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Improving the function of vessel traffic services in China through costs and benefits analysis

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IMPROVING THE FUNCTION OF VESSEL TRAFFIC SERVICES IN CHINA THROUGH COSTS AND BENEFITS ANALYSIS

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DECLARATION

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

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

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ABSTRACT

Title of Dissertation: **Improving the Function of Vessel Traffic Services in China through Costs and Benefits Analysis**

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This dissertation is a study of cost-benefit analysis of vessel traffic services in China with the purpose of improving the function of vessel traffic services.

A general introduction to vessel traffic services is given, including its definition, purpose and categories. It also describes the factors needed to be considered in establishing a VTS and how the levels of VTS are divided.

The description of cost-benefit analysis methods is provided and various costs and benefits of vessel traffic services are examined and the framework to compare the costs and benefits that aims to make certain whether the VTS is justified, is introduced.

After providing an introduction to the VTS development in China, two VTS centres are evaluated in detail to see whether they are justified or not. Their costs and benefits are listed and calculated and then they are compared. Some other VTS centres in China are also evaluated using the same method, but only the evaluation results are given.

Having finished the evaluations of VTS centres, measures that should be taken by the China Maritime Safety Administration to improve the function of VTS in promoting maritime safety, increasing traffic efficiency and protecting the marine environment are discussed.

In conclusion, the results of the evaluation of the VTS centres in China are examined.

KEYWORDS: Vessel Traffic Services, Cost-Benefit Analysis, Maritime Safety, Traffic Efficiency, Environmental Protection

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LIST OF ABBREVIATIONS

CA	Concerted Action
CBA	Cost-Benefit Analysis
CEC	Commission of the European Communities
CMSA	China Maritime Safety Administration
COST	European Concerted Action in the field of Shore-based navigation aids systems
EC	European Commissions
EDI	Electronic Data Interchange
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IMO	International Maritime Organization
IRR	Internal Rate of Return
m	million
NPV	Net Present Value
O&M	Operation and Maintenance
R&D	Research and technical Development
RMB	RenMinBi
SAR	Search And Rescue
TI	Traffic Image
VHF	Very High Frequency
VTMIS	Vessel Traffic Management and Information Services
VTS	Vessel Traffic Services

Chapter 1

Introduction

The evolution of Vessel Traffic Services (VTS) can be said to have its origins in the establishment of the first shore based radar station in Liverpool in 1948. Today VTSs are so costly that millions dollars will be needed to establish it. The costs of operation and maintenance (O&M) are also very high. Thus the necessity of conducting a cost benefit analyse of VTS has been recognized by the international maritime industry.

The benefits of VTS must be offset against the investment and O&M costs of the VTS. Both the benefit and the combined costs depend, to a large extent, on the type of VTS and the level of services provided. A cost benefit analysis can provide a rational framework for evaluation of a project at three levels:

- Contributing to a fundamental implementation decision;
- Assisting in selection of the optimum design and lay-out; and
- As a tool to evaluate performance.

VTS will play an increasingly important role in the maritime industry because it absorbs advanced technologies in order to improve the safety, and efficiency of navigation and protect the marine environment. Thus, it will be very helpful to consider the costs and benefits generated by this service.

China expedites its development of VTS projects these years, especially since the 1980's. Many main ports have established VTS to improve maritime safety, increase traffic efficiency and protect the marine environment. Some VTS projects are still under development, while others may need to replenish or upgrade their equipment. It is therefore necessary to conduct a cost and benefit analysis of VTS in China.

Up to now, some research has been done on this subject, such as the European concerted action in the field of shore-based navigation aids systems, know as COST 301, conducted by the Commission of the European Communities which aimed at assessing potential benefits of shore-based marine traffic systems in aspect of safety and efficiency of traffic in European waters, Canadian Coast Guard Vessel Traffic Services final report, International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) vessel traffic services manual, etc. In China, some institutes have also done some research on this subject, but most of them are still at an elementary stage.

The objectives of this dissertation are as follows:

- To establish a cost beneficial analysis framework for Vessel Traffic Service (VTS).
- To examine the current status of VTS in China
- To evaluate several Chinese VTS centres in terms of their costs and benefits and conclude about their justification.
- To recommend on how to improve the functions of the current VTS in maritime safety, marine environmental protection and shipping efficiency in China.

In Chapter 1 the background of the subject and the objectives of the dissertation are set out. Chapter 2 gives the definition, purpose, categories and levels of vessel traffic services. Factors to be considered in establishing a VTS are also discussed in Chapter 2. In Chapter 3 the cost-benefit analysis method is first introduced and then a framework for cost-benefit analysis of VTS is established after analysing the cost and benefit of VTS. Chapter 4 provides an introduction to the development of VTS in China. After that, the cost-benefit analysis method is used to evaluate some Chinese VTS centres in the same Chapter. Chapter 5 consists of the observations and recommendations for VTS in China. The recommendation on how to improve the functions of VTS in China is discussed. Chapter 6 is the last Chapter of this dissertation, which provides the conclusions of this work.

Chapter 2
Vessel Traffic Services

2.1 Vessel Traffic Services as a Concept

The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA, 1993) provides a definition in its Vessel Traffic Services Manual, which is as follows:

> A VTS is a service implemented by a Competent Authority, designed to improve the safety and efficiency of vessel traffic and to protect the environment. The service should have the capability to interact with the traffic and respond to traffic situations developing in the VTS area.

The International Maritime Organization (IMO, 1997) adopts this definition in its Assembly Resolution A.857(19) named “Guidelines for Vessel Traffic Services”.

In the same guideline, IMO (1997) gives the purpose of a VTS as follows:

> The purpose of VTS is to improve the safety and efficiency of navigation, safety of life at sea and the protection of the marine environment and/or the adjacent shore area, worksites and offshore installations from possible adverse effects of maritime traffic.

The Commission of the European Communities (CEC) (1988) conducted a research and technical development (R&D) project entitled the European Concerted Action in the Field of Shore-based Navigation Aids Systems, known as COST 301, which surveyed the VTSs in Europe. According to the statistics, the reasons for establishing a VTS are: efficiency of traffic flow (65%), traffic density (59%), pollution risks (58%), narrow waters (55%) and co-ordination of services (50). The aims of VTS are: safety of traffic and environment (82%), efficient flow of traffic (78%) and aid to navigation (68%). These data show a consistency with the definition and purpose given in the two documents.

2.1.1 VTS Services

There are three kinds of services that a VTS can provide, namely information service, navigational assistance service and traffic organization service (IALA, 1998).

IALA (1998) gives the definition of information service as indicated bellow:

> An information service is a service to ensure that essential information is available in good time to assist the shipboard navigational decision making process.

For this service, VTS broadcast information regarding waterways and weather condition, hazards, the position, identity and intentions of other traffic, *etc*. at fixed times and intervals or when deemed necessary by the VTS or at the request of a vessel.

Navigational assistance service as defined in the VTS manual is (IALA, 1998):

> A navigational assistance service is a service to assist the navigational decision making process on board and to monitor the effects.

When requested by a vessel or deemed necessary by the VTS, a navigational assistance service will be rendered especially in difficult navigational or meteorological circumstances or in case of defects or deficiencies.

The VTS manual defines traffic organization service as follows (IALA, 1998):

> A traffic organization service is a service to prevent the development of dangerous situation and to provide for the safe and efficient movement of traffic within the VTS area.

The traffic organization service concerns the operational management of the traffic and forward planning of vessel movements to prevent congestion and dangerous situations. It may also include establishing and operating a system of traffic clearances, mandatory reporting of movements, routes to be followed, speed limits to be observed, *etc*.

VTS can also play a very important role in allied services, port operation, emergency services, *etc*. This is a supporting activity of VTS. The purpose is to increase the safety and efficiency of the traffic, protection of the marine environment and the effectiveness of the VTS itself. At the same time, VTS, if preparing implemented, can reduce the reporting burden of the vessel.

2.2 Categories of Vessel Traffic Services

2.2.1 Categories of VTS in accordance with Location

According to the location of a VTS, it can be characterized as a port or harbour VTS, a coastal VTS or a river or fairway VTS. A port or harbour VTS is mainly concerned with vessel traffic to and from a port or harbour, regardless of whether it is a seaport or a river port. A coastal VTS involves vessel traffic passing through the coastal area. A river or fairway VTS, on the other hand, regulates vessel traffic passing through a specific area of a river or fairway. There can also be combinations of any of the VTS categories described above.

Usually, a port or harbour VTS and a river or fairway VTS will provide navigational assistance services or a traffic organization service, but a coastal VTS will normally only provide an information service.

According to COST 301 (CEC, 1998), among the 152 VTS centres in Europe, 67% are port or harbour VTS, 18% are river or fairway VTS and 8% are coastal VTS.

2.2.2 Categories of VTS in accordance with Funding Resources

A VTS can be funded by public or private capital. A publicly funded VTS is usually supported by a municipal or national government. The main purpose of this kind of VTS is safety of traffic and protection of the environment. Sometimes a VTS fee may be charged but mostly the service is provided free. A privately funded VTS is usually operated by the port itself or a corporation. The operating mechanism is similar to a pilot station and its main purpose is to increase the efficiency of traffic, so that less turn around time will be needed and more vessels can be regulated within the same time period. This is of considerable benefit to vessels. Thus, in such cases a VTS fee is usually charged. At any rate, whatever may be the purposes, they cannot be mutually exclusive and can function together. So the outcome of all kinds of VTS is that safety is improved, the marine environment is protected and traffic efficiency is increased.

In the United States, VTS and related information systems are federal, federal/private, private, or port authority operations. The U.S. Coast Guard has installed and operated VTS systems in a number of major U.S. ports. These are paid for from appropriated federal funds. In some other ports, private entities have deployed VTS-like systems, such as in the ports of Los Angeles and Long Beach (LA/LB) and the Delaware River and Bay. The LA/LB system, authorized by state legislation, is managed by the local Marine Exchange and is manned by both the Marine Exchange and the Coast Guard, both of which have agreements with the state. The Delaware Bay system is operated by local pilots, and costs are recovered through increased pilot charges to vessels. This system is fully private and does not have the legal authority to mandate participation or to direct traffic. (National Research Council, 1996)

2.3 Factors to be Considered in Establishing a VTS

While planning to establish a VTS in the port area or costal area or on a river, the responsible agency should consider certain factors in order to decide the nature of the VTS.

According to IALA (1998), these factors fall into three categories and are as follows:

- Physical Factors:
  - Local Geography: This is the determining influence on the size of the area to be covered by a VTS.
  - Local Conditions: This refers to the prevailing weather, especially the visibility, wind, tidal range and direction and strength of tidal stream.

- Vessel Traffic:
  - Numbers of vessels and types: The number, size, type, equipment, manoeuvrability and cargo of the vessel need to be considered.
  - Commercial factors: The distribution of ship arrivals and departures is needed.

- Other activities: Naval operations, oil and gas production and recreational activities that may take place within the area should also be taken into account.

- Environmental Aspects:
  - The areas that are environmentally sensitive need to be identified and suitable measures need to be developed, e.g. routeing vessels clear of these areas and carefully organizing traffic flow so as to limit the numbers of vessels.
  - Mandatory ship reporting systems which have been adopted by the IMO and are partly or completely within the VTS area must also be taken into account.

A VTS must be suitable for the prevailing conditions of the area intended to be covered. Regardless of its purpose, a VTS will have a two-fold function, namely, the facilitation of commercial efficiency and maritime safety including environmental protection on the other hand. Thus, the responsible agency must find the balance between these two needs; *i.e.,* to organize traffic so that efficiency is increased, and at the same time, improve maritime safety and protection of the marine environment.

VTS is undoubtedly a capital-incentive undertaking. It costs a significant amount of money to build a VTS, which can be to the turn of millions of dollars. So in order to make it fully functional, a VTS must be established to adapt the service to the prevailing conditions of the port. If it is over functional, there will be some wastage of function and capital. A VTS can have maximum benefit only when it is established according to the actual and identified needs of the port, sea or river area.

2.4 Levels of Vessel Traffic Services

Different VTSs have different purposes and priorities. They provide different kinds of services and are equipped with various facilities. Also, the investment of VTS differs widely. VTS can thus operate at different levels. There is no unified classification of a VTS levels in the world until now, but some regions have determined their own classification.

In the COST 301 project (CEC, 1988), four levels of VTS are considered that carry out functions typical of a coastal VTS. These are as follows:

- Level 0: No VTS, used as a datum level
- Level 1: VTS with VHF communications
- Level 2: VTS with VHF communications and a single radar
- Level 2A: As for Level 2, but with five radar stations linked by microwave and with automatic radar processing.

These levels were defined in terms of implementation features. The area covered, external functions and quality of services provided were implied from these parameters, rather than being explicitly stated.

Chinese researchers (Yu & Wu, 1989) also provide a classification of VTS levels, but from a different perspective. Unlike CEC's classification, which divides VTS levels in accordance with their equipment, Chinese classification is based on division of VTS levels according to the services provided. There are 5 levels in Chinese classification which are explained below.

Level 0 is the lowest level, which by its very character is not a VTS. It only provides services that any port or harbour will provide, such as pilotage service, security and law enforcement service through patrol boats, *etc*.

Level 1 is a traffic information service, which entails communications between shore and on-board stations, exchanges of meteorological and hydrographic information related to navigational safety and broadcasting of other information as and when it is necessary.

Level 2 is a traffic monitoring and danger warning service. At this level, a VTS centre is established. The centre will monitor the traffic situation within the VTS area and analyse and evaluate various data. The VTS centre should broadcast periodically or when it is deemed necessary, the information on ships' movement, hazards or dangers, *etc*.

Level 3 is a traffic advisory service. A VTS centre can provide position, course, *etc*. of other traffic to a ship when it is required by the ship because of encountering difficulty in navigating or due to equipment breakdown or any other reason. Advice or proposals will also be given when a ship faces collision or any other navigational danger.

The highest level is level 4, which is a traffic organization service. The VTS centre at this level will organize the traffic and carry out forward planning of vessel movements to prevent congestion and dangerous situations. This may include arranging the order of passage through a specific area or one-way waterway, designating anchorages, or requiring vessels to sail to safe area or take any other safety measure.

Usually, the more adverse the natural conditions, the more is the traffic flow, consequently the level of VTS needed is higher. Thus, the scale and the level of service are determined by the natural and traffic situations of the area that the VTS is intended to cover.

Chapter 3
Using Cost-Benefit Analysis in VTS

3.1 Introduction to Cost-Benefit Analysis

3.1.1 Cost-Benefit Analysis as a Concept

Cost-benefit analysis (CBA), also know as benefit-cost analysis (BCA), is a widely used tool in public service and policy analysis, *e.g.* in project and policy analysis, especially for major capital projects. As the name implies, CBA helps the decision-maker to select the best choice of decision through analysis of the cost and benefit in the same monetary units of the project or policy and comparing the different costs and benefits of various solutions.

> Cost-benefit analysis (CBA) is a method of measuring and evaluating the relative merits of public investment projects in support of sound economic decisions. It takes into consideration all of the effects of a project on members of society, irrespective of who is affected or whether the effect is captured in financial accounts. (Transport Canada, 1994)

> CBA is useful in planning and decision-making as it provides a common framework in which all of the important effects of investment choices can be made visible and, to the extent possible, quantified. It is a key tool in the quest for value for money. (Transport Canada, 1994)

3.1.2 Function of Cost-Benefit Analysis

Cost-benefit analysis has often been used as a primary tool in evaluating large-scale capital projects. It can be used to address several questions, such as:

- Whether a project should be undertaken;
- Which of several alternatives should be selected;
- Choosing the appropriate scale of the project or projects. (Duncombe, 2001)

As Henry (1979) points out, there are really two different goals for using CBA:

- To provide answers to which choice to select (the traditional view of CBA);
- To provide a process to assist in decision-making.

Nowadays, the second function is becoming increasingly important.

3.2 Analysis of the Costs and Benefits of VTS

Before starting a project, it must be decided that an act should not be undertaken unless its benefits outweigh its costs. In order to determine whether whether that happens, all benefits and costs should be expressed in a common scale to enable comparison with each other. Therefore, while planning the establishment of a VTS, a cost-benefit analysis must be used to decide where the VTS should be established, what kind of services are needed, at which level the VTS should be, how much the cost will be and what the benefits will be. Only when the benefits outweighs the costs, should a VTS be established.

Since there will always be some difference for cost & benefit evaluation between the design stage and when a project has been established and is in operation, CBA should also be used to evaluate the cost and the benefit of the operation of the project.

The purpose of this is to minimize the cost and maximize the benefit by fixing the items of cost and benefit. Also, it will be clear to the decision-maker how to adjust the policy and priority and avoid making similar mistakes if it proves that going ahead with the project was a wrong decision. In the case of VTS, which is usually a public service, if the decision-maker wants to charge for the service, the fee to be charged can be based on the result of the cost-benefit analysis.

The methods used in the above-mentioned two stages are the same. However, the costs and benefits to be analysed at the project operation stage are the real costs and benefits while those at the design stage are only forecasts and therefore are not so accurate.

3.2.1 Costs of VTS

“Cost is a measure of the value of the inputs to a process. It is the sum of the economic prices paid for those inputs” (Wu, 1999). The inputs can be classified as labour, capital, and resources. They are in the forms of design costs, equipment costs, building costs, maintenance costs, wages, *etc*. Like all other projects, costs of VTS can be divided into two categories, namely, capital costs and operational and maintenance (O&M) costs (Canadian Coast Guard, 1984). Capital costs are also known as initial costs, which constitutes the costs for land, building, equipment, staff-training, *etc*. These kinds of costs are mainly involved in the construction or development phase. While a VTS is in operation phase, the costs will be the O&M costs, which are also often referred to as running costs, which includes the costs for personnel and maintenance.

The costs associated with VTS development include the following:

- Land acquisition or opportunity costs of land used;

- Construction costs, including all such costs, whether incurred for the construction of a new facility or for the modernization or refurbishment of an existing facility;
- Equipment purchase and/or lease, including spares;
- Vehicle purchase and/or lease;
- Project-related training, including initial training costs for staff, for example, to learn how to operate new equipment. This should include not only the costs of the training programmes but also related travel, accommodation and productivity lost due to the absence of staff being or training;
- Other capital expenditures, including all capital not elsewhere accounted for such as general furnishings;
- Other start-up costs;
- Transition costs, including those resulting from disruptions during the implementation of the project;
- Decommissioning costs, if any, for facilities to be closed down or material to be discarded;
- Construction management;
- Contingencies; and
- Costs to other parties, including capital and training necessary to implement the project and accrue the benefits (*e.g.*, access roads to expanded or new facilities, special equipment required by users).

For a CBA, capital costs are measured by the cash expenditures required in future years - not by depreciation. To include depreciation, as well as cash expenditures, would result in double counting of capital costs.

When a VTS is in operation, the O&M costs generated would include:

- Direct operating costs. The labour component would include regular salaries and wages, overtime, bonuses, allowances and fringe benefits;

- Maintenance costs;
- Overhead and other supporting costs;
- On-going training;
- Periodic capital outlays, such as to mid-life refits over and above regular maintenance; and
- Operating and maintenance costs incurred by other parties, such as construction of new access roads, cleaning of grounds, *etc*.

3.2.2 Benefits of VTS

"A benefit is something that promotes well being or value received. There are many types of benefits, which can be divided into intangible and tangible benefits" (Wu, 1999). As to VTS, the benefits are safety, environmental protection, improvements and efficiency among other things.

IMO (1997) resolution A.857 states:

> The benefits of implementing a VTS are that it allows identification and monitoring of vessels, strategic planning of vessel movements and provision of navigational information and assistance. It can also assist in prevention of pollution and co-operation of pollution response.

There are several benefits accrued to safety of traffic through the establishment of VTS. Such benefits can be summarized in the following words:

Safety of traffic can be improved by foreseeing and preventing situations of an unacceptable risk, by contributing to safe encounters from previously perceived measures and by assisting ships to stay within navigable waters. The benefits to safety of traffic depend on the type, *i.e.* the services provided and the functions performed.

A good information service ensures that information that is essential is available in a timely manner to the shipboard decision making process, either by broadcast at fixed times or whenever it is considered necessary by the VTS authorities, and is normally provided to the general traffic. The benefits may be limited by a lower update rate and the fact that certain information may also be available from other sources such as wind and tide indicators, weather forecasts, signals, *etc*. In any case, the ships may be better able to adapt their behaviour to the prevailing conditions and thus achieve a safer flow of traffic.

A traffic organization service deals with forward planning of movements to prevent the development of dangerous situations. Enforcement is an integral part of such a service. The principal benefits are reduction of risk from situations which ships even with careful observations cannot foresee. They depend on the knowledge of not only the positions of ships', but also their identities, sizes, cargoes, movements and destinations. The benefits also depend on the range and reliability of traffic extrapolations, because as a strategic measure this service is based on assumed future conditions.

Navigational assistance service, as the name implies, assists the decision making process on board relating to navigation. The assistance provided is in the form of information and advice. As a tactical measure, such information and advice reduces the risk of actual movements. The actual benefits depend on resolution and accuracy of the displays, availability of ship data including the identity of the ship, and a permanently available communication link. If information on position, adjacent traffic and course advice when requested is provided on a continuous basis, this service has proven to contribute to the safety of traffic in a significant way.

Co-operation with allied services and other interested parties results in a supporting service through exchange of information, use of common data bases and agreements relating to actions to be taken. Benefits are achieved by taking into account the availability of resources of the related services when establishing sailing plans. Also, benefits can be derived from giving assistance in emergencies according to pre-established contingency plans, to adjacent VTSs with advance information and by interacting on the traffic in accordance with agreed actions. In this way, the probability or the consequences of accidents are reduced and adverse interactions on the traffic can be reduced (IALA, 1998).

According to IALA (1998), the benefit of VTS to efficiency of traffic is achieved through avoiding delays and optimising traffic flow. These depend on the type of VTSs, especially the services they provide and the functions they perform.

An information service ensures that essential information is available in a timely manner on board the ships. It may confirm the ships' decision making relating to continuing its voyage in certain cases and thus unnecessary delays are avoided.

A traffic organization service can set the sailing plan of ships by foresighted planning in order to adapt to the space facilities of the VTS area such as the availability of anchorages, berthing or locks. Thus, the benefit that ships reduce unnecessary high speeds with following waiting times may be achieved.

Since a navigational assistance service provides continuously updated navigational information and, if needed, navigational advice, the benefits of this service is achieved by helping ships to continue their voyage even in difficult situations such as fog or storm and withdrawn pilot cutter. Navigational assistance service may also reduce delays of ships that otherwise might have occurred due to not entering a VTS area, not departing a berth or sailing with reduced speed.

The benefits of co-operation with allied services, emergency services and adjacent VTSs and supporting and data exchanging service may be achieved by providing allied services with advance information. Through providing ship data and navigational assistance to shore and ship based emergency services, the co-operation optimises their resource planning, the traffic throughput and the use of available facilities. The efficiency of their actions when needed is also increased. Furthermore, the co-operation services make better use of available data by exchanging ship data with adjacent VTSs, and thus unnecessary VHF occupation is avoided and the reporting burden of ships is reduced.

All the benefits resulting from the improvement of efficiency are partly referred to the ships, partly to the shore side (IALA, 1998).

VTS can also achieve a lot of benefits in marine environmental protection since the services and functions that enhance safety of traffic have already contributed potentially to marine environmental protection. However, a VTS has certain additional functions to improve the protection of marine environment. These can be found in the following area:

- Amplified traffic organization and navigational assistance for ships with dangerous or noxious cargo to prevent accidents;
- Information to competent authorities about movements of ships with dangerous or noxious cargo to assist their check planning by port control;
- Co-operation with emergency and clean-up services, assistance to their ships, action agreement and corresponding measures to limit the consequences of pollution and to protect the other traffic;
- Identification of the potential sources of pollution, thus reducing illegal and deliberate spills (IALA, 1998).

The benefits in marine environment protection depend on the VTS knowledge of ship movements, cargo, data exchange, communication networks, trained procedures and information or sensors concerning pollution (IALA, 1998).

As we can see from the above, contrary to the costs of VTS, most of the benefits of VTS are not easily quantifiable. Therefore, a method must be found to quantify the benefits of VTS into comparable values, *i.e.* monetary values, so that comparisons can be made with the cost of VTS. In order to achieve this, benefits can be calculated by the costs that are avoided by the operation of the VTS. These include the accidents and the losses that have been decreased, the time that has been saved, and the damage to the environment that has been decreased.

Therefore, in order to quantify the benefits of a specific VTS, first, the following items must be recorded:

- the navigational accidents happened within the VTS area before the VTS was in operation. The data should include the types of accidents, *e.g.* collision, stranding; probable reasons that led to the accident and the circumstances during accident, *e.g.* visibility, tide, storm, behaviour of affected ships;
- amount, composition and behaviour of traffic within the VTS area to be considered, including categories of ships;
- specific conditions that may impair the traffic;
- accidents relating to environmental pollution, especially those relating to hazardous substances. (IALA, 1998)

After getting all of these data, the benefits of VTS can be calculated. The calculation includes:

- the probability of accidents if the VTS is not established and in operation, resulting from the registered ship movements, taking into account fairway layout and width, amount of encounters and sizes of concerned ships, distribution of traffic all day around, dependent on visibility;
- the cost caused by the accidents probably happened if the VTS is not established and in operation, taking into account ships and cargo, human life, remedial actions, potential consequences for the traffic flow and potential environmental consequences;
- the time lost because of waiting or reduction of speed and the costs per unit of time for ships (according to category) and harbours and finally the resulting costs due to the loss of time of all ships and harbours if the VTS is not established and in operation within the VTS area (IALA, 1998).

3.3 Framework for Cost-Benefit Analysis of VTS

3.3.1 Calculation of Costs and Benefits

As mentioned previously, both the costs and the benefits of VTS must be put into standard units so that they can be compared directly. This involves three main things: expressed in a common numeraire (*e.g.* dollars, euros, *etc*.); adjusting for inflation where necessary, *i.e*., converting from nominal dollars to constant dollars; and expressing all of them in present values (adjusting for differences in the time of occurrence of costs and benefits). (Treasury Board of Canada Secretariat, 1998)

3.3.1.1 Step 1: Expressing Costs and Benefits in Numeraire

Having identified all the costs and benefits, the next step is to express them all in numeraire. In most cases, a dollar of investment is used as the unit of measurement in

CBA. However, a dollar of consumption or a dollar of foreign exchange may also be used as the numeraire while evaluating the costs and benefits of VTS. All of these are acceptable, but clarity and consistency are essential. If price distortions are widespread in a particular economy, the cost-benefit analysis of VTS may be calculated by the use of border prices or world prices as the numeraire, that is, as the best measure of true value of costs and benefits. Since the interest costs payable on the capital funds required to implement a project are implicitly taken into account in the computation of net present value, they should not be included in a CBA. The interest costs are taken into account by means of the discount rate. (Treasury Board of Canada Secretariat, 1998)

3.3.1.2 Step 2: Converting Costs and Benefits into Constant Dollars

All the costs and benefits identified and expressed in the previous step are in nominal dollars, which do not have standard purchasing power because the value of the unit of measurement itself changes over time due to inflation leading to a loss in the purchasing power of the currency and therefore cannot be aggregated if they occur at different times. They can only be added or subtracted when they occur within the same period as long as the period is short, which is usually one year.

Nominal dollars are simply the face value of the currency and need to be converted to constant dollars, which have constant purchasing power. In doing so, a base point of time at which to express the constant dollar value must be selected, which is often convenient to use (t_0). Any point is acceptable, but the most frequent choices for t_0 are the times when the analysis is being done, the start of the project, or the start of a new fiscal year.

If a nominal dollar amount at time t_n is to be converted to a constant dollar at t_0, the following formula can be used:

$$C = {}^{N}\!\Big/_{(1+i)^n} \tag{3-1}$$

where C is the amount in constant dollars; N is the amount in constant dollars; i is the annual rate of inflation (%); and n is the number of periods between t_0 and the actual occurrence of the cost of benefit at t_n. (Treasury Board of Canada Secretariat, 1998)

However, this step is not always necessary because sometimes all the costs and benefits are estimated and expressed in value at time t_0 and thus there is no need to convert. It is also not necessary when there is no inflation or the inflation is so little that it can be ignored.

3.3.1.3 Step 3: Expressing Costs and Benefits in Present Value

> "$1 today is worth more (even without inflation) than $1 tomorrow due to the risk and the ability to invest the funds." (Duncombe, 2001)

The figures of costs and benefits of VTS are not yet in a standard unit even when they are expressed in constant dollars because constant dollars make a difference whether they are in terms of current purchasing power or future purchasing power although they have standard purchasing power. The values of costs and benefits at various times must be converted to values at a single point in time in order to make them fully comparable. Thus, the value must be converted to present values.

The formula to convert a future value of the costs and benefits of VTS into the present value is similar to the adjustment for inflation, which is as follows:

$$PV = {}^{FV}\!\Big/_{(1+k)^n} \tag{3-2}$$

where PV is the present value at time t_0; FV is the future value at t_n; k is the discount rate (%); and n is the number of periods between t_0 and t_n. (Treasury Board of Canada Secretariat, 1998)

There are two kinds of discount rates, namely, the fiscal discount rate and the social discount rate. The fiscal discount rate is only appropriate when the project has few, if any, social implications (Wu & Zhang, 1998). Since VTS always has numerous social implications, the social discount rate shall be used while calculating the costs and benefits of a VTS project.

3.3.1.4 Merging of Step 2 and Step 3

As we can see, the formulas used to calculate constant dollars and present value separately are almost the same. Therefore, in order to simplify the calculation, step 2 and step 3 are merged into one step. Because of the outcome of step 2, constant dollars is used in step 3 as future value, the merging can be done as the following formula shows:

$$PV = \frac{FV}{(1+k)^n} = \frac{1}{(1+k)^n} FV = \frac{1}{(1+k)^n} \times \frac{N}{(1+i)^n} = \frac{N}{((1+k)(1+i))^n} \qquad (3\text{-}3)$$

where *PV, FV, k, N, I, n* have the same meanings of formula (3-1) and (3-2).

Furthermore,

$$(1+k)(1+i)=1+k+i+ik \qquad (3\text{-}4)$$

If we introduce:

$$r=k+i+ik \qquad (3\text{-}5)$$

Then, formula (3-4) is as follows:

$$(1+k)(1+i)=1+r$$

and formula (3-3) can be rewritten as follows:

$$PV = \frac{FV}{(1+k)^n} = \frac{1}{(1+k)^n} FV = \frac{1}{(1+k)^n} \times \frac{N}{(1+i)^n} = \frac{N}{(1+r))^n} \qquad (3\text{-}6)$$

Here, r is in fact the real interest rate while k is called nominal interest or discount rate as mentioned before and i is the inflation rate. It should be noted that many analysts simply refer r to the discounting rate or interest rate.

By using this formula, analysts only need to determine r, the real interest rate, and then use it to calculate. The calculation is simplified considerably and therefore, this formula is used by most analysts to calculate the present value of costs and benefits of VTS which can be compared directly afterwards.

IALA (1998) gives the similar discounting formula to calculate the cash values of costs and benefits, which is as follows:

$$V_x = \frac{V_y}{(1+i)^n} \qquad (3\text{-}7)$$

where V_x is the value of costs and benefits at time x; V_y is the value at time y; n is the time difference between y and x; and i is the interest.

This formula will be used in Chapter 4 to calculate the present value of the costs and benefits of a VTS project.

3.3.2 Decision Rules of Cost-Benefit Analysis

3.3.2.1 Net Present Value

The Net present value (NPV) is the present value of all benefits minus the present value of all costs. Both the present value of benefits and costs must be discounted at the appropriate discount rate. An NPV is always specific to a particular point in time, which is generally expressed as t_0. t_0 can be the start of the project or the time when the analysis is made. (Wu & Zhang, 1998)

The Net present value is simply the present value of benefits minus the present value of costs, which can be expressed by the following formula:

$$NPV = \sum_{i=1}^{n} (B_t - C_t) \frac{1}{(1+i)^t} \tag{3-8}$$

where NPV is the net present value of a specific VTS project, n is the life-span of the VTS project; B_t is the total benefits of year t; C_t is the total costs of year t; and i is the discounting rate.

If the result comes out that NPV is positive, then the project is justified in the case of an established VTS. For a VTS in planning, the one option with highest NPV should be selected.

3.3.2.2 The Internal Rate of Return

The internal rate of return (IRR) is the discount rate (or interest rate) that makes the NPV of the project zero. If the IRR of a VTS is higher than the standard discount rate, then it means this VTS project is well justified. If the CBA is attempting to select one among the alternatives, the one with the higher IRR is preferred.

Usually, IRR will produce the same result with the NPV decision rule, but it is not always like that. Therefore, when the IRR decision rule is used, the analyst must interpret it with care.

3.3.2.3 The Benefit-Cost Ratio

The benefit-cost ratio is the ratio of the present value of benefits to the present value of costs. If the benefit-cost ratio is greater than 1, presumably the VTS is justified. On the other hand, the alternatives of VTS in design with a benefit-cost ratio of less than 1 should be rejected. Also, the alternative with higher benefit-cost ratio has higher priority most of the time.

The formula to calculate the benefit-cost ratio is as follows:

$$BCR = \frac{\sum_{i=1}^{n} B_t \frac{1}{(1+i)^t}}{\sum_{i=1}^{n} C_t \frac{1}{(1+i)^t}} \tag{3-9}$$

where *BCR* is benefit-cost ratio of a specific VTS project; n is the life-span of the VTS project; B_t is the total benefits of year t; C_t is the total costs of year t; and i is the discounting rate.

The problem with this decision rule is that it is sensitive to how costs and benefits are recorded and it does not take into account the scale of the project. Thus, similar to IRR, the benefit-cost ratio measure must be used carefully.

3.3.2.4 Payback Period

The payback period is the time that the project takes for the cumulative present value of benefit to become equal to the cumulative present value of costs.

Generally, the shorter payback period the VTS needs, the better it is. However, it can be misleading sometimes because it ignores everything that happens after the payback point. Therefore, it must be used together with the other decision rules.

Chapter 4
VTS in China

4.1 VTS Development in China

VTS development in China came relatively recent. The first VTS centre was constructed in the port of Ningbo in 1978. However, since then, the development has been quite rapid. At present, twenty VTS centres and forty-nine radar stations are dotted along the Chinese coast and inland rivers (including Hong Kong). These cover most of the significant sea ports, important coastal waterways and fairways in rivers.

Table 4.1 shows the types and scales of VTS in China.

Table 4.1 Types and Scales of VTS in China

Name of VTS	Type of VTS	Scale of VTS
Chengshantou	fairway	1 VTS centre, 2 radar stations
Dalian	port	1 VTS centre, 2 radar stations
Hong Kong	combination of port and fairway	1 VTS centre, 7 radar stations
Guangzhou	combination of port and fairway	1 VTS centre, 4 radar stations
Lianyungang	port	1 VTS centre, 1 radar station
Nanjing	fairway	1 VTS centre, 3 radar stations
Nantong	fairway	1 VTS centre, 3 radar stations
Ningbo	combination of port and fairway	1 VTS centre, 4 radar stations
North Changshan	fairway	1 VTS centre, 1 radar station
Qingdao	port	1 VTS centre, 2 radar stations
Qinhuangdao	port	1 VTS centre, 1 radar station
Qiongzhou Strait	fairway	1 VTS centre, 4 radar stations
Shanghai	combination of port and fairway	1 VTS centre, 4 radar stations
Shenzhen	port	1 VTS centre, 1 radar station
Tianjin	port	1 VTS centre, 1 radar station
Yantai	port	1 VTS centre, 1 radar station
Yingkou	port	1 VTS centre, 1 radar station
Zhanjiang	port	1 VTS centre, 1 radar station
Zhangjianggang	fairway	1 VTS centre, 2 radar stations
Zhenjiang	fairway	1 VTS centre, 2 radar stations

Among the twenty VTS centres, 2 VTSs are with capital costs of less than 1 million RMB, 11 VTSs between 5-10 million, 3 VTSs between 30-70 million and Hong Kong is more than 70 million.

As the main purpose of VTSs in China is to promote safety of navigation, and at the same time to protect the marine environment and improve traffic efficiency, most VTSs in China provide an information service and navigational assistance service. They broadcast information about waterways and weather conditions, hazards, traffic situation, *etc*. to all of the vessels in the VTS area at fixed times. If a ship is involved in difficult navigational or meteorological circumstances for whatever reason, the VTS will render assistance to help the ship overcome the difficulties. In 1998, some 1265 accidents were avoided with the assistance of VTS and 5078 violations of regulations were corrected. In the port of Dalian, the number of violations of regulations dropped sharply from an average of 1200 per year before the VTS was established to an average of 36 per year after the VTS came into operation (Liu, *etc*. 1999). The benefits are obvious.

A few VTSs also provide a traffic organization service. Through operational management of the traffic and the forward planning of vessel movements, these VTSs prevent congestion and dangerous situations and increase the transit capacity considerably. For example, the original transit capacity of Shanghai Beicao fairway was 16 vessels at every high water. However, it has now increased to 27 vessels since the VTS has been in operation. The increase is 69%. In another entrance route of Shanghai port, the transit speed has increased from 9 knots to 11 knots (Wang, *etc*. 1999).

VTS plays an important role in co-operation with allied services and emergency services. Some VTS centres are incorporated with Search and Rescue (SAR) centres. VTSs supported and participated in SAR 593 times in the year 1998.

All the VTSs in China today have been established and funded by the China Maritime Safety Administration (CMSA), which is under the leadership of the Ministry of Communications. CMSA and its branches are also responsible for the operation and maintenance of VTS all over the country. There is no VTS fee currently charged in China.

4.2 Utilizing the CBA Method to Evaluate Some Chinese VTS Centres

Here, the cost-benefit analysis method is used to evaluate two Chinese VTS centres in detail and give the results of the evaluation of some other VTS centres.

4.2.1 VTS Centre A

4.2.1.1 General Introduction to VTS Centre A

The construction of VTS centre A was started in 1989 and was put into operation in 1994. It consists of a radar surveillance system, VHF communication system, VHF direction finding system, ship data processing system and a hydrometeorology system.

VTS centre A provides traffic safety information service on request, traffic organization service, safety information transmitting service, hydrometeorology information service on request, navigational assistance service on request, anchorage arrangement on request and supports allied activities on request. (China Maritime Safety Administration (CMSA), 1999)

4.2.1.2 Identification of Parameters

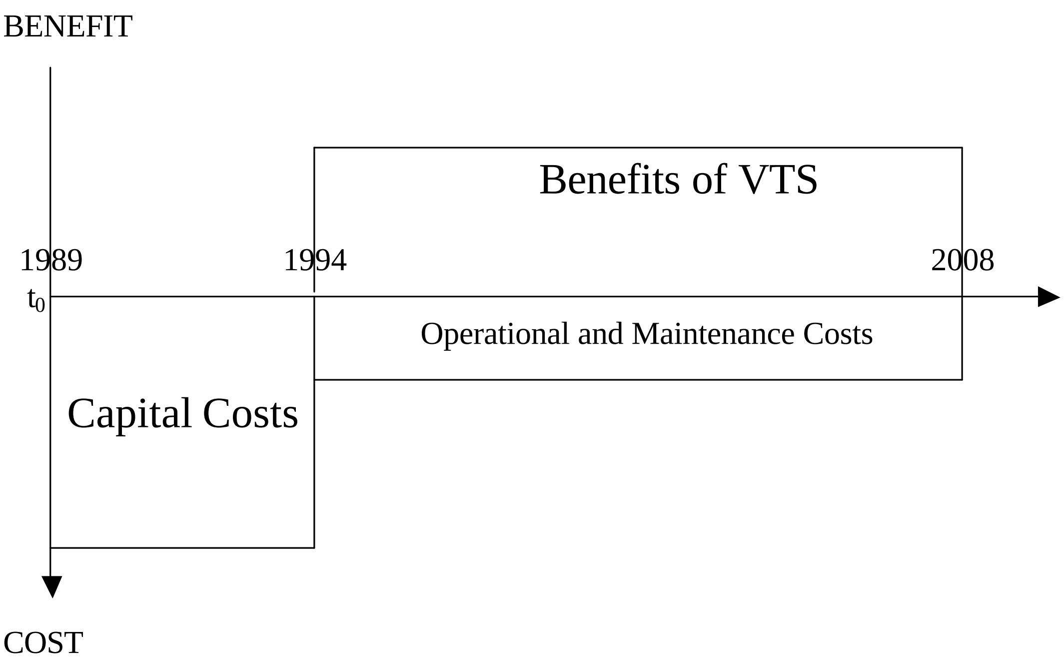
Since the VTS started construction in 1989, that time is chosen as the base point of time in reference to which all the costs and benefits are calculated.

The social discount rate is usually decided by individual countries. For example, it is 10% in Canada. In China, it is recommended as 12%. So that is used as the social discount rate here.

A VTS usually has a life-span of 15 to 20 years. Here 15 years is chosen.

The costs and benefits cash flow is shown in figure 4.1.

Figure 4.1 Costs and Benefits Cash Flow of VTS Centre A



4.2.1.3 Calculation of Costs

The capital cost is 60.53m (million) Renminbi (RMB). As this was spent in 1989, there is no need to convert. As the O&M costs occurred after 1994, all of them must be converted to the 1989 value. The formula (3-7) is used here to calculate the value at year 1989.

The costs and converted value of year 1985 are listed in table 4.2.

Table 4.2 Costs Calculation of VTS Centre A

Year	Cost (thousand RMB)	Converting formula	Converted Value of Cost at Year 1989 (thousand RMB)
1989	60,530	N/A	60,530
1994	4,335	$4335 \times (1\text{-}12\%)^{5}$	2,288
1995	4,335	$4335 \times (1\text{-}12\%)^{6}$	2,013
1996	4,335	$4335 \times (1\text{-}12\%)^{7}$	1,772
1997	4,769	$4769 \times (1\text{-}12\%)^{8}$	1,712
1998	5,202	$5202 \times (1\text{-}12\%)^{9}$	1,646
1999	5,636	$5636 \times (1\text{-}12\%)^{10}$	1,570
2000	6,069	$6069 \times (1\text{-}12\%)^{11}$	1,487
2001	6,503	$6503 \times (1\text{-}12\%)^{12}$	1,403
2002	6,936	$6936 \times (1\text{-}12\%)^{13}$	1,316
2003	7,369	$7369 \times (1\text{-}12\%)^{14}$	1,231
2004	7,803	$7803 \times (1\text{-}12\%)^{15}$	1,147
2005	8,236	$8236 \times (1\text{-}12\%)^{16}$	1,065
2006	8,670	$8670 \times (1\text{-}12\%)^{17}$	987
2007	9,104	$9104 \times (1\text{-}12\%)^{18}$	912
2008	9,537	$9537 \times (1\text{-}12\%)^{19}$	841
Total costs of VTS centre A			81,920

Note: the original data of costs are from "VTS Benefits Evaluation" (Fang & Zhuao, 1997).

Finally, the total converted cost of VTS centre A is 81,920,000 RMB.

4.2.1.4 Calculation of Benefits

As the benefits of VTS centre A could only be gained after the VTS was put into operation, which was in 1994, the benefits were estimated yearly after the year 1994. It is mentioned in Chapter 2, the benefits of VTS are the costs that VTS saves. Therefore, all the benefits are estimated here.

The benefits of VTS centre A can be divided into several categories, which are benefits due to a decrease in maritime accidents; benefits due to an increase in passing capacity; benefits due to a decrease in waiting periods for high tide; benefits from environmental protection and other benefits that do not belong to the previous categories. As for the case of O&M costs, all the benefits must be converted to the value of year 1989.

Table 4.3 gives the value of benefits of VTS centre A.

Table 4.3 Benefits Calculation of VTS Centre A

(All the figures are in thousands of RMB)

Year	Benefit due to decrease in maritime accidents	Benefit due to increase in passing capacity	Benefit due to decrease in waiting for high tide	Benefits from environment protection	Other benefit	Converted value of benefit in 1989
1994	5,476	20,562	18,251	600	270	23,831.8
1995	5,561	22,508	18,251	600	270	21,915.2
1996	5,678	24,455	18,251	600	270	20,128.9
1997	5,814	26,402	18,251	600	270	18,462.6
1998	5,923	28,348	18,251	600	270	16,897.4
1999	6,085	30,295	18,251	600	270	15,457.1
2000	6,207	32,242	18,251	600	270	14,109.3
2001	6,354	34,188	18,251	600	270	12,867.6
2002	6,498	36,135	18,251	600	270	11,720.3
2003	6,642	38,082	18,251	600	270	10,663.1
2004	6,800	40,028	18,251	600	270	9,692.8
2005	6,965	41,975	18,251	600	270	8,800.5
2006	7,012	43,922	18,251	600	270	7,973.4
2007	7,134	45,868	18,251	600	270	7,223.7
2008	7,278	47,815	18,251	600	270	6,541.2
Total benefits of VTS centre A						206,284.8

Note: the original data of costs are from “VTS Benefits Evaluation” (Fang & Zhuao, 1997).

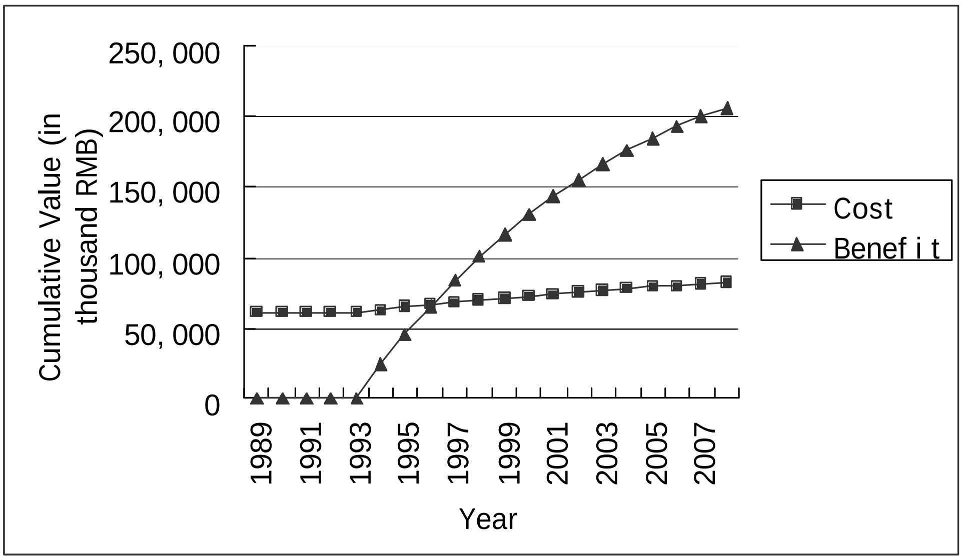
Finally, the total converted benefit of VTS centre A is 206,284,800 RMB.

4.2.1.5 Decision Rules

Having identified and converted all the costs and benefits into standard units that can be compared directly, what is now necessary is to calculate the net present value (NPV), benefit-cost ratios and payback period. The calculation method has been explained in Chapter 3. As to the other decision rule, internal rate of return, since it is rather complicated, is not used here.

- NPV=206,284,800-81,920,000=124,364,800>0, therefore VTS project A is justified.
- Benefit-cost ratio=206284800/81920000=2.5>1, means that VTS project A is justified.
- As figure 4.2 shows the benefits and costs are equal in 1996, which is 7 years after the commencement of the project. This is the payback period.

Figure 4.2 Cumulative Value of Costs and Benefits of VTS centre A



All the above criteria show that VTS centre A is justified.

4.2.2 VTS Centre B

4.2.2.1 General Introduction to VTS Centre B

VTS centre B also started construction in 1989 and was put into operation in 1994. As for VTS centre A, the components of VTS centre B are radar surveillance system, VHF communication system, VHF direction finding system, ship data processing system and hydro-meteorology system.

The services provided by VTS centre B are: navigational warning services, consulting services, traffic organization services, navigational assistance services, anchorage arrangement and support of allied activities. (China Maritime Safety Administration (CMSA), 1999)

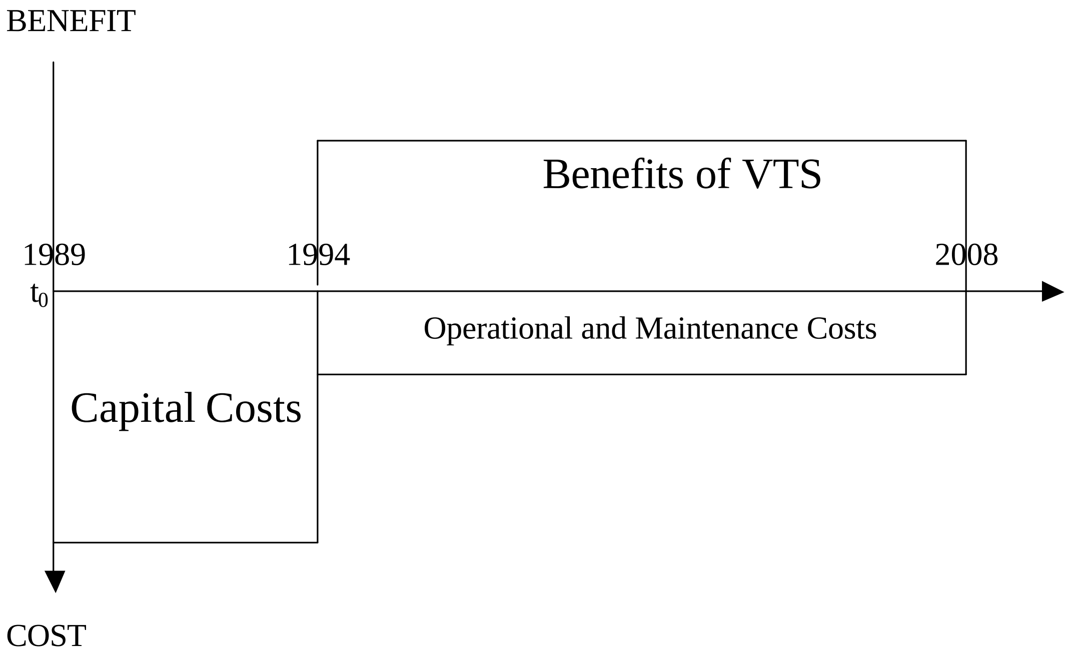
4.2.2.2 Identification of Parameters

All the parameters are identical to those of VTS centre A, which are:

- The base point of time at which all the costs and benefits are calculated is 1989.
- The social discount rate is 12%.
- The life-span of VTS centre B is 15 years.

The costs and benefits cash flow is shown in figure 4.3.

Figure 4.3 Costs and Benefits Cash Flow of VTS Centre B



4.2.2.3 Calculation of Costs

The capital cost of VTS centre B is 15.86million Renminbi. This does not need to be converted.

As the O&M costs occurred after 1994, all of them must be converted to the 1989 value. The formula 3-7 is used here to calculate the value for 1989.

The costs and converted value for 1985 are listed in table 4.4.

Table 4.4   Costs Calculation of VTS Centre B

Year	Cost (thousand RMB)	Converting formula	Converted Value of Cost at Year 1989 (thousand RMB)
1989	15,860	N/A	15,860
1994	769	769 X $(1-12\%)^{5}$	405.8
1995	749	749 X $(1-12\%)^{6}$	347.8
1996	1,024	1024 X $(1-12\%)^{7}$	418.5
1997	1,580	1580 X $(1-12\%)^{8}$	380.5
1998	1,580	1580 X $(1-12\%)^{9}$	334.8
1999	1,580	1580 X $(1-12\%)^{10}$	294.7
2000	1,580	1580 X $(1-12\%)^{11}$	259.3
2001	1,580	1580 X $(1-12\%)^{12}$	228.2
2002	1,580	1580 X $(1-12\%)^{13}$	200.8
2003	1,580	1580 X $(1-12\%)^{14}$	176.7
2004	1,580	1580 X $(1-12\%)^{15}$	155.5
2005	1,580	1580 X $(1-12\%)^{16}$	136.8
2006	1,580	1580 X $(1-12\%)^{17}$	120.4
2007	1,580	1580 X $(1-12\%)^{18}$	106
2008	1,580	1580 X $(1-12\%)^{19}$	93.3
Total costs of VTS centre B			19,519

Note: the original data of costs are from “VTS Benefits Evaluation” (Fang & Zhuao, 1997).

Finally, the total converted cost of VTS centre B is 19,519,000 RMB.

4.2.2.4 Calculation of Benefits

As the benefits of VTS centre B could only be gained after the VTS was put into operation in 1994, the benefits were estimated yearly after the year 1994. It is stated in Chapter 2, the benefits of VTS are the costs that VTS saves. Therefore, all the benefits are estimated here.

The benefits of VTS centre B can be divided into several categories, which are benefits due to the decrease in maritime accidents; benefits due to an increase in passing capacity; benefits due to a decrease of stopping navigation in fog; benefits from environmental protection and other benefits that do not belong to the previous categories. All the benefits must be converted to the value for 1989.

Table 4.5 gives the value of benefits of VTS centre B.

Table 4.5 Benefits Calculation of VTS Centre B

(All the figures are in thousands of RMB)

Year	Benefit due to decrease in maritime accidents	Benefit due to increase in passing capacity	Benefit due to stopping navigation in fog	Benefits from environment protection	Other benefit	Converted value of benefit in 1989
1994	170	737	60	0	38	530.4
1995	170	890	60	0	38	537.8
1996	170	778	60	0	38	427.5
1997	170	899	60	0	38	419.7
1998	170	1,038	60	0	38	413.3
1999	170	1,199	60	0	38	408.6
2000	170	1,384	60	0	38	404.9
2001	170	1,599	60	0	38	402.7
2002	170	1,847	60	0	38	401.4
2003	170	2,134	60	0	38	401.2
2004	170	2,464	60	0	38	401.5
2005	170	2,846	60	0	38	402.8
2006	170	3,288	60	0	38	404.7
2007	170	3,797	60	0	38	407.1
2008	170	4,386	60	0	38	410.2
Total benefits of VTS centre B						6373.8

Note: the original data of costs are from "VTS Benefits Evaluation" (Fang & Zhuao, 1997).

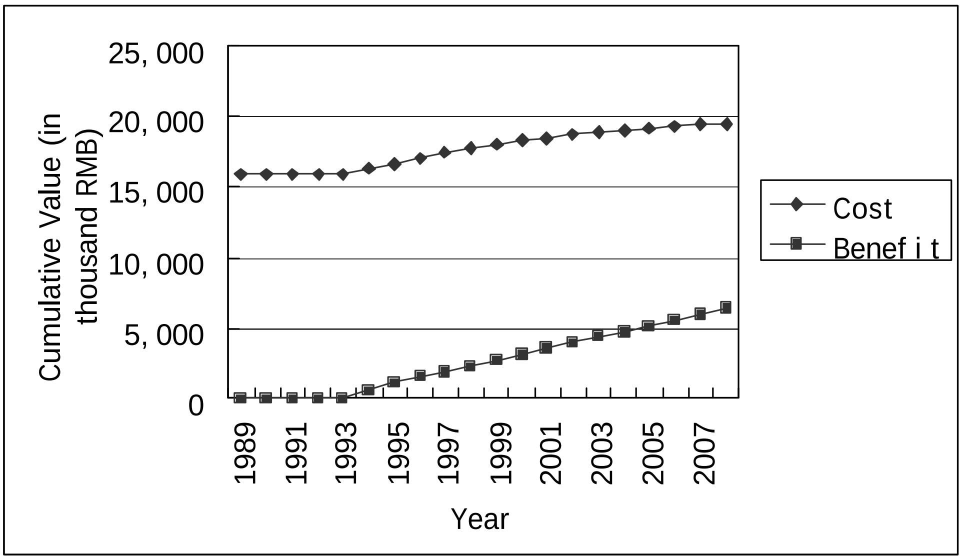
Finally, the total converted benefit of VTS centre B is 6373,800 RMB.

4.2.2.5 Decision Rules

All the costs and benefits into standard units that can be compared directly have been identified and converted, what need to be done now is that the net present value (NPV), benefit-cost ratios and payback period must be calculated. The calculation method has been explained in Chapter 3. As to the other decision rule, the internal rate of return, since it is quite complicated to calculate and is therefore ignored in this exercise.

- NPV=6373.8-19519=-13145.2<0, therefore VTS centre B is not justified.
- Benefit-cost ratio=6373.8/19519=0.33<1, so it means that VTS centre B is not justified.
- From figure 4.3 we can see that the benefits of VTS centre B never outweigh the costs.

Figure 4.4 Cumulative Value of Costs and Benefits of VTS centre B



All the above criteria show that VTS centre B is not justified.

4.2.3 Other VTSs

Table 4.6 gives the out come of the evaluation of some other VTS centres.

Table 4.6 Out Come of the Evaluation of Some Other VTS Centres

VTS centre	Costs (in thousand RMB)	Benefits (in thousand RMB)	PNV	Benefit-cost ratio	Payback period
1	8,339	13,075	4,736	1.57	7
2	9,859	11,041	1,182	1.12	8
3	62,014	91,638	29,624	1.48	9
4	8,354	9,568	121	1.15	11

Note: the original data of costs and benefits are from "VTS Benefits Evaluation" (Fang & Zhuao, 1997).

The result of the analysis shows that all of these VTS centres are justified.

Chapter 5
Observations and Recommendations for VTS in China

Although most VTS centres in China are justified since the benefits outweigh the costs, there is still room for improvement. In order to improve the functions of VTSs in China and make them more cost-effective, considerations should be given to the following:

5.1 More VTSs are Needed

VTS has had a rapid development in China. Some 20 VTS centres have been constructed since the first VTS began to break ground in 1987. However, VTS is still at a developing stage and a lot more work is needed.

China now has more than 400,000 vessels of all kinds and sizes under its flag. Their total gross tonnage is over 40,000,000. The output of seaports in 2001 was more than 14 billion tons while the design capacity of the ports was only 13 billion tons, meaning that the seaports are overloaded. It is estimated that the output of Chinese ports will be 20 billion tons by 2005 and be further increased to 30 billion tons by 2010. Therefore, more port capacity is needed. This must be done with an increase of berths, anchorage, *etc*. at the existing ports instead of increasing more ports.

The previous trend and the development of waterborne transport will inevitably cause a continuous increase in ship density. Meanwhile, with the expansion of high speed craft, very large vessels and ships carrying dangerous cargoes, the requirement for traffic management and services will become increasingly higher and VTS may be one solution.

VTS has proved to be an effective method for improving safety, increasing efficiency and protecting the environment of ports and fairways. With science and technological developments, VTS will play a more important role in the maritime industry. Therefore, China must continue her route to develop VTS at a steady pace.

There are thousands of ports dotted along the 18,400 km long coast line of China. Further, the inland rivers accommodate more than 500 ports. Among these ports, 42 have an output of more than 1 million tons, while only 13 of them have established a VTS centre. The coverage is only 31%. This is not to say that each port must operate a VTS, but some of them will need to have VTS more urgently than others.

For example, according to the statistics of Shanghai Shipping Exchange (2001), the port of Zhoushan ranked the 12th among the ports with cargo traffic outstripping 10 million tons in 2001, followed by Zhanjiang and Yantai. The fact is that Zhoushan does not have a VTS in operation or in construction. Both Zhanjiang and Yantai have had VTS in operation for a few years. There are some other ports that are in a similar situations, *e.g.* the ports of Fuzhou and Zhongshan. All of these ports have a significant traffic flow and the natural conditions are not better than those which have a VTS in operation. Therefore, they also need VTS to serve the port and benefit the relevant parties.

5.2 VTS must be Established in accordance with its Needs

As discussed in Chapter 4, one VTS centre is obviously unjustified because it is over invested. The reason for this is that its service level is higher than its needs.

The first thing before VTS construction commences is to determine definatively the objectives of the VTS. This should be done before everything else. Without a clear and precise objective, there will be many problems afterwards.

> The precise objectives of any vessel traffic service will depend upon the particular circumstances in the VTS area and the volume and character of maritime traffic. (IMO, 1997)

So the objectives must be adapted to the natural conditions and the traffic situations of the intended area. If the fairway is broad and deep enough for vessels visiting the port, there are seldom strong winds, rough seas, strong currents and fog, and the traffic is not congested, then a VTS centre may be not necessary or even if one is established, the level of services should be low. In another situation, if the vessels navigating in the intended area are mostly small vessels that are not equipped with VHF, although the volume of vessels is quite high, there is no use for VTS because no communication can be established. On the other hand, if the port is always busy and a lot of vessels enter and leave the port or wait at anchorages, a VTS in this area will be very helpful and may generate substantial benefits. Whether a VTS is needed or at what level it should be operated must be determined by the particular circumstances within the intended area and the volume and characteristics of the traffic, *i.e*. the actual needs of the area.

5.3 A Good Plan is the Key to Success

> VTS systems are increasingly complex real-time systems which require development and procurement disciplines to minimize possible failures from the use of untried technologies, late delivery or cost overrun and to reduce the risks inherent in the acquisition of such systems.
>
> The overall objective (of planning and establishing VTS) is to produce a system which meets exactly the requirements of the VTS authority, and against which the design can be validated fully, verified and tested before development. (IALA, 1998)

For anything, a good plan is crucial to its success. As mentioned earlier, VTS is a capital-intensive project, which can cost millions of dollars. If there is no scrutinized plan and design, many mistakes will occur. Some of them may be vital.

Planning and designing a VTS project may include identification of the needs, definition of the requirements, a feasibility study, *etc*. The VTS authority must confirm first whether a VTS is needed, what are the requirements for the VTS, what kind of services will be provided, which areas will be covered, what will be the scale of the VTS, and what kind of equipment may be needed to fulfill the requirements. Then the cost-benefit analysis should be used to evaluate the costs and benefits of each alternative. The best one should be selected.

As mentioned before, all VTSs are under the control of the China Maritime Safety Administration and its branches. CMSA is responsible for the design and development of all VTS projects. After a VTS has been developed, a branch of CMSA will operate it. Another thing that needs to be done by China Maritime Safety Administration is evaluation of several proposed VTS projects. Construction on the most urgent one must then be specified. Because VTS is usually a big programme which needs sizable capital and time to develop, it is not possible to start constructing several VTS centres at the same time. Therefore, there must be a rational arrangement to decide the order in which each should be started. This is also part of the planning.

While carrying out the cost-benefit analysis, it is better that it be done by external experts. The reason for doing so is: firstly, there may not be sufficient in-house expertise. Secondly and most important, the external experts will not have any personal biases as in-house experts do. The personal biases will have a significant effect on the data identification and finally the result of the analysis. For example, if an in-house expert wants more investment, he may tend to inflate the benefits which will result in the costs being greater. Therefore, the analysis conducted by the external experts will be more precise and objective.

5.4 VTS Services Need to be Paid for

As mentioned in Chapter 4, all VTS centres in China are now funded by the government and no VTS fee is presently charged. This has caused some problems. The main problem is that O&M costs sometimes are not enough or are not given in time.

China is still a developing country and the money is needed everywhere. The Chinese Government has made extensive efforts to develop VTS in order to improve maritime safety, increase traffic efficiency and protect the marine environment. VTS has or may confer considerable benefits. However, these benefits are mostly social benefits which cannot flow into the pockets of the government or perhaps only a small proportion of the benefits may benefit the government indirectly, through taxation on profits of shipping companies. Therefore, from the fiscal perspective of the government, the benefits of VTS do not cover the costs. As a result, sometimes it is difficult for the CMSA branch operating a VTS to find capital to cover the operational and maintenance costs which will be generated every year. There have been some instances where VTS services have stopped for a few days or even a month due to the failure of equipment. One of the reasons for this is that there is no money to purchase the spares needed. We can imagine the situation of a busy port working without the surveillance of VTS. In fact, it can be much worse if there is a VTS halt during the typhoon season.

Since privatization of VTS in China is not possible in the near future for several reasons, the best solution for a deficit in O&M costs is to charge a VTS fee in China.

Although VTS is a kind of public service, it is still a service and safety has a value attached. So it is rational that those who benefit from this service should pay for it. For VTS, the direct and most beneficial ones are the ships navigating within the VTS area. Therefore, these ships should pay for the services. It is a practice at many ports around the world to charge a VTS fee in order to recover a portion of the costs. The followings are some examples:

- Fees charged by the Marine Exchange at L.A./Long Beach:
  Vessels 150m to 190m: per arrival; about $ 166 USD
  Intermediate charges also apply: vessels over 310m: per arrival; about $ 283 USD.

- Fees charged by the Port of Rotterdam:
  The VTS for per trip is: vessel 41m. to 100m.: $ 132 USD
  Intermediate charges also apply: vessel over 250m: $ 1475 USD.

- Fees charged in Russia:
  Russia's VTS fee is based on cubic metres: between $ US 0.0067 to 0.025/m3.
  This depends on the port and applies to each call at or departure from a port.
  A 10,000 GRT vessel could pay about $ 589 USD for entry or exit.
  A 40,000 GRT vessel could pay about $ 2355 USD for entry or exit.

- Fees charged in the Philippines:
  Manila charges 1.9 cents/GRT for international traffic, per visit
  or 0.3 cents/GRT for domestic traffic
  So far a 10,000 GRT vessel, fee = $ 192 (international ship), per visit or $ 32 for a domestic ship.

- Fees charged in Canada:
  Eastern domestic vessel: at $ 2.17 per GRT, a 10,000T vessel would pay $ 21.8k

per year; of this, 11% or $ 2394 per year is chargeable to VTS;

Cruise ship: $ 541 per call; or $ 60 per call for VTS element;

Foreign vessel: at $0.113 per Tonne, 10,000T of cargo loaded or unloaded would attract a fee of $ 1126; of this, 11% or $ 124 is the VTS element. (Barker, 1997)

The CMSA should also charge a VTS fee to vessels visiting a VTS area in order to recover some VTS costs. The quantity of the fee needs to be considered by the experts.

5.5 The Quality of VTS Operators Needs to be Improved

> Given the role of VTS in the provision of safety and efficiency services to shipping and in the protection of the environment, the need to avoid confusion on the part of users travelling from one VTS to another and the importance of professionalism on the part of VTS operators in determining the extent of trust placed in the functioning and effectiveness of a VTS, it is essential that VTS personnel be adequately qualified and trained to carry out their functions, … (IMO, 1997)

VTS operators play a very important role in achieving the objectives of VTS. For example, if a VTS operator has an incorrect understanding of a vessel's movement or intention, he/she will transmit this wrong information to all the other vessels and this may lead to dire consequences. Therefore, no matter how advanced the equipment is, VTS cannot function properly if it does not have qualified VTS operators.

The content of the work of VTS personnel varies considerably with respect to the type of VTS in existence. This is determined by the age, scope and sophistication of the equipment in which the Harbour Authority has invested and on the type of operation in which the operator is involved. In some ports, the VTS personnel are expected to communicate information to ships within the VTS area, whilst in others they assume the role of traffic managers. (Hughes, 1998)

The Commission of the European Communities (1988) concluded in its R&D programme COST 301 that there is a lack of a systematic approach to VTS personnel career development in Europe, which shows in the large variations in standards of qualifications of VTS operators, lack of formal training programmes and varieties in services provided and procedures used. In fact, in China, the situation is now the same. Although IMO has worked out "Guidelines on Recruitment, Qualifications and Training of VTS Operators" in its Assembly Resolution A. 857(20), there is no standard for recruitment, qualification and training in China at present. As such, some VTS operators are not qualified.

As Hughes (1998) indicates, the requirements for VTS operators should be as follows:

> The common requirements for the majority of VTS operators at different ports, are communication skills, radar interpretation and both specific and general nautical knowledge. To qualify fully for a particular port, an endorsement should be obtained, which would include local knowledge of the area, types of shipping using the port, emergency procedures and the local bye-laws concerned. The officer responsible for the VTS centre would, in addition to his normal maritime qualifications and those required for a VTS operator, be required to have port and risk analysis management experience, together with legal knowledge, concerning the bye-laws and the liability of the work involved.

VTS operators now in China have different backgrounds. Some are newly graduated from university with various majors, including maritime administration, navigation, nautical engineering, electronics, computer, *etc*. While others have been transferred from other departments of the MSA. Table 5.1 shows the qualification components of VTS operators according to a survey conducted in 1995.

Table 5.1 List of Educational Background of VTS Operators

Educational Background	Quantity	Percentage
Graduates from university	92	47.7%
Graduates from training school	41	21.2%
Graduates from technical secondary school	22	11.4%
High school	31	16.1%
Secondary school	7	3.6%

Source: Shi. (1999). Discussion on development of VTS in China.

There is one thing here that is crucial and must be given attention. In China, a graduate from high school and secondary school usually cannot communicate in English and does not have a general knowledge of computers. Even graduates from training school and technical secondary schools have problems with these two aspects if they do not major in them. Therefore, it is not surprising that 80% of VTS operators need improvement on English listening and spoken English as well as computer skills. This is evident from the same survey.

Another problem for current Chinese VTS operators is the lack of nautical experience. At least in 7 VTS centres, nobody has had any nautical experience. Some newcomers have never even been on board ship. This will inevitably limit VTS capability to provide the navigational assistance services.

It is therefore necessary for CMSA to ensure that each VTS operator is fully qualified. This can be done through recruiting newly qualified persons, and removing existing unqualified VTS operators, and most importantly, various training opportunities are needed, including initial training for new hands, and in-service training for those who are already VTS operators.

5.6 Developing VTIMS

> Although more and more sophistication in the development of VTSs, these last keep a very local status limited by their radars and VHF coverages. Thanks to the development of Electronic Data Interchange (EDI) technics, is born the concept of VTMIS which is defined as a shore-based interactive traffic and management information system that services a predefined region containing a number of interconnected VTSs and a part of the high sea bordering the territorial waters of Coastal State. (Degre, 2000?)

VTIMS means vessel traffic management and information services, which is a relatively new concept. A committee established by the European Commission (EC) to monitor the progress of R&D actions launched by the respective Directorate General (DG) of the EC named Concerted Action (CA) on VTIMS (1999) has been working on a definition describing VTIMS with the following results:

> Vessel Traffic Management: the set of efforts (measures, provisions, services and related functions) which, within a given area and under specified circumstances, intended to minimize risks for safety and the environment, whilst maximizing the efficiency of waterborne and connecting modes of transport.

> Vessel Traffic Management and Information Services intend to respond to public and private demand for facilitating Vessel Traffic Management. VTMIS include services distributing in given areas (at regional, national or transnational level) the pertinent information to be used both in real time and in retrieval modes by actors involved.

The objective of VTMIS is to improve the efficiency, including interconnectivity and interoperability with other modes of transport, and the safety of shipping and environmental protection (Koopsmans, 1998).

The Concerted Action (1999) on VTMIS also drew up the following explanatory notes:

> The implementation of or participation in a VTMIS in a given area does not presuppose the existence of any specific type of equipment as long as it is adequate for the tasks to be performed. However it implies that all services which are or will be implemented in the area, such as VTS, Allied Services and other information services, are interlinked and co-operate according to commonly harmonised procedures.

So we can see here that VTS is not necessary for a VTMIS. In fact, as Koopsmans (1998) stated:

> VTMIS are not (existing) systems or services. It is a concept, a kind of umbrella, for all activities improving the exchange of information for the services relating to movements of vessels or the cargo. The shortest possible description would be: "VTMIS are improving vessel traffic information".

However, VTMIS need a network within a region to link a number of nodes where the functions of collecting, storing and processing information available at the local level can be performed. The existing VTS, or newly established VTS, may act as a node of VTMIS. On the other hand, VTMIS can provide more connection and more information to VTS and improve the functions and services of VTS. Therefore, VTS and VTMIS can work together.

VTMIS can help VTS in two aspects: first, various parties can be connected through EDI technology, including VTSs, ports, ships, *etc*. So a VTS can easily get the information needed. Second, VTMIS can generate and transfer the so-called Traffic Image (TI), which is composed of information of the traffic, the environmental conditions and the resources needed by the vessels in a specific area. This totally changes the information exchanging system VTS is now using, which can only exchange voice information. With TI exchanging, ships can have a better knowledge of the current traffic situation.

Europe has done a lot of research concerning VTMIS, but in China, few people are working concerning VTMIS. So this sector must be speeded up and incorporated with VTS to improve the services of VTS.

5.7 Quality Management for VTS

When VTS was first introduced in China, it was accepted as a concept of one of the tools to manage the vessel traffic. Although this view has changed gradually through the years, there are still a few people, including some VTS operators, who regard it as a kind of management instead of services. They treat VTS operators as managers instead of ones who are providing services. This is why some captains feel that "Chinese ports have a lot of catching up to do". (Parker, 1999)

At any rate, this kind of view must be altered, especially for those involved in VTS operation. They should acknowledge that VTS should try not to intervene in navigation but to facilitate safe traffic flow by providing the authorization to proceed, dictating speed restrictions, safe fairway management relating to vessel movements, awareness of plans and the provision of warnings (Parker, 1999). Therefore, VTS should avoid giving orders. They should give advice and suggestions.

As a service, VTS must keep its service standard. The best way for VTS to keep its service standard is to introduce quality management. Now we have requirements on the quality management of seafarer's training and examination centre and certification authority in the STCW convention. In the SOLAS convention, the incorporated ISM code requires each ship and shipping company to establish a quality system to ensure safety at sea, prevention of human injury or loss of life and the avoidance of damage to the marine environment. VTS is also a sector where a quality system is needed. Although there are no requirements on this aspect thus far, it will be of great assistance if a quality system is put in place.

In order to establish a quality management system, ISO 9002 can be employed. It is an international standard that lays down the framework that a service provider can use to achieve a consistent level of service to its customers.

If all the Chinese VTS centres can implement ISO 9002, the quality of services will improve considerably and as a consequence, the benefits will also be much greater.

Chapter 6
Conclusions

From earlier analysis, one can arrive at the following conclusions:

First, the costs for any VTS are usually high. The initial investment can have a significant difference, ranging from several thousands of dollars to millions of dollars. Also, O&M costs that are needed annually every year are also quite significant.

Second, a VTS can generate numerate benefits, although the benefits are not gained by the operating agency alone, in this case, the China Maritime Safety Administration. The ports, ships, shipping companies and the marine environment all benefit from VTS.

Third, the benefits should outweigh the costs, otherwise, the VTS project is a huge waste of human as well as financial resources. As discussed in Chapter 4, most VTS projects in China are justified. They give more benefits than they cost. However, VTS centre B is not cost effective. The reason for this is that it is over-invested. In other words, according to the natural conditions and traffic flow situations, *etc.*, port B does not need such a sophisticated VTS as it now has. The level of VTS today in port B is higher than the level of need for VTS. Therefore, the investment in VTS centre B cannot be returned within its life span, which is a very big waste. If a cost-benefit analysis had been employed before the project began, the situation would have been different.

Finally, many measures must be taken to improve the functions of VTS in China. These measures include the following:

- More VTS centres are needed to be established in China;

- Each VTS must be established in accordance with its needs;
- A good plan is needed before starting a new VTS project;
- It is better to charge a VTS fee in order to cover some proportion of VTS costs;
- All VTS operators must be qualified;
- A quality management system will help VTS significantly; and
- VTMIS is needed to be developed.

References

Barker, L. (1997). *Cost Comparison: Vessel Traffic Services Fees at Foreign Ports Compared to VTS Element of Canada's Marine Services Fee*. Retrieved August 2, 2002 from the World Wide Web:
http://www.ccg-gcc.gc.ca/mcts-sctm/Publications/contact/Contactmar97_e.htm#Fee

Canadian Coast Guard. (1984, October). *National Vessel Traffic Services Study: Final Report*. Canada: Author.

China Maritime Safety Administration (CMSA). (1999, August). *Vessel Traffic Services Guide for User*. Beijing: People's communication publishing house.

Commission of the European Communities (CEC). (1988). *COST 301 Shore-based Marine Navigation aid Systems: Main Report*. Luxembourg: Office fro Official Publications of the European Communities.

Concerted Action on VTIMS. (1999, January). *About VTMIS-Vessel Traffic Management and Information Services*. Retrieved May 14, 2002 from the World Wide Web: http://www.vtmis.de/abtvtmis.htm

Degre, T. (2000?) *Marine Traffic Management, VTS and VTMIS*. Retrieved May 14, 2002 from the World Wide Web:
http://www.maritime.deslab.naval.ntua.gr/neptune/traffic.html

Duncombe, W. (2001). *Benefit-Cost Analysis (BCA)*. Retrieved June 1, 2002 from:
www_cpr.Maxwell.syr.edu/faculty/dumcombe/Ppa723/lecture%2016.pdf

Fang, X. & Zhuao, L. (1997). *VTS Benefits Evaluation*. Dalian: Unpublished research project report.

Henry, R. (1979). The Role of Cost-Benefit Analysis in Policy Making. In R. Haveman and J. Margolis (Eds.) *Public Expenditure and Policy Analysis*, Second Edition. Dallas: Houghton Mifflin Company.

Hughes, T. (1998, September). Vessel Traffic Services (VTS): Are We Ready For The New Millenium? *The Journal of Navigation. 51(3)*. 404-420.

International Association of Marine Aids to Navigation and Lighthouse Authorities. (1993). *IALA Vessel Traffic Services Manual*. France: Author.

International Association of Marine Aids to Navigation and Lighthouse Authorities. (1998). *IALA Vessel Traffic Services Manual*. France: Author.

International Maritime Organization. (1997, December 3). *Guidelines for Vessel Traffic Services*. (IMO A 20/Res.857). London: Author.

Koopmans, M. (1998, June 11). *Guidelines on Vessel Traffic Management and Information Services (VTMIS)*. Retrieved May 14, 2002 from the World Wide Web: http://www.vtmis.de/vtmisc03.htm

Liu, G. Liang, Y. & Ding, B. (1999). VTS Development and Future in China. *1999 Collection of Theses on VTS*. Beijing: International Maritime Affairs Research Insititue.

National Research Council. (1996). *Vessel Navigation and Traffic Services for Safe and Efficient Ports and Waterways*. Retrieved August 2, 2002 from: http://stills.nap.edu/html/vessel/

Parker, C. J. (1999, June). VTS keeping ships apart and keeping ships afloat or…? *Seaway*s. 1999, June. 3-4

Shanghai Shipping Exchange. (2001, December 17). *Port with cargo traffic outstripping 10 million tons*. Retrieved August 1, 2002 from the World Wide Web: http://www.chineseshipping.com.cn/

Shi, G. (1999). Discussion on Development of VTS in China. In *1999 Collection of Theses on VTS*. Beijing: International Maritime Affairs Research Institute.

Treasury Board of Canada Secretariat. (1998, July). *Benefit-Cost Analysis Guide*. Retrieved May 2, 2002 from the World Wide Web: http://www.tbs-sct.gc.ca/fin/sigs/revolving_funds/bcag/bca_e.html

Transport Canada. (1994, September). *Guide to Benefit-Cost Analysis in Transport Canada*. Retrieved May 2, 2002 from the World Wide Web: http://www.tc.gc.ca/bca/Guide_e.htm

Wang, Z, *etc*. (1999). To Improve the Transit Capacity in Yangtze River by Bringing VTS Function into Play. In *1999 Collection of Theses on VTS*. Beijing: International Maritime Affairs Research Institute.

Wu, C. & Zhang, M. (1998). *Economics in Technology*. Dalian: Dalian Science and Technology University Publishing House.

Wu, Y. (1999). *Benefit-Cost Analysis in Engineering Design*. Retrieved June 2, 2002 from: asudesign.eas.asu.edu/education/MAE540/wu95.doc

Yu, B. & Wu, Z. (1989). Quantified Research on division of port VTS levels. *Journal of Dalian Maritime University*. 1989, 3.