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Analysis and evaluation on cost and benefit of VTS

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Analysis and Evaluation on Cost and Benefit of VTS

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Declaration

I certify that all the material in this research paper 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 research paper reflect my own personal views, and are not necessarily endorsed by the University.

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Title: **Analysis and Evaluation on Cost and Benefit of VTS**

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Abstract

The research paper is a study on the cost benefit of VTS by using the synthetical evaluation method .

The Object of VTS is to aid the mariner in the safe use of navigable waterways; and to contribute to keeping the seas and adjacent environment free from pollution.in other words it improve the safety and efficiency of traffic and prevent the pollution form sea.The cost of establishing and operating VTS is enormous.It contains construction cost,operating cost and so on.Therefore,to study the cost benefit analysis of VTS is important.

In this paper,the method of CBA is studied from many aspects,as shown in the following:

1)The Relationship between the Types of VTS and Profit of VTS

2)The methods of cost calculation

3)The quantitative calculation of VTS Benefit

4)how to reduce cost and improve the benefit

This paper provided evaluation index system on the Cost-benefit of VTS.

Then it carried out the analysis of cash quantification on cost-Benefit of TialljinVTS and Dalian VTS .Based on the analysis ,the author put forward many suggestions to maximize the benefit and reduce the cost.Especially ,the localization of VTS equipments is presented.

KEYWORDS: Cost and Benefit Analysis; VTS;Evaluation;profit.

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List of Abbreviations

BCR	Benefit cost rate
CBA	Cost Benefit Analysis
DMU	Dalian Maritime University
ENPV	Economic Net Present Value
EIRR	Economic internal rate of return
EI(s)	Evaluation Indicator(s)
IMO	International Maritime Organization (London)
INS	Meteorological Bureau
i	Social discount rate
IALA	International Association of Lighthouse Authorities
MSA	Maritime Safety Administration
NAS	Management Information System
NM	Nautical mile
TSS	Traffic Separation Scheme
Tp	Stable investment recovery period
Tp*	The Dynamic Payback Period(
TOS	Traffic organization service
VTS	Vessel Traffic Service
ZS	Zhoushan

Chapter1

Introduction

1.1Backgroud

For several centuries,shipping has always been a main transportation way in the world trade.According to the statistics ,seaborne volume accounted for around 80% of the whole international transport of goods.In the premise of ensuring the transportation, Besides,the owners pay attention to improving transport efficiency and economy ， they enhance maritime traffic safety .In order to assist the ship to navigate quickly and safely,the authorities set up AIDS for navigation in their coastal waters.

The most earliest aids to navigation were buoys and beacons .With the development of radio technology,the radio Omni-directional Range appeared first and Later, a radar beacon was used in navigation.

As the speed ,the ships scale and the number of the ships increase， more advanced traffic management methods are needed.Hence,the passive traffic management methods such as TSS,prohibited area ，recommend the traffic flow,limited speed were established.

These passive traffic management techniques have remarkably improved the safety of navigation and environmental protection in most of the coastal water.However, in the offshore, especially,in the narrow channel there are an increasing number of ships , which causes traffic congestion, delaying a lot of shipping schedule.Therefore,the port charge and traffic expense increase.

At the same time the possibility of accidents increased ,leading to life and property loss． In order to solve these problems，it is necessary to develop many management methods including monitoring the ship movement,provide the information,advice and instruction.By these methods,it can get the benefit and organize the traffic

flow ,meantime low down the risk of accident and environmental pollution,this interaction is called“VTS”.

Based on the requirement of IMO,IALA VTS committee submits the definition of VTS:

“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 hav e the capability to interact with the traffic and to respond to traffic situations developi ng in the VTS area.”(IALA, 2012,p53-54) In fact,definition of VTS contains “Vessel Traffic System”,“vessel Traffic Management System”,Vessel Traffic service and so on.

The construction of VTS in China started relatively late,but developed faster and faster.From 1978 to 1982 the first VTS(Beilun VTS) was built in city of Ningbo .

So far, there are 33 VTS centers and more than 120 radar stations in China.It covers most of the important coastal waters , the trunk of the Changjiang River and Zhujiang River.

But the cost of establishing one VTS is very large, according to the statistics in China , building the small-scale VTS need an investment of at least 1 million yuan, for large one needs an investment of tens million or even one hundreds million RMB yuan.

VTS maintenance and operation cost is also very impressive, for the larger VT S， its annual operation and repair costs reached millions RMB yuan.The construction scale of some VTS are not reasonable, resulting in waste.And there was not a good method on analysis of VTS cost benefit.

Specifically, VTS benefit should be the compensation of the VTS investment and operation cost.Benefit and cost depend largely on the types of VTS and the grade of service.

Based on the inherent characteristics of VTS ,the analysis of cost-benefit is the qualitative analysis and quantitative estimation of VTS project construction and operation cost and benefit, find ratio or difference between the cost and benefit , this

analysis can offer the scientific decision-making basis for VTS planning and constructions in the future. Moreover， based on the expect investment revenue and operation and maintenance costs and benefits,it help users make the integrated decision-making.Then it can avoid the loss of state property and provide some reference for the expansion of the system.

At last ， it achieves minimizing the VTS cost so as to optimize the cost benefit of VTS.Therefore ,the effective estimation of the costs and social and economic benefit of VTS has become a big problem.

1.2Research Status of the CBA of VTS

VTS costs as much as millions or even hundred millions RMB , and the daily maintenance cost is very high, thus cost -benefit analysis of VTS becomes more and more important.

IALA has provided a analytical framework.In the “ *IALA VESSEL TRAFFIC SERVICES MANUAL* ”， European scholars put forward a cost benefit analysis framework of VTS， And it studies how to analyze and calculate the cost benefit of VTS;Canadian Dr.Tony.Quon said in the article“cost benefit evaluation of VTS”,take the Canada which focusing on risk assessment and environmental protection. For example, it proposes a navigation risk index and the regression model about estimate the number of accidents； moreover ,they researched the application of reducing risk and environmental protection in VTS which developed by US Coast Guard.D.JMaio.etc.from United States Department of Transportation in one paper outlined the Cost Benefit Analysis of VTS in the 82 deepwater port and 23 research area under control of US Coast Guard .

Japanese scholars Namio Mizuky, Yahei Fujii article “ cost benefit analysis of VTS”wrote the port control（VTS）was restricted by the factors of port water,thus to build the VTS needs investigating the factors of port first.

In China,the history of VTS is only more than 30 years .it lacks the systematic study on CBA of VTS. It started late, but it still needs further work.

IALA VTS committee thinks this area is still in development.They hope to to upgrade the decision-making process which evaluates the effectiveness and efficiency of VTS to provide reference for the future project of VTS

The research on the CBA of VTS in china concentrated on Institute of Marine technology in Dalian Maritime University .On the basis of the completion of the project of "post evaluation of VTS project",professor Fang Xiang lin published"VTS cost effect analysis of evaluation methods and models"in the international academic conference.Meantime,professor Fang published "Vessel traffic management system for the cost benefit analysis and evaluation method"in 2000,then presented model how to improve traffic activities, traffic accident.Due to VTS with the modern management methods, it becomes more and more important.Therefore， the research on the cost benefit analysis of the VTS is immediate.

1.3 Main contents

Although cost benefit analysis of VTS has been widely studied both at home and abroad and achievements has been made in this field.There is only little comprehensive research on CBA of VTS. This paper tries to make a detailed analysis of CBA methods on basis of the former researches ，and takes the DalianVTS and TianJin VTS for example which were analyzed ,in order to advance the further research on the methods.The paper mainly involves the following tasks：

(1)By the analysis of VTS cost and benefit, this paper puts forward a reasonable method to calculate the cost of VTS .

(2)The paper proposes the evaluation index system of VTS cost-benefit analysis,and analyzes their advantages and disadvantages

(3)To combine the applied above method to evaluate and analyze benefit of Ningbo VTS.

(4)To study and put forward the effective ways to improve the benefit of the VTS

Chapter 2

The Relationship between the Types of VTS and Profit of VTS

2.1 The types of VTS

Since Vessel traffic system / service (VTS) put into operation all over the world, it improves the vessel traffic safety, traffic efficiency and protects the coast environment(IALA VTS Manul,2012,p54).

Obviously,the VTS project has gained great economic and social benefits. But the VTS consistently devoted considerable manpower and material resources to that end, and the differences among different levels VTS is substantial.Therefore, before the construction of VTS, according to the needs level and management level, to rank the corresponding VTS which reduces unnecessary waste by the competent authority can is especially important(Tian Hongwei ,2000).

The determination of VTS management level is determined by the management functions.According to the IMO Resolution A.857(20)“VTS guide ”， the cause of establishing the vessel traffic system is：

(1)to assist voyage in appropriate area

(2)The organization of ship running in order to improve the efficiency of VTS area of traffic flow

(3)processing the data of the ship

(4)Participating in the event of maritime affairs

(5) To support allied activities

(6)VTS is especially suitable for building in areas that may include or a combination of the following area :a)high traffic density;

b)the vessels which carry hazardous cargoes;

c)navigational difficulties;

d)narrow channel;

e)environmentally sensitive.

f)near the harbour\ the inbound and outbound channel

To this end, IMO Resolution A.857(20) ‘Guidelines for Vessel Traffic Services’ has specified the function of VTS，including: data collection, data evaluation, information services, navigational assistance service, traffic organization service, support allied activities(IMO ,VTS Guide,1998).

But the determination of VTS management function is determined by the natural conditions , traffic conditions and port planning .That is to say,it is determined by the needed level of port. According to the main factors which influence needed level of VTS , based on the domestic and foreign literature,our researchers made on-the-spot investigation, summed up 33 factors.Then after repeated screenings,at last 26 factors have been identified as main factors concerning the coast harbour VTS.The factors are divided into six categories（Qiu Min ,1992, pp.24-35）

As shown in Figure1

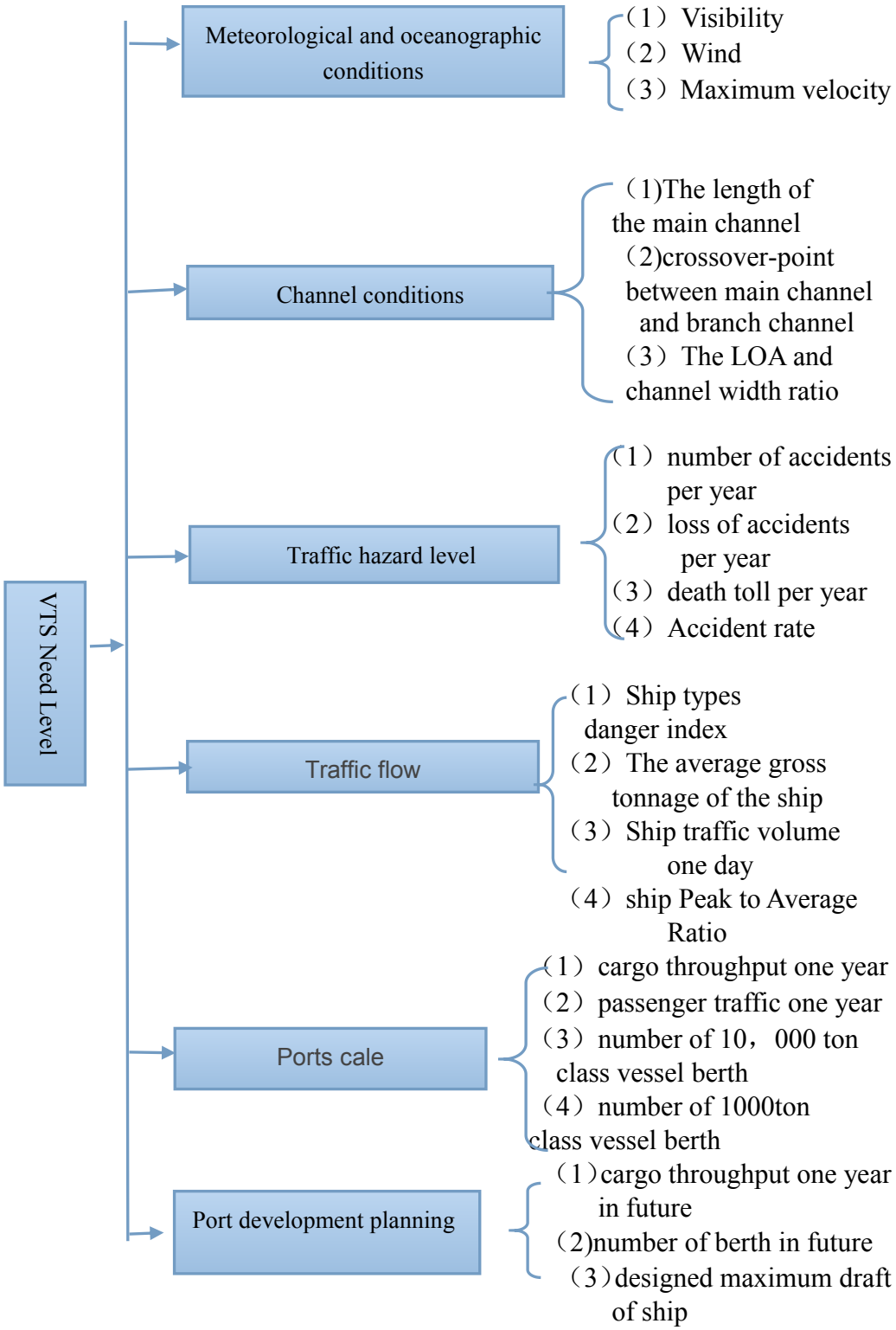

Figure 1-main factors concerning with the coast harbour
Source：complied by the author 2014

The determination of VTS management functions directly affect the technical indexes of the VTS equipment and investment scale, and reasonably selection of the influencing factors concerning management functions is the key to specifying the management functions.

Through investigation and study, referring to research results home and abroad, finally from the need level 26 factors ， the seven factors were selected as the influence factors of China's coastal port VTS management function(Chen Houzhong ,2002):

1）losses caused by the traffic accident in a year

2）more than 500 gross tonnage ship traffic volume

3）cargo throughput per year

4）The accumulation of low visibility in days

5）the number of 10,000-ton class berth

6）crossover-point between main channel and branch channel

7）the dangerous cargo throughput one year

According to these seven factors,Chinese scientists have carried on the research about how to rank China port vessel traffic management hierarchy（IALA ,2012 ,pp77 -79and Tian Hongwei,2000,pp3-10）;

Based on the international maritime organization VTS guide , the Chinese researchers analyze the foreign classification method, combined with the actual and future development of our ports, the management function of VTS in China is divided into five grades.

level 0 traffic law and regulations management

Using the port and the navigation rules, ship visual signal and sound signal regulation, pilot system,Traffic Separation Schemes, speed limit and Patrol boat cruise ， the authority manage the vessels

level 1：traffic information service

The services offered include: Vessel Movement Reporting System,monitoring marine traffic ， making ship-to-shore communication，collecting and exchange a number of relevant data about hydro-meteorological data and vessel traffic, transportation information releasing system and so on.

level 2：Traffic monitoring and alarm service

Establishing VTS equipped with the appropriate equipment, monitoring vessels whether abiding by navigational rules and regulations, and analyzing and synthesizing various kinds of data and display the live traffic, timely sends the movement of ships ,traffic conditions, navigation information such as obstacle and avoiding collision with relevant vessels.

level 3： navigational assistance service

This service is normally rendered at the request of a vessel or by the VTS when decided need to take actions ， including providing assistance through difficult navigation condition

level4：Traffic organization service/management

A traffic organization service is a service to prevent the development of dangerous maritime traffic situations and to provide for the safe and efficient movement of vessel traffic within the VTS area(IALA,2012,p175).

According to the traffic condition and the voyage plan, VTS can organize the traffic, including establishing and implementing the ship sailing licensing system, ordering the priorities through special area, design more reasonable oceanic navigation route and limiting speed, designating anchor point, send the suggestion and instruction , implementing traffic control when necessary.

From the foregoing ， through several levels, each of which builds added capabilities upon the prior one.

The relevant factors from 63 costal VTS all over the world were collected and analyzed by Professor Fang Xianglin and other researchers.Then they calculated the average of samples of various levels port VTS . At last,combining with the consulting,they put forward quantitative range average of corresponding factors about China's coastal ports V T S management function of each level（Table1） .

There is no standard of level 0 in the table，because in china no VTS is level 0.Ports shall achieve the functions of different levels（Tian Hongwei ,2000,pp.8-9）.

Table 1-port VTS classification standard of management function;

Level / Standard / Factors（unit）	level 1：Traffic information service	level 2：Traffic monitoring and alarm service	Level3：Navigational assistance service	level4：Traffic organization service/management
Accidental loss （10,000RMB/year）	40	75	100	500
Traffic volume Per day	16	20	24	70
Annual throughput （10,000tons/ year）	500	1500	2800	9800
10,000ton class berth	9	16	24	60
Visibility <1nm(days per year)	12	22	32	40
Channel cross point	1	2	4	8
Dangerous cargo throughput （10,000tons/year）	150	350	800	3000

Source：Tian Hongwei ,2000 .

2.2 Analysis of the relationship between the VTS management level and the VTS cost-benefit

VTS is a system involving wide range and very complex systematic project.

Take VTS in China. For example，we will find that the investment from the table is at least millions, then hundreds of millions on more equipment and other projects.Moreover , the operation and maintainance cost is enormous.

Table2-total investment of part of VTS in China

NO.	name	Total	scale	Construction

		investment(10,000yuan)		time
1	Dalian VTS	365	1station	1984-1988
2	Ningbo 1stage	850	3stations	1978-1982
3	Ningbo three stage VTS	1667	5stations	1998-2002
3	Tianjin VTS	4724	1stations and center	1985-1995
4	Qingdao yellow island VTS	860	1station	1984-1992
5	Qingdao 2 stages	1322	1station and center	1986-1996
5	Shanghai 1 stage VTS	6053	4stations	1985-1994

Source:Tian Hongwei ,2000.

Obviously, if the management level and equipment level of hardware improve ,the cost will increase ten times or even dozens of times.It is close to exponential manner between both investment and scale.

The figure below displays relationship of VTS between the cost and levels of administration.

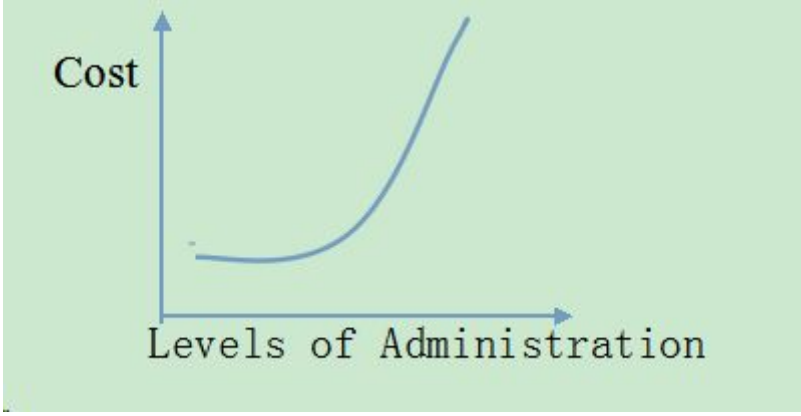

Figure 2- Relationship of VTS between cost and levels of administration

Source:the author，2014

It is clearly observed from the graph that when the VTS construction costs are at the low management level ， the curves become relatively flatter,but once management level become higher,the curve increases rapidly.

The figure below shows the relationship among passing traffic volume, ship accidents and management level（fujii ,1998,Project Post-Devaluation of VTS in China,pp.2-5）.

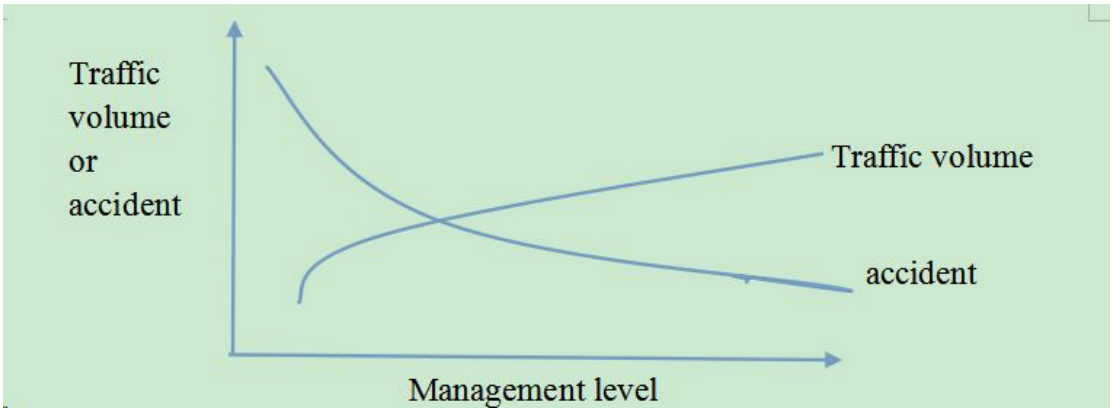

Figure3- relationship between traffic volume or accident and management level
Source：complied by author,2014

As can be seen from the above, the management level is low, the ship to reduce accident rate is more significant, and obviously the traffic volume rate increases rapidly.

But with the increase of management level, the traffic accident curve flattens

When the traffic flow reaches limit, even continuing to improve the level of traffic management, it will also be of no help.

Because the traffic volume can only stay at a certain level, and the number of accidents is relatively stable.It suggests that the management level at a certain level, if continuing to increase, improving vessel traffic flow and reducing the number of traffic accidents are not obvious.

With all these analyses, it is obvious that the higher VTS management level ,the larger the cost will be.The management function is stronger, the greater the VTS revenue should be, and vice versa.When the investment in its management functions, while the cost is larger, but management function can not be exerted sufficiently.As a result,its costs are difficult to recover and will cause waste.

When VTS management level is low, the management function of the VTS is insufficient.The returns in the long term may be small, repeated construction make

waste.Therefore，only the VTS investment is adapted to its management level, it is the best investment. That can create the greatest social and economic benefits(Fang xianglin, Shaozepin , 2002,p.1).

Chapter 3

The Methods of Cost Calculation

A cost is the value of the total of various expenses that occur when a business makes items, and provides services.It includes the sum of the quantity of the product , the source of productive factors , each unit price and so on.

3.1 The composition of the cost

The cost of VTS is the expense related to the VTS . IALA consider that the cost components of a new VTS consist of two distinctive elements, namely the initial investment costs and the lifetime operating costs(IALA,2012,p.70).

The investment costs are the total costs initially incurred for investments such as:

- preparation (e.g. feasibility studies, tendering, procurement, legislation);
- equipment purchase and installation (e.g. radar, VHF and other communication, computers, software, VTS work consoles, vessels/vehicles);
- building works (e.g.VTS centres, radar locations, VHF masts, power/water/telephone connections);
- project management and administration (including intermediate measures);
- organization set-up (e.g. recruitment and training of staff).

The operation costs are the annual costs incurred over the lifetime of the VTS for expenditure such as:

- maintenance and repairs of the building works (including spare parts);
- personnel (including replacement and additional/refresher training);
- insurance cover (if appropriate);
- maintenance and repairs of the equipment (including spare parts);
- consumables (e.g. Power and data exchange).

According to the characteristics of the project engineering in China,the researcher argue that the cost of VTS consist of the cost of project construction , operation and other expenses.(Tian Hongwei ,2000,pp15-16)

(1)the cost of project construction

- Prophase investigation and test
- Plans, specifications, bidding and negotiation
- Infrastructure(power supply,telephone,waterway and so on)
- Buliding
- Purchase the devices and spare parts
- Installation, acceptance procedures, training

-Additional intermediate measurement

-During the study of management and administration and so on

(2)Operation and maintenance costs, mainly including the following ：

- Labor costs (such as wages, welfare training）;
- Energy (equipment, heating, air conditioning）;
- Rates (radio link, data and telephone cables）;
- Training;
- Publications (user information, chart);
- Materials (spare parts, replacement parts);
- Vehicle;
- The potential spending for a third party;
- Technical team or entrust;
- maintenance (hardware and software system)s;

(3)General administrative management, mainly including management, business, meeting and insurance, etc

Generally speaking, a large-scale national economic life of the work plan to share four types:

- Research Development Test and Evaluation abbreviated to(RDTE);
- Equipment and capital investment

• cost during the lifetime

• Benefits during the lifetime

The first three items are contained in the costs.

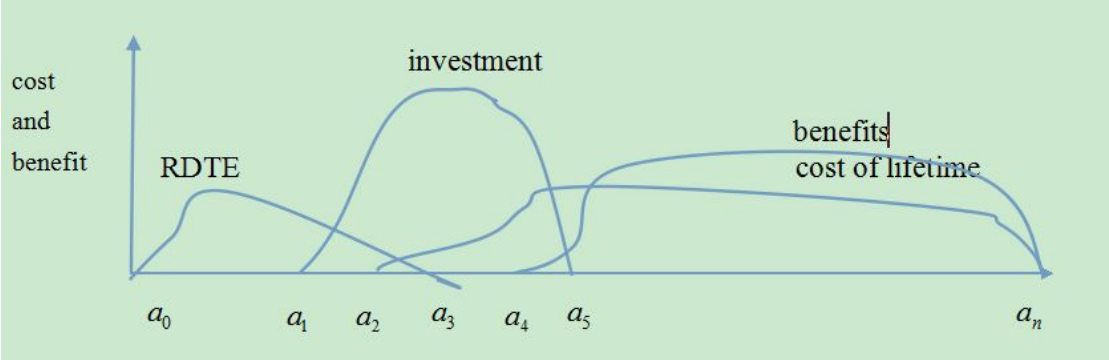

Figure 4- diagrammatic sketch of the economic life of VTS

Source: Shao Changfeng.（2002）

A large and complicated plan always contains many RDTE.Before the realization of the benefits.The up-front cost can seem pretty high in the beginning,even the process often stretches out to years ， but no benefits. Therefore, the overlapping of expenditure is a common occurrence.

Actually ,testing and evaluation as well as the limited research and development will continue during the whole investment，Profit is lagging

For instance, the VTS is equipped with radar chain, after the completion of each radar chain, the usage charges.

Sometimes at the end of the last radar station to put into use and keep steady running state, some problems can be solved.

3.2 Estimation of Method with respect to VTS Cost

Cost estimating methods are generally macroscopic method and microscopic method.Usually only one of them is used.The macroscopic method is that based on the similar system statistics and research,we can find the cost estimating internal relations.Microscopic method is to estimate labor cost , miscellaneous expense, management and profit of each element.Sometimes,we can use the two method at the same time.

Chapter 4

VTS benefit analysis and calculation

VTS benefits is all the contribution to the national economy.In quantitative analysis ,it is expressed in currency value .

The Beneficiaries of the country are people on board are shipowners, port services departments, other ship ,the people live in or along the coast waterways and so on.

Because the benefits of VTS have a wide range and the uncertainty,some aspects are difficult to make the quantitative description ,such as the quantitative of life expectancy, the consequences of environmental pollution accidents, and VTS benefit to strengthen national defence,the quantitative calculation of the benefit of VTS mainly aiming at the benefit of operation ,as follows:the benefit of improving the safety and efficiency of navigation, safety of life and the protection of the environment.

But it is difficult to calculate other benefit quantitatively ,it only makes a qualitative analysis.

In western countries,the VTS is understood as a kind of service, but clearly this is not the only possible viewpoint.For example ,in China,VTS is considered as the administrative authority which could order the vessels to stop taking actions.

In this paper, according to China's actual conditions , VTS benefit is divided into service ,management and marginal benefits.

In fact,based on the different culture background,in China management can also be understood as a service, but it is necessary to separate from the VTS service benefit when we make the qualitative analysis in order to clearly reflect VTS benefit.

In the quantitative analysis, management and service benefits are often integrated together to work, when it is carried on the quantitative calculation, it is the combination of management profit and the service profit.

4.1 The Qualitative Analysis of VTS Benefit

4.1.1 The Service benefit analysis of VTS

Service benefit of VTS is the benefit when deemed necessary by the VTS or at the request of a vessel.

It can be divided into three types：the benefit of improving the safety and efficiency of navigation and the protection of the environment.

1）profit of traffic safety

The VTS can use three ways to improve marine traffic safety: prophetically prevent the unacceptable risk ;

To assist safety meeting by the scientific prediction above；

keep the ship within the navigable waters.

As the traffic safety,the benefit depends on its type, and their level of management.

(a)The information service (INS)is provided by broadcasting information at fixed times and intervals or when deemed necessary by the VTS or at the request of a vessel, Usually,INS is provided for all vessels.It makes the vessels better accommodate the real conditions so as to realize the safety of traffic flow.

For example ,it is illustrated that the data of ZhouShan(ZS) VTS by the following table in 2010:

Table3-the relevant data of ZS VTS

	Service area	All year	monthly average	daily mean
Receive report	Cezi island area	47452	3954	130.0
	Majishan island area	13395	1116	36.7
INS	Cezi area	52249	4354	143.1
	Majishan area	2337	195	6.4

Source:complied by the author

(b)Traffic Organization Service(TOS)

TOS helps the vessels prevent the danger.IMO Resolution A.857(20) defines it as：A Traffic Organization Service (TOS) is a service to prevent the development of dangerous maritime traffic situations and to provide for the safe and efficient movement of vessel traffic within the VTS area.Obviously, TOS is involved in the development of the scheduled plan to prevent a dangerous situation.

Its benefit mainly embodies in avoiding the danger when the seaman can't see the smaller ships even after careful lookout,then cannot foresee the risk.Benefit not only depends on the knowledge of the location of the ship, but also depends on the ship identification , size, goods, movement status and destination, etc

In addition, it still depends on the traffic range and reliability, because the service as a kind of strategic measure, and it is basis of the hypothetical future

For instance，the port VTS in China organize the traffic to some extent.

Especially in bad weather conditions,its effect is particularly significant.

(c)Navigational Assistance Service(NAS)

NAS is a service to provide such information and advice to assist on-board navigational decision-making .

As a tactical measures, it reduces the dangers of actual movement which still exists in the strategic plan .

The benefit depends on the display resolution and accuracy, identification number and availability of some ship data , as well as the always available communication lines.

If the relevant ship position is on route, adjacent traffic conditions and course advice can be supplied continuously, then the service has been proved to the contribution to traffic safety.

(d)Allied Service

To carry out allied service and other aspects of cooperation is a kind of support service which uses common database exchange information and keeps the action consistent.

The benefits from the following aspects：

When making the voyage plan ,we can take the advantage of resources of the the allied service .We can implement previously determined incident plans to assist emergency services.We can provide information in advance for adjacent VTS ,even the traffic and the agreed actions can interact with each other.

This can reduce the probability of accidents and the consequences and avoid adverse impacts on the traffic

2) Benefit Analysis of VTS due to the Traffic Efficiency

VTS can avoid delays and make the traffic flow optimization to improve the traffic efficiency.

To get the benefit in this aspect ,it depends on its type, or management level,that is to say, it provides the function of service and operation。

(a)INS can ensure that ships can get important and timely information ,and in some cases it can confirm the ship on decision-making navigation so as to avoid unnecessary delays.

For instance,VTS can offer passenger information, provide the the information about the foreign ships for the pilot's in order to reduce the delay of the ship.

Table4-the number of INS in Zhoushan VTS area in 2010

	Service area	All year	monthly average	Daily average
Receive reports	Cezi	47452	3954	130.0
	Majishan	13395	1116	36.7
TOS	Cezi	52249	4354	143.1
	Majishan	2337	195	6.4

Source:complied by:the author

(b)TOS can make the vessel voyage plan adapted to arrangement of the VTS site facilities through the foreseen plan .the benefit is that it can avoid unnecessary wait .

Table5-the number of TOS in ZS VTS area in 2010

	Service area	All year	monthly average	Daily average
Receive reports	Cezi	47452	3954	130.0
	Majishan	13395	1116	36.7

TOS	Cezi	19403	1617	53.2
	Majishan	374	31	1.0

Source:complied by:the author

(c)NAS provide continuous and update navigational information and advice(If necessary)

This service is a service to aid a ship in difficult navigational or meteorological circumstances. This kind of service can reduce the delay of the vessel. Without such services,ships may not enter the VTS area, delayed without leaving berth or speed up .

Table6-the number of NAS in ZS VTS area in 2010

	Service area	All year	monthly average	Daily average
Receive reports	Cezi	47452	3954	130.0
	Majishan	13395	1116	36.7
NAS	Cezi	207	17	0.6
	Majishan	173	14	0.5

Source:complied by the author

(d)The cooperation with the allied service,emergency services and adjacent VTS.

The support and data exchange service can offer allied service forecast information and make profit.The cooperation can provide the ship data and navigational assistance for ships and shore-based emergency services , so as to optimize the arrangement of their resources , traffic throughput and the use of available facilities.It can increase their navigational efficiency if necessary.In addition , to exchange ship data with the adjacent VTS to better use the available data and avid using VHF unnecessarily.

3)the benefit analysis of VTS due to environmental protection

To improve the services and functions of traffic safety has made important contributions to the protection of environment.However, there are some additional facilities in VTS to improve the environmental protection,as follows:

(a)For carrying dangerous goods and hazardous cargo ships ,VTS should strengthen the traffic organization and aid them to prevent accidents.

(b) To report ship movements which carry dangerous and harmful goods information to the competent authority in order to help them to check.

Thus, VTS eliminates unsafe factors and enhances the port security which plays an important role, and the management benefit is enormous.

(c)the benefit of monitoring the assistant navigation facilities.

VTS can monitor the AIDS to navigation within the VTS area, timely remind the vessels which endanger the safety of AIDS to navigation to avoid collision, in order to To improve the integrity rate of the AIDS to navigation.

VTS can also find shift and lost beacon in time.VTS can save the maintenance cost of AIDS , also bring indirect benefits for the vessel traffic safety and efficiency.

4)Identify potential sources of pollution, so as to reduce illegal discharge deliberately

4.1.2 The Management benefit analysis of VTS

Management benefit of VTS is that the VTS ,in accordance with relevant regulations, finding the vessels violate the rules and regulations or which is in danger,then order the vessels take actions to avoid the accident in order to gain the benefit.

It mainly reflects the following aspects：

(a)Find and correct ship violation, improve efficiency of navigation and anchoring order so as to create the profit.

VTS operator(VTSO) can monitor ship in the waterway whether lieto ,anchored arbitrarily，overtake illegally through the ship's radar tracking or not.

If the seaman do not follow the advice of VTSO， in accordance with the voice and image records VTS can give education and administrative penalties.

In this way,the navigation environment of the port waters is improved. In addition,it can ensure the safety and efficiency of vessel traffic and environmental protection which brings benefits, and save manpower, and material resources.

Table7-the data in Zhoushan VTS area

	Service area	All year	monthly average	Daily average

Receive reports	Cezi	47452	3954	130.0
	Majishan	13395	1116	36.7
correct violation	Cezi	1612	134	4.4
	Majishan	98	8	0.3

Source :complied by the author

(b)the benefits of monitoring safe navigating vessels

VTS operator can monitor the mooring ships and sailing ships in VTS area,and rectify the unsafe factors.To timely correct the existence of the risk of collision ,anchor positon insecurity,dragging and so on,so as to bring higher benefits.

Table8-the avoid danger data in Zhoushan VTS area in 2010

	Service area	All year	monthly average	Daily average
Receive reports	Cezi	47452	3954	130.0
	Majishan	13395	1116	36.7
Avoid dangerous situation	Cezi	633	53	1.7
	Majishan	202	17	0.6

Source:complied by the author

4.1.3 The Marginal Revenue Analysis of VTS

The marginal revenue of VTS is that due to the construction and operation of VTS,it brings the revenue and is mainly improving the reputation,defense, ship insurance and so on .

(a)VTS as a modern management tool has become an important symbol of modern port.Through VTS service, it can promote the navigational safety of ship in the port, improve the efficiency of vessel traffic, make the Chinese and foreign ship in or out the port with a sense of security.The improvement of the credibility of the port can improve their competitiveness in the shipping market.In addition,because of the VTS service,it ensures the normal production and timely delivery of the shipping and the owner . This can generate the indirect benefits.

(b)VTS can monitor illegal vessels by modern management tool, and it even can carry on allied activities with navy in time of war.That can maintain the authority of the state and bring indirect social benefit.

(c)As a result of the VTS service,it can reduce the number of vessel traffic accidents and reduce shipping insurance compensation.

4.2 The Quantitative Calculation of VTS Benefit

It is an important principle called with and without Principle (Captain Robert.G.Ross.US,1998)that it can be used of the quantitative calculation of VTS benefit.The calculation of VTS benefit needs some the statistics with or without VTS, normally one year as a statistical period, its benefit is always expressed in monetary value.

Benefit is mainly reflected in the improvement of traffic safety in VTS area ,the increase of the channel transit capacity such as in fog,in dark and benefit of environmental protection.

Thus,the benefit in these aspects needs the quantitative calculation.

The definition and calculation method are described below:

Monetary unit is ten thousand yuan RMB.

4.2.1 The Safety Benefits Calculation of VTS

VTS can improve the traffic safety, mainly reducing traffic accidents (referred to as VTS can avoid accidents such as collision aground) brought about by the benefits

The calculating formulas is:

VTS profit per year=(annual average number of accidents within VTS area relative to the number of the accidents without VTS reduce rates) × (Annual average accidents loss within VTS area) (1)

1)the quantitative of risk degree

Improving safety means reducing accidents and risks

VTS can influence ship decision-making process.Firstly, and it can be prescient arrangements to prevent a dangerous situation in the future. Secondly, it supplies added ship information for the execution of the current manoeuvre.

In both cases ,we should avoid the unacceptable risk , which means how to quantify risk.

several quantitative methods of risk is shown as follows:

1) the mathematical analysis of risk degree

(a)Collision probability

The risk of maritime accident is the traffic accident rate in an certain waters ,and it is mainly the risk of the collision, stranding,rocks, etc.

The first type of traffic accidents is the collision accident, due to the aground, rocks and touching accidents can come down to the collision between ships and underwater or overwater fixed objects.

Thus the study of the risk of collision at sea is not only meaningful for sea ship collision accidents, also for aground and rocks.

Collision rate directly reflects the marine traffic risk ,but it can not reflects potential marine risk.Based on the analysis and research, it seems that using the actual collision rate or encounter rate to assess the risk of collision at sea are not comprehensive, so this paper adopts the method of collision probability assessment the risk of collision at sea.

The most important representatives are Fujii method and Lewisn method(Wu Zhaolin, 1993 ,p.286).

Collision probability is defined as the ratio of collision frequency in an area per unit time with estimates of geometry by Fujii(Shao Changfeng ,2002,p.28).

The formula is:

$$P = N_g N_c \qquad (2)$$

In the formula:

P -collision probability based on the geometric collision frequency;

N_c - actual collision frequency in one area during one period;

N_g -estimated geometric collision frequency。

Geometric collision frequency is that for all ships with autopilot navigate at a certain course and speed, collision frequency will happen.

Based on the above method,Fujii got the results of the collision probability in the Japanese waters from 1970 to 1981.(Shao Changfeng ,2002,p.28).

log P =-4.08 ± 0.16 collision during overtaking (Nc＝41)

log P =-4.86 ± 23 collision under the hend-on situation(Nc=25)

log P =-4.9 ± 0.18 collision under the crossing situation(Nc=18)

logP=-4.44 ± 0.43 collision with the working fish vessel(Nc=33)

Fujii thinks the collision between ships or collision between ships and fixation, the collision probability P is normally about 1/10000.

The study is based on the assumption that there may be a universal value (P) all around the world.This P is a function of multiple variables,such as weather,category, nationality of ship and so on.

Lewins defines the collision probability as the ratio of the actual collision frequency and the estimation encounter frequency per unit time(Shao Changfeng ,2002,p.28).

The expression is:

Pen=Nc/Nen (3)

Where Pen-collision probability based on the encounter frequency;

Nc-actual collision frequency in one area during one period;

Nen-estimated collision frequency in this area during one period.

According to the different visibility and encounter situation Lewsin also can get the collision probability , respectively,and then summed to get the result of total collision probability.

The expression is:

$$P = \sum P_{ij} = \sum \frac{G_{ij}}{N_{ij}} \qquad (4)$$

Including: P -collision probability based on the encounter frequency;

P_{ij}—actual collision probability under visibility （i）encounter situation（j） ;

Nij—estimated collision probability in visibility （i）encounter situation（j）;

i-visibility(sunny,fog,and smog);

j-types of encounter situation(head-on,overtake and crossing)。

(b)encounter rate

Encounter is a concept or traffic model put forward by a maritime traffic engineering scholars in the study.

They defined one condition that“if two vessels keep their course,relative distance between them is below a certain value”as encounter.Encounter rate is defined as the number of encounter per unit area and per unit time.

About the forecast of the number of potential encounters in certain waters,Mr Fujii、Lewison and so on had put forward solutions.

A brief introduction as follows:

As illustrated in Figur5.Suppose that there is the traffic flow A and traffic flow B within objects waters which Length is D width is W.

We can calculate the number of the encounters during one vessel in the traffic flow A showed in this graph navigate the distance D meet the traffic flow B. A certain distance defined in the previous article is supposed as encounter radius r.

The time for a ship navigating distance D in traffic flow A is D/ V_A ,

The number of encounters with traffic flow B Within distance D is the number of vessels traffic flow B within the area as shown diagonal lines in the picture(Shao Changfeng ,2002,p.25).

If the area is M，there is：

$$M = A_1B_3 \times 2r = 2r \bullet D\left[1 + (V_B / V_A)^2 - 2(V_B / V_A)\cos\theta\right]^{1/2} \quad (5)$$

due to traffic flow B density, $d_B = N_B\sqrt{A_1}B_3V_B$

So number of meetings per unit time called encounter rate λ is(Shao Changfeng ,2002,p.26).：

$$\lambda(1, N_B) = M \times d_B /(D / V_A) = 2r \cdot d_B(V_A^2 + V_B^2 - 2V_AV_B\cos\theta)^{1/2} \quad (6)$$

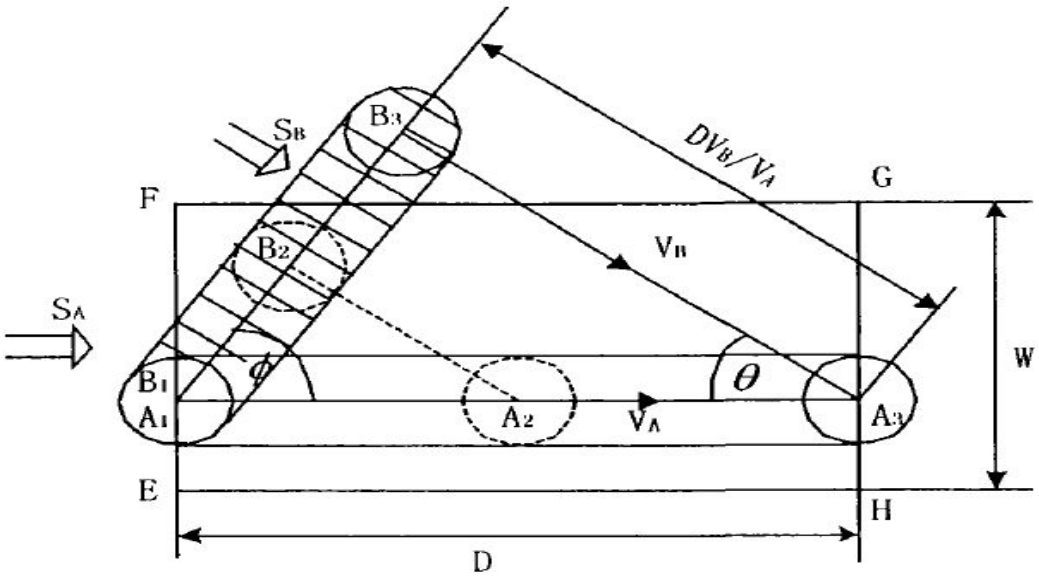

Figure5-analysis of the encounter between cross traffic flow and the main traffic flow

Source: Shao Changfeng.（2002）, Study on VTS benefit Evaluation and Risk Assessment .Dalian Maritime University, China,Dalian.

If the density of the traffic flow A is d,the encounter rate per unit area in this waters is(Shao Changfeng ,2002,p.27).:

$$\lambda（N_A，\ N_B）= 2r \cdot d_A \cdot d_B \left(V_A^{\ 2} + V_B^{\ 2} - 2V_A V_B \cdot \cos\theta\right)^{1/2} \quad （7）$$

In other words, it can be most conveniently expressed by encounter radius,the density of traffic flow, relative velocity vector.

According to the different type, encounter radius can be determined in advance; Traffic density can be determined through simulation; The speed of the traffic flow is determined by ship's velocity distribution and then the relative speed vector can be found out.

Lewisn uses pure mathematics method, assuming that the two vessels flows meet each other, the encounter area is defined as a circle with a radius R,the estimating encounter frequency is shown by the formula(Shao Changfeng ,2002,p.27)..

$$N_{en} = \frac{2R \cdot S_A \cdot S_C}{\sin\theta} \int_0^\infty f_C \cdot dV_C \cdot \int_0^\infty \frac{f_A}{V_A} \left[1 + \left(\frac{V_A}{V_C}\right)^2 - 2\left(\frac{V_A}{V_C}\right)\cos\theta\right]^{\frac{1}{2}} dV_A \quad （8）$$

including:

N_{en} —encounter frequency；

R —encounter radius；

S_A —the throughput capacity every hour on the unit width of traffic flow A , also known as the flow rate

S_C —flow rate of traffic flow C(actual observed value)；

V_A —speed of traffic flow A(actual observed value)；

V_C —speed of traffic flow C(actual observed value)；

f_A —The ship velocity distribution of traffic flow A(actual observed value)；

f_C —The ship velocity distribution of traffic flow C(actual observed value)；

θ — the Angle between the main flow direction of two traffic flow (Angle of encounter)。

In this article, the domain of encounter rate is defined in the range of [0, 1], and is divided into 3 classes, i. e. high, middle and low.The membership function is illustrated as below:

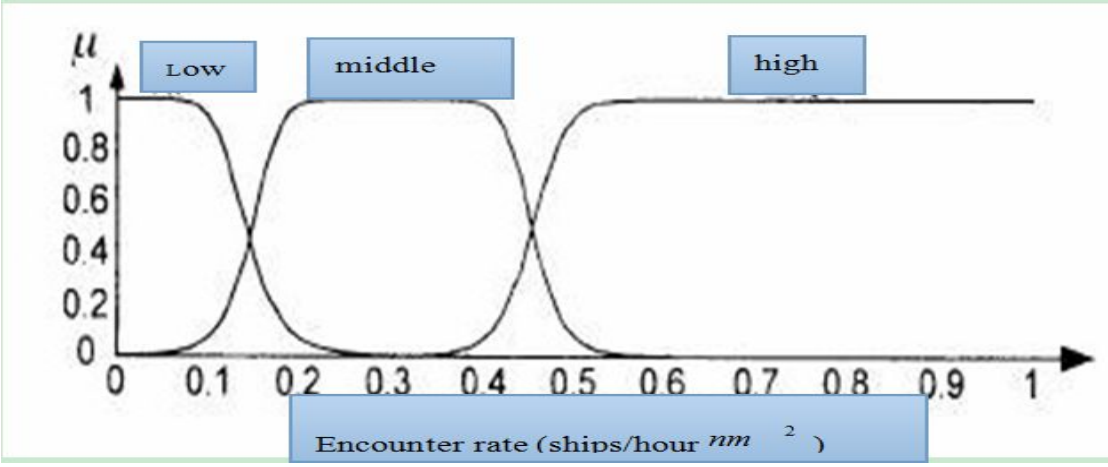

Figure6-the curve about the membership function of encounter rate

Source:Shao Chang feng, 2002

Encounter rate in the Ningbo VTS area： From September 12, 2010 to September18, 2010 , the actual observation data are input the formula ,the encounter rate is

calculated .The result is 0.77 ships per hour square nm.Obviously,this area is the waters with high encounter rate.

There are several methods,as follows:

(a)To estimate the existing situation and the experience.

For instance, we can get the value of the accident rate through statistical analysis.

Accident rate depends on the channel type, traffic distribution and relevant environment parameters.

The advantage of this approach is that it considers the objective reality

The disadvantage of this approach is that conditions and parameters can not accurately know, and even change when it is considered.

(b)Make empirical estimates by the practical experience.

Along the channel the risk of traffic can be estimated by the experienced seamen.

The advantage of this solution is: fast assessment and low cost.

Defect is: empirical estimation is subjective ,and at the same time in the new conditions it may be invalid.

(c)Mathematic model

Mathematic model is a calculation Method Based on Ship Domain Model.ship domain is the area around ship but the other ship should not enter .

Advantage :To some extent, it is objective;

Disadvantage :The application for narrow channel is not very ideal.

(d) simulation method

Within one simulation,degree of safety in certain situations can be tested.

It can be simulated on the computer, and it can also be tested in the operate emulator .

The advantage of this method is:it can get the repeated measure data in short time which has statistical significance. Simulator and the operator can contain human factors .

Weakness:The reliability of the simulation and the accuracy of detection is more difficult.

(e)Sweep path and estimation of the ship trajectory

This is a combination of several methods.Ship trajectory was recorded, waterway cross section shows the distribution of track, the overlapping between the distribution characteristics of different traffic direction displays collision risk .

For example,the graph below is distribution characteristics within Ningbo VTS area.

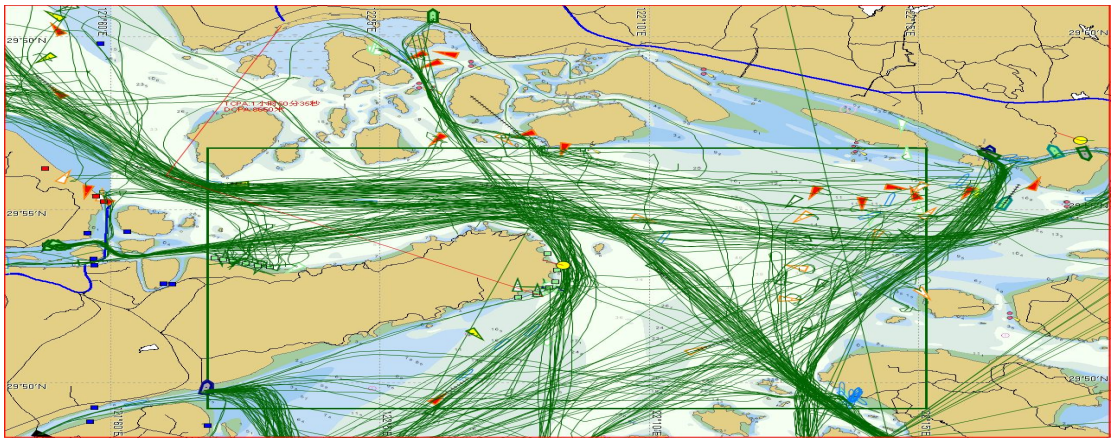

Figure7-Traffic distribution 0700-2300 in Sep 19th,2010

Source: complied by the author,2011

Through comparison and analysis of the track, in combination with the practical density ,ship types ,ship speed and other factors, we can conclude that there are seven node location where the high collision risk exists .it shows in the graph below:

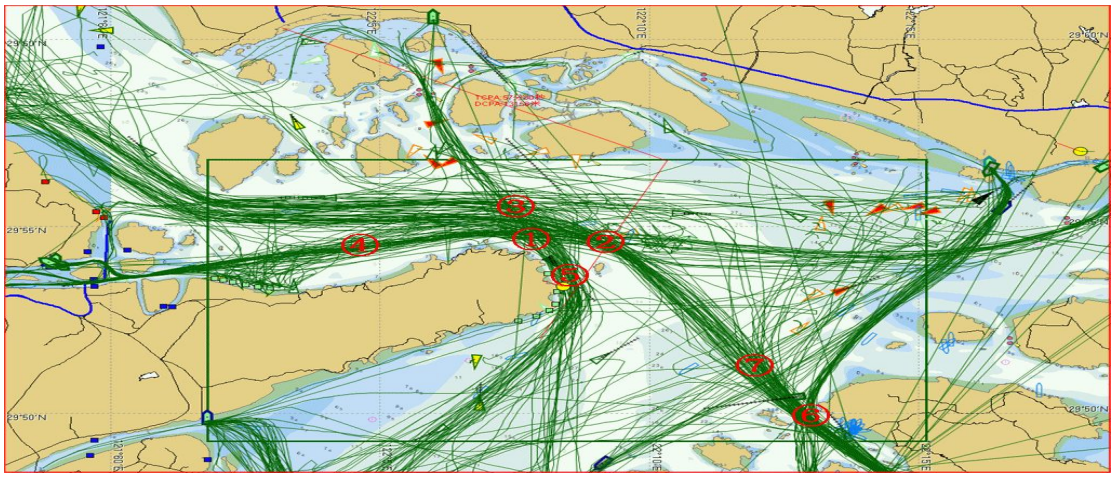

Figure 8- seven node location within Ningbo VTS area

Source: complied by the author ,2011

The advantage of this method is:it can provide sufficient track in short time which has statistical significance.

Weakness:The recorded track does not always correspond to intersection situation, and therefore it is not representative.

Obviously, all methods have advantages and disadvantages; it is not a perfect method,hence in most cases, we can use several methods.

we will discuss several kinds of mathematical calculation methods about the marine traffic.The considerations above contains many aspects of quantitative risk . These problems are useful for VTS to reduce the potential risk.

2)The accidental factors of the accident

Some researches suggest that 80% of accidents are caused by human errors.

23% of them are violation of the rules and regulations and wrong decision-making when meeting and overtaking vessels,2% is associated with high speed,16% is environment estimation error,11% is error of navigation,such as out of control ,6% is the communication error.

3)processible dangers

Statistics show that a VTS which provides information services and traffic organization service can reduce 50% of accidents in areas of high traffic density.

Some announce that within TSS (traffic separation scheme)in international waters, VTS can reduce 20% accidents with limited infrastructure.

The safety benefit of the VTS is also very significant in our country。

Take Tianjin VTS for example,since 2002 the port VTS benefit evaluation system has been operated between Tianjin VTS and DaLian Maritime University cooperative ,the value of Tianjin port VTS benefit assessment increases year by year.In 2008 the benefit evaluation ended，direct social benefits produced by Tianjin VTS is as high as 69.43 million yuan, compared with 2004, 29.12 million yuan, increased by 140%, among them, the benefits in terms of traffic safety, but also increased by nearly 400%.From 2003 to 2008， accident rate in Tianjin port waters fell to 0.08% from 0.026%, year-on-year decline in 67.5%

Obviously, the VTS safety benefit in China is close to the figures published by the European and American countries VTS.

Thus we can infer that a valid VTS through the vessel traffic management and information service, can reduce the 1/3 loss of vessel traffic accidents.

4.2.2 The benefit of promoting the VTS efficiency

The benefit of VTS efficiency is :improving the channel transit capacity,improving the transit capacity in fog and transit capacity at night.

1)The benefit of raised the channel transit capacity(10,000yuan/year)=(annual weighted traffic volume within VTS area)x(standard ship number days)x(mean reduced navigation time due to VTS/ship)

The simplified formula is:

$$E = \sum B_{mn} T_{mn} \quad (9)$$

In the formulas:

m-the number of providing NAS for the n types of tons ship per year;

n-classification ships cost per day among different tons per day ;

Bmn- one ship-day expense

Tmn-mean reduced navigation days due to VTS/ship

For example, the NingBo VTS provided navigational assistance service(NAS) 10 times for 20000-ton ships, each time NAS can reduce the passing time 8 hours;provided navigational assistance service(NAS) 20 times for 10000-ton ships, each time NAS can reduce the passing time 12hours;

provided navigational assistance service(NAS) 10 times for 5000-ton ships, each time NAS can reduce the passing time by 12 hours;

Suppose that as 20000 deadweight tonnage ship,the one ship-day expense is RMB 1,5000yuan;as 10000 deadweight tonnage ship,the one ship-day expense is RMB 1,0000yuan;as 5000 deadweight tonnage ship,the one ship-day expense is RMB 6000yuan.

The benefit of raised the channel transit capacity per year=1.5X10X8/24+IX20X12/24+0.6X10X12/24=18(10,000yuan).

2)the Benefit of raised passing through capability of fog day

Benefit of raised Passing through capability of (fog day)(10,000Uyany/ear)=(average fog days within VTS area Per year)x(standard ship numbers need aid from VTS per fog day)x(reduced navigational time delay for each ship)x(berthing cost of each standard ship)

The simplified formula is:

$$E = \sum B_{mn} T_{mn} \quad (10)$$

m-the number of providing NAS in fog days for the n types of tons ship per year;

n/Bmn/Tmn-the same as above

3) benefit of improving the navigation at night

For the port with restricted navigation at night and restricted by other cause,VTS can improve vessel night navigation ability.

Benefit of raised night passing through capability of (fog day)(10,000Uyany/ear) =(increased rate of vessel navigating at night)×(Benefit of standard ship navigating days)×(weighted traffic volume in VTS area)×(vessel shipping time due to increased night sailing ability)

The simplified formula is:

$$E = \sum B_{mn} T_{mn} \quad (11)$$

m-the number of providing NAS at night for the n types of tons ship per year;

n/Bmn/Tmn-the same as above.

The calculation of the three aspects above is getting benefits by the VTS to avoiding shipping delays and accelerating port cargo turnaround.

By data exchange in VTS area, it also contributes to the traffic efficiency.

Due to the better arrangement of resources (pilot, tugboat, gate , the port facilities, etc), further benefit can be improved.

4.2.3 VTS benefits of environments protection

VTS benefit of environments protection is that the benefit is gained while it avoids pollution from the vessels which carry dangerous and harmful goods when traffic accidents happen and avoid pollution dispersion.

The formula is:

Benefit of environmental protection(10000yuan/year)=(annual average decline rate of pollution accident)×(annual average value because of Pollution within VTS area)×(reducing cost because of discovering the pollution accidents in order to avoiding pollution dispersion) (12)

To reduce rate of pollution accident due to application of VTS , it can be obtained by statistical calculation for different management level VTS .

Direct loss of ship pollution accidents usually can be gained by calculating the removed pollution.It is difficult to calculate indirect loss because of pollution accidents.The interior ministry of the United Statesthe developed coastal and marine environment natural resources damage assessment model(NROAM/CME) to solve the problem(Yan Fashan,2003 ,p.43-54).

(NROAM/CME)This model provides a simplified evaluation,which only requires a small amount of field observation, including measuring unit discharge or destruction of the affected area.

NROAM/CME can estimate the effect of Marine animals when the 46 kinds of oil and chemical substances discharged into the ocean .

The software discs of model can be bought from the National Technical Information Service Center of USA.But information security should be considered.

The reducing cost per year because of discovering the pollution accidents timely in order to avoiding pollution dispersion can be calculated can be calculated by the sum of total loss due to pollution dispersion in one year.

4.2.4Material Benefit of Reduced Manpower

Such as the number of manpower reduced,annual average salary,decrease buoys,cruise boats and less cruising time.

VTS can provide first-hand information for the department of ports by collecting information so as to gain benefit from the number of men power reduced,lower the maintenance costs of buoys, decrease cruise boats and less cruising time,lower the communication cost.Because the ports have different situations ,it should be calculated separately.

The paper above considers main benefits of VTS ,but indirect social benefits produced by the VTS actually, such as the loss of the spirit due to traffic accident casualties , defense profit, the benefit of the port's credibility, enhancing the benefit of the social insurance, etc.Because the social benefit is hard to quantify, the real benefit will be greater than the above value calculated .

4.2.5 A Summary of the Quantitative Calculation of VTS Benefit

The benefit of the VTS is equal to the sum of the Benefit of reduced manpower,material and consumption.environments protection,promoting the VTS efficiency,Safety .

So it should focus on benefits of safety, efficiency and environmental and collect the relevant data carefully.Only to collect the data fully, the results can be closer to the reality.And indirect social benefits are difficult to quantify, but we should be clear that real income is far greater than calculated value.

Chapter5

The Evaluation Index System of the VTS Benefit

Social goal of VTS study is basic principle of maximizing the net social benefit, so the evaluation index system is commonly used to adopt formula which get largest benefit and satisfy constraint value of a certain social resources. According to the economic evaluation principles, evaluation index system of VTS （Fang Xianglin,1998）is as follows:

1）Economic Net Present Value(ENPV)

ENPV is the index reflecting project contribution to the national economy.

The formula is:

$$ENPV = \sum_{i=0}^{n} \frac{B_{Ti} - C_{Ti}}{(1+r)^{i}} \qquad (12)$$

Where n is calculation term, B_{Ti} / B_t below is the Benefit of VTS i or t year;C_{Ti} / C_t below is the cost of i or t year,i or i_s below is the social discount rate. $B_{Ti} - C_{Ti}$ is the net benefit of VTS i year.

2）EIRR

Economic internal rate of return(EIRR) is the index reflect the project's net contribution to the national economy.(Zhou Huizhen , 2003,p.288-385)

The formula is :

$$\sum_{i=0}^{n} \frac{B_{Ti} - C_{Ti}}{(1+EIRR)^{i}} = 0 \qquad (13)$$

Internal rate of return is widely regarded as the profitability of the project investment.It reflects the investment efficiency.

When economic internal rate of return is equal or greater than the social discount rate,it shows that project's net contribution to the national economy at or above the required level. Then the project should be considered as acceptable project.

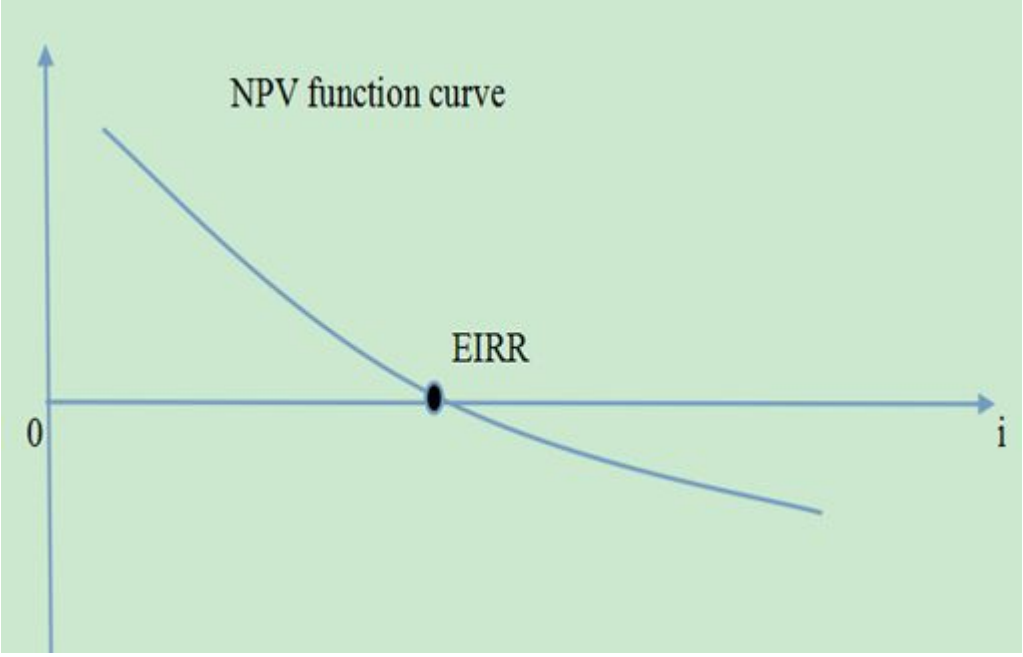

Figure9-NPV function curve and EIRR

Source:Zhou Huizhen（2003）

3）BCR

Benefit cost rate reflects ratio between all the contribution to the national economy and the cost for the project.the formula is:

$$BCR = \frac{\sum_{t=1}^{n} B_t \frac{1}{(1+i_s)^t}}{\sum_{t=1}^{n} C_t \frac{1}{(1+i_s)^t}} \qquad (14)$$

When BCR>l,Operating of VTS is normal. The bigger the ratio, the bigger the social benefit.

4) stable investment recovery period(Tp)

Investment payback period in capital budgeting refers to the period of time required to recoup the funds expended in an investment.

The formula is :

$$\sum_{t=0}^{T_p} NB_t = \sum_{t=0}^{T_p} (B-C)_t = K \qquad (15)$$

Where K is total investment,

B is benefit t-th year;C is the cost t-th year ;NBt is net benefit t-th year.

5）The Dynamic Payback Period(Tp*)

$$\sum_{t=0}^{T_p^*} (CI-CO)_t (1+i_0)^{-t} = 0 \qquad (16)$$

Where Tp^* is The Dynamic Payback Period;

CI is the inflow of cash t-th year

CO is the outflow of cash t-th year

i0 is basic discount rate.

6)Social discount rate(i)

Social discount rate is given by National Planning committee,usually the current social discount rate is used.

7)Selection of base year

Usually, the year when VTS was Put into operation should be selected.

8)Calculation term

Generally ,the lasting time of VTS is considered as being 15 — 20 years .

The calculation term contains operating period and construction period.In general operation period is considered to be15 to 20 years.

Chapter 6

Example Analysis

Dalian VTS and Tianjin VTS have run for many years. According to the Tianjin port statistical data in 2010 and some data with respect to Dalian VTS,this study will use the cost-benefit calculation method above respectively to carry out the example analysis.

1)Based on cost benefit analysis of the Tianjin VTS ,benefit and cost flow of the national economic evaluation are listed in the table below;

Table9-benefit and cost flow of the national economic:10,000yuan

NO.	year / item	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	benefit			614	699	895	1030	1025	1289	1376
2	cost	4724	324	200	238	250	220	263	298	314
3	Net benefit			414	461	645	810	757	996	1062
4	Accumul-ated benefit	4724	5044	4630	4169	3524	2714	1957	961	101
5	NPV	4724	286	330	328	410	460	383	450	429
6	Accumlated NPV	4724	5010	4680	4352	3942	3482	3099	2649	2220

Continued table

NO.	year / item	2003	2004	2005	2006	2007	2008	2009	2010
1	benefit	1493	1609	1726	1842	1959	2075	2190	2306
2	cost	331	347	364	381	398	414	431	448
3	Net benefit	1162	1262	1362	1461	1561	1661	1759	1858
4	Accumul-ated benefit	1263	2525	3887	5348	6909	8570	10329	11187

5	NPV	419	406	392	375	358	340	321	303
6	Accumlated NPV	-1801	-1395	-1003	-628	-270	70	391	694

Source：Tianjin MSA,2011

Then we can get the results

Table10- VTS benefit evaluation indexes of a port

No.	Benefit evaluation indexes	Unit	results
1	ENPV（i=12%）	10000Yuan	694
2	EIRR	%	13.81%
3	BCR		1.14
4	Static investment recovery period	Year	7
5	Dynamic investment recovery period	Year	13

Source:complied by :the author

According to the results,it is crystal clear that NPV of the project is more than 0,and BCR>l,thus national economic benefit of this project is advisable.

2)Based on cost benefit analysis of the Dalian VTS

Suppose that the calculation term of the VTS is 15years and the social discount rate is 6%.

(a)Total investment in 1982:After adjusting price ， total investment of Dalian VTS project is RMB 3.65 million yuan in 1982。

(b)operating and maintenance cost :

The cost during 15 years converted to 1982 is 7.46million yuan.

(c)total cost by translation adjustment to 1984 =365+746=11.11million yuan

3)the calculation of benefit

The benefit of Dalian VTS is gained by reducing the traffic accidents,reducing waiting time in fog day and reducing the pollution accidents.

Table11-the benefit of Dalian VTS

NO.	Item / value	unit	Value
1	Safety benefit	10000yuanRMB	140
2	Benefit due to the	10000yuanRMB	72

	traffic efficiency		
3	Benefit of environmental protection	10000yuanRMB	40
4	total	10000yuanRMB	252

Source:complied by the author

Because other benefits are difficult to estimate accurately and the share is still small, we can ignore it temporarily .By the translation adjustment to 1982,we can get that 252 × 0.49097=124(10,000yuan)(0.49097 check the single-value conversion table,n=12,i=6%)

The total benefit during 15years is 124×15=1860(10,000yuan)

4)VTS benefit evaluation indexes calculation

Table12- VTS benefit evaluation indexes of Dalian VTS

No.	Benefit evaluation indexes	Unit	results
1	ENPV（i=6%）	10000Yuan	749
2	EIRR	%	10.7%
3	BCR		1.14
4	recovery period	Year	4.78

Source:complied by the author

According to the national economy evaluation Principles and the benefit evaluation indexes above the benefit analysis of the port is made as follows:

(a)EPNV=7490,000Yuan)>0. The VTS Project is proved advisable.

(b)EIRR=10.7% It is more than 6%.That is to say,it reach or over the required level.

(c)BCR=1.14 Obviously,it is morethan1. It shows that the project is worth the investment.

(d)Investment recovery period=4.78years

Suppose that the investment payback period is n years, 365 + n×98×0. 49097 =252 x0. 49097 ×n, n=4.78.

The national economy evaluation indexes is good,in other words,VTS project is advisable.

Chapter 7
Conclusion and Future Work

7.1 Conclusion

This paper, based on the research results at home and abroad,carried on the quantitative analysis of the VTS operation benefit .it is impossible to quantify on the qualitative analysis.

To create the CBA model,and to analyze the Tijian VTS and Dalian VTS.

The analysis of VTS benefit can deepen people's understanding of VTS function ;

And when the CBA was carried out,it must choose reasonable evaluation index on the basis of the characteristics of the respective VTS in order to make reasonable decision of construction.This is because it can make the advantage and disadvantage of the types,number,distribution become clearer.In addition,it no only saves lots of money and improve the efficiency,it also takes better actions of safety.

But we need to know to the environmental benefits of VTS operation, because there is no good method in theory;in practice there are no sufficient are the relevant data, which causes a blank the research area in China.

7.2 Future Work

(a)All users should operate the equipment correctly and be responsible for the daily maintenance to make the equipment stay in good order.Because the normal operation of equipments is the basis of gaining the benefit ,the training should be strengthened.

(b)Maintenance cost is enormous,in china almost all the VTS is import equipment from abroad, so training a repairing team can save lots of maintenance cost.even,the authority can carry on the technical reform by the domestic researchers.

This paper concludes that, the VTS priority is given to the localization of imported equipment and technical progress to reduce the cost.

(c)To establish regional VTS. Regional VTS has been achieved in Europe.For example the Danish government and the Swedish government established regional VTS called SOUND VTS. SOUND VTS located in Malmo Sweden was founded in 2007.the regional VTS can reduce the cost because of the scale increase effect.

(d)To increase technological exchanges with other countries' VTS, learning from each other in order to improve the construction and management of VTS.

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