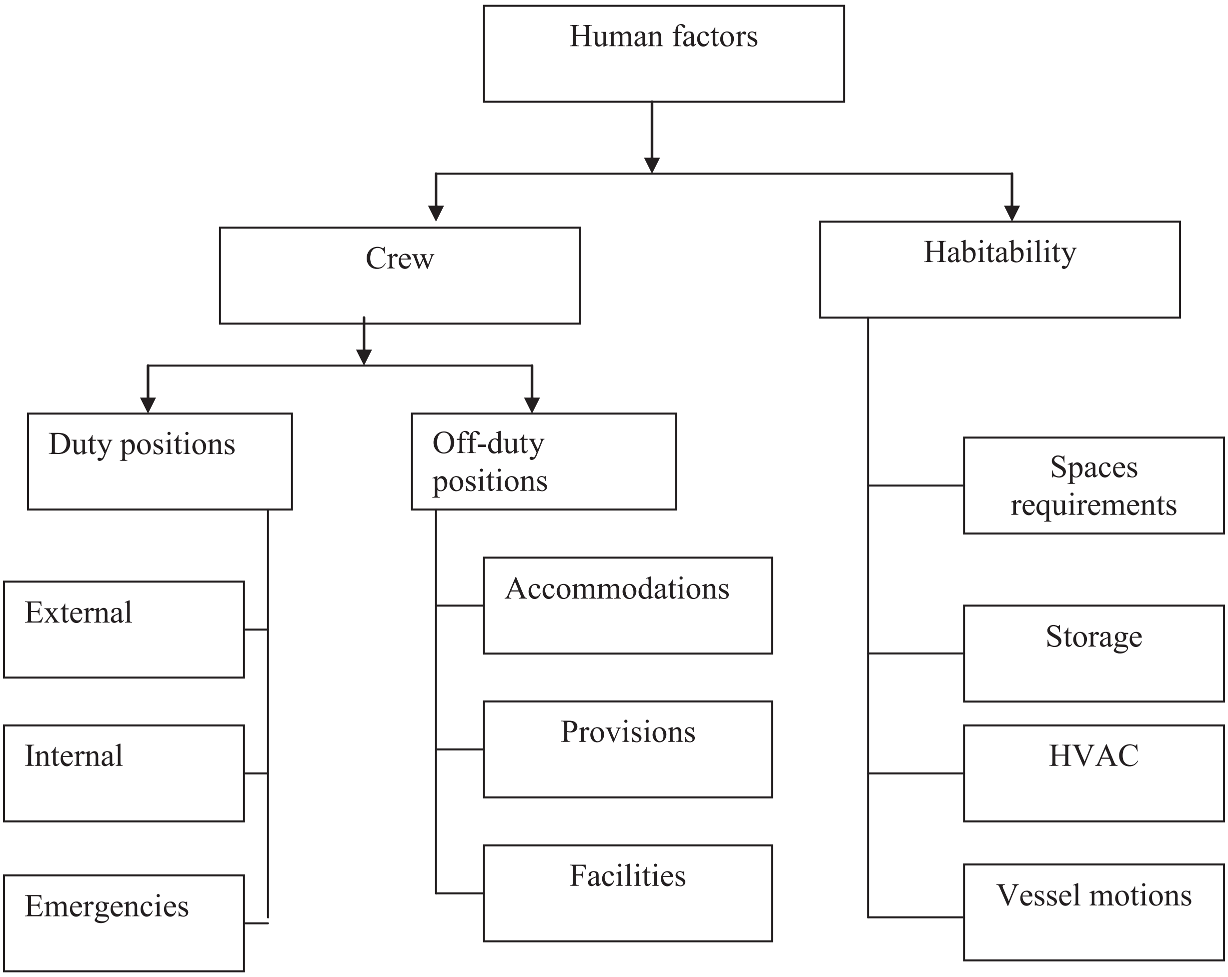


Figure 8-5. Human factors in future fleet of the SBG.

8.10.5.1 Crew Requirements

In order to get the best from the crew especially where the mission is securing the SA coasts and borders, there must be facilities on board for the crew and the people assisted or rescued in the Red Sea and Gulf of Arabian coasts where the SBG fleet undertake the missions of the SBG, where the climate is very hot as well as the high humidity for most of the year. These factors effect the performance of the crew especially if there is no suitable crew provision of accommodations and storages even during the duty positions and at the times of res in order to get ready for their next duty.

Clearly the environment in which the crew work and spend their off-duty hours is significantly influenced by:-

- The general arrangement of the vessel and the adequacy of the spaces and of the traffic flow between them,
- The provision of good ventilation and cool air,
- The ambient background noise and vibration levels, and
- The motions at sea of the vessel.

It is reasonable to assume that the above relate to normal patrolling conditions and that at times in hot pursuit or interception conditions, where high power levels and rapid transit through and across waves occur, are somewhat different special conditions.

Arrangement design, as well as reflecting crew workspaces, machinery and equipment compartments, workshops and stores, etc, must allow for the requisite level of privacy for the individual crew members, commensurate with the Saudi cultural and religious norms.

This will particularly reflect in the design of the larger vessels, rather than in the design of the smaller inshore craft whose patrols/missions tend to have a duration measured in hours, etc.

Some of the above aspects are discussed in a little more detail in the following sub-sections.

The internal spaces in the vessels of the future SBG fleet is a very important issue, because their missions require flexibility of crew movements both on the main deck and inside of the bridge, for example for controlling the vessel in good manner and for watching the widest possible area of the sea in order to monitor for other vessels for surveillance security and rescue purposes. Vessel bridges are typically very narrow often such that no more than two persons can move at the same time; this will reduce the ability of the crew to perform their duty as crew and security officers.

Spaces in the engine room are also very important for the crew in order to be able to monitor and maintain the engines and auxiliary machinery.

8.10.5.2 Habitability

For the crew, the 'habitability' of the various spaces within a vessel is extremely important as it affects both their morale and sense of comfort and thus their efficiency in accomplishing their assigned tasks and their relaxation when off duty.
Habitability can be considered in terms of:-

- The physical nature of the spaces in which they work and relax,
- The availability of secure storage for their personal effects,
- The air quality provided by heating, ventilation and air-conditioning systems, and
- The physical environment measured in terms of motions, vibrations and noise levels.

8.10.5.2.1 Space Requirements

All spaces within the confines of a hull will include the communal spaces that the crew will share, depending on their rank, and the individual private spaces, again depending on their rank. Such spaces must be designed to provide the crew members with sufficient room, including floor area and deck height, for their comfort and be suitably lit, furnished and appointed according to the maximum possible duration at sea. Work spaces must reflect good ergonomic practices.

8.10.5.2.2 Stores

There must be adequate secure storage spaces provided for each crew member for all of his personal effects and work related clothing, etc. There should also be provision for wet clothing and equipment with drying facilities for the same. This should also include provision for the personal storage of food and liquids including refrigeration as and where appropriate. There are documented standards for typical allowances of this nature.

8.10.5.2.3 HVAC

The provision of HVAC, that is heating, ventilation and air-conditioning equipment, will be essential, albeit that the heating component will not be in much demand for most of the year. The supply of cool dry air will be most important for ensuring the comfort of the crew at times of high ambient air temperatures and extremely high humidity which is typical of operations in both the Red Sea and the Gulf of Arabia. (Cool dry air will also be needed for on-board electrical and electronic equipment in order to ensure reliability, etc.)

8.10.5.2.4 Vessel Motions and Crew Comfort

It is well known and documented that the comfort level in ship spaces, both work and off-duty, is considerably affected by the overall motions of the vessel when being operated in a seaway, by levels of vibration caused and excited, primarily, by the propulsive machinery and power transmission/propeller equipment and by noise levels, also caused by propulsive machinery and equipment. The motions of the vessel, whether assessed in terms of amplitudes or acceleration levels, can sometimes be reduced by careful selection of the hull shape and by limiting the speed and heading in heavy weather. In the case of vibrations and noise, the internally transmitted levels can often be ameliorated by suitable mountings and rafts under machinery and power transmission shafts and by other damping and attenuation techniques. If the propeller appears to be the source of some vibrations then careful redesign may be required including blade shape, number of blades, etc. For each of the above, International standards can be referred to in order to determine the levels which have been found, through experience and observation, to be acceptable to the crew and passengers on-board vessels. The potential discomfort levels caused by vessel slamming may require special consideration, as such may occur only for a relatively small percentage of the time of a typical patrol. The motions of a vessel during extreme seas will also be an exceptional condition and during which the vessel will normally be at a sufficient speed to maintain a heading into the waves.

8.11 Assurance of Request for Proposal to the Industry

The process of promulgating, advertising and circulating, a Request for a Proposal, RFP, to potentially interested vendors often depends on the normal established national/governmental process that is mandated by higher authorities. Sometimes it appears in a regular government publication together with other recently issued requests and solicitations of a wide nature (e.g., as in the USA). Alternatively the RFP may be presented in various world-wide trade journals and other openly available publications.

The RFP should be promulgated as openly as possible and a certain amount of time should be allowed, several months for example, in order to ensure that all potential and possible vendors and shipbuilders, etc., become fully aware of it and thus avoid any bias. The SBG will no doubt wish to make this release in such a manner that a fair and open competition is facilitated. This should include sending copies to any vendors /shipyards who may have responded to any earlier circulated Request for Information, RFI.

The RFP may be kept reasonably brief with a much more detailed RFP being subsequently provided to vendors who express an interest in responding.

The RFP should possibly provide all potential vendors with a limited measure of flexibility in order to avoid the situation where the vendors may wish to propose and offer improvements that they consider to be cost-effective based on their own state-of the art expertise, and of recent technical innovations, etc, and may otherwise be inhibited from doing so.

The RFP should set reasonable time scales for any response to be delivered to a stipulated SBG office on or before a specified data and to provide contact points. Possibly schedules should be set such that a potential vendor can make early contact with the SBG when and where they may request some clarification of any aspect or item within the RFP that they find to be insufficiently clear etc. A formal log should be kept of all such communications.

Additionally, it is very important that the RFP identifies a schedule for building and commissioning a new vessel so that the vendor can determine if such is feasible within their current workloads and build schedules. The RFP could also indicate if it is for a single vessel or if several identical vessels may be eventually procured within a specified time scale.

The RFP must identify all design, construction, commissioning, legal and cost factors, etc. together with clear statements of penalties that may result to the vendor for non-compliance in any aspects; this will include performance and quality standards, etc.

Obviously the RFP will not immediately result in a formal contract with the proposer who provides the most cost-effective, cost-benefit response, (all received responses will be subject to a carefully structured evaluation process, as discussed in the following sections). The results from a selected response will most likely be followed by a process of discussion, refinement and negotiation before a comprehensive legally binding specification is agreed upon and a full schedule is signed.

The SBG issued RFP provisions will probably include the following examples (and clearly many more).

A list of defined national and international standards that the craft must conform to, including for:

- Design,
- Construction,
- Equipments,
- Performance,
- Safety.

For the larger vessels a specific classification society may be mandatory.

8.11.1 Defined Minimum Target Values

For example the RFP will contain a spectrum of conditions that the design must satisfy (with documented proof being submitted to the SBG)
For the hull structure for example:

- Buckling avoidance,
- Fatigue life assurance.

The SBG will seek to define the wave and weather environment for the target lifespan of the vessel.

For hull equipment for example:

- Minimum service intervals,
- Mean time between failures.

For maintenance inspection, (ease of removal/replacement of machinery and equipment).

For achieving habitability the RFP will identify the standards that be met for:

- Noise level,
- Vibration,
- Motions.

8.12 Evaluation of Proposals

It is important that the SBG has a well thought-out and systematic methodology for evaluating all aspects each proposal as and when it is received from vendors. This methodology must be fairly and equally applied without bias to each received proposal. The methodology must be as scientific as possible and each proposal must be subject to exactly the same evaluation process and level of security. This should be undertaken by a small team of SBG technical, operational, and managerial staff. There should be three groups, within this team, namely:

- Technical,
- Business,
- Legal.

The overall proposal evaluation process that should be considered for a base-line approach by the SBG is outlined in Figure 8.8 This proposed process contains some of the elements in the current process that is followed by the SBG, as discussed in the previous chapter, but put on perhaps a more formalised and scientific footing.

A full backup strategy will be needed in the event of two or more proposals being assessed to be tied and appearing to be of equal overall value to each other. For the larger vessels the process will be more rigorous. Before any proposals are evaluated in detail, a quick review may be able to eliminate any proposals that clearly do not meet the critical requirements laid down in the RFP and thus do not merits further attention. The formal evaluation of proposals can be in the form of check lists, weighted points based systems, or any other such scientific approach. This is discussed further in Section 8.12.1.2

All vendors who submit a proposal should be provided with a response from the SBG; in the event of their proposal being rejected. It would be good practice to inform the unsuccessful vendors as to the deficiencies of their proposal, areas of short-fall, unsuitability, and so on, but without being too detailed so that the vendor understands the reasons and in the future may improve its submissions in response to a new SBG RFP.

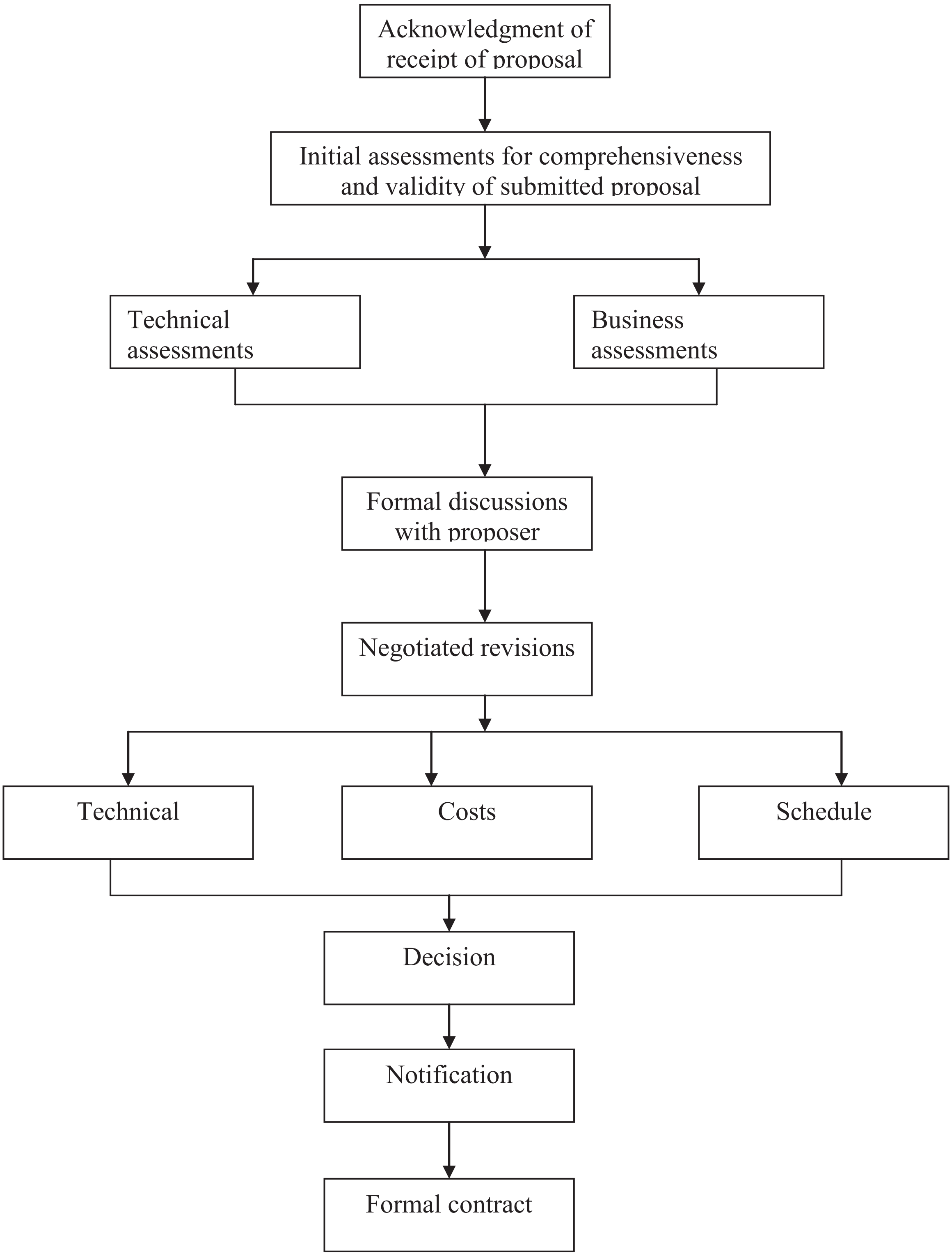


Figure 8-6. Proposed evaluation process for received proposals by the SBG.

8.12.1 Outline of Proposed Evaluation Process

The proposed process for the evaluation of received proposals should pass through several notional stages, as outlined below:

8.12.1.1 Stage 1

Rejection based on value judgements of design features and items of equipment, etc, costs that clearly are at variance with the aim and substance of the Request for Proposal (RFP), for example:-

- Meeting specifications, over and under attainments, value of hull,
- Status of proposer's previous design and build history,
- First operation and lifetime costs,
- Commissioning and delivery issues.

The following illustrates some of the initial items to be considered when reviewing a proposal from a vendor

- Has the proposal addressed all aspects of the RFP? Is the proposal complete?
- Are the characteristics and general aspects within the specified limits?
- Are the projected costs below the specified maximum limits?
- Are the proposed delivery and commissioning dates acceptable to the SBG?
- Does the proposer accept all specified contractual obligations?
- Does the proposer offer an acceptable warranty and product support package?

It is to be noted that in Figure 8.6 there is a step that relates to formal discussions with a proposer. This could be a difficult and politically delicate undertaking and must be approached with great caution.

For the larger and more complex vessels that will be required for the SBG future fleet it may be very difficult for a vendor to create a design that meets all requirements expressed within the RFP without some forms of discussions and clarification with the technical staff of the SBG. However the SBG must be careful not to propose any amendments that may be construed to have been found-in or learned from the design submitted by a competing vendor. The legal implications of this are such that it would be prudent to delay this. However it is unavoidable that a technical team evaluating more than one proposal will become aware of the relative merits of different approaches and the team will thus need to be very careful in its communications once the evaluation process has started.

In this context the procedure that is currently followed by the SBG is certainly the more robust and perhaps an intermediate initial decision step should be incorporated into the schematic given in Figure 8.6 before any discussions with a provisional vendor are undertaken.

8.12.1.2 Stage 2

This is the stage at which a very detailed evaluation of each proposal will be undertaken. Each proposal must be subjected to exactly the same evaluation process.

This stage, however, must be able to recognise that each proposal will have different advantages and some disadvantages, areas of particular excellence and others of a typically average nature, some-what unique features and others that are fairly conventional, etc. Thus each proposal needs to be assessed and judged on a weighted sum of the whole approach, rather than on a limited number of selected features and based on which an excellent overall design could lose-out against a design that excelled in a very limited aspect, etc. (This is an area in which the current proposal review process could be considered to be lacking in flexibility).

Many aspects of a proposal can be assessed in an objective manner where numerical data and values can be easily assigned for the purposes of evaluation.eg. The volumes and capacities of various spaces and tanks. However other aspects can only be assessed in a subjective manner, e.g. the habitability of crew spaces and for which it may be difficult to minimise any bias in the assessment process, (This aspect of objective and subjective assessments was observed in the survey that was undertaken).

When aspects of a proposal are being evaluated on a subjective basis the possibility of any bias can be minimised if the specific element is divided into a number of smaller elements each of which can then be individually evaluated on their merit.

The following very simple example illustrates the weighted point based system which could be adapted for use by the SBG. Clearly important decisions must be made in breaking a complex design within a proposed, into a sufficient number of components and elements suitable for individual evaluation and which must be appropriate to all the submitted proposals. Here the technical staff and the original preparers of the RFP must be fully involved as they will have the best appreciation of the properties of a design that best suits the needs of the SBG. This also applies to deciding upon the weighting factors that will be assigned to each of the elements that will be chosen for the proposal evaluation process. These decisions should, indeed must, be made before the formal evaluation process begins in order to demonstrate that the SBG is following a scientific and un-biased process and be of particular value if an unselected vendor questions the decisions of the SBG.

Thus a weighted point based system could be used to evaluate the technical elements, costs, and political issues of the submitted design. The following very simple example illustrates a weighted point's based approach for the technical features of a proposed vessel.

- Establish a list of important aspects of a technical nature,
- Give each items in the list a weighting factor, W, that reflects its value in comparison to the other items in the list; for example, the most important item or items could get a weighting factor of around, say, 20 and all other items being given lesser weightings accordingly.

The above items could be considered as salient measures of merit.

- Assess the elements of each proposed design against a given scale of attainment and assign a numeric measure of performance,N, against each one; for example:

Complete excellent performance = 10

Typical average performance = 5

Give other appropriate assessments a number accordingly.

For a small vessel this process could be kept relatively short. However for the large long endurance vessels it would be for more detailed, which has many components as necessary to allow for the general size and relative complexity of a proposed design.

Vendors	Weighted factors *W*	1	2	3	4	5	6	7	8	9
Cost	18	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*
Speed	18									
Endurance	18									
mission requirements	18									
crew requirements	16									
expected life	10									
new technology	10									
vendors reputation	9									
after sale service	10	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*
Total ∑(measures of design performance		*NW*	*NW*	*NW*	*NW*	*NW*	*NW*	*NW*	*NW*	*NW*

Figure 8-7. Measure of received proposal by the SBG (simple illustration only) with relative importance value 1 to 20 examples only

The simple example above illustrates the simple weighted-points based proposal assessment concept. The larger and more complex the vessel then the larger will probably be the list of aspects/features for which a proposal's measures of performance will be created.

Both the list of aspects/features and the assignments of levels of importance, (weighting factors) will require careful thought, study and effort on the part of the technical committee that is given the responsibility of assessing and passing judgement of the proposals that are received. This work must be carefully planned and undertaken before the proposals are opened. This can only be done by a committee of technical (and both financial and legal) experts who have a very clear understanding of the needs of the SBG and of the current state of the art. This is thus best undertaken by people who have been involved in the SBG acquisition programme since the earliest days when the SBG future needs were being studied.

The above figure shows a simple, rather crude, set of items. However for a complex vessel each of these items and many others could be approached by a detailed breakdown into components and subjected to a similar process of weighted points based analysis, establishing the W values, before then incorporating the result into the equivalent of the above table. For example, crew requirements could be expanded into a large itemised list and each item given its weighting factor and then subject to individual points based assessments.

Clearly in order for the assigned SBG staff to be able to study all of the details contained within a vendor's proposal a quite considerable amount of data, drawings, reports and information must be made available to them.

The following is a non-exhaustive list, but is sufficient to illustrate the scope and breadth of the information that the technical evaluation committee will probably expect to see. In this context the various calculation reports will be most important as such could subsequently form the basis of the guarantees that the SBG will expect the vendor to provide if their bid becomes the successful one, (and the vendor should be informed that this may, or will, be a prerequisite of their bid being successful).

In this case it becomes essential that calculations are made according to approved methods, e.g. as recommended by some of the classification societies and, where possible, with the results validated against approved international standards, eg. acceptable maximum levels of noise and vibration, etc. If a vendor uses calculation methods that are of an innovative or unusual nature then the SBG should be able to reserve the right to have them independently verified/ validated by acknowledged experts and at a cost that is charged to the vendor.

For the hull, machinery and propulsion outfit aspects, the following must be provided and in sufficient detail for evaluation:

- Drawings,
- Performance documents,
- Embodied specifications.
- With supporting calculations substantiating all measures of hull and equipment performance.

Critical Drawings

- General arrangements,
- Machinery installations,
- Equipment installations,
- Structural arrangements /details for:
    - Hull,
    - Deckhouse and masts.
- Inspection, access and for equipment removal.

Additional drawings for mooring, towing, docking, etc;

Critical documents:

- Trim, stability, and longitudinal strength booklet
- Machinery and equipment operations,
- Supporting calculations/covering:
- Resistance and propulsion,
- Manoeuvring performance,
- Slamming,
- Range and endurance,
- Installed equipment performance,
- Structural strength and fatigue assurance calculations,
- Vibration and noise assessment,
- Machinery and equipment reliability.

Supporting Data

Similar vessels Manufacturer's documents, (installation, commissioning operating)

- Machinery,
- Equipment,
- Components,
- Maintenance aspects.

Business Assessments

This need to include:-

- Cost of ownership,
- First cost,
- Spares costs,
- Anticipated running cost,
- Anticipated maintenance cost.

Vender/Proposers Professional Record;

- Level of expertise,
- Current track record,
- Commercial stability,
- Preferred supplier,
- Ability to keep to schedule,
- Strength of product support.

Effects on SBG Operations.

These need to include:

- On crew, (number, skills, special training, etc.),
- On shore facilities, (docking, maintenance, repair, skill. etc),
- On fleet integration, (communications, material transfer, etc.),

- On SBG ship to ship interfaces,
- Numeric comparisons between alternative proposals.

8.12.1.3 Stage 3

Discussion with selected designers/shipyards to clarify final points and make contractual decisions. Getting details of new constructions sufficient for issuing a solicitation for proposals to interested designers/shipyards and input based upon field trip survey results. For this reason it is useful to convert survey results into numeric values, although this is not always possible where subjective comments are involved. However, some factors may be difficult to put into numeric form e.g. quantify hull form geometry as distinct from stability and manoeuvring performance aspects; comments on hull form geometry could be related to the degree of slamming, deck wetting in heavy seas /generation of spray, etc.

8.12.2 Evaluation of Proposals

Thus the evaluation of proposals may take a combination of approaches depending on the size and complexity of a proposed design, including:-

- Weighted points,
- Development of assessment points,
- Availability , reliability and maintainability, ARM, considerations, for hull, machinery, equipment, etc,
- Human factor considerations,
- Operational capability trade off,
- Environmental issues,
- Demands on crew abilities/specialisations,
- Demands on on-shore facilities,
- Sea worthiness and motion predictions,
- Performance of the vender’s similar vessels,
- Capability for service life extension and future developments,

- Efficacy of painting /anti corrosion systems.

8.12.3 Effect of Vessel Sizes on Decision Making During Proposal Analysis

Clearly, any methodology that is devised and adopted by the SBG will need to be capable of being modified and adjusted to meet the requirements and characteristics of all types and sizes of vessel to be taken into service. Small vessels will probably have limited flexibility in terms of future adaption to different missions at an individual level and clearly will be less complex in many ways. However, this should not preclude coordinated operations within an overall integrated fleet as long as communication equipments enables network centric operations; for example, coordinating mini–UAV operations in restricted in-shore waters, sending and receiving all forms of data and difficulties in navigation due to coral reefs, especially in the absence of accurate navigation maps for the Red Sea coast. This means that such small craft should have sufficient space for more equipment or for equipment replacement with improved capabilities should it be needed in the future, including both for surveillance and communication and special purpose display equipment (similar to typical graphics workstations). This issue is one that should be studied during future operations analysis activities within the SBG. Small vessels may well be customised adaptations of existing commercial designs, or designs that have gone into service with other coastal authorities who have needs that are similar to those of the SBG. This is potentially the most cost effective approach that the SBG could take in same cases, particularly for the smaller high speed crafts.

At the other end of the scale, the SBG's s future requirement studies may lead to the acquiring of vessels that are larger than those that are currently in service. Although the proposals for new vessels may have some similarities to those of existing vessels in the other fleets (such as hull form, general arrangements, etc.), the specific requirements of the SBG should lead to a high degree of uniqueness in terms of size, equipment fitting, etc. An existing hull form generally means that a good measure of its performance can be found from other user's service feedback reports.

In the case of large vessels, more rigorous evaluation, including by the proposing vendors, of the specifications developed by the SBG is required. Clearly, the acquisition of a new class of large vessel will require a great deal of detailed study by the SBG in order to formulate a rigorous set of requirements that, when met, will lead to a design that provides good service for many years (e.g. 10-20 years and more).

8.13 Evaluation Criteria

This is clearly an important activity, not only for the SBG but also for vendors who will have probably spent appreciable time and effort in preparing their response. They will wish to have their submission fairly and equally evaluated, and the SBG has to be seen to have done so. Development of the specific evaluation criteria will thus need to be carefully planned well in advance of the receipt of any response and will probably be undertaken by the SBG staff who were involved in the earlier activities shown in Figure 8.1, principally in undertaking the various operational research and internal configuration and outline design studies. It must not be done in an ad-hoc manner.

The scope and details considered when developing the evaluation criteria will depend on the size and complexity of the class of vessel being considered; clearly, the complexity and costs of larger vessels means they will require increased levels of attention.

8.14 Final Selection and Development of New Construction

As stated earlier, the selection of a winning proposal is unlikely to result in the immediate award of a contract to build one or more vessels. The detailed evaluation of a successful design that has been submitted to the SBG in response to a RFP will quite probably have identified some areas of technical deficiencies or areas where the design and its cost can be improved. Also, further clarification may be required on certain points. Additionally, there are likely to be many minor details that were not included in the original RFP non in the vendor's response. Thus, a series of meetings can be expected, particularly in the case of the larger vessels, between the staff of the SBG and the successful vendor, at which many aspects and details will need to be discussed and a suitable approach agreed upon. All resulting material will then be used to form a detailed and comprehensive build specification document including all drawings and lists of components for the vessel (see Section 8.16), from which the new vessel will be checked possibly during construction and certainly at delivery. At this stage the agreed cost and the build, commissioning and delivery schedules will be written into a formal contract. Penalties for any non-compliance will be set; including failure to meet performance requirements will also be fixed at this point.

At this stage final documentary proof of adequate performance will, or should, be required from the vendor. Of particular concern to the SBG will be the need to be assured of the integrity of the hull structure, (similar would also be required for the vessel's propulsive system) as it will be a major factor for both first cost and through-life cost. This is briefly discussed in the following two sections.

8.14.1 Fatigue Life Validation

Proposals for new construction should explain the manner in which the design will be shown /demonstrated to have an adequate fatigue life. Possibilities include:

- Results of calculations by an approved method,
- Results from measurements,
- Experience of similar ships built by the vendor.

This includes the hull primary structure and the mounting points for machinery, propulsive systems, steering, and other major equipment. If the proposed new design is different from a base-line existing design, then an extrapolation approach should contain an indication of the relevant measure of confidence in the anticipated fatigue free lifetime of the new design. The SBG should specify the required fatigue life in years, e.g. 20 years miniumum. For a non-metallic FRP structure an acceptable equivalent approach will need to be agreed upon.

8.14.2 Hull Structure Integrity

The contract must be such that the vessel supplier demonstrates, to the satisfaction of the SBG, that the vessel will not suffer from slamming damage and environment and operational related forces during its operational lifetime. The required proof could be by either or a combination of:

- Suitable and appropriate calculations,
- Rigorous comparison with similar vessels constructed by the supplier,
- Data obtained from measurements such as strain gauges, pressure transducers and accelerometers, (with particular reference to slamming forces)

This level of verification will increase in importance with the number of vessels to be constructed to the same design.

Both the SBG and the vessel supplier must establish formal definitions of what constitutes unacceptable damage, particularly for structures of a FRP types, and as to what factors of safety are to be included. The SBG should be able to numerically evaluate the slamming performance of its own current fleet such that it can identify that which is acceptable and that which is unacceptable.

Where a vessel is to have high installed power some forms of vibration assessment, including shafting, may be required

8.15 Oversight and Appraisal

It will be important to the SBG that any newly designed vessel is designed and constructed in such a way that it is fit for purpose (and, in particular, contains no fabrication or equipment installation defects). The SBG could assign this task, or these tasks, to an approved and well recognised independent agency (particularly in the case of larger vessels), such as a formal classification society. Alternatively, the SBG could, with some assistance from specialist agencies /companies, undertake this work itself if it has available staff with the required knowledge, experience and skills. There needs to be oversight and appraisal of the detail design process and its validation, including demonstration of the adequacy of the structure, the machinery and the equipment/outfit. At the least, the SBG could request appropriate documentary proof from the builder comprising calculations and analyses, in order to clearly demonstrate fitness for purpose, etc

Attention to the construction phase is similarly important in order to ensure that (for example):

- The correct as-specified materials and manufacturing processes are used, including welding and painting, etc. ,
- Specific and mandatory fabrication quality standards are followed,
- Equipment installation is undertaken according to original manufacturers' requirements,
- Proper checks are made of the alignment of critical items, such as power shafts, etc.

If work of this nature is not assigned to an approved agency then the SBG may need to maintain a team of inspection staff at the builder's site that have both the authority and the relevant breadth of expertise appropriate to the various tasks that they will undertake.

8.16 Comprehensive As-built Specifications

These specifications will identify the full and exact details of the vessel that will be built and delivered to the SBG. It is according to this that the formal contract will be based and all costs agreed. Any deviation from this specification by the builder will only be allowed following discussion with the SBG. It may result in amendments to the specification and mutually agreed cost changes and, if necessary, schedule changes. This will then be the full and final description of the expected as-built and delivered vessel.

The formal specification may consist of three major sections, namely hull, machinery and outfit. The specification will include full details of all equipment and machinery to be installed in the vessel, such as the item's manufacturer and both design and model numbers. The SBG must be given copies of all manufactures' literature, including that related to installation, operation and maintenance. This specification is, of course, not the only document against which the vessel will be checked upon delivery.

The final activity will be the creation of a formal contract, including agreements on:

- Detailed specifications covering all aspects of the vessel that is to be delivered,
- Requirements for all necessary checks and approvals, for example structure (classification society), meeting of formal safety requirements, and regulations,
- Machinery and equipment test certificates that are to be provided
- Results of manufacturer's and SBG commissioning trials to be provided at the time of delivery,
- Agreed commissioning and delivery schedules,
- Staging of interim payments, etc.

8.17 Building and Commissioning

The oversight and appraisal activities undertaken during the detail design and building phase are discussed in an earlier section. It is very important that comprehensive meeting and documentary records are kept, particularly of any problems and difficulties that have been experienced and subsequently resolved and, most importantly, of how they were resolved.

The commissioning phase will include the start-up and function checking of all items of equipment and machinery, including safety and emergency equipment which must be demonstrated to meet the manufacturer’s operating criteria. This may include demands on related equipment, power input and output, etc. The list could be quite considerable and highly detailed in the case of larger vessels. The commissioning phase is thus essential to the SBG in establishing if the SBG requirements and all mandatory national and international safety requirements have been met. In addition, there will be a series of pre-delivery acceptance tests to determine the actual performance of the vessel, including the following:

- Speed-power tests,
- Range and endurance tests,
- Manoeuvring tests,
- Inclining experiments,
- Behaviour in heavy seas,
- Equipment operational tests,
- Machinery functioning,
- Steering equipment,
- Electrical and electronic equipment compatibility and interference checks,
- Weapons tests,
- Safety equipment.

There will be a wide range of such tests each using a formal pre-agreed procedure that will need to be undertaken by a joint team of primarily SBG and the vendor's staff. There will also need to be a formally agreed procedure that will have to be followed by both parties in the event of any test that is deemed to be a failure. The burden of proof should be placed on the vendor in all cases and situations. However in the event of a disagreement between the SBG and a vendor a formal litigation process should have been agreed upon in advance.

8.18 Summary

Figure 8.1 provides a simplified graphical overview of the various activities and interactions that would be involved in the proposed new vessel acquisition process. Within each of the components, given in Fig. 8.1 there will be many various complex activities and particular decisions that will need to be made in the most careful manner possible. As the process is followed it will always be possible to return to an earlier stage if some refinement appears to be advantageous. It is thus a complex overall process but one in which full consideration will be given to, and at, each stage and conceptually resulting in new vessels that will best meet the fullest of SBG requirements, both as stated and operationally needed and implied in the fullest possible manner.

8.19 Conclusions

It is clear that the SBG must undertake many different studies before circulating a RFP for a new vessel, including collection of data and information from SBG members, about the small vessel market, and about internal and international political forecasts. In addition, information about the SBG's mission requirements, both anticipated and potential, will be necessary. In order to finalise the SBG's requirements for small craft, detailed information and feasibility studies must be formulated by technical officers and officials of the SBG. This should be approved by the committee and there could be a reputable agency working as a consultant, as well as the correct selection of a supporting classification society if relevant. This could be regarded as being the culmination of the first stage in the overall process.

The second stage is in carefully and fairly selecting the best proposal which meets in a balanced way the requirements of the SBG and involves further analyses of all received proposals, taking into consideration the positive and negative aspects of each proposal, before discussing and negotiating minor details with vendors. The third stage is to secure a full and formal contract with the selected vendor. This must be clear so as to protect the SBG's rights at all the stages of the building and commissioning of the vessel.

The fourth stage, which takes place during the building period, involves the SBG monitoring committee and classification society assessing the progress of the builder and ensuring the quality of the work and workmanship. The classification society's and SBG committee's role must be clear and included in the contract. The fifth stage, which involves the receiving and commissioning of the vessel, is very important. Several actions must be taken during trials of the vessel by the vendor, classification society and SBG members. The vessel must be tested carefully in different types of weather and sea conditions covering all operational scenarios.

The sixth stage is the agreement after sales support and service, including supply of software, hardware and spare parts, as well as full technical and training support. Finally, the SBG must acquire new technology in the broad field of border security along with a strong fleet with high specifications. This may include new technology of, such as, unattended aerial vehicles, UVA, helicopters and radars, and operations within a coordinated and combined network-centric environment.

In conclusion an ideal situation would be one in which the SBG were to create a permanent staffing arrangement that was tasked with taking a holistic through-life-cycle approach to vessels within the fleet. This would need them being involved in all aspects of each vessel, (not just each design) from the initial postulation of future needs, through the whole design, construction and service life cycle, the recording of all aspects of performance and maintenance, through to the final removal of a vessel from service and an analysis of its complete set of records.

In this way the SBG will evolve a growing central core of knowledge, capability and technical expertise, in the same manner as found in some other similar prestigious organisations around the world, and that the Saudi people will gain much from.

9 CHAPTER Nine: Conclusions and Recommendations

The Saudi Border Guard takes on a huge responsibility to secure the kingdom's land borders and coasts of more than 8500 km in total length, including cruising in the adjacent territorial waters of about 660000 square miles. The Border Guard is also prepared to respond to calls from vessels that are in distress in adjacent international waters.

Building a strategy to secure these long borders and large sea areas must take into consideration all the many aspects of good crew training, in the application of modern and well developed technology, and in having vessels with high capability and the ability for performing full range of the SBG tasks.

The Saudi Border Guard is a relatively new agency, certainly so compared with similar old and well established organisations in other countries in, for example, Europe and North America. Thus its organisation, its style of operation and its equipment and operational experience bases are still evolving. However its responsibilities are increasing quite considerably and will most likely continue to do so in the years ahead. Thus operational changes need to be anticipated and plans made to meet them effectively.

During the field investigation a huge amount of information was collected through the survey, involving a questionnaire and direct interviews with SBG members, and from which most of the assembled material is given in the appendix B of this thesis and which can be used to advantage for further studies in order to improve future fleet vessel specifications.

Clearly evolution and of the SBG fleet specifications must meet the full future actual and anticipated requirements of the SBG, their evolving missions, the crew requirements and of the environment in which these vessels operate.

A continuous series of studies and research, of international, regional and local political forecasts, being aware of developments of new technology and equipment forecasts, and a rigorous and continuous evaluation of the operations of the SBG vessels, taken in consideration with the field trip results, is a rational scientific way to achieve the required comprehensive specifications for the future fleet that is to be operated by the Saudi Border Guard.

Using very high quality selected specifications for the vessels for the future fleet is not in itself sufficient to secure the borders of the Kingdom, but other types of modern technology should be involved in the SBG and in its overall coordinated operations.

Using other means to support the sophistication of the vessels to search the many thousands of sq nm, to increase the overall effectiveness of the operation in detecting, tracking and intercepting vessels, and to help to reduce maintenance costs will be the good of the fleet. On the other hand using helicopters and other aerial means for search and rescue purposes will result in shorter response times, less operation and maintenance costs and provide more surveillance over a larger sea area. Coordinated operations of individual vessels and with both land and air based assets in a network-centric environment in which data is collected, evaluated and shared in a coordinated manner could be of quite considerable benefit to the SBG and the other related agencies of the Kingdom.

For example new technology in the form of small unmanned aerial vehicles (UAV) particularly of the vertical take-off helicopter type, operating from platforms on the larger vessels can perform and enhance some missions of the SBG with excellent results and possibly at less cost. This possible approach is worthy of study and evaluation.

The acquisition methods suggested and reviewed in this study have, if adopted by the SBG, implications which include:-

- The formation of a permanent in house team of naval architect, marine engineers and systems specialists, etc. This team would oversee and undertaken the above activities. The team would also be responsible for maintaining fleet technical effectiveness, including vessel mid-life up-dates, service life extensions, etc.,

- A joint training group for future engineers and specialists.

This team of technical experts could be shared, with the Kingdom's Naval Force to become a centre of technical excellence.

The central technical group would have the overall function that could be defined as to Study, Plan, Acquire, and Sustain (SPAS) an operational fleet through:

- A small group of experienced naval architects, mechanical and systems engineers, maintenance specialists, etc,
- Involvement at many levels ,
- Establishing planned inspection and maintenance programmes,
- Supported in an ad-hoc limited form with members by people from:
  - SA universities,
  - experienced sea crew members,
  - experienced land establishment's staff, and,
  - Carefully selected private companies.

This central group would also be tasked with the training of next generation staff members. As well as providing specialised technical training to officers and crew of the SBG.

This needs to be formally established by higher levels in the Saudi government, (as a parallel with the UK RCNC (Royal Corps of Naval Constructors) and the US Coast Guard organisations, for example).

With time this group could become a recognised centre of excellence and expertise, in small specialised vessel design and possibly lead to the future design and construction of vessels at shipyards in the kingdom. It is important, however, to maintain the high integrity style of operation of the current establishment.

It is clear from the proposed new vessel acquisition method that the following can be achieved:

- Participation of all involved parties in decision-making,
- Obtain the desired benefit from the visits to the in-service vessels and their crews which are similar to those that are required to be purchased,
- Take an advantage of previous in-house and open market experiences in the building and operating of similar vessels,
- An adequate verification of the experiences of competing companies,
- Implementation of the government procurement list with the least complications and/or potential for abuse,
- Transparency and simplicity of the overall acquisition process,
- To take an economic view by facilitating a fair and unbiased open competition between companies as well as to keep an eye on the actual costs of future maintenance and repairs,
- An accurate supervision and follow-up investigation when a good choice of the representative of the owner and consulting experts is obtained,
- Reduce the problems that have long existed between the building companies and the new vessel receiving commissions,
- Reduce the overall time necessary to procure the new vessels,
- To achieve a scientific and technical process approaching the design and construction of the marine vessels,The possibility of realistic planning to secure the actual, projected and perceived requirements of the Border Guards for new vessels.

There must be an emphasis, on all implications of reliability, availability, and maintainability (RAM) in future design studies and vessel specifications, etc, perhaps the better way round is ARM, that is to increase vessel and equipment Availability due to designed-in Reliability and well anticipated and planned Maintainability. Similarly there must be a future plan for the progressive updating of the most important items of operational equipments, compatible with developments in technology, so that the vessels maintain a high level of operational effectiveness and efficiency, during their full service life.

Further Work and Studies

It is very difficult to conclude this report by providing recommendations for further work and studies for other future general researchers to consider following in pursuit of their own interests and goals. This is because it needs, in many cases, an intimate knowledge of the practices and culture within the Saudi Border Guard.

However there are some areas that are certainly in common with similar organisations around the world. Thus such possible areas of research could include:

- Risk assessment studies,
- Increased levels of on-board automation,
- Advances in equipment for sub-sea-surface hazard detection to avoid coral reefs, etc.,
- Advances in hull structural materials, specifically composites and other non-metallics,
- Design Optimisation for facilitating various aspects of access, inspection, maintenance, repair and replacement,
- Stand-off remote inspection equipment for suspect vessels and their cargoes.

10 References

- Abt C, Birk SD, Harries S (2001). Parametric Hull Form Design. A Step towards One Week Ship Design. 8th International Symposium on Practical Design of Ships and Other Floating Structures. PRADS. Shanghai.
- Almeter J (1993). Resistance Prediction of Planing Hulls: State of the Art, . Marine Technology 30(297-307.
- Andre-fouet S, Muller-Karger F, Hochberg E, Hu C, Carder K (2001). Change detection in shallow coral reef environments using Landsat 7 ETM+ data.
- Andre–fouet S, Kramer P, Torres-Pulliza D, Joyce KE, Hochberg EJ, Garza-Perez R, Mumby PJ, Riegl B, Yamano H, White WH, Zubia M, Brock JC, Phinn SR, Naseer A, Hatcher BG, Muller-Karger FE (2003). Multi-site evaluation .
- Askin Ercetin 2001. thesis (operational level naval planing using agent based imulation naval postgraduate school Monterey, California.
- Asheville NC (1982). Climatic study of the Red Sea South and Gulf of Aden Naval Oceanography Command.
- Begen MA, Puterman ML (2004). Development of a Catch Allocation Tool Design for Production Planning at JS Mcmillan Fishries. Royal Institute of Naval Archtecture. Centre for Operations Excellence. Sauder School of Business- The University of British Columbia. 2053 Main Mall Vancouver, BC, V6T IZ2, Canada.
- Behairy AKA, Sheppard CRC, El-Sayed MK (1992). A review of the geology of coral reefs in the Red Sea. . UNEP Regional Seas Reports and Studies 152(1-36.
- Birmingham R, G Clemand, R Driver, D Maffin (2002). Understanding engineering design. theory and practice demand edition.
- Blount DL, Fox DL (1976). Small-Craft Power Prediction Marine Technology 13(14-45.
- Blount DL, Codega LT (1992a). Dynamic Stability of Planing Boats Marine Technology 29(1):4-12.
- Blount DL, Codega LT (1992b). Dynamic Stability of Planing Boats. Marin*e Technology* 29(4-12.

- Bolger PC (1994). Boats with an Open Mind: 75 Unconventional Designs and Concepts. 1st ed. Camden: International Marine/ Ragged Mountain Press.

- Bonatti E, Clocchiatti R, Colantoni P, Gelmini R, Marinelli G (1983). Zabargad (St. John's) Island: An uplifted fragment of sub-Red Sea lithosphere. Journal of the Geological Society of London 140(677-690.
- Brewer T (1994). Understanding Boat Design. 4th ed. Camden: International Marine.
- Burgess TF (2001). A general introduction to the design of questionnaires for survey research. Edition: 1.1.
- Buxton IL (1987). Engineering Economics and Ship design, British Maritime Technology Limited London, UK.
- Camden M (1994). Understanding boat design T Brewer editor: International Marine, pp. 147pp.
- Cavallucci D, Lutz P, Kucharavy D (2002). Converging in Problem Formulation: A Different Path in Design. Proceedings of DETC/DTM. ASME Design Engineering Technical Conferences from September 29 - October 2, 2002 Montreal, Canada.
- Clausen HB, Lutzen M, Fiis-Hansen, Bjorneboe N (2001). Bayesian and Neural Networks for Preliminary Ship Design. Marine Technology, 38, 268-277.
- Coleman RG (1993). Geologic Evolution of the Red Sea Oxford: Oxford University Press.
- Committee on Transportation and infrastructure (2005). The Analytic Hierarchy Process and Expert Choice. Subcommittee on Coast Guard and Maritime Transportation. U.S. House of Representatives.
- Cong J, Pan Z (2001). Interconnect Performance Estimation Models for Synthesis and Design Planning. Department of Computer Science. University of California, Los Angeles, CA 90095.
- Cook CC (1992). A Guide to Safe and Efficient Recreational Boating in Florida.

- Coral Reef Ecology, Mangrove Bay, Egypt (2004). Coral Reef Ecology Mangrove Bay, Red Sea. Department of Evolutionary Biology, WWU Munster.
- Curry R, Europe ABS Lts, UK, An Assessment of ISO 12215 Small Craft Hull Construction with Classification Society Rules. The Royal Insttitution of Naval Architects. Presented at the International Conference on Small Craft Regulations, London, October 20 - 21, 2004.
- Devlin s (1996). Devlin's boatbuilding: how to build any boat the stitch-and-glue way: international marine, pp. 198pp.
- Dr. Clark Briggs*2000A Process for Design Engineering Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 91109.
- David D. Rudko 2003, logestical analysis of the littoral combat nship naval postgraduate schoolL Monterey, California.
- Doerry N (2005). Zonal ship design , Technical Director, Future Concepts and Surface Ship Design naval sea systems command U. S. Coast Guard Research and Development center.
- Du Cane P (1951). High-Speed Small Craft London: Temple Press.
- Easterbrook S (2003). How Theses Get Written: Some Cool Tips. Dept of Computer Science. University of Toronto.
- El Raey M (2004). Adaptation to Climate Change for Sustainable Development in the Coastal Zone of Egypt. University, Paris: Global Forum on Sustainable Development: Development and Climate Change.
- Fan MaP, M., (1997). Structural Design of High Speed Craft – A Comparative Study of Classification Requirements Fast Sea Transportation Conference:27-53.
- Forbes A (2002). Protecting the National Interest: Naval Constabulary Operations in Australia's Exclusive Zone. Royal Australia Navy . Sea power centre.
- Fox K, Gornsten, R. and Stumbo, S. (1993). "Wake Wash: Issues and Answers" SNAME Pacific Northwest Section. "Wake Wash: Issues and Answers" SNAME Pacific Northwest Section.

- Fridsma G. (1971). 'A systematic study of the rough water performance of planing boats.', Stevens Institute of Technology, Hoboken Laboratory, SIT-DL-71-1495, USA.
- General Directorate of Border Guard, statistics of smugglers/infiltration in KSA, 2004-2007. p. 10.
- Gerr D (2000). Boat Strength for Builders, Designers, and Owners. 1st ed. Camden: International Marine.
- Gillet P (1985). Small is Difficult: The Pangs and Success if Small Boat Technology Transfer in South India. Centre for Appropriate Technology. Nagercoil, India.
- Gilmer TC, Johnson B (1982). Introduction to naval architecture. MD Annapolis editor: United States Naval institute.
- Gore JL (1985). SWATH Ships. Naval Engineers Journal:83-112.
- Graham TH (1996). Design Methodology of Small Fast Planing Craft: MSc Thesis. University College London.
- Grigoropoulos GJ (2004). Hull Form Optimization for Hydrodynamic Performance. Marine Technology, 41, 167-182.
- Gulbrandsen O (1973). Weight and Cost estimates for small fishing vessels, FAO investigates Ferro-cement fishing craft, FAO, Rome.
- Guldhammer HE (1976). CRS diagrams for design calculations of the stability of ships, The Technical University of Denmark, Lyngby, Denmark.
- Hamlin C (1996). Preliminary Design of Boats and Ships. 1st ed. Maryland: Cornell Maritime Press.
- Heiss, G. A. 1994. Coral reefs in the Red Sea: growth, production, and stable isotopes.
- Harries S, Valdenazzi F, ABT C, Viviani U. Investigation on Optimization for the Hydrodynamic Desing of Fast Ferries. ^th International Conference on Fast Sea Transpotation. Southampton. September 2001.
- Hecker JEZ (2003). Coast Guard Challenges during the Transition to the Department of Homeland Security.
- Herrmann C, Moeller G (2002). Strategic design planning: A key requirement of brand management.

- Hideki Kawashima Takanori 2004. A Hull Form Generation Method on Initial Design Stage Hino Center for CFD Research, National Maritime Research Institute Mitaka, Tokyo, Japan 9th Symposium on Practical Design of Ships and Other Floating Structures Luebeck-Travemuende, Germany.
- Hoggard MM, Jones MP (1980a). Examining Pitch, Heave and Acceleration of Planing Craft Operating in Seaway. High Speed Surface Craft Symposium, Brighton:491-504.
- HSC Code. International Symposium & Seminar on The Safety of High Speed Craft, RINA, London.
- Hoggard MM, Jones MP (1980b). Examining Pitch, Heave and Acceleration of Planing Craft Operating in Seaway, . High Speed Surface Craft Symposium, Brighton.
- Holtrop j, Mennen GGJ, Sahoo K (1982). "An Approximate Power Prediction Method". International Shipbuilding Progress 29.
- Holtrop J, Mennen GGJ (1984). An approximate power prediction method.
- Hsiao S, Chou J (2004). International Journal of Industrial Ergonomics 34, 421-443.
- Ikeda Y, Katayama T, Porpoising oscillations of very-high-speed marine craft. 2000. (http://www.jstor.org/pss/2666882). International Ship Building Progress.
- Paul (1985) hydaulic design of small boat harbors department of the Army U. S. Army Corps of Engineers Washington, D.C.
- International-Conference-on-safety-of-fishing-vessels (1977). Inter-Governmental Maritime Consultative Organization, IMACO, London.
- International Code of Safety for High Speed Craft: HSC Code, International Maritime Organization. (1995).
- Ivian 2004, A Procedure for the Design of Low-Wash High-Speed Monohull Ferries National Technical University of Athens,
- James L. Rogers 1997, reduction design cycle time and cost through process resequencing .
- Jastrzebski T (1997). An Overview of Some Structural Design Aspect of the IMO.

- Jeong SH, Koo JD, Chun HH, Jeong UC (2004). A Study on the Development of Super High Speed Monohull. 9th Symposium on Practical Design of Ships and Other Floating Structures. Luebeck-Travemuende, Germany.
- John G. Housley and Edward F. Thompson, 2201, planing and design .
- Karayannisl T, Molland AF, Williams YS. School of Engineering Sciences, Ship.
- Kawashima H, Takanori H (2004). A Hull From Generation Method On Initial Stage. 9th Symposium in Practical Design of SHips and Other Floating Structures. Luebeck-Travemuende, Germany. Center for CFD Research, National Maritime Research Institute. Mitaka, Tokyo, Japan.
- Ketut Buda Artana1 and Kenji Ishida1 2003, Spreadsheet Modeling to Determine Optimum Ship Main dimensions and Power Requirements at Basic Design Stage Marine Technology, Vol. 40, No. 1, January 2003, pp. 61–70
- Koelbel JJG (1995a). Comments on the Structural Design of High Speed Craft. Marine Technology 32(77-100.
- Koelbel JJG (1995b). Comments on the Structural Design of High Speed Craft Marine Technology 32(2):77-100.
- Kofed- hansen H, kirkegaard J (1996a). "Technical Investigation of Wake Wash from Fast Ferries." Danish Hydraulic Institute: Danish Hydraulic Institute.
- Kofed- hansen H, kirkegaard J J (1996b). nvestigation of Wake Wash from Fast Ferries 1996: Danish Hydraulic Institute.
- Lambert A (2003). The Royal Navy, John Ericsson, and the Challenges of New Technology. International Journal of Naval History. Volume 2, Number 3.
- Lambert A (2003). John Ericsson and the Revolution in Naval Warfare 1850-1880. Swedish National Defence College, Stockholm. Symposium 14 November.
- Lewis, E.V.,(1988) "Principles of Naval Architecture", Vol. 2, The Society of Naval Architects and Marine Engineers, Jersey City.
- Loy JM (1998). Shaping America's Joint Maritime Forces: in the 21st Century.
- Majumder M, Akintu¨ rk 1A1, alis SMC (2002). Optimized Design of Small Craft Marine Technology, Vol. 39, No. 2, April 2002, pp. 67–76.

- Macfarlane GJ, Renilson MR (1999). "WaveWake – A Rational Method for Assessment" International conference for coastal ships and inland waterways, . London, RINA.
- Macfarlane GJ, Renilson MR (2000). "Assessment and Characterisation of Vessel Generated Wave Wake. " SeaAustralia. Sydney.
- Macpherson DM (1996). The Ten Commandments of Reliable Speed Prediction. The Small Craft Marine Engineering Resistance and Propulsion Symposium, University of Michigan, USA.
- Mandler MB (2003). Crew Endurance Management Practices A guide for Maritime Operations. Technical Director. United States Coast Guard. Research and Development center 1082 Shennecossett Road.
- McCormack JW (2001). Safe Harbors Design Project. Center for Social Policy. University of Massachuestts, USA.
- Maritime Areas per the UN convention of law of the Sea of 1982
- Miller PH (2001). Fatigue Prediction Verification of Fibreglass Hulls. Marine Technology, 38, 278-292.
- Mohamad Z, Shamsuddin B A, Conceptual Design of a Fibre Reinforced Plastic FishingBoatstradional Fisheries in Malaysia Fisheries Industry Development Division Fisheries Development Authority of Malaysia (LKIM).
- Mohammadi B, Pironneau O (2002). Applied Optimal Shape Design. Journal of Computational and Applied Mathematics 149, 193-205.
- Oosterveld MWG, Oossanen VP (1975). Further computer analysed data of the Wageninggen B-screw series, International Ship Building Progress.
- Paul H. Miller 1993, Seaworthiness and Safety Yacht Design, Dept of Naval Architecture, Ocean and Marine Engineering
- Persga (1998). Red Sea and Gulf of Aden.
- Paul 2004, Offshore Sailboat Attributes, Professor of Naval Architecture
- United States Naval Academy.
- Phillips EM, Pugh DS (2005). How to get a PhD. 4th ed. Maidenhead, Berkshire, England: Open University Press.
- Phillips EM, Pugh DS (2000). How to Get a PhD. A handbook for Students and their supervisors. Third Edition.
- Phillips SJ (1998-1999). Jane's High Speed Marine Transportation. 31st ed.

- Rao SS (1996). Engineering Optimization Theory and Practice. 3rd ed.: John Wiley and Sons.
- Rawson KJ, Tupper EC (2001). Basic Ship Theory. 5th ed. Oxford: Butterworth Heinamann.
- RenilsonL, S. (1988). “An Investigation into the Effect of Hull Form on the Wake Wave Generated by Low Speed Vessel’s”Ship Hydrodynamics Centre Report, AustralianMaritime College, Tasmania: AustralianMaritime College, Tasmania.
- Richard Birmingham 2004. Design for Stability and for Instability – Finding the Right Balance for Small Craft Professor of Small Craft Design School of Marine Science and Technology Newcastle University, UK.
- Rudko DD (1992). Logistical Analysis of the Littoral Combat Ship. Lieutenant Commander, Supply Corps, United States Naval Reserve. B.S., United States Naval Academy.
- Samson C. Stevens1 and Michael G. Parsons2 2002. Effects of Motion at Sea on
- Crew Performance: A Survey, Marine Technology, Vol. 39, No. 1, January 2002, pp. 29–47
- Saunders HE (1965). Hydrodynamics in Ship Design, New York: The Society of Naval Architect and Marine Engineers.
- Savitsky D (1964). Hydrodynamics Design of Planing Hull. Marine Technology 1(71-95.
- Savitsky D, Brown PW (1976). Procedures for Hydrodynamic Evaluation of Planing Hulls in Smooth and Rough Water Marine Technology 14(4):381-400.
- Savitsky D (1985). Planing Craft. Naval Engineers Journal:113-141.
- Sawhney N (2002). Thesis Proposal: Next Steps. What should the thesis research focus on?.
- Shenoi RA, Harari Y (1993). Principle Aspects concerning Structural Design of High Speed Craft. International Conference on High Speed Passenger Craft – Future Development s and Nordic Initiative”, London, RINA

- "Shore Protection Manual" Coastal Engineering Research Centre (1984). U.S CORPS of engineers, Department of the Army, Waterways Experiment Station.
- Siddall M, Smeed DA, Hemleben C, Rohling EJ, Schmelzer I, Peltier WR (2004). Understanding the Red Sea response to sea level. Earth and Planetary Science Letters. 225(3-4):421-434. conomics.
- Stopford M. (2004). Maritime e 2nd edition.
- Steward RM, CE, Butman, BS (1995). (1994). Boat Building Manual Maine. In: Marine Engineering Economics and Cost Analysis: International Marine/Ragged Mountain Press Hunt.
- STtumbo S, Fox K, Dvork F, Elliot L (1999a). "The Prediction, Measurement and Analysis of Wake Wash from Marine Vehicles" *Marine Technology* 36(pp 248-260.
- Stumbo S, Fox K, Elliot L (1999b). "Hull Form Considerations in the Design of Low Wake WashCatamarans." Proceedings of the Fifth International Conference on Fast Sea. Transportation, FAST '99, Seattle.
- Teale J (2006). How to Design a Boat: Sail and Power. 3rd ed. London: Adlard Coles Neutical an imprint of A & C Black Publishers Ltd.
- Treale J (1998). How to design a boat. NY Dobbs ferry editor: Sheridan house, pp. 156pp.
- Thomas (2003). Critical Significance of Human Factors in Ship Design, National Biodynamics Laboratory College of Engineering University of New Orleans.
- Trower G (1993). Yacht and small craft design: from principles to practice: Wiltshire, U.K The crowood press, ltd.
- Tupper EC (2004). Introduction to Naval Architecture. 4th ed. Oxford: Elsevier Butterworth-Heinemann.
- United States Coast Guard (2005). Coast Guard Morale, Well-being, and Recreation Manual. Washington, USA.
- U.S. Coast Guard (1984). Navigation and vessel Inspection Circular No. Department of Transportation United States Coast Guard, 8-84.
- Valdenazzi F, Harries S, Viviani U, Abt C. Seakeeping Optimisation of Fast Vessels by Means of Parametric Modeling.

- Vasconcellos JM, Latorre R (1997). Development of BOATDSS high speed boat design database. Ocean Engineering, 26: 891-904.
- Wang J (2002). A Brief Review of Marine and Offshore Safety Assessment. Marine Technology, 39, 77-85.
- W ielinga B J, Schreiber ATH (2002). Configuration design problem solving, University of Amsterdam, Department of Social Science Informatics, Roetersstraat 15, 1018 WB Amsterdam, The Netherlands. E-mail:
- Woud JK, Stapersma D (2002). Power Plant Concept. Design of Propulsion and Electrical Power Generation Systems, IMarEST, London.
- Saudi Border Guard headquarter archive.

11 Appendix A

Saudi Border guard Maritime – offshore and coastal patrol concept of operation (CONOPS)

11.1 Introduction

This document describes the offshore and coastal maritime surveillance concept of operation for the SBG.

11.1.1 Purposes:

This maritime concept of operation is intended to augment the SBG effort to enhance its borders and coasts protection capabilities and provide emergency response in a timely manner. This concept of operation must be used by the SBG' procurement committee in the writing the requests of proposals (RFPs) for new capabilities.

The concept of operation demonstrates how the SBG procurement committee envisions various assets being used within the maritime domain as guide for the future development and as a part of the larger SBG modernization effort and how these assets will work under the core and operational capabilities being provided by the system integration department.

11.1.2 Goals

This CONOPS attempts to address several problems currently impacting surveillance operation and performing the SBG missions.

Patrolling is currently conducted visually with less reliance on technology. Boat commanders often have only VHF and UHF communication, with limited access to navigational radar, hindering their ability to detect and intercept threats while underway, and requiring the assistance of shore-based assets for interception of threats.

- The current maritime structure within the SBG has the adverse effect of causing operation to be compartmentalized within each sector, of both the regions in the east (Gulf of Arabia) and west (Red Sea), as assets within one sector are usually prevented from extending into adjoin sectors. While this acceptable for some small boat operation, larger assets are not efficiently employed, and instead are often relegated to making short patrol, preventing the SBG from capitalizing on their more robust capabilities.

- The "stove-piping" of the SBG communications under the current maritime component allow for a flow of information that is exclusive linear, with information and orders flowing directly from main headquarter in capital city Riyadh to the region to the sector to post. Rarely is information capable of moving laterally across sectors and almost never is information shared directly between regions. This impacts the ability of all commanders to have a common operating picture of current event.
- Their must be a fixed coastal surveillance system which provides substantial coverage of the SBG coasts and borders. Maritime patrols need to link with new future capabilities.

The CONOPS must present herein attempts to remedy of these problems currently impacting the SBG fleet by restructuring coastal and offshore patrol area and identifying the capability gaps effecting coastal and offshore surveillance.

11.1.3 Structure

A brief discussion on maritime threats and missions has been explained in this section and earlier chapters, the concept of operation must describe:

- Current SBG maritime fleet structure and hierarchy,
- Areas of responsibility and how they defer from current areas of responsibility,
- Roles and responsibilities or different SBG missions, and
- Mission profiles under the concept of operations.

11.2 Maritime Threat and Missions

The SBG maritime component is responsible for observing and securing the Kingdom of Saudi Arabia 2640 kilometre (1425 nautical miles) coastline, and for missions within the maritime area of responsibilities. The existing configuration of fixed outposts, bases, command facilities, land-based and seaborne patrols, and limited sensors and communication systems, lacks the capability to provide high level of confidence that the SBG can accomplish its missions across its full area of responsibilities. The focus of most current operation is the immediate coastal waters, with less capability for offshore patrolling.

11.2.1 Threats

Current and emerging threats to the security and tranquillity of the Kingdom will continue to be valid in the foreseeable future. The SBG must provide early warning, emergency response, and threat mitigation for the Kingdom. The SBG requires the capabilities, tools and process necessary to deter, detect, classify, identify, respond, and resolve these threats.

Current threats to the sovereignty of the Kingdom of Saudi Arabia coasts areas include, but are not limited to, the following:

- Smuggling of drugs,
- Smuggling of contraband, humans and livestock,
- Smuggling of weapons and explosive,
- Terrorist activities,
- Political activities,
- Economic migrants,
- Refugees,
- Illegal fishing and pollution, and
- Piracy.

Emerging threats are primarily the result of unstable or failing political environments and armed conflicts beyond the border areas. These threats include but are not limited to the following:

- Organized militias with political, religious or state sponsorship,
- Terrorist organization who threaten the critical infrastructure in the border area and within the Kingdom,
- Cross-border instability from a failed state and anarchy.

11.2.2 The SBG Maritime Missions

The maritime missions have six defined mission areas for which it is responsible:

- Search and rescue (SAR): including search and recovery of persons and material from the water, transfer of personal between vessels, towing of disabled vessels, providing SAR service through rescue coordination centres to areas beyond the exclusive economic zone, and providing on-board medical assistance as well as limited fire fighting capability.
- Law enforcement (LE): Deter, detect, classify, identify, respond, and resolve all contact that enters the Saudi contiguous zone and territorial sea. Include threats mitigation and prevention in Saudi Arabia waters, including illegal drugs trafficking, human trafficking, illegal immigration, smuggling of weapons and contraband, illegal fishing, and piracy.
- Critical infrastructure protection (CIP): include protection of critical infrastructure through out the SBG maritime area of responsibility. Supports port security, the security of off-shore and near shore drilling platforms, petro-chemical and desalination facilities, and other critical infrastructure.
- Marine environment protection: the SBG maritime assets shall detect, record, and coordinate the resolution of pollution incidents. As part of incident response and resolution, SBG maritime assets (typically being the first responders to incidents within the KSA maritime area of responsibility) will act as command and control centres in support of these efforts, until the responsible KSA entry arrives.
- Recreational boat safety and lifesaving: In recreational areas along both coasts (Red Sea and gulf of Arabian),the patrol craft shall be capable of monitoring boa safety, conducting vessel boarding and inspections, rescuing distressed persons, and enforcing safety and security zones.
- Support defence operations: If necessary, the SBG maritime component assets shall be capable of cooperating with KSA Navy vessels as well as international vessels to interdict foreign hostile vessels, disable hostile targets, conduct patrols and enforce security zones both inside and outside of the territorial waters of SA .principally, the SBG has a nearly warning role in support of defence operations.

11.3 Current SBG Maritime Forces Structure and Hierarchy

The SBG component is headquartered in Riyadh. The fleet perform missions in the Gulf of Arabian along the eastern seacoast and in the Red Sea along the western seacoast. Marine forces are divided regions, with each region consisting of several sectors. Each of the sectors is divided again into posts, the lowest level of command. Additional headquarters are located at the regional level and are used the operational level of command.

Maritime assets are generally controlled and operated at the sector level. The SBG sectors include both land and maritime assets, and are often commanded by an officer from the SBG land component. Maritime personal fill a variety of positions at headquarter, regional, sector and post levels.

11.4 Current Maritime Structure Within the Border Guard

The SBG maritime component uses a hierarchical organization structure similar to other Border Guards BGs components to organise units based in mainland port areas and on islands. The following diagram shows the current SBG maritime component organization:

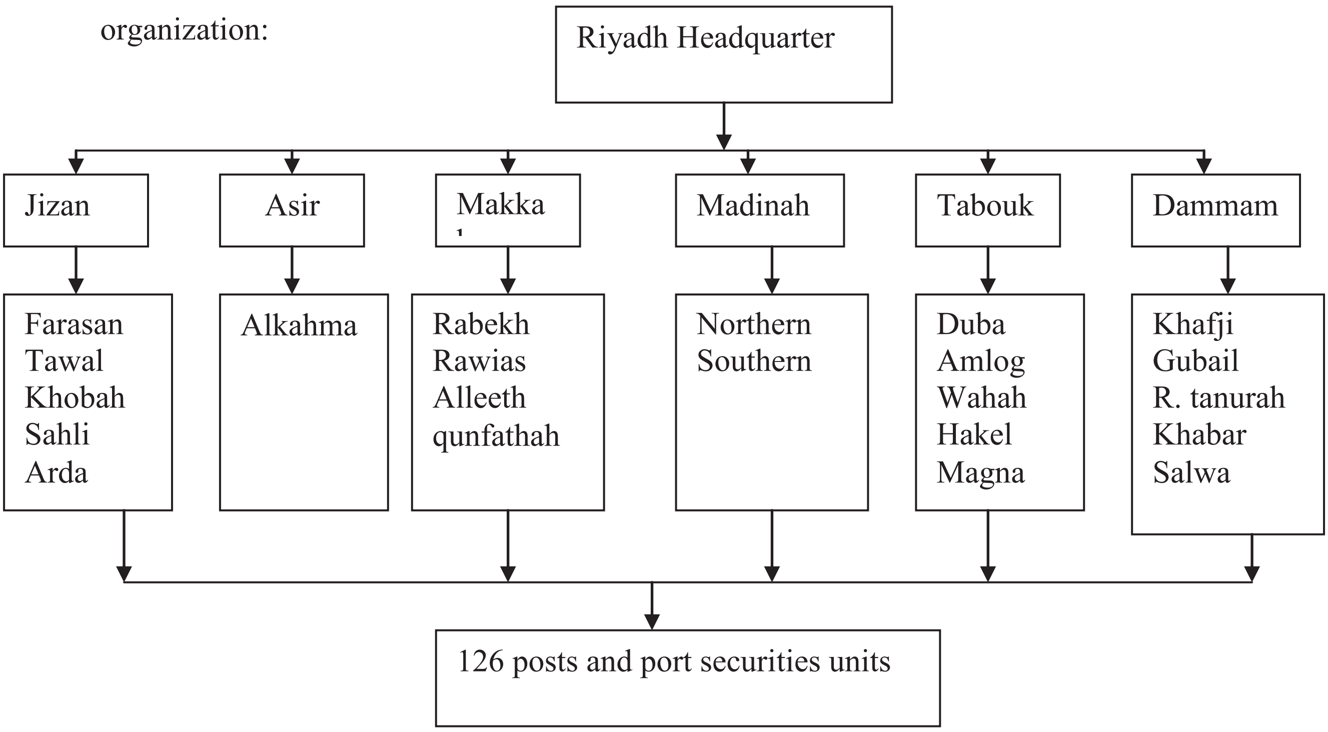


Figure 11-1 The SBG Maritime component

Headquarters: the HQ in Riyadh provides strategic direction to the regions. It also provides major acquisition and financial support for assets, human resources, training, and maintenance stores.

Regions: The SBG operate six maritime command centres that coordinate maritime operations for the regions. There is one region along the Easter coast (in the eastern province), and five regions on the Western Coast. Regional commands provide operational support for patrol and response vessels, and usually have maintenance and dry-docking/ boatlift facilities to support lower echelon units within their sectors. In some cases, one region will have maintenance capability which is used to support other regions.

Sectors: sector commands are primarily responsible for day-to-day operations. Operations are largely compartmentalized within each sector. Sector commands maintain tight control of their assets and vessels generally patrol only within their designated sectors (generally defined as 20 nm in depth from the coastline).

Posts: located along the coastline, posts reported to the sectors. Posts support and operate vehicles to conduct visual patrols, respond to intercept mission and provide life saving patrols for designated swimming areas.

The roles for each of these levels of command can be defined as follows:

Level of command	SBG organization	Description
Strategic level of command	Riyadh headquarters	Identifies overall SBG strategy and organization
Operation level of command	Regional headquarters	Link strategy with tactics through resources, and logistics
Tactical command	Sector headquarter	Conduct daily operations through manoeuvre
Tactical command	Posts Port security	Conducts daily operations through manoeuvre

Figure 11-2 The SBG headquarters level of command

11.5 Maritime Assets

The maritime forces structure over 500 vessels comprising a wide range of vessel classes and capabilities which are used for the following tasks:

- Conduct interdiction patrols (deter, detect, classify, identify, respond and resolve).
- Conduct response missions to respond and resolve (with initial detection from another source).
- Provide support to SAR missions.

Provide surf zone life saving protection in designed areas near population centres (not part of this concept of operations).

11.5.1 Provide Support to Maritime Disasters.

Most of the fleet can be categorized as patrol boats of various sizes- long range, medium range, short range and coastal patrol boats. Not that the classifications of current nomenclature classification societies (LR, MR, SR, etc. these classification societies assets are primarily stationed in Jeddah and Dammam.

11.5.1.1 Current Vessel Classes Include:

Class	comments
Long range Patrol Boats	These boats vary from 26 to 38 m in length, and usually fall under regional commands. These entered service prior to 1989. These boats provide offshore surveillance and help coordinate SAR events. They also report on pollution, and support efforts to curb illegal fishing. Patrol duration depends on particular vessel (the 26m boats usually patrol for a day, where as the 38m boats may patrol for up to 3 days). They are responsible for patrolling an area usually 100 nm or less out from the coast and up to 600 nm from north to south. If they identify a target but are unable to intercept, they coordinate with the Regional or Sector HQs for support. These boats generally lack communication ability with other echelons and units, equipment being the

	main limiting factor. In most cases, radios across the fleet are land vehicle radios installed on the boats, but they are not made for operating in the Maritime environment and are subject to failure.
Medium Range	There are only two of these boats, 22 m in length which entered service in 1992. They are used out of Jizan to help patrol the farasan Islands. Often they will be paired with smaller boats (CPBs); the smaller boats intercept targets which the 22 m boats detect with their radar.
Short Range Patrol Boat	These boats vary from 15to 17m n length. Forty-six of these SR boats have entered service. Since 2003. These boats are primarily used SAR, patrolling, and smuggling interdiction operations. They are often tasked from regional Commander.
Coastal Patrol	These boats vary form 7m to 12.8m in length. Since 2001, 216 of these boats have entered service. These boats are operated at sector and post levels. They are mostly used within a few miles of land to interdict targets, including high-speed smuggler boat and illegal fishing vessels.
Landing Craft	The landing craft are almost 30 years old and several have major mechanical issues. They are regarded as non-operational.
Hovercraft	The hovercraft range between 11m and 20m, and entered service between 1981 and 2002
Rubber Boats	Approximately 100 rubber boats entered service in 2003

Table 11-1The SBG fleet breakdown

11.6 Maritime Areas

The following illustration depicts Saudi Arabia maritime areas as defined under UNCLOS 82. These are intended as a review of the KSA s different sovereign waters (definitions of these areas follow below). Although new CONOPS AORs include various portions of these areas, they are not one and the same.

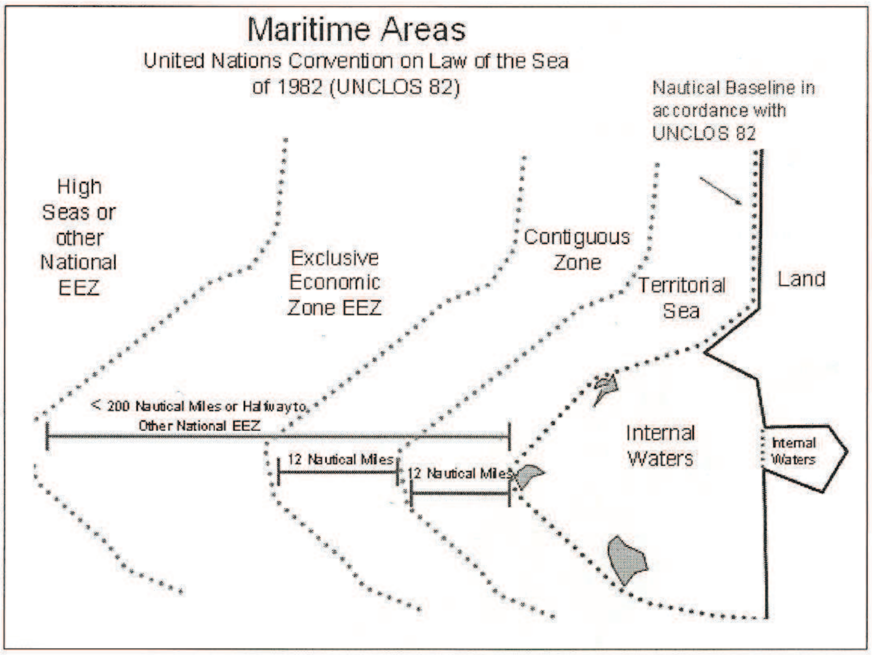


Figure 11-3 Maritime Areas per the UN convention of law of the Sea of 1982

Nautical Baseline (NB) – The baseline from which the breadth of the territorial sea is measured shall be the low-water mark along the coast of SA, including the coasts of all islands.

Internal Waters (IW) – the internal waters include any areas of the sea that are on the landward side of the baseline of the territorial sea of SA.

Territorial Sea (TS) – The territorial sea comprises those areas of the sea having , as their inner limits, the baseline described above, and, as their outer limits, a line measured seaward from that baseline, every point of which line is distant 12 nautical miles from the nearest point of the baseline.

Contiguous Zone (CZ) – The contiguous zone comprises those areas of the sea having, as their limits, the territorial sea, and, as their outer limits, a line measured seaward from the territorial sea, every point of which line is distant 12 nautical miles from the nearest point of the territorial sea.

Exclusive Economic Zone (EEZ) – The EEZ is any part of the medium line between SA and any other country less than 200 nautical miles from the nearest part of the baseline of the territorial sea. In all instance, the EEZ is less than 200 nm due to close proximity of neighboring countries waters.

11.7 Current Areas of Responsibility

Current maritime patrol areas extend from the shore to the outer limit of the EEZ. Borders with other countries extend from the shore to the EEZ. Together, they form the patrol area from which the SBG is responsible. Within these zones, are divided between regions and sectors.

Areas within a few miles of shore fall under sector and post control, and are usually patrolled by coastal patrol boats up to a few nautical miles offshore. The long, medium, and short range assets patrol in the deeper further offshore.

On the east coast, the eastern portion of the SBG patrol zone is currently patrolled by the KSA Navy, as the SBG does not have the capability to patrol the whole zone. The west coast is divided between five different regions, and vessels rarely operate outside their sector or regional waters.

The following diagram depicts the current patrol areas for the different regions with maritime responsibility.

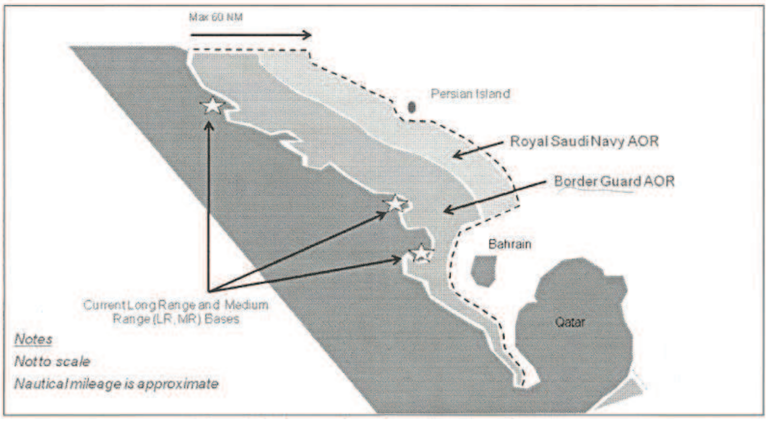


Figure 11-4 Current state Operations –East Coast

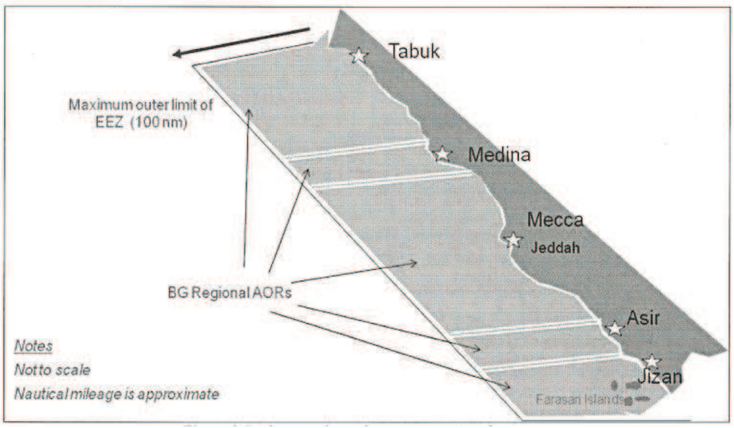


Figure 11-5 Current state operations – West Coast

11.8 Future State Offshore and Coastal Surveillance Concept of Operations

The future-state concepts of operations -area of responsibilities realign responsibilities based on capabilities currently being developed in this thesis.

11.8.1 Concept of Operation

Patrolling zones are delineated between the offshore area [waters greater than 15 nautical miles from the SA coast], and the coastal waters which fall under surveillance of the coastal radar system. Coastal surveillance has planned coverage throughout areas, but little or no coverage into the offshore areas beyond 15 nm. There are significant areas in which the planned coastal surveillance doses not cover any portion of the TS or CZ.

11.8.1.1 Coastal Areas of Responsibility

Coastal areas of responsibilities fall within 15nm of the coast, concurrent with the area to be covered by the coastal surveillance system. Although this area includes most of the waters within the nautical baseline, as well as portions of the TS and CZ waters, it is independent of these areas and may not include them if they are not within 15nm of the coast. There are significant sections where the coastal surveillance will not provide coverage out to the nautical baseline.

11.8.1.2 Offshore Area of Responsibility

The offshore AORs encompass waters beyond 15 nm from the coast to the outer limits of the EEZ.

The SBG currently organizes its maritime assets among the two coasts, but dose not have a coastal command to integrate operation. Under this concept of operation, the SBG has separate coastal commands for the east and west coasts, responsible for coordinating offshore patrolling operations.

A coastal command structure enable command decisions are more appropriate at the coastal level with out going to the SBG headquarter. A coastal perspective encourage communication between leaders at all levels and helps discourage stove-piping, while making best use of technology to build a common operating picture.

Coastal commands enable the most effective use and coordination of resources for the entire coastal area, particularly offshore patrol resources and assets. As logistics coordinators for their respective coasts, the coastal commands provide a central point for logistics planning and distribution, warehousing, repair and supply parts, and depot level boat maintenance for each coast, creating efficiencies for maritime facilities and support system. The coastal commanders are responsible to man, train, and maintain all maritime assets within their command, and to facilitate and synchronize maritime missions on each coast.

Coastal commanders will be located at coastal command centres and have operational control of the offshore patrol assets to facilitate patrolling operations outside of coastal surveillance range. The coastal commanders will generally operate from fixed, land-based command centres, but will additionally have the capability to conduct command and control of operations at sea. This will be achieved through the acquisition of two dedicated command and control assets.

11.8.2 East Coast AOR Operations

For the east coast, this produces little change, as the eastern province regional command is the only region operating in that AOR. The regional commanders also functions as coastal commander, with all maritime sectors reporting directly to him.

11.8.2.1 East Coast Coastal AOR (Coastline to 15 nautical miles)

The East Coast falls under the jurisdiction of the eastern province region. Because of the concentration and importance of critical infrastructure (on and offshore), the CIP mission is a top priority in the East. Critical infrastructure includes desalination plants, port facilities, and significant oil infrastructure along and off the coast. This area also includes significant fishing activity. Smuggling is a threat near the Bahraini and Qatari water boundaries.

In the East Coast, current coastal patrol boat and short range boats are augmented with high-speed interdiction (HSI) assets capable of speeds in excess of 50 kts. Assets in these zones conduct some patrols, but they are primarily in a reactive mode, on-call to intercept targets identified by the coastal radars and other sensors systems. The SBG also designates off limits areas around critical infrastructure, and intercepts any vessels that challenge these areas.

11.8.2.2 East Coast Offshore AOR (15nm through the EEZ)

The offshore AOR in the East Coast is approximately 5984nm square. On average, this area measures approximately 136 nm north to south, and 44 nm to west to west. It is bounded in the north with Kuwaiti waters and in the south by Bahraini waters. There is also a small section of coastal waters south of Qatar. The eastern boundary is the outer edge of the EEZ bordering Iranian waters. This area includes some portions of the TS and CZ nearer to the coast, and the EEZ to the east. Critical infrastructure is located throughout the East to the Offshore AOR, including an abundance of ARAMCO oil infrastructure. Shipping traffic includes tanker traffic loading at oil facilities. Fishing boats also fish the shallow waters in this area.

Larger vessels with an endurance minimum of 2 days (optimally 4 days) in deep sea conditions conduct maritime missions from Bahraini waters north to Kuwaiti waters (approximately 136 nm north to south, bounded in the east by the agreed border with Iran). Primary focus for these vessels is beyond coastal radar coverage, which may include portions of the TS, CZ, and EEZ areas. Assets may conduct operations for several days at a time, based on risk assessment and intelligence estimates.

In addition to SAR and patrolling missions, CIP is a primary mission for these vessels. The SBG designates off limit areas around critical infrastructure, and intercepts any vessels that challenge these areas.

The following diagram depicts the future patrol areas for the East Coast AORs.

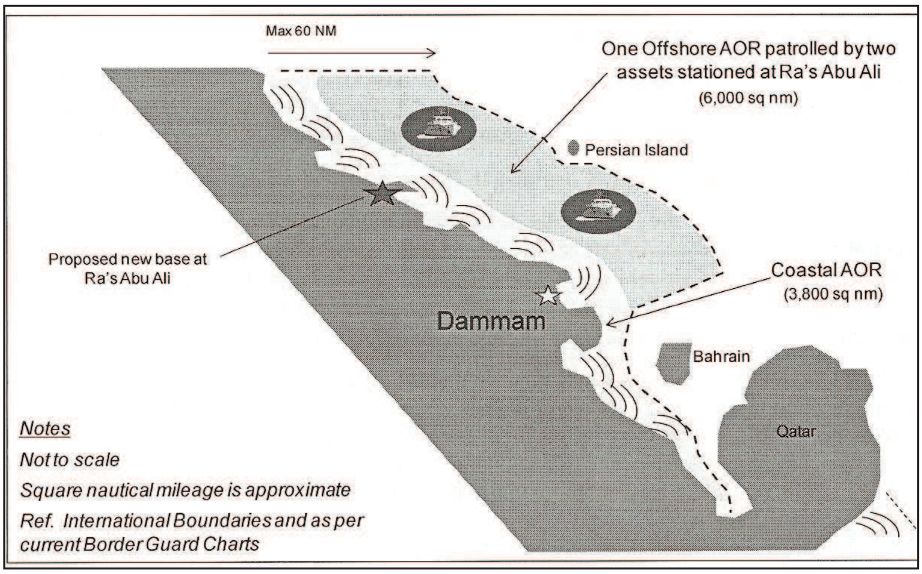


Figure 11-6Future state operation of East coast

11.8.3 West Coast AOR

The addition of the West Coast Command is a significant change, as currently the West Coast is divided among 5 separate, largely autonomous regions. Inserting a Coastal Commander to coordinate the entire West Coast operation improve communication and mission effectiveness. The West Coast Commander has operational control of offshore patrol assets and centrally coordinates offshore patrol operation.

The regional commanders report to the coastal commander, coordinate information exchange with local authorities as well as other regional SBG commands, and provide direction to sectors within their regions. Regional maritime commanders may tactical control of offshore patrol assets, but their operations will be coordinate through the coastal command to ensure synchronization and maximize efficient use of offshore patrol assets.

11.8.3.1 West Coast Coastal AOR (Coastline to 15 nm)

The West coast Coastal AOR is organized along current Regional divisions, out to 15 nm from the shore. Fishing activities is common and widespread along of the Red Sea coast. To the south, in the area around Jizan and the Farasan Islands, smuggling is a persistent threat from Yemen and other neighboring countries. Critical infrastructure is less common than in the Gulf; it includes shore-based desalination plants throughout the coast and petro-chemical facilities at Yanbu and Jizan.

Assets operating in these waters fall under Regional, Sector and Post control, and focus on intercepting targets identified by other assets (shore-based radar, offshore patrol, etc.). Current coastal patrol boats and short range boats are augmented with HIS assets capable of speed in excess of 50 knt. Assets in these zones conduct some patrol, but they are primarily in a reactive mode, on-call to intercept targets identified by the coastal radar and other sensors system. The SBG also designates off limits area around critical infrastructure, and intercepts any vessels that challenge these areas.

11.8.3.2 West Coast Offshore AOR (Fifteen nautical miles through the EEZ)

On the west coast, this area encompasses roughly 44,550 sq.nm, stretching approximately 810 nm from the Gulf of Aqaba to the Yemini border. From east to west, this area averages approximately 55 nm. Regular patrolling of this area provides the SBG with surveillance beyond the coastal radars and patrol boat presence to potential threats.

Primary shipping lances run north and south, servicing several ports along the Saudi coastline. Ferry traffic generally east and west between Egypt, Sudan and KSA. Fishing is also prevalent, though closer to the coast, in the in the shallower water. Persistent smuggling threatens the southern portion surrounding the Farasan islands. Unlike the East Coast, there is little to no critical infrastructure located in the Offshore AOR. This area is split into three zones (Northern, Central, and Southern zones) for patrolling.

Northern Zone: The Northern Zone extends from the western limit of coastal radar coverage through the EEZ from the east to west, and from the Gulf of Aqaba 240 nm south. This is the same as the current regional AOR for Tabouk. It includes less of the TS and CZ, as these areas generally fall within 15 nm of the coast. Assets from Tabouk patrol this zone.

Central Zone: Assets from Jeddah Patrol the central zone. Zone extends from the western limit of coastal radar coverage through the EEZ from east to west. It encompasses the area from the current regional AORs of Medinah and Makkah, roughly 460 nm from north to west.

Southern Zone: The Southern Zone extends from the western limit of coastal radar coverage through the EEZ from east to west, and 90 nm north from the southern border with Yemen. Islands push the nautical baseline further away from the coast, so this zone includes significant portions of the TS and CZ not covered by the coastal surveillance system. This covers offshore areas currently under the Regional AORs of Jizan and Asir. Assets from Jizan patrol this zone. Although much of the Farasan islands will have the land-based radar coverage and fall over the coastal AOR. Offshore operations will be coordinated with the coastal efforts (as they are now) to limit smuggling, illegal fishing activities, and secure the border with Yemen.

Offshore assets conduct patrolling for up to three days at a time (and have a minimum endurance of five days at sea), based on risk assessments and intelligence estimates. These vessels also have the capability to provide local command and control (C2) for SAR and disaster response situations, excess berthing to transport rescued or training personnel, a deployable boat to intercept threats over the horizon, and boarding operations on subject vessels. The following diagram depicts the future patrol areas for the east coast AORs.

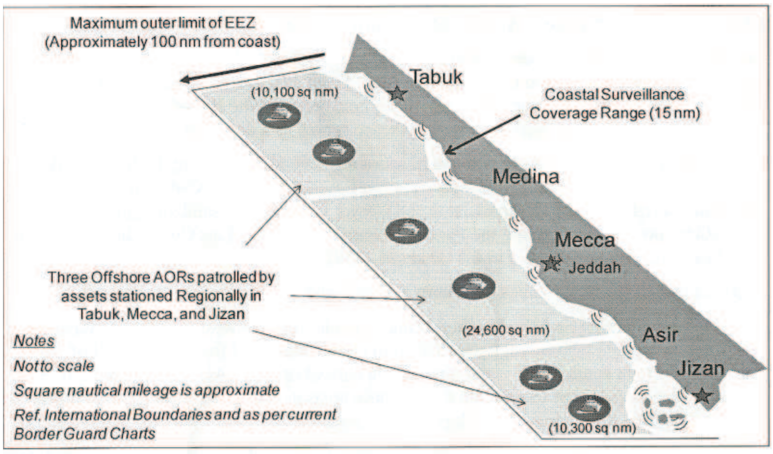


Figure 11-7 Future state operation – West Coast

11.8.3.3 AOR Mission Role

Three of the six missions for the BG maritime component drove the requirements analysis to develop capabilities. The requirements for search and rescue (SAR) response, law enforcement (LE), and critical infrastructure protection (CIP) missions, were developed to drive capabilities. In optimizing capabilities to meet these three missions, assets should also be capable of performing the other three mission areas _ marine environment protection, recreational boating safety and support to defence operations.

To conduct operations in these mission areas, the SBG must have the capability to deter, detect, classify, identify, respond and resolve threats to its borders:

- Deter_ presence of BG Maritime personnel and assets discourages illegal activity,
- Detect surveillance provides awareness of what is happening with the AOR,
- Classify _ targets are classed based on size, speed and activity,
- Identify _ determination whether a target is a threat,
- Respond _ intercept threats before they reach the KSA, and
- Resolve _ interdict threats and bring the situation to a conclusion in a safe and timely manner.

11.8.4 Coastal AORs

Within the coastal AORs, much of the detection capability will be provided by the SIE coastal surveillance system, as well as offshore patrol assets and other sources. The main focus will be the capabilities to identify, respond and resolve threats near the KSA coastline.

The following sections discuses the capabilities needed within the coastal AORs to accomplish the three primary maritime missions (SAR, LE and CIP).

11.8.4.1 Coastal Search & Rescue (SAR)

The primary SAR focus for maritime assets in coastal AORs is resolve SAR events. They may also aid in detection of SAR events, though other means will also be integral to locating distressed vessels and persons.

- Deter – patrol operations in the coastal AOR provides a presence near the shore to encourage safe operation of vessels,
- Detect – much of the capability to detect persons or vessels in distress is provided by other means, including the planned coastal surveillance system, offshore patrol assets, and civilian vessels. Coastal patrol assets will likely be directed through chain of commands from the Rescue Coordination Centre (RCC) (the radio and communications equipment will be specified through the SIE program) based on other detection means to search for and resolve SAR events,
- Large number of current fleet CPBs does not have radar and thus are entirely dependent on other platforms for detections beyond eyesight. Coastal patrol assets should have on-board radar to augments other assets and provide local detections and search capability. Radar will aid these assets in locating and responding to SAR incidents.
- Classify – Most SAR events will be classified through emergency alerts or other vessels that have local presence. The costal surveillance system will have a capability to provide classification vessels within its range. Through its radar and other optical sensors. Coastal patrol assets should augments this

capability through radar as atmospheric conditions at times may limit either the rage or effectiveness of the surveillance system.

- Identify – Determinations of a SAR events will usually be made through other sources, through coastal patrols should have communication and radar system to augment other platforms.
- Respond – in the coastal AORs, coastal patrol assets will be primary responders to SAR events and as such, require high-speed to enable fast response capability. For the coastal AOR, 2 hours is the standard response requirement for SAR incident (30 minutes preparation/ 90 Minutes travel).
- Resolve – As they will be primary responders in SAR events, Coastal patrol assets need to have space for up to 3 crew and 3 passengers, along with adequate safety and emergency response equipment.

The costal AOR includes waters within 15 nm of the coast. The SBG sector and post stations along the coast are generally 40 nm or less apart, but not all stations have boat assets. Therefore, selected boats supporting SAR mission may need a capability of 50 kts to quickly respond to SAR incidents.

In addition they require a capability to operate in waters up to sea state 4 to provide SAR response.

11.8.4.2 Coastal Law Enforcement (LE)

Since coastal radars will provide coverage for nearly all this AOR, the focus of operations in this area will be identify, respond and resolve targets detected by coastal radar. Programmed patrolling will be executed, with random boarding of vessels in support of fishing and other laws.

- Deter – Patrol operations in the Coastal AOR provide a presence neat the shore to discourage illegal activity such as smuggling and illegal fishing.
- Detect – Much of the detection capability is provided by other means. The primary source is through the planned coastal surveillance system, and other sources include offshore patrol assets as well as civilian vessels. Coastal patrol assets should have internal detection capability through on-board radar to augment other assets and provide local detection when atmospheric conditions limit other sensor performance.

- Classify – The coastal surveillance system will have a capability to provide classification of targets within its range, through its radar and optical sensors. Coastal patrol assets should augment this capability through radar, as atmospheric conditions may at times limit either the range or effectiveness of the coastal surveillance system (at least the outer perimeter).
- Identify – On-board radar will help coastal patrols track and identify targets by observing their actions and behaviour. A radar range of 12 nm will be required to locate and identify vessels in the local area.
- Respond – Selected coastal patrol assets supporting LE missions require +50kts speed to intercept and potentially boat vessels operating illegally within KSA coastal waters.
- Resolve – Crew space is required for at least 3, with space for an additional passengers. Storage space is required for small arms and other equipment related to interdiction operations.

11.8.4.3 Coastal Critical Infrastructure Protection (CIP)

In the coastal AOR, CIP includes ports, desalination plants, oil, and petro-chemical infrastructure. There is an immediate need to protect this infrastructure, so one asset should be stationed at all critical infrastructure at all times.

- Deter – Static and mobile patrols based at or near critical infrastructure provide deterrence, as well as local awareness and immediate response. Coastal patrol assets should have overhead shelter to enable personnel to remain on station for 8 – 12 hours.
- Resolve- crew space is required for at least 3, with space for additional passengers. Storage space is required for small arms and other equipment related to interdiction operations. In addition, assets should have a 7.62mm/.50 cal mount and storage for small arms to respond to these events.

11.8.5 Offshore AORs

In the offshore AORs, the SBG will depend primarily on Maritime and other Saudi Government assets to deter, detect, classify and identify targets since this area is outside the effective range of the costal surveillance system. Active patrolling provides the SBG with extended surveillance capability, SAR detection and response, and presence (deterrence).

SBG assets will respond to and coordinate SAR operations offshore, and will help detect threats and coordinate responses from other assets.

SBG offshore patrol assets also require a high-speed deployable boat, providing extended range intercept capability. The deployable boat will be utilized to conduct boarding operations, search islands, interdict detected vessels over the horizon, and assist on SAR operations.

The following sections discuss the capabilities needed within the offshore AORs to accomplish the three primary maritime missions (SAR, LE and CIP).

11.8.5.1 Offshore Search and Rescue (SAR)

The primary SAR focus of maritime assets in offshore AORs is to o respond and resolve SAR events. They also aid in detection of SAR events, and are integral to locating distressed vessels and persons, along with other means such as commercial traffic and foreign government notifications.

- Deter- offshore patrol operations will help civilian traffic avoid potentially dangerous situations and increase response times to potentially minimize the impact of SAR events,
- Detect, classify, identify – offshore patrol assets provide the SBG with surveillance coverage well beyond the shoreline, and are instrumental in locating and responding to SAR incidents. Communication with the common operating picture as the situation develops,
- Respond- given the size of the offshore AORs, a 12 hours response time is required for a SBG maritime asset to provide on- scene command a control, coordination, and actual response. It is reasonable to assume that a vessel may need
- To travel as much as 300 nm, requiring a top speed of 25 kts to 30 kts. The vessel should have appropriate communications equipment to effectively coordinate with headquarters elements and direct other assets which are responding to the event. Since these operations may to conduct SAR operations in excess of sea state 5 conditioned, with survivability in extreme

sea states well beyond sea state 5. The deployable boat expands the capability to respond to and perform SAR operations.

- Resolve- offshore patrol assets require space for additional passengers and adequate safety and emergency response equipments.

11.8.5.2 Offshore Law Enforcement (LE)

The primary capabilities for LE focus on surveillance coverage of KSA waters. In the offshore AORs, SBG maritime patrol assets are the primary means to detect, classify, and identify threats before they reach KSA shores. Programmed patrolling will be executed, centrally coordinated at the coastal command level to ensure integration of effort and paramount, to direct interception and interdiction of threats. In island areas near the coastal AORs (such as the farsan islands), these offshore assets will continue to work in conjunction with smaller assets to detect and intercept threats.

- Deter – patrol operations in the offshore AOR provide a SBG presence to discourage illegal activity such as smuggling, illegal fishing and immigration,
- Detect – radar with a high probability of detection at a range of 12 nm will be required to detect vessels at sea (including high-speed vessels with small radar cross sections),
- Classify – powerful radar is required to track and classify vessels,
- Identify- powerful on – board radar will help patrols track and identify targets by observing their actions and behaviour,
- Respond- appropriate communications equipment is required to effectively coordinate with headquarters elements and direct other assets which are responding to the event, providing on- scene command and control. Since these operations may occur up to 100 nm off shore, the asset requires the capability to conduct patrolling operations in excess of sea state 5 conditions, with survivability in extreme sea states well beyond sea state 5. Although these vessels do not require the extreme speeds of the smaller coastal patrol boats, they should have a top speed of approximately 30 kts to intercept slower threats. The deployable boat capability enables these assets to intercept threats over the horizon.

- Resolve-conduct boarding of other vessels and take on additional passengers or detained personnel. Storage space is required for small arms and other equipment related to interdiction operation.

11.8.5.3 Offshore Critical Infrastructure Protection (CIP)

In the east coast offshore AOR, CIP includes oil and patrol- chemical infrastructure (there is no offshore critical infrastructure in the red sea AOR). Much of this infrastructure has security personnel and infrastructure in place at all times. Maritime assets augment and support other security forces located at critical infrastructure.

- Deter- patrol operations in the offshore AOR augment static at patrols at critical infrastructure and provide a SBG presence to discourage attacks and threats to CIP,
- Deter- although security forces located at CIP will provide immediate detection in the local areas, the offshore assets augment this by extending the range of detection capability. Radar with a high probability of detection at a range of 12 nm will be required to detect vessels at sea (including high speed vessel with small radar cross sections),
- Classify-powerful radar is required to track and classify vessels near critical infrastructure,
- Identify- powerful on board radar will help patrols track and identify targets by observing their actions and behaviour,
- Respond- a response time of two hrs requires the capability to achieve +30 kts to respond CIP events in the gulf.
- Resolve- offshore patrol assets require space for additional passengers. In addition, assets should have a.50 cal mount and storage for small arms to respond to these events.

11.9 Mission Scenarios

The following scenarios illustrate how this CONOPS will guide operations to address events under the SAR, LE, and CIP missions for which the SGB Maritime Component is responsible.

These scenarios are organized along the Deter-Detect-Classify-Identify-Respond-Resolve framework to illustrate the command & control role and asset capabilities required to effectively address threats for each mission.

11.9.1 Search & Rescue (SAR)

Each year, millions of people from across the world visit Saudi Arabia for the Hajj. In 2011, over 1.7 million pilgrims arrived in Saudi to perform the Hajj.

As Mecca in near the western coastline of the country, many people use ferries to cross the Red Sea from Egypt to arrive in the Kingdom. This Hajj traffic is in addition to normal ferry traffic from Egypt, which is quite extensive as a large number of Egyptians work in Saudi Arabia and regularly cross the red sea.

High speed wave-piercing catamaran ferries operate between Egyptian and Saudi ports. In this example, a 74m wave-piercing catamaran, carrying 400 passengers and 80 cars, leaves Duba, Saudi Arabia for Hurghada, Egypt. Duba is located approximately 100nm east from Hurghada. The ferry regularly makes this trip in a little more than 3 hours at a cruise speed of 33 kts.

The ferry departs Duba at 8pm, travelling at 33 kts. The weather is windy and

Cool, producing moderate sea state conditions. About 1 hour into the journey,

A malfunction triggers an explosion in the engine room, directly wounding several personnel, and making the engines inoperable. The explosion throws passengers about and causes a number of injuries.

The blast also produces a leak along the bottom of hull. The ferry starts taking on water. This problem is exacerbated as the crew uses fire hoses to put out the fire, adding additional water. After about 30 minutes, the crew is able to put the fire out and slow the leaking water, leaving the left rear of the ferry about 15 feed lower in the water.

The ferry’s distress cal reaches a cargo ship which is located 100 nm south of the ferry on southerly heading. The cargo ship contracts the regional coordination centre (RCC) in Jeddah to pass on the distress call.

Upon notification, the RCC alerts the west coast commander as well as Egyptian authorities. Since the in incident in nearer to the Saudi coast, the KSA border guard will lead the rescue effort, with Egyptians support.

Two SBG offshore patrol boats (OPBs) are patrolling the Tabouk offshore AOR.

One is currently about 100 nm north, near the Gulf of Aqaba; the other is about 70 nm south of the ferry, and was preparing to return to Duba after a 3 days patrol. The west coast commander orders these vessels to immediately make their way to the ferry to provide assistance. He also directs that the reserve offshore patrol boat stationed at Duba depart immediately since this is the closest vessel (approximately 30 nm away).

The RCC coordinates with other ministry of interior elements to provide aviation and other support.

The Regional commander in Tabuk contacts the local ferry operators in Duba to release an empty ferry boat so that passengers can be picked up and transported to safety.

The ready reserve offshore patrol boat departs Duba, travelling at 30+kts, and arrives on the scene at certain time. This patrol boat provides local command & control for this operation, regular updates to the RCC through out the operation, and immediate assistance to the ferry passengers. The RCC update the common operating picture for all subordinate units, and also briefs the SBG headquarters in Riyadh.

The patrol boat uses its radar to find and home in on the ferry, which has drifted several miles from its first reported location. The patrol boat radios the RCC and the other patrol boats the new location.

The ferry s emergency boats have all been dispatched. The ferry captain informs the patrol boat captain that there are a certain number of people still on board, including others seriously wounded.

Te SBG helicopter assets arrive. The patrol boat sends some of crew members aboard the ferry to hep, and the patrol boat coordinates the evacuation of the casualties on the helicopter.

The patrol boat s launch is deployed to search for the additional passengers in the water that did not make it into the life oats. They are brought back to the patrol boat and evaluated for injuries.

Another helicopter arrives and takes on wounded passengers collected by the launch.

The ferry continues to takes on water. Anther patrol boat arrives on the scene after one hour. It takes on wounded and immediately departs back to port.

The third patrol boat arrives after half hour. The ferry is now much lower in the water, so the ferry captain commands that remaining crew evacuate the ferry to the patrol boats. The launch then deployed again to check for injuries among the passengers on the life boats, many of whom were injured during the explosion or evacuating the ferry.

The third patrol boat takes o injured and departs for Duba. The first patrol boat stays on station to coordinate the search for passengers, as the other patrol boats transport passengers (beginning with the wounded) back to station (Duba).

The West Cost Commander has ordered that all available assets converge on the ferry, so additional patrol boats and crews are briefed on the situation and dispatched from Duba. They start arriving after half day and begin searching for other passengers in the water nearer to where the explosion occurred.

The ferry sinks after one hour. And then after four hours, an empty ferry from Duba arrives to take on injured passengers. Patrol boat crewmembers assets passengers boarding the relief ferry. The patrol boats then stay on station to search for survivors for an additional two days.

11.9.2 Law Enforcement (LE)

The Farasan Islands extend west into the Red Sea along the Saudi/Yemini Maritime border. This area sees a high incident rate for illegal smuggling and fishing. Because of this, the SBG concentrates offshore and coastal patrolling operations along the border and among the islands.

In this example, an offshore patrol boat is patrolling the waters along the Yemini border, just south of the Farasan Islands, and 50 nm west of the KSA coastline.

Coastal radar on one of the Farasan Islands detects a fast moving target approximately 15 nm east of the patrol boat, moving north from Yemini waters. The target cannot be classified or identified with land-based surveillance optics due to weather conditions. The West Cost Commander and Jizan Regional commander discuss the situation as the target is tracked. The West Coast Commander assigns the offshore patrol boat assets to the jizan Regional Commander to investigate this target.

The Regional Commander alerts the Farasan Sector Commander to dispatch assets to assist. The Sector Commander orders two coastal patrol boats (CPBs) from an island post to the east to provide assistance.

As the CPB gets to within 10 nm, it is able to detect the target on its radar. It follows the target as it approaches and stops at one of the southern Farasan Islands. Patrol boat continues closing on the target and prepares its high speed launch for deployed.

Once near the island, the patrol boat determines that the target is a small speedboat. Three people have disembarked from the boat and are burying something in the sand on the island. Then they notice the patrol boat, they immediate get back to the boat and leave the island, heading east. The patrol boat fires its 0. 5 cal at the target. But the target does not stop.

The deployable boat is launched and pursues the target. The patrol boat follows to track the target on its radar and vector the launch and the CPBs toward the target; it also sends a situation report to the Regional and sector Commanders, notifying them to the target s description and locations. It reports the target' heading so that ground forces can be alerted along the coastline where smugglers may be aiming to beach the boat. The Sector Commander dispatches a utility boat carrying an all terrain vehicle to the island to investigate and collect evidence.

The CPBs converge on the target at high speed. When the vessel will not stop, they concentrate fire on the near of the boat to disable the engine.

The SBG closes in on the boat and boards it to apprehend the suspects. The detainees are transferred to the offshore patrol boat which it arrives on the scene, and transported to Jizan for hand-over to the local authorities. The smuggler boat is recovered to Jizan port and impound.

11.9.3 Critical Infrastructure Protection (CIP)

The KSA has numerous facilities considered critical infrastructure located offshore in the Arabian Gulf. Due to the number of critical facilities, the heavy maritime traffic in the offshore area and the proximity to several other countries' national water, critical infrastructure protection in the East Coast Offshore AOR is an essential and important mission.

Most of these infrastructures are oil and petro-chemical infrastructure, the preponderance of which is also secured by Saudi ARAMCO security forces. These facilities are surrounded by restricted zone in which authorized vessels and personal are allowed. The SBG maritime forces work in conjunction with ARAMCO and other security forces to protect this infrastructure. The SBG provides deterrence through presence, early warning and interception of approaching vessels, and support to security forces at these facilities.

In this scenario, ARAMCO security identifies a suspicious vessel which has stopped just outside the restricted area around an oil drilling facility. The vessel is a larger, 40+ ft. powerboat. ARAMCO contacts the east Coast Commander, who is also the Eastern Province Regional Commander, and who has operational control of the offshore patrol boat. The Commander directs an offshore patrol boat to investigate this suspicious vessel.

With two offshore patrol boats on patrol in the Arabian Gulf continuously, there is one asset in close proximity to the facility. This offshore patrol boat quickly comes within range to use its surveillance suite to detect the target and then closes on the target to achieve visual identification. The patrol boat then readies its deployable boat for launch.

Upon arriving, the patrol boat deploys the launch with several armed personal to board the vessel and investigate. The team boards and learn that the vessel has had engine trouble and is leaking fuel into the water.

The passengers have the proper identification, and a search of the vessel conforms that there is no contraband weapons abroad. The patrol boat coordinates a two for the powerboat to a nearby port in Dammam. It also coordinates with the appropriate environmental office to notify them of the leaked fuel.

11.10 Gaps between Current / Future Maritime Fleet

11.10.1 Capabilities Needed

Based on this CONOPS, and focusing on offshore and coastal surveillance, the SBG maritime component needs the following capabilities in order to fulfil its missions.

Mission	Capabilities
LE offshore AOR: patrol the gulf AOR once every 10 hrs; patrol the red sea AOR once every 24 hrs with concentrated patrolling in the Farsan island and other higher risk areas	• Detect vessels with a small radar cross section at a range of 12 nm • Asset endurance of 3 days+ 2days reserve (including crew, fuel, fresh water and food) • Patrol speed 15 kts / pursuit capability to 30 kts
LE coastal AOR: provide additional coverage to augment SIE coastal surveillance within 15 nm of coast, and intercept / interdict threats approaching the coastline	• Intercept vessels travelling 50+kts • Detect vessels with a small radar cross section at a range of 6nm • 12 hr endurance
SAR response offshore AOR: respond to a SAR event within 12 hours in offshore AOR	• Travel 300 nm in 12 hrs (25 kts speed) • Conduct operations in sea state 5
SAR response coastal AOR: respond to a SAR event within 2 hours in coastal AOR	• Travel 50 nm in 90 minutes • Sea state 4 capable
CIP offshore AOR: respond to CIP incident in gulf within 2 hrs	• 30 kts speed • 50 cal + small arms
CIP coastal AOR: stage vessels at CIP to provide immediate response; to coastal AOR CIP incident within 2 hrs	• Fast response, travel 50 nm in 90 minutes • 50 cal +small arms • Overhead cover (shade) for personnel
Pollution: provide excess berthing and equipment for pollution operations	• +4 berthing • Excess equipment capacity
Support defensive Ops: interoperability with other C4ISR, (RSN, etc.), interdict capability	• Mounting for electronics suite specified in SIE • Capable of self defence

Table 11-2**Table** mission and capabilities trace (Mapping)

11.10.2 Gaps

Several gaps persist between the current fleet assets and the capabilities out line in this CONOPS

No common operating picture (COP): Although this will be partially addressed but the SIE program, it bears mention here because any new SBG maritime assets will need to be compatible with whatever electronics suits is specified by the SIE. This is particularly needed for coordinating command and control. SAR responses and offshore surveillance operations, as well as feeding information to the COP. Currently, not all inventories have communications capabilities, and of the vessels that do, not all the systems are working in order. All vessels will need dictated marine communications equipment.

Limited offshore surveillance capability: The SBG currently patrols only a small portion of the offshore area, due primarily to a lack of available/ serviceable assets, and a lack of offshore patrolling. It not unusual any longer ranges assets to be unavailable due to maintenance and parts availability issues. In addition, these assets are divided up between different regional commanders, and restricted to patrolling waters witch fall into that particular region; very little cross-coordination takes place to synchronize offshore patrol operations.

Lack of interceptor capability: the SBG has some CPBs with a max speed of approximately 45 kts, which may bee too slow to intercept some smuggling boats. Most of these CPBs lack radar systems, and must rely on surveillance capabilities of other assets.

Lack of utility capability: The SBG is required to search island and replenish island posts with supplies and personnel. It currently has no utility vessels focused on these types of missions, so it must task its patrol assets with these missions, thereby degrading the offshore mission’s effectiveness.

11.10.3 Required Offshore Surveillance

The current fleet is composed of a variety of vessels of different ages and manufacturers, requiring distinct training, maintenance and logistic efforts. This inhibits the capability of the SBG to conduct effective offshore patrolling operations. Based on the CONOPS, one class of offshore patrol boat must be purchased to support the variety of offshore maritime missions for witch theSBG is responsible.

For every asset patrolling a particular offshore AOR, there will be two assets in port. At least one asset will provide a ready reserve capacity for each port in the event of an accident offshore (such as a large scale SAR operation). Assets not on ready reserve will conduct recovery operations from recent patrols, and training and maintenance operations in preparation for the future operations. Offshore patrol operations must be at least three days in duration.

A total of thirty offshore patrol boat assets are needed to provide the offshore mission capabilities as described in this CONOPS (both east and west coasts).

11.10.3.1 East Coast Offshore AOR (6 Total assets)

To provide the ability to surveil the entire east coast AOR every 7-8 hours, two offshore patrol boats (OPBs) are required to be on stations at all times. One OPS will be on ready reserve to assist in the event of an emergency, and three OPBs must be in a training/maintenance cycle.

11.10.3.2 West Coast Offshore AOR (24 Total Assets)

To provide the ability to surveil the entire West Coast AOR every 24 hours, eight offshore patrol boats the required to be on station at all times (two in the northern zone, three each in the central and southern zones). Additionally, one OPB for each zone will be on ready reserve at ports in Tabouk, Mecca and Jizan. Thirteen patrol boats must be on the maintenance and training cycle at any one time.

The following table summarizes asset distribution among the different AORs:

Offshore AORs	Assts Required	Assets in patrol schedule		
		On station (3 days)	Maintenance & training	Ready reserve status
East coast	6	2	3	1
West coast	24	8	13	3
Total	30	10	16	4

Table 11-3 Deployment of future offshore patrol assets

11.10.4 Required High Speed Interceptors

The current fleet of interceptors is mostly allocated to the east coast, and is composed of a variety of vessels of different ages and manufacturers, some of which do not have sufficient speed to match the threats. Based on this CONOPS, additional High Speed Interceptors must be purchased to support the variety of coastal and offshore Maritime missions for which the SBG is responsible.

The need for interceptors has been identified by Region and Sector and in some cases down to Outpost. To achieve the minimum required capability. 50 High Speed Interceptors assets are needed to provide the coastal and offshore mission capabilities as described in this CONOPS (both east and west coasts).

To achieve an additional capability required and address requirements due to current high speed boats coming to the end of their useful life, an additional 94 HIS may be required.

11.10.4.1 East Coast AOR (20 Total Assets)

To achieve the minimum required capability, including the ability to respond and resolve threats within the East Coast AOR, a total of 20 High Speed Interceptors are required.

11.10.4.2 West Coast AOR (31 Total Assets)

To achieve the minimum required capability, including the ability to respond and resolve threats within the West Coast AOR, a total of 20 High Speed Interceptors are required.

The following table summarizes asset distribution among the different AORs. It is proposed that these quantities of boats be procured in two phases to ensure that facilities and other full capability integration issues are resolve before all boats are delivered.

High speed interceptor				
Region		Minimum required capability	Additional capability	Comment
East coast	Dammam	20	15	Currently have 44 of the engine HSI
West coast	Tabouk	4	14	
	Madinah	3	6	
	Makkah	8	17	
	Asir	3	6	Currently have 4 of the 3 engine HSL
	Jizan	13	36	
	Makkah			
Total		51	94	

Table 11-4 deployment of future high speed interceptors

11.10.5 Utility Boats

The lack of utility boats to undertake the island search mission and other supporting tasks, results in the use of current medium and long range patrol boats to undertake these tasks.

This is an inefficient use of these vessels and results in the less than optimal utilization of patrol boats. Based on this CONOPS, utility boats must be purchased to support the variety of coastal and offshore maritime missions for which the SBG is responsible.

Utility boats have been identified by region and sector and in some cases down to the outpost. To achieve the minimum required capability, 32 utility boats are needed to provide the coastal and offshore mission capabilities as described in this CONOPS (both east and west coasts).

To achieve an additional capability level, a further 9 UBs may be required.

11.10.5.1 East Coast AOR (8 total assets)

To achieve the minimum required capability, including the ability to respond and resolve threats within the east coast AOR, a total of 8 UBs are required.

11.10.5.2 West Coast AOR (24 total assets)

To achieve the minimum required capability, including the ability t respond and resolve threats within the west coast AOR, a total of 24 UBs are required.

The following table summarizes assets distribution among the different AORs:

Utility boats			
Region		Minimum required capability	Additional capability
East coastal Dammam		8	6
West coastal	Tabouk	6	0
	Medinah	2	1
	Mekkah	8	2
	Asir	2	0
	Jizan	6	0
Total		32	9

Table 11-5 deployment of future utility boats

11.10.5.3 Required Command and Control Boats

In order to provide a flexible and agile command and control structure, there is a requirement to provide a seaborne command and control capability. Based on this CONOPS, one class of command and control boat must be purchased to support the variety of offshore maritime missions for which the SBG is responsible.

Offshore patrol operations will be at least three days in duration.

A total of two command and control boat assets (east and west coasts) are needed to provide a total of two command and control for the offshore mission capabilities as described in this CONOPS.

The following table summarizes asset distribution among the different AORs:

Command and control boats	
Region	Minimum required capability
East coastal	1
West coastal	1
Total	2

Table 11-6 deployment of future command and control boats assets

Appendix B

12 Overall Comparison Between the SBG Members in All Vessel Types

All commanders in all vessel types who responded to the questionnaire occupied commanding occupation. All but one was working in offices. The only commander who is working on board was in the vessel 26.5 metre length. The differences between commanders regarding their current local work are not statistically significant (Pearson Chi-Square, p = 0.41).

12.1 Total Experience of Work Regarding Type of Vessel

General distribution of total experience (months) of work on boat in all commanders working in all vessel types, is shown in Figure 11.2.

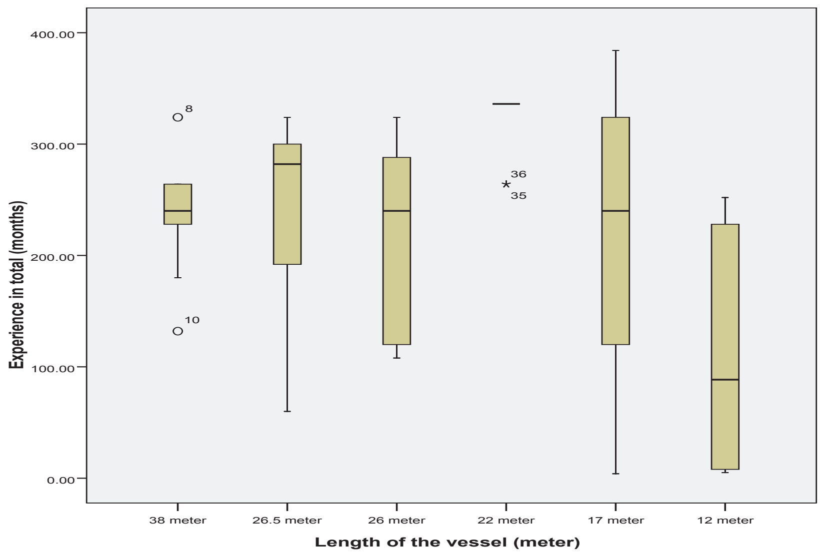


Figure 12-1Total experience of members for all vessel types.

Table 13.2 shows that the means and medians duration (months) of total experience in all vessel types differed between members. This difference was statistically significant between groups (ANOVA: p < 0.001). While Post Hoc tests for multiple comparisons showed no significant differences between commanders in most vessel types (Bonferroni: p > 0.05: 0.059-1.0), these variations were statistically significant between commanders working in vessel 26.5 and 12 metre length (Bonferroni: p =

0.046), and commanders working in vessel 22 and 12 metre length (Bonferroni: p < 0.001)

12.2 General Inquiries

12.2.1 General Satisfaction

The vast majority of members working on different vessel types were generally satisfied and very satisfied but not those working in vessel 26.5 metre length (Figure 12.2). The overall differences in satisfaction between members in all vessel types were statistically significant (Pearson Chi-Square, p = 0.001).

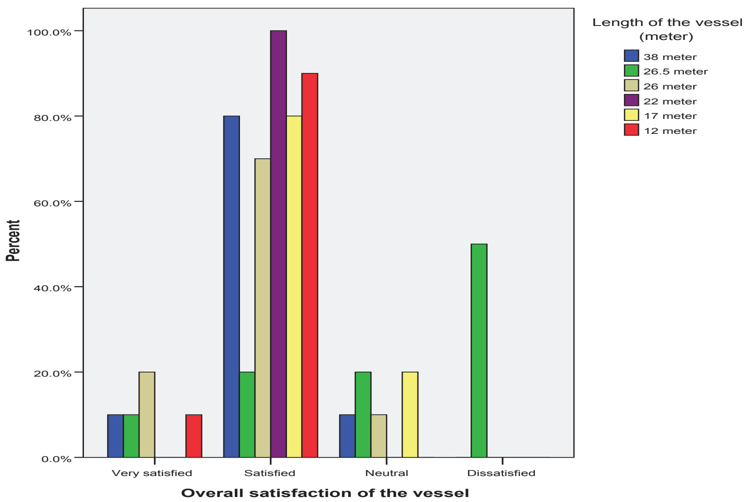


Figure 12-2 Overall opinion of satisfaction of all vessel types.

12.2.1.1 Economically Operation of the Vessel

Half of members (50%) working on vessel 26.5 metre length stated that the economically operation of this vessel was less than average. However, all other members working in all vessel types stated that the economically operation of this vessel was average and above average (Figure 12.3). Overall differences between all vessel types regarding the economically operation were statistically significant in members (Pearson Chi-Square, p = 0.001).

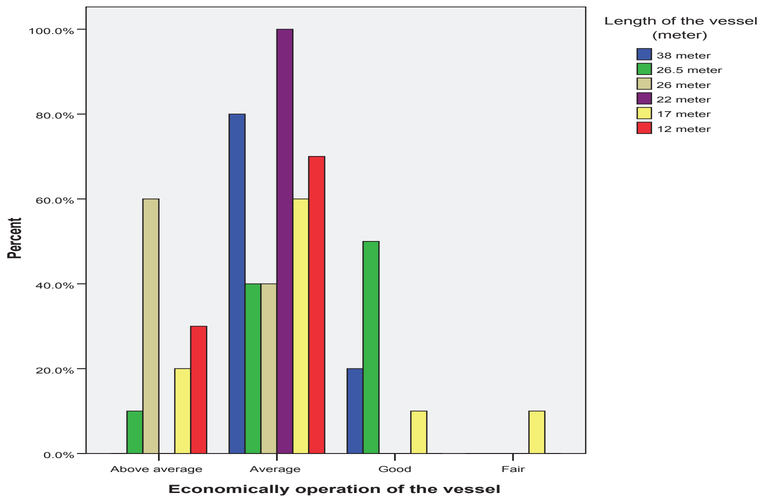


Figure 12-3 Overall opinion of economically operation of all vessel types.

12.2.1.2 Survivability of the Vessel

In total, 60% of members working on vessel 26.5 metre length, 30% of those working in vessel 17 metre and 20% in vessel 26 metre length stated that the survivability of their vessels was less than average. However, the remaining commanders working in all vessel types stated that the survivability of their vessels was average and above average (Figure 12.4). Overall differences between all vessel types regarding the survivability were statistically significant in commanders (Pearson Chi-Square, $p = 0.002$).

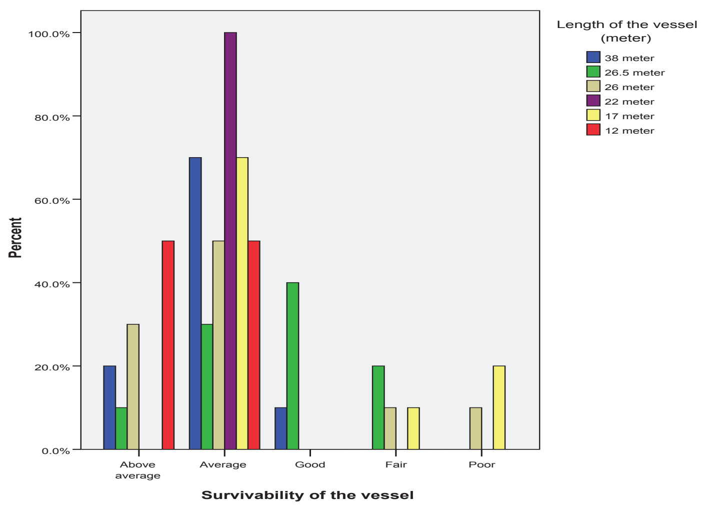


Figure 12-4 Overall opinion of survivability of all vessel types.

12.2.1.3 Maintainability of the Vessel

Half of members (50%) working on vessel 26.5 metre length and 17 metre length stated that the maintainability of their vessels was less than average. This was seen in 20% and 10% of members working on vessels 38 and 26 metre length respectively. However, all other members working in all vessel types stated that the maintainability of their vessels was average and above average (Figure 12.5). Overall differences between all vessel types regarding the maintainability were statistically significant in members (Pearson Chi-Square, p = 0.019).

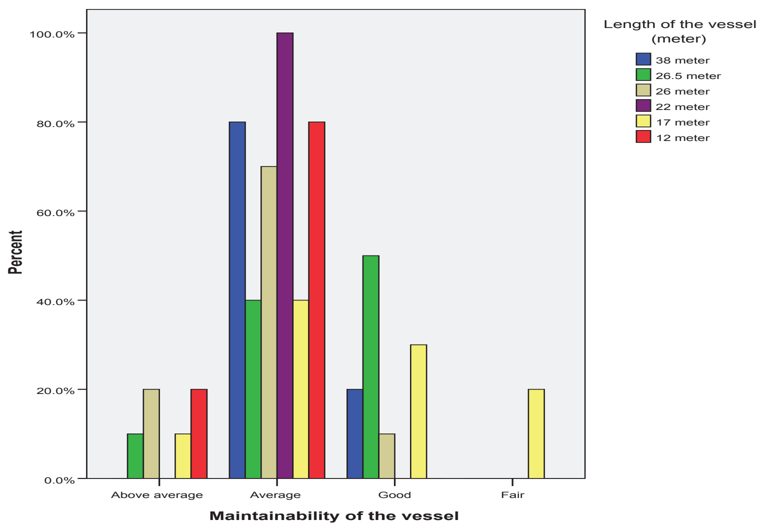


Figure 12-5 Overall opinion of maintainability of all vessel types.

12.2.1.4 Condition of the Vessel in General

In general, the majority of commander responders were satisfied or more regarding the condition of their vessels but only 50% of members working in vessel 26.5 metre length reported so (Figure 12.6). However, the differences between members in all vessel types regarding their opinion about the condition of their vessels were not statistically significant (Pearson Chi-Square, p = 0.16).

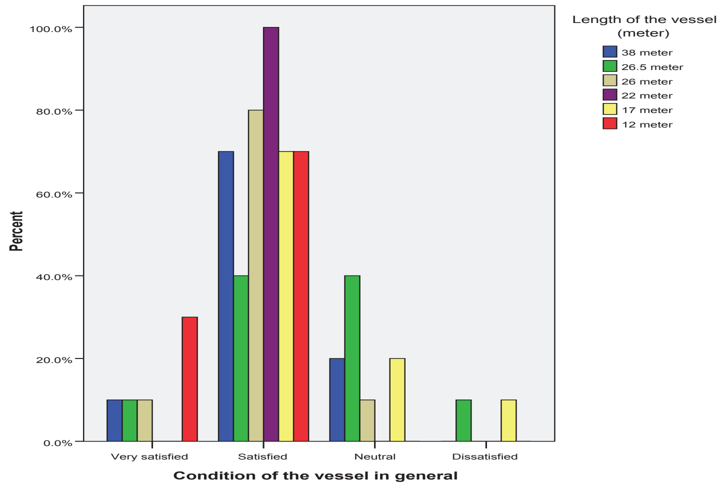


Figure 12-6 Overall opinion of the condition of all vessel types generally.

12.2.1.5 Feeling About the Maintenance Cost of the Vessel

Figure (12.7) shows different feelings about the maintenance cost of all vessels between members. Therefore, the differences were statistically significant (Pearson Chi-Square, $p < 0.001$).

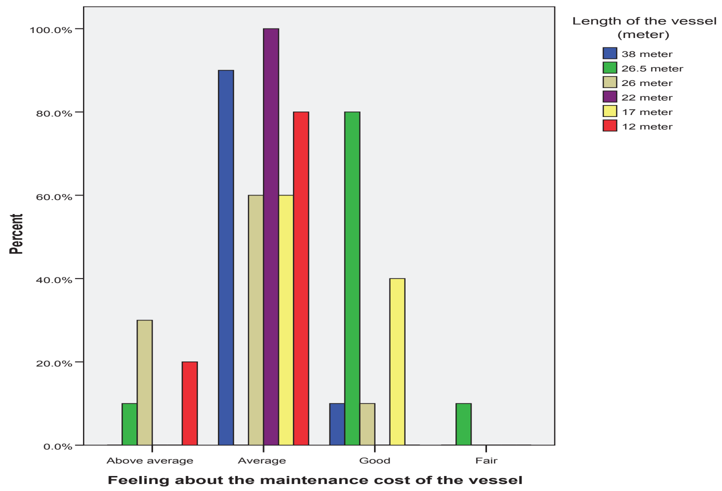


Figure 12-7 Overall feeling about the maintenance cost of all vessel types.

12.2.1.6 The Safety of the Vessel to Sail at Night

Although the responses varied between commanders in all vessel types regarding the safety to sail at night (Figure 12.8), it was intriguing to see no significant differences between commanders in this regard (Pearson Chi-Square, $p = 0.12$).

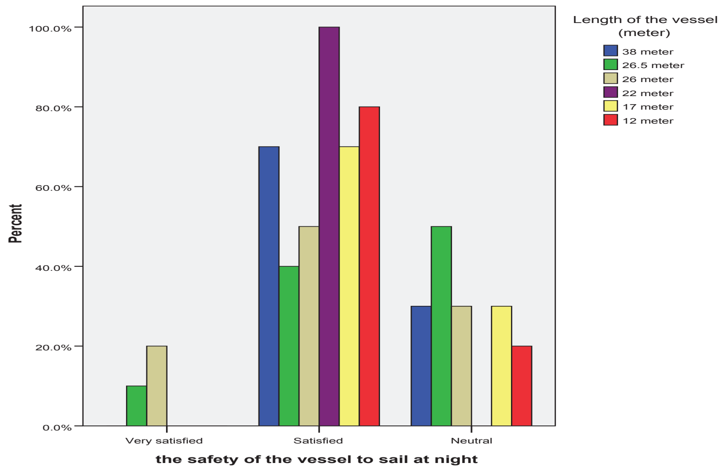


Figure 12-8 Overall opinion of the safety for all vessel types to sail at night.

12.2.1.7 The Feeling About the Comparison Between This Vessel and Other Vessels

The feelings about the comparison between vessels, reported by the members, differed (Figure 12.9) significantly (Pearson Chi-Square, $p < 0.001$).

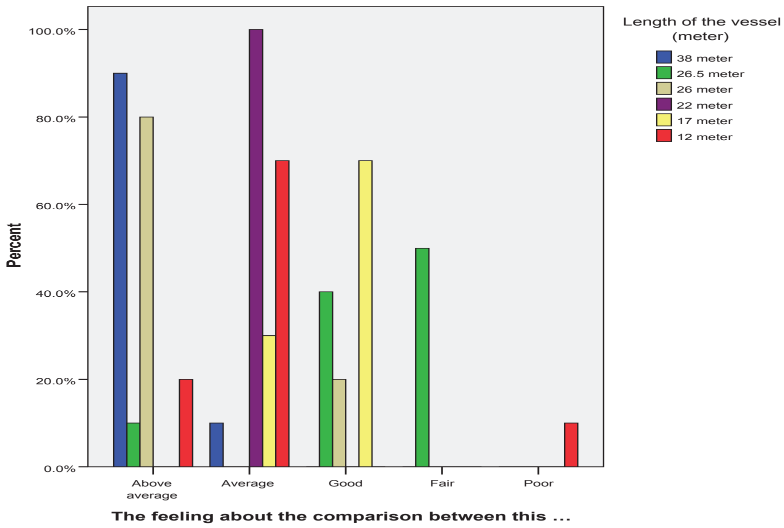


Figure 12-9 Overall feelings about the comparison of all vessel types.

12.2.1.8 Speed of the Vessel

The vast majority of members in all vessel types were satisfied and very satisfied regarding the speed of their vessels (Figure 12.10), though the differences were not statistically significant (Pearson Chi-Square, $p = 0.41$).

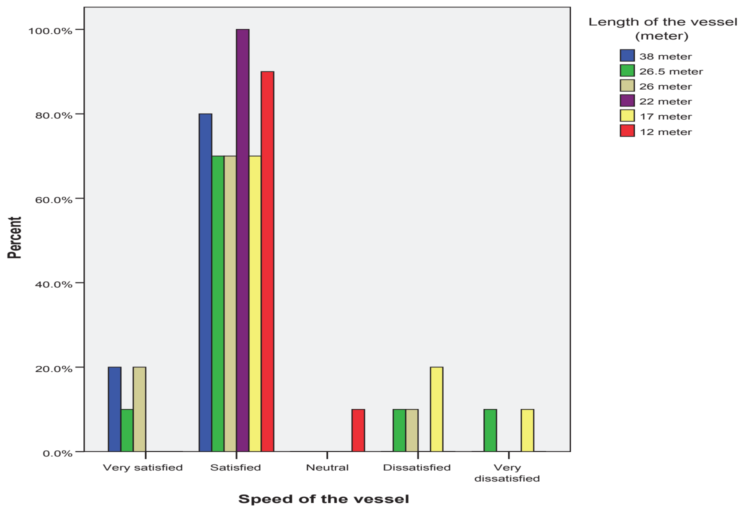


Figure 12-10 Overall opinion on the speed of all vessel types between members.

12.2.1.9 Sailing of the Vessel in the Open Sea

The only members (100%) who were completely satisfied with the sailing in the open sea were those working in the vessel 38 metre length. This was noted in 50% of those working in vessel 26 metre length. The remaining members were neutral, dissatisfied and very dissatisfied in this regard (Figure 12.11). The differences between members in different vessel types regarding this issue were statistically significant (Pearson Chi-Square, $p < 0.001$).

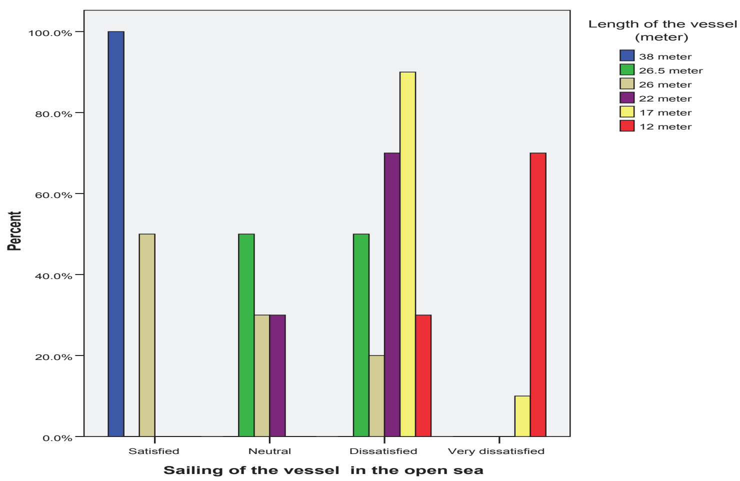


Figure 12-11 Overall opinion regarding the sailing for all vessel types in the open sea.

12.2.1.10 Sailing of the Vessel Close to the Coast

Figure (12.12) shows that few members were satisfied about the sailing close to the coast in most vessel types. The remaining members were neutral and dissatisfied. Thus, the differences between members were not statistically significant (Pearson Chi-Square, $p = 0.19$).

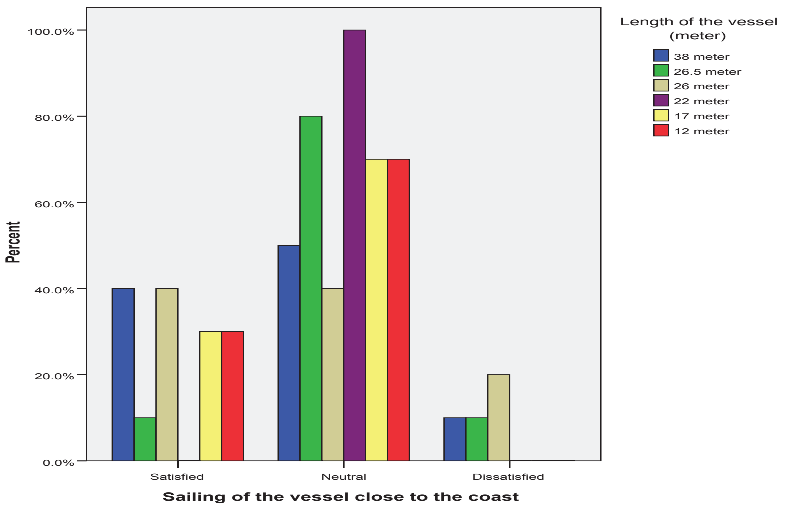


Figure 12-12. Overall opinion regarding the sailing close to the coasts for all vessel types close to the coast.

12.2.2 Crew Requirements

12.2.2.1 Spaces of the Accommodations

Overall (Figure 12.13), 80% and 70% of members working in vessels 38 and 26 metre lengths were very satisfied regarding the spaces of the accommodation respectively, the remaining members in those vessels were satisfied similar to all members working in vessels 22 and 17 metre lengths but not to those working in vessels 26.5 and 12 metre lengths who showed to be neutral (80%, 70% respectively). The only dissatisfied case was noted in one commander working in vessel 26.5 metre length the differences between members therefore, were statistically significant (Pearson Chi-Square, $p < 0.001$).

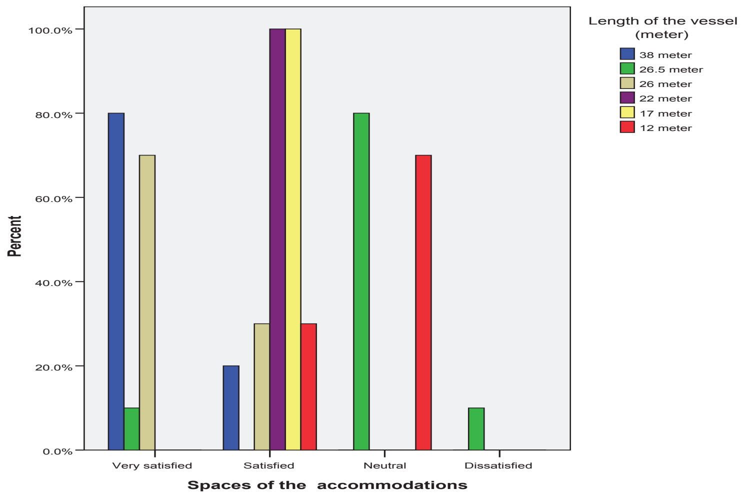


Figure 12-13 Overall opinion regarding the spaces of the accommodations for all vessel types.

12.2.2.2 Spaces of the Mess Room

Only six members answered this part of questionnaire in vessel 12 metre length, two (33.3%) were satisfied and 4 (66.7%) were very dissatisfied regarding the spaces of the mess room. The majority of other members in other vessel types were satisfied (Figure 12.14) but not those working in vessel 26.5 metre length who were neutral (90%). The differences between members for this point in different vessel types were statistically significant (Pearson Chi-Square, $p < 0.001$).

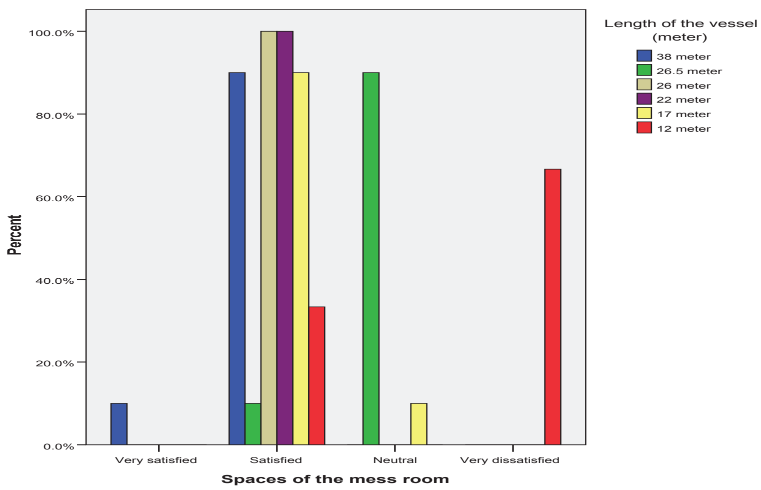


Figure 12-14. Overall opinion regarding the spaces of the mess room for all vessel types.

12.2.2.3 Spaces of the Bridge

Only 8 members answered this part of questionnaire in vessel 22 metre lengths who were satisfied regarding the spaces of the bridge. It was noted that there were significant differences between members working in vessel 26.5 metre lengths who were very dissatisfied (90%) about the spaces of the bridges and other members who were mostly satisfied (Figure 12.15) in other vessel types (Pearson Chi-Square, $p < 0.001$).

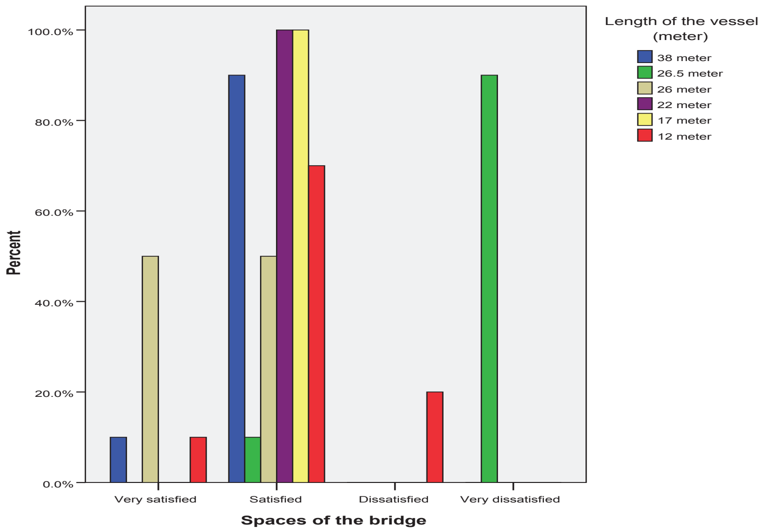


Figure 12-15. Overall opinion regarding the spaces of the bridges for all vessel types.

12.2.2.4 Spaces of the Engine Room

The majority of members were satisfied about the spaces of the engine room in all vessel types but only 50% of members working in vessel 26.5 metre length showed so (Figure 12.16). The remaining members working in vessel 26.5 metre length were netural (30%) and dissatisfied (20%). The differences between members regarding the level of satisfaction about spaces of the engine room of their vessels were statistically significant (Pearson Chi-Square, $p < 0.001$).

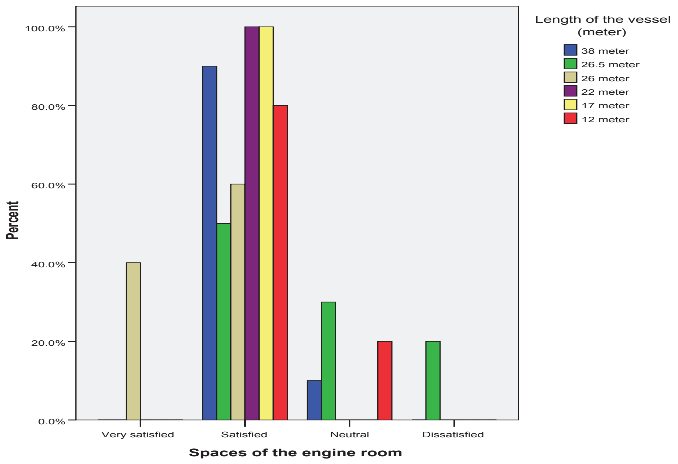


Figure 12-16. Overall satisfaction of the spaces of the engine room between members in all vessel types.

12.2.2.5 Spaces of the Main Deck

Similarly to the previous section, the majority of members working in vessel 26.5 metre length were very dissatisfied (70%) and neutral (20%) regarding the spaces of the main deck unlike to the vast majority of other members in other vessel types who were satisfied or more. (Figure 12.17) shows the level of satisfaction between members in the previous vessel types was statistically significant in this regard (Pearson Chi-Square, $p < 0.001$).

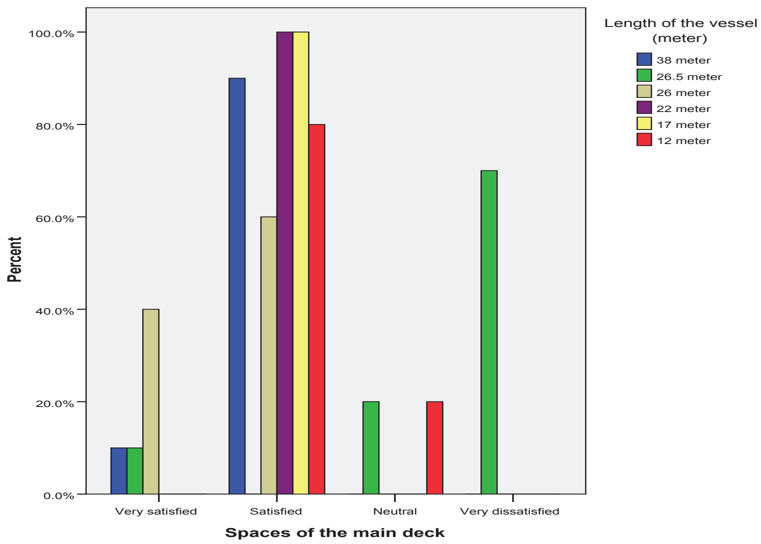


Figure 12-17 Overall opinion regarding the spaces of the main deck for all vessel types.

12.2.2.6 Spaces of the Stores

Same, the majority of members working in vessel 26.5 metre length were neutral (80%) regarding the spaces of the stores unlike to the vast majority of other members in other vessel types who were satisfied or more (Figure 12.18). The level of satisfaction between members in the previous vessel types was statistically significant for this issue (Pearson Chi-Square, $p < 0.001$).

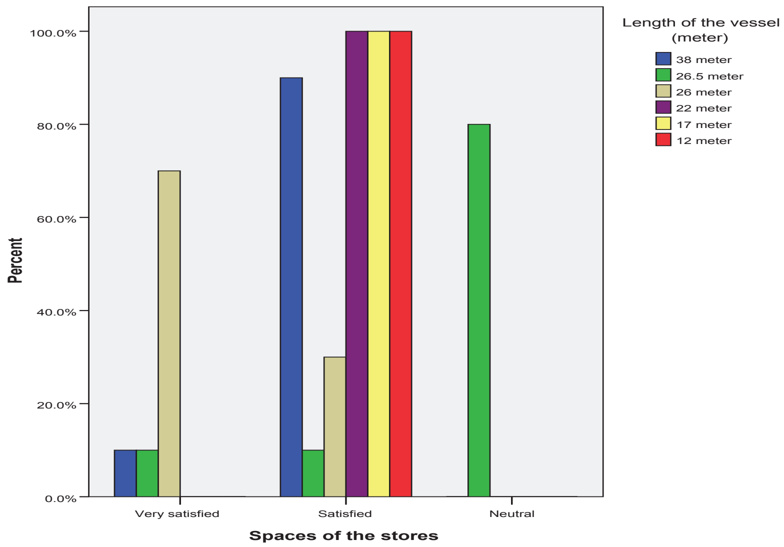


Figure 12-18. Overall opinion regarding the spaces of stores for all vessel types.

12.2.2.7 Fresh Water Tanks Capacity

While the majority of commander responders (80%) were satisfied regarding the fresh water tanks capacity in vessel 38 metre length, only few members reported so in other vessels where they showed higher level of neutrality or less (Figure 12.19). The differences between members were statistically significant in this regard (Pearson Chi-Square, $p = 0.003$).

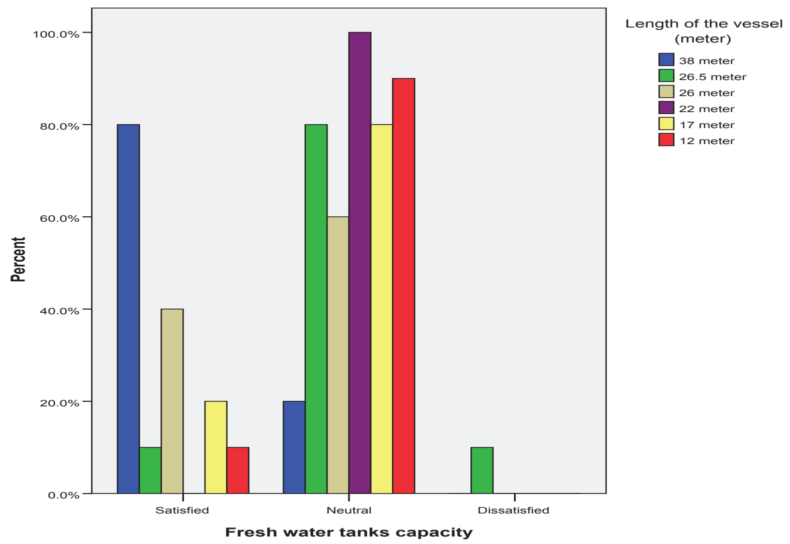


Figure 12-19. Overall opinion regarding the fresh water tanks capacity for all vessel types.

12.2.2.8 Fuel Tank Capacity

While the majority of commander workers showed higher percentages of satisfaction regarding the fuel tank capacity in vessels 38, 26, 22 and 12 metre lengths, few showed so in vessels 26.5 and 17 metre lengths who reported higher level of neutrality or less (Figure 12.20). The level of satisfaction between members therefore, varied significantly (Pearson Chi-Square, $p < 0.001$).

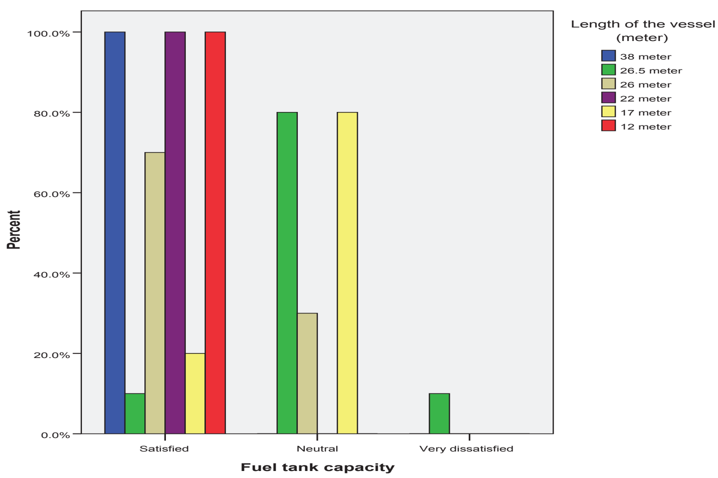
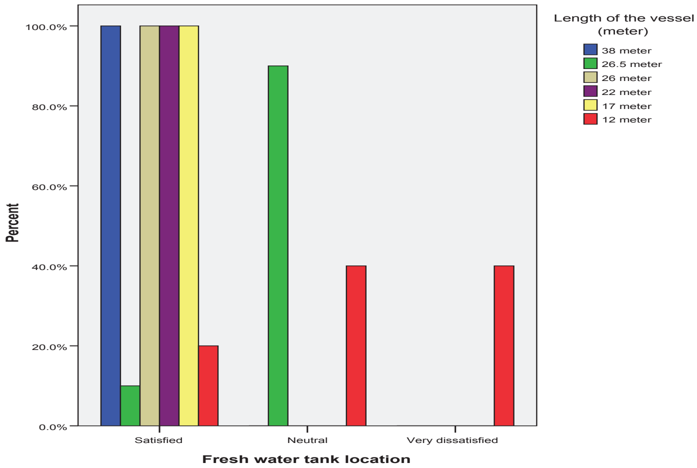


Figure 12-20. Overall opinion regarding the fuel tank capacity for all vessel types.

12.2.2.9 Fresh Water Tank Location

All members were satisfied about the fresh water tank location in vessels 38, 26, 22 and 17 metre lengths but not those members working in vessels 26.5 who were mostly neutral (90%). However, members working in vessel 12 metre length were likely to be very dissatisfied (40%) or neutral (40%) and only 2 were satisfied (Figure 12.21). The differences between members in these vessel types regarding fresh water tank location were therefore, statistically significant (Pearson Chi-Square, $p < 0.001$).



(

Figure 12-21.Overall satisfaction of fresh water tank location between members in all vessel types.

12.2.2.10 Fuel Tank Location

One hundred percent of members working in vessel 38 metre length were satisfied regarding fuel tank location. This was noted in 70% of members working in vessel 26 metre length unlike to the vast majority of other members working in other vessel types who showed higher level of neutrality (Figure 12.22). The differences between members were also significant in this regard (Pearson Chi-Square, $p < 0.001$).

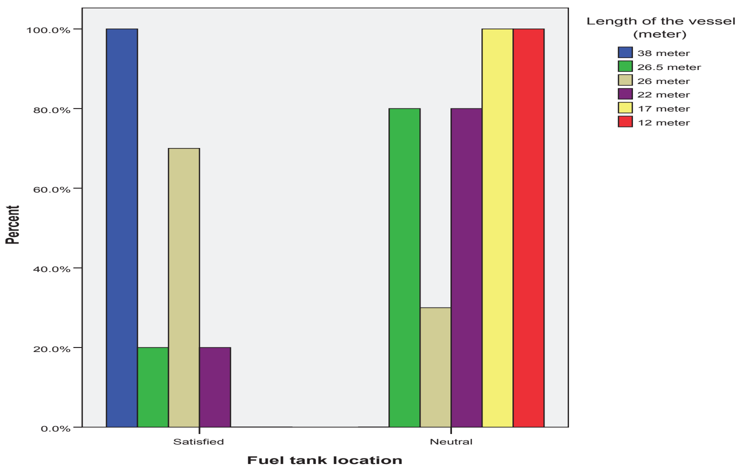


Figure 12-22. Overall satisfaction of fuel tank location between members in all vessel types.

12.2.2.11 Accommodation Location

The differences between members working in different vessel types regarding the accommodation location, varied significantly (Pearson Chi-Square, $p < 0.001$). While 100% of members working in vessels 38, 26 and 17 were satisfied or more about the accommodation location, 70% reported so in the vessel 22 metre length, 30% in 12 and only 10% in vessel 26.5 metre length (Figure 12.23), though the differences between members were statistically significant in this regard (Pearson Chi-Square, $p < 0.001$).

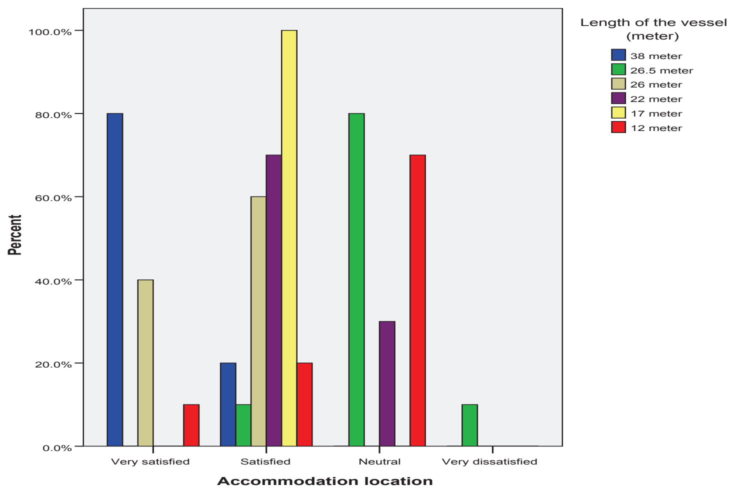


Figure 12-23. Overall opinion regarding the accommodation location for all vessel types.

12.2.3 Hull and geometric

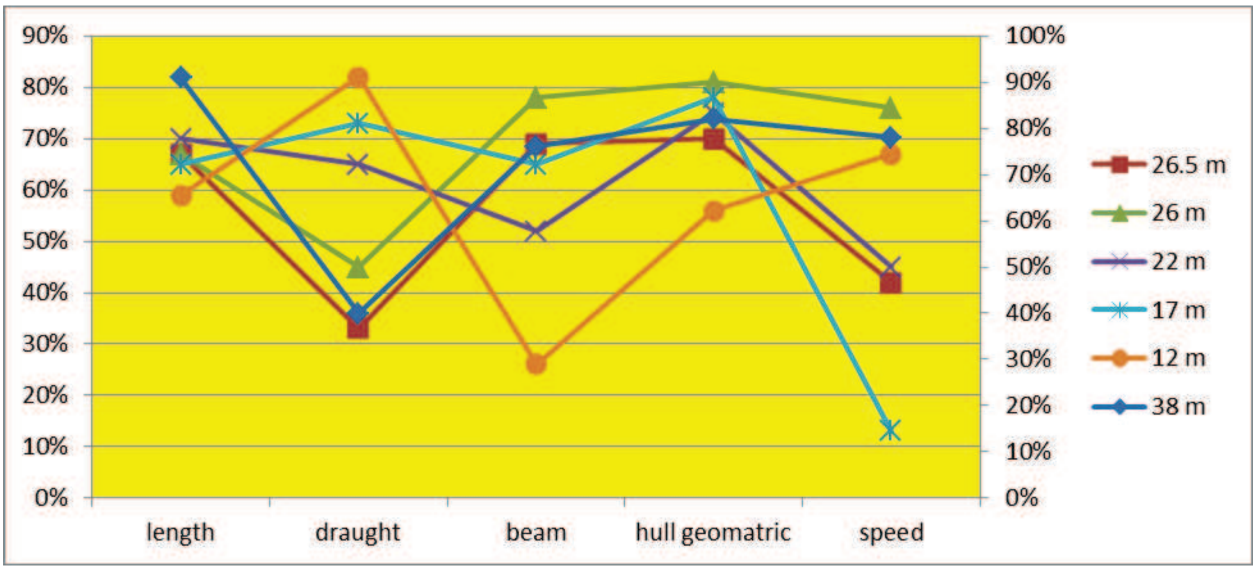


Figure 12-24 The SBG'members satisfaction about the current fleet general specification

12.2.3.1 Geometric of the Hull

Although the vast majority of members were satisfied or more. (figure 12.24) shows that the level of satisfaction between members working in different vessel types regarding their opinion about the geometric of the hull varied significantly (Pearson Chi-Square, $p < 0.001$).

12.2.3.2 Draught of the Vessel

All commander responders reported to be satisfied or more, regarding the draught of the vessels with 38, 26 and 22 metre lengths. This was noted in 90% of members working in vessel 12 metre length. In total, 60% of members working in vessel 26.5 and 70% in vessel 17 metre lengths were less than satisfied (Figure 12.24). The differences between members were statistically significant in this regard (Pearson Chi-Square, $p < 0.001$).

12.2.3.3 Length of the Vessel

Although the vast majority of members were satisfied or more.(Figure 12.24) Shows that the level of satisfaction between members working in different vessel types regarding their opinion about the length of their vessels varied significantly (Pearson Chi-Square, $p < 0.001$).

12.2.3.4 Beam of the Vessel

Although the vast majority of members were satisfied or more, (Figure 12.24) shows that the level of satisfaction between members working in different vessel types regarding their opinion about the beam of their vessels varied significantly (Pearson Chi-Square, $p < 0.001$).

12.2.3.5 Maintainability of the Hull

The vast majority of commander responders were satisfied about the maintainability of the hull in all vessels but not those working for vessel 26.5 metre length (Figure 12.25). One commander in vessel 17 and 6 in vessel 26.5 metre length were neutral. Three members in vessel 26.5 metre length were dissatisfied and very dissatisfied.

The differences between members were significant in this regard (Pearson Chi-Square, $p < 0.001$).

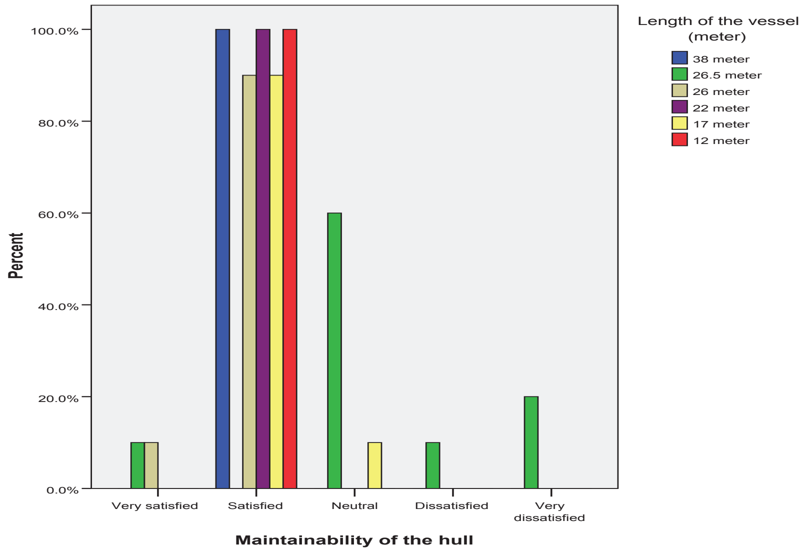


Figure 12-25. Overall opinion of the maintainability of the hull with all vessel types.

12.2.4 Power and Propulsion System

12.2.4.1 The Quality of the Propulsion System

The vast majority of commanders were satisfied (80-100%) regarding the quality of the propulsion systems in all vessels (Figure 12.26). The differences between members were not significant in this regard (Pearson Chi-Square, $p = 0.78$).

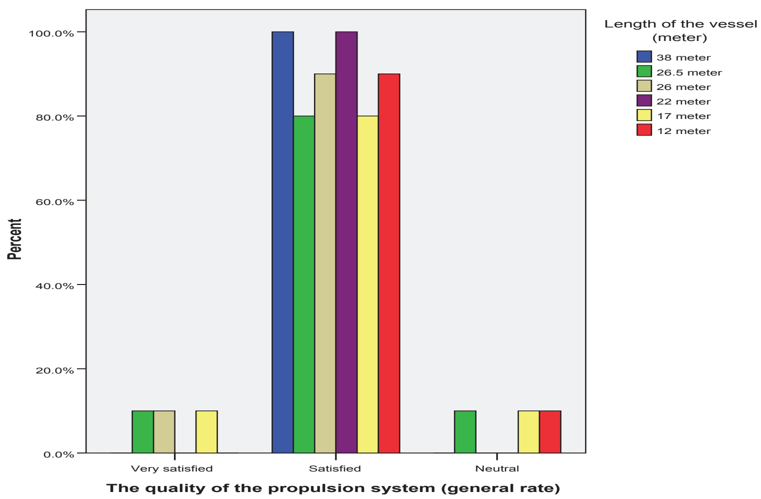


Figure 12-26. Overall opinion regarding the quality of the propulsion systems in all vessel types.

12.2.5 The Quality of the Communication Equipments

The majority of members reported that the quality of the communication equipments in most vessels were average and above average but not in those working for vessels 26.5 and 17 metre lengths who reported less an average level (Figure 12.27). The differences between the members were statistically significant in this regard (Pearson Chi-Square, p < 0.001).

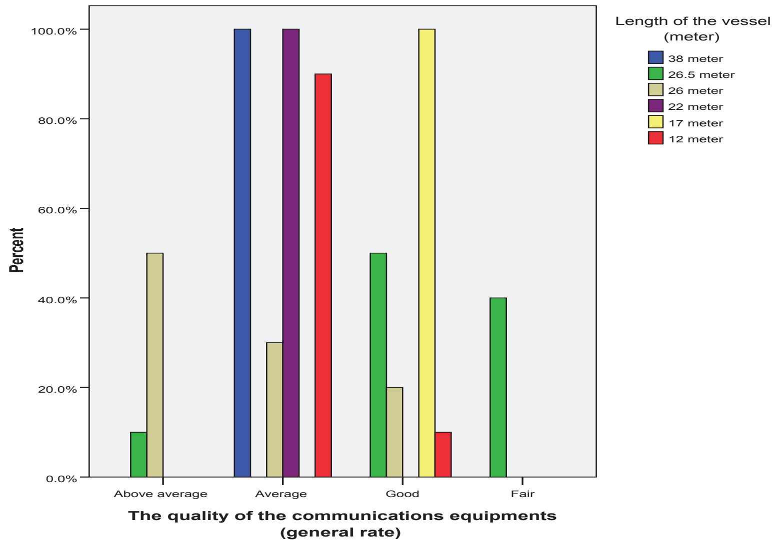


Figure 12-27. Overall opinion regarding the quality of the communication equipments of all vessel types.

12.2.5.1 Boat Navigation and Communication Equipments Operable and Adequate for Area of Operation

The majority of members reported that the boat navigation and communication equipments operable and adequate for their area of operation in most vessels were average and above average but not in those working for vessels 26.5, 17 and 12 metre lengths who reported less than an average level (Figure 12.28). The differences between the members were statistically significant in this regard (Pearson Chi-Square, p < 0.001).

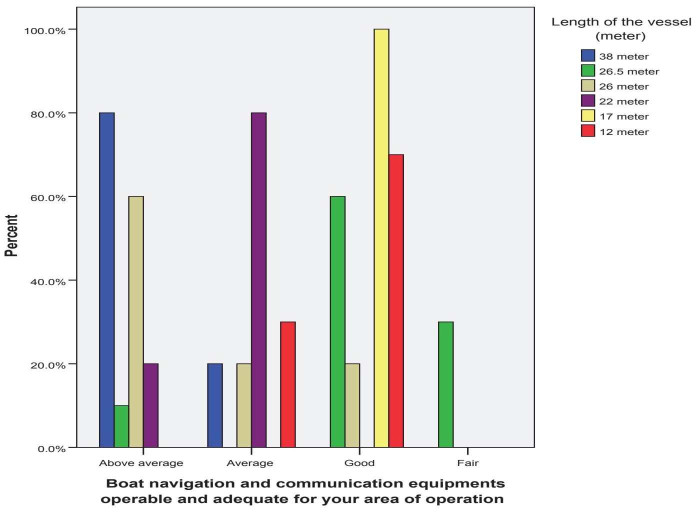


Figure 12-28 Overall opinion regarding the boat navigation and communication equipments operable and adequate for their area of operation of all vessel types.

Appendis C

Some Sample of the Current SBG Fleet General Specifications

	Long Range	Medium Range		Short Range
O A L	38.6 m	26.5 m	22.5 m	12.8 m
LWL	36.2 m	24.86 m	19.10 m	12 m
Beam	8 m	5.92 m	5.6 m	3 m
Height	3.8 m	3.35 m	2.9m	
Draught	1.9 m	1.85 m	2.05m	1 m
Displacement	280 tonnes	91.3 tonnes	55.9 tonnes	10 tonnes
Range	1700NM	500 NM	400 NM	250 NM
Max.speed	38 knots	28 kts	32 knots	35.6 knots
Cruise speed	35 knots	15 kts	30 knots	30 knots
Hull material	steel	steel	aluminium	fibreglass
Superstructure material	aluminium	aluminium	aluminium	fibreglass
Building date	1998	2002	1993	1988
Fuel tank capacity	36 tonnes	10.5 tonnes	6000 litres	1.4 tonnes
Fresh water capacity	2.5 tonnes	2 tons	2000 litters	0.4 tonnes
Crew number	20	11	11	5

Table 12-1The SBG current fleet general specifications

Appendix D : The Field Trip Questionnaire

D1. Vessel Information:

Vessel name:
Vessel type:
Year built:
Expected age:
Builder
Normal location of the vessel:
Length(LOA):
Beam(moulded):
Draught(max):
Displacement :
Economy (cruising)speed:
Max.speed:
Endurance:
Range:
Range type: Long Medium short
Crew: Officers: Engineers: Sailors Total crew:
Hull type:
Hull material:

C2.Questionnaire:

C2.1. Personal Information

Gender: □-male □-female	**What is your marital status?** □-single □-married □-separated □-divorced
Which of the following age group do you fall into? □-18-24 □-25-34 □-35-49 □-50 or older	What is your education level? □- less than high school □-completed high school □-BSc □-MSc □-PhD □-more detail
Occupation □-commanding □-navigation □-mechanical □-electrical □-marine engineering □-hull fitting □-other	**Current location of work?** □-on board □-work shop □-office □-other
How long have you worked on the boat?	**Experience :**

C2.2.. General Question

Overall how satisfied are you with the vessel? □-very satisfied □-satisfied □-neutral □ dissatisfied □-very dissatisfied If not satisfied, Why? How can be improved.
How do you feel familiar with the boat? □-very satisfied □-satisfied □-neutral □ dissatisfied □-very dissatisfied

If not satisfied, Why? How can be improved.
Economically operation of the vessel is: □Above average - □-Good □-Fair □-poor **If poor, why?**
Survivability of the vessel is : □Above average- □-Average □-Good □-Fair □-poor **If poor, why?** **Moreover, how can be improved?**
Maintainability of the vessel is -□Above average □-Average □-Good □-Fair □-poor **If poor, why?** **Moreover, how can be improved?**
Condition of the vessel in general is: □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improved?
Do you feel the maintenance cost of the vessel is :

-□Above average □-Average □-Good □-Fair □-poor **If poor, why?** **Moreover, how can be improved?**
Is this vessel suitable to sail safely at night? □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improved?
What are the accidents of the vessel during the last five years? **Why these accidents happened?** **Moreover, how can be avoiding?**
Based on your experience ,how does this vessel compare with other vessels in our fleet: -□Above average □-Average □-Good □-Fair □-poor **If poor, why?** **Moreover, how can be improved?**

C2.3.Stability &Manoeuvring

Speed of the vessel: □-very satisfied □-satisfied □-neutral

□dissatisfied □-very dissatisfied **If not satisfied, Why?** **Moreover, how can be improved?**
Stability of the vessel in general: □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Stability of the vessel during cruising : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Stability of the vessel in rough weather : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Stability of the vessel during the anchoring : □-very satisfied □-satisfied □-neutral □dissatisfied

□-very dissatisfied **If not satisfied, Why?** How can be improving.
Sea sickness in rough weather : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Manoeuvring of the vessel during cruising : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Manoeuvring of the vessel during rough weather: □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Vibration of the vessel : Above average-□ □-Average □-Good □-Fair

□-poor

If poor, why?

Moreover, how can be improved?

Vibration of the vessel in the rough weather?

Above average-□

□-Average

□-Good

-□Fair

□-poor

If poor, why?

Moreover, how can be improved?

Vibration of the vessel in high-speed?

Above average-□

□-Average

□-Good

□-Fair

□-poor

If poor, why?

Moreover, how can be improved?

Sailing of the vessel in the open sea:

□-very satisfied

□-satisfied

□-neutral

□dissatisfied

□-very dissatisfied

If not satisfied, Why?

How can be improving.

Sailing of the vessel close to the coast:

□-very satisfied

□-satisfied

□-neutral

□dissatisfied

□-very dissatisfied

If not satisfied, Why? How can be improving.
Berthing of the vessel is : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Controlling the vessel in rough weather is : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.

C2.4.Crew Requirements

Spaces of the accommodations : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Spaces of the mess room □-very satisfied □-satisfied □-neutral

□dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Spaces of the bridge □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Spaces of the engine room □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Spaces of the main deck □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Spaces of the stores □-very satisfied □-satisfied □-neutral □dissatisfied

☐-very dissatisfied

If not satisfied, Why?

How can be improving.

Fresh water tanks capacity

☐-very satisfied

☐-satisfied

☐-neutral

☐dissatisfied

☐-very dissatisfied

If not satisfied, Why?

How can be improving.

Fuel tank capacity

☐-very satisfied

☐-satisfied

☐-neutral

☐dissatisfied

☐-very dissatisfied

If not satisfied, Why?

How can be improving.

Fresh water tank location

☐-very satisfied

☐-satisfied

☐-neutral

☐dissatisfied

☐-very dissatisfied

If not satisfied, Why?

How can be improving.

Fuel tank location

☐-very satisfied

☐-satisfied

☐-neutral

☐dissatisfied

☐-very dissatisfied

If not satisfied, Why How can be improving.
Accommodation location □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.

C2.5.Hull and Geometric

Condition of the hull Above average-□ □-Average □-Good □-Fair □-poor **If poor, why?** **Moreover, how can be improved?**
Overall how do you rate the quality of the hull material? □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.

Geometric of the hull ☐-very satisfied ☐-satisfied ☐-neutral ☐dissatisfied ☐-very dissatisfied **If not satisfied, Why?** How can be improving.
Superstructure height ☐-very satisfied ☐-satisfied ☐-neutral ☐dissatisfied ☐-very dissatisfied **If not satisfied, Why?** How can be improving.
Draught of the vessel: ☐-very satisfied ☐-satisfied ☐-neutral ☐dissatisfied ☐-very dissatisfied **If not satisfied, Why?** How can be improving.
Length of the vessel : ☐-very satisfied ☐-satisfied ☐-neutral ☐dissatisfied ☐-very dissatisfied **If not satisfied, Why?** How can be improving.

Beam of the vessel : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Maintainability of the hull : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Is zinc consumption normal? □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Condition of the hull- keel joint : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Do you feel the maintenance of the hull –keel joint is:

□-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Condition of the hull- superstructure joint: □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Hull maintenance including renew some plates is : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Moving on the main deck in normal weather: □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Moving on the main deck in rough weather is : □-very satisfied

□-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Is your deck surface is non-skid? □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Is your anchor of proper size, fitted with a length of chain of ample size and rode of : □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.

C2.6.Power and Propulsion System

Overall how do you rate the quality of the propulsion system □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.

Condition of the propulsion system □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Do you feel the maintenance coast of the propulsion system is: □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.

C2.7.Electricity &Navigation and Communication

Overall, how do you rate the quality of the electrical system? □-very satisfied □-satisfied □-neutral □dissatisfied □-very dissatisfied **If not satisfied, Why?** How can be improving.
Overall, how do you rate the quality of the communications equipments? -□Above average □-Average □-Good □-Fair □-poor

If poor, why? **Moreover, how can be improved?**
Is your boat navigation and communication equipments operable and adequate for your area of operation: -□Above average □-Average □-Good □-Fair □-poor If poor, why? Moreover, how can be improved?

C2.8. General Questions:

What recommendations would you offer for improving the specification of the vessel?
What is it you would most like to change in this vessel specification?
What are some aspects of the vessel specifications that can be improve?
If you were not very satisfied with this vessel specification, please describe your reasons for your dissatisfaction?
If you were not very satisfied with these vessel specifications, please describe your proposed requirements in the future in the vessel design?
In your opinion what's the best specifications for our fleet in the future (long range) Length : Beam : Draught: Speed : Crew number:

Endurance : Range: Hull type : Hull material : Propulsion type : Crew accommodations requirements : Bridge dimensions : Deck area: Superstructure material : Superstructure height : Fresh water tank capacity &location : Fuel tanks capacity & location:
In your opinion what's the best specifications for our fleet in the future (medium range) Length : Beam : Draught: Speed : Crew number: Endurance : Range: Hull type : Hull material : Propulsion type : Crew accommodations requirements : Bridge dimensions : Deck area: Superstructure material : Superstructure height : Fresh water tank capacity &location : Fuel tanks capacity & location: Other:
In your opinion what's the best specifications for our fleet in the future

(short range)

Length :

Beam :

Draught:

Speed :

Crew number:

Endurance :

Range:

Hull type :

Hull material :

Propulsion type :

Crew accommodations requirements :

Bridge dimensions :

Deck area:

Superstructure material :

Superstructure height :

Fresh water tank capacity &location :

Fuel tanks capacity & location:

Other:

Appendix E List of Abbreviation

ARM	Availability, Reliability, and Maintainability.
AIS	Automatic Identification System
AOR	Area of Responsibility
Attitude	A vessel's position relative to the wind, sea, hazard, or other vessel.
Beam	T he widest point of a vessel on a line perpendicular to the keel, the forean-aft centreline
C4ISR	Command, Control, Communication, Computer, Intellegance, Surveillance, and Reconnaissance
CIP	Critical Infrastucture Protection
Coastal	At or near a coast
CONOPS	Concept of Operation
COP	Common Operatong picture
Craft	Any air or sea-surface vehicle, or submersible of any kind or size.
Crew	The members who's working on board including vessel commander, technicians and the other crew.
Commanders	The official members of SBG and working in the offices.
Deck	The horizontal plating or planking on a ship or boat.
Deep "V" hull	A hull design generally used for faster seagoing types of boats
Draught	Measured from the waterline, it is the point on a vessel's underwater body that reaches the greatest depth
EEZ	Economic Exclusion Zone
FCI	Full Capability Integration
HAVC	Heating, ventilation and air conditioning

HSI	High Speed Interceptor
KSA	Kingdom of Saudi Arabia
Knot (kn or kts)	A unit of speed equivalent to one nautical mile (6,080 feet) per hour. A measurement of a ship's speed through water. A collective term for hitches and bends.
LE	Law Enforcement
Long range	The current vessels of SBG, with the range of 1500knots or more.
Medium range	The current vessels of SBG, with the range of 700knots or less
OPB	Offshore Patrol Boat
Planing hull	A boat design that allows the vessel to ride with the majority of its hull out of the water once its cruising speed is reached.
Propeller	A device consisting of a central hub with radiating blades forming a helical pattern and when turned in the water creates a discharge that drives a boat
Range	A measurement of distance usually given in yards. Also, a line formed by the extension of a line connecting two charted points
RCC	Rescue coordinate centre
RFP	Request for Proposal
SAR	Search and Rescue
SBG	Saudi Border Guard
Shaft	A cylindrical bar that transmits energy from the engine to the propeller.
Ship	Any vessel of considerable size navigating deep water, especially one powered by engines and larger than a boat. Also, to set up, to secure in place. To take something aboard.
Short range	The current vessels of SBG, with the range of 200, knots or less.

Stern	The extreme after end of a vessel
Rescue Boat	Coast Guard boat used to perform SAR missions, including surf and bar operations in adverse weather and sea conditions They are self- righting and self-bailing. Fast response for rescuing people, and delivering damage control equipment or emergency medical services. They are an alternative, not a primary resource, and are used to arrive on scene quickly and stabilize a situation until a more capable unit arrives.
RFP	Request for proposal.
Technicians	The SBG members which working in marine workshop and technical office.
UAV	Unattendable area vehicles
UB	Uitility Boat
Vessel	Includes every description of craft, ship or other contrivance used as a means of transportation on water. “Any vehicle in which manor goods are carried on water
UK	United Kingdom
UVA	Unmanned vehicle aerials
USA	United State of America