A Ship Based Approach to Determine the Effectiveness of VTS Systems in Reducing Vessel Accidents in Congested Waters

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ABSTRACT

Safety has become a major issue in maritime community as the adverse effects of increased marine transportation have become a serious problem especially at congested waters like narrow straits, ports and port approaches. As a precaution, shore-based centers called VTS, have been used widely in these water bodies for monitoring, controlling, and directing the vessel traffic and also collecting and disseminating information about the traffic situation and navigational hazards. In this study the author explains the effectiveness of VTS systems in reducing vessel accidents by using the experiences and the perceptions of the mariners who had direct experiences on these systems as user. The maximum benefit to be obtained through the introduction of a VTS system was estimated by using the causal factors of accidents as a starting point on collisions and groundings. Also the results of this study have been compared with the studies that were done on this subject by different institutions and at different levels.

1- Introduction

In March 1967 the tanker Torrey Canyon ran aground off the South—West coast of England spilling 120.000 tons of oil into the sea. This disaster and clean-up costs along the coast totaled 2 million pound. For the first time general public were made aware of the danger that the maritime traffic posed to the environment and this accident promoted investigations into how such damage could be avoided in the future.

Before the 60 s the marine casualties affect a limited group of people such as ship and cargo owners, insurance companies and the crew but as result of technological developments in ship building sector, the demand for large ships and explosive and noxious cargoes which are carried, vessel casualties began to affect great communities, large areas and long periods.

The adverse effect of marine transportation becomes a serious problem especially at congested waters like narrow straits, ports and port approaches where the limited water bodies are used by great number of users for different purposes. Beside conventional waterway management tools, shore-based navigation support systems have been used widely in these water bodies for monitoring, controlling and directing the vessel traffic in these water bodies for more than 2 decades.

William O'Neil, Secretary-General, IMO stated in one of his speech that the principle of control had been accepted in all other modes of transport and there is no need for not extending it to shipping when safety would be enhanced . This statement is of great importance for the changing future of marine navigation. Masters and the officers may share their commanding authority with the shore-based centers for enhancing safety of navigation especially on coastal waters, ports and ports approaches, as it is at aviation. So the effectiveness limits of VTS systems and the factors effecting the VTS effectiveness must be identified and the mechanisms which will enhance the co-operation between ship and VTC must be developed.

2. VTS Definition and Legislative Background

Vessel Traffic Services (VTS) are the assortment of personnel, procedures, equipment, and regulations assembled for the purpose of traffic management in a given body of water. A VTS includes some means of area surveillance, traffic separation, vessel movement reporting, a traffic center, and enforcement capability. These functions are not dissimilar to the advanced air traffic control and management systems.

Although it was first introduced in 1948 at the port of Liverpool, the value of VTS in navigational safety was first recognized by IMO in Resolution A.158 (ES.IV), Recommendation on Port Advisory Systems adopted in 1968, but as technology advanced and the equipment to track and monitor shipping traffic became more sophisticated, new guidelines were needed on standardizing procedures in setting up VTS. As a result in 1985 IMO, adopted Resolution A.578 (14), Guidelines for Vessel Traffic Services which said that VTS was particularly appropriate in the approaches and access channels of a port and in areas having high traffic density, movement of noxious or dangerous cargoes, navigation difficulties, narrow channels or environmental sensitivity.

Revised Guidelines for Vessel Traffic Services, including Guidelines on Recruitment, Qualification and Training of VTS Operators , were adopted as Assembly resolution A.857 (20) in November 1997.These guidelines are associated with SOLAS Regulation V/8-2. In June 1997 IMO Maritime Safety Committee adopted a new regulation 8-2 to Chapter V — Safety of Navigation- which sets out when VTS can be implemented.The regulation states that VTS contribute to the safety of life at sea, safety and efficiency of navigation and the protection of the marine environment, adjacent shore areas, worksites and offshore installations from possible adverse effects of maritime traffic. Governments may establish VTS when, in their opinion, the volume of traffic or the degree of risk justifies such services . The new SOLAS regulation also states that; contracting governments planning and implementing VTS shall, wherever possible, follow the guidelines developed by the organization. The use of a VTS may only be mandatory in sea areas within the territorial seas of a coastal states.

According to official definition of VTS at IMO Resolution A.857(20), Vessel Traffic Service (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 to respond to traffic situations developing in the VTS area[1] . interaction with the traffic and to respond to traffic situation are the goals of VTS that make it different from all other vessel traffic management tools. The term competent authority used in the definition is; the authority made responsible, in whole or in part, by the government for safety, including environment safety and efficiency of vessel traffic and the protection of the environment [2]. It is very important to mention the difference between the terms VTS authority and competent authority VTS authority is the authority with responsibility for the management, operation and coordination of the VTS, interaction with participating vessels and the safe and effective provision of the service [3]. Service area of the VTS should be delineated and formally declared and this VTS area may be subdivided in sub-areas or sectors.

The surface picture of vessels and their movements in a VTS area -VTS Traffic image-, is created at the center where VTS is operated -VTS center- by appropriately qualified persons performing one or more tasks contributing to the services of the VTS -VTS operator-.

The approach to VTS operations differ from country to country and also from authority to authority that is responsible for management, operation and coordination of the VTS. For instance in Europe, primary purpose for VTS operations is to increase the throughput of port facilities. Maritime safety and environmental protection are secondary benefits. The driving force of these systems has been the need to improve efficiency in order to compete with other national ports and, ultimately more important, with those in the country or countries next door. In the USA and Canada installation of VTS is motivated primarily by safety objectives as the majority of them are managed by coast guard and other public utilities (Moore,1997).

2.1 VTS Services

As a service provider, VTS should comprise at least an information service and may also include a navigational assistance or traffic organization service or any other coordination with allied services,

The Information Service; is provided by broadcasting information at fixed times and intervals or when deemed necessary by the VTS or at the request of a vessel by predetermined declared VHF channels and may include for example reports on the position, identity and intentions of other traffic; waterway conditions; weather; hazards; or any other factors that may influence the vessel's transit.

The Navigational Assistance Service is especially important in difficult navigational and or meteorological circumstances or in case of defects or deficiencies. This service is normally rendered at the request of a vessel or by the VTS when deemed necessary [4].

The traffic organization service concerns the operational management of traffic and the forward planning of vessel movements to prevent congestion and dangerous situations, and is particularly relevant in times of high traffic density or when the movement of special transports may affect the flow of other traffic. The service may also include establishing and operating a system of traffic clearances or VTS sailing plans or both in relation to priority of movements, allocation of space, mandatory reporting of movements in the VTS area, routes to be followed, speed limits to be observed or other appropriate measures which are considered necessary by the VTS authority 5. Also VTS makes cooperations with the allied services which are actively involved in the safe, secure and efficient passage of the vessels through the VTS area. An overall summary of basic and co-operatve VTS services are shown in table 1.

Table 1: Basic and Co-Operative VTS Services

Basic VTS services				**Co-operative services**		
Information	**Navigational assistance**	**Traffic organization**	**Regulatory**	**Emergency**	**Transport-oriented**	**Support**
Traffic information	Position and movement info on own vessel	Establishment and operation of a scheme of routes	Law enforcement	Search & Rescue	Port operations	Pilot management
Meteo. Information	Identities and movement info on other vessels	Establishment and operation of a reporting system	HAZMAT	Environment monitoring	Terminal management	Tug management
Fairway conditions	Warnings to individual vessels	Allocation of maneuvering space	Port state control	Pollution fighting	Intermodal transport chain	
Hydrographic Information	Shore-based pilotage	Forward planning of movements	Customs	Fire Fighting	Ship operators	
NAVTEX		Assignment of sailing plans to individual vessels	Marine police	Civil Protection		
		Enforcement of traffic rules	Immigration			
			Port and coast security			
			Health control			

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3. VTS Effectiveness

VTS systems have been variously defined and existed in a number of configurations. Their basic objective is to provide information and advice on other traffic and navigational hazards for ships. It is a system designed to decrease uncertainty and to increase the situational awareness of the bridge team. The expected effectiveness that VTS systems could have in reducing vessel casualties and associated dangers are determined in this study. The weight average effectiveness level for major causal factors of groundings and collisions were defined which reflected the estimated reduction in vessel casualties that could be expected to occur with the introduction of VTS systems. An acceptable analytical method has yet to be developed for fully measuring the effectiveness of VTS systems relative to all the factors that affect operational risk. Further more VTS performance data from which effectiveness might be assessed are limited. Nevertheless major port needs and VTS studies, accident investigations and limited near-miss documentation demonstrate that substantial benefits can be achieved through VTS operations (NRC,1994).There are 3 potential alternative techniques for estimation of the VTS effectiveness. These are,

1- Statistical analysis of casualties in situations with and without a VTS.

In this method the effects on casualties before and after a change to VTS are examined. It can have limitations, particularly if the traffic demand characteristics change during the period (Fabre et al,1988) and this method can be possible only if a significant number of casualties occur before and after, and if no other factors change in the meantime (NRC,1994). So this method needs long period of statistical casualty observations. Also statistics must be accurate and well prepared to reach reliable results.

2- Simulation of a VTS system.
Simulation is creation of an analogy or likeness of a real—world phenomenon and is widely used in maritime education and training but its effectiveness for defining the VTS systems is not accurate. This method includes the use of full mission bridge simulators coupled with a simulation of a VTS center as well as various forms of a mathematical simulation. (Maio et al,1991)

3- Synthesis of expert opinions.
This is a widely used method to develop VTS effectiveness estimates. The opinions of experienced mariners and/or VTS operators are collected and then analyzed (Fabre et al,1988).Focus groups and/or questionnaire techniques are generally used for data collection.

3.1 Literature Related to VTS Effectiveness

There is a large VTS related literature concerning its history, organization and functions, authority in which control of VTS is vested, VTS legislation, equipment and capital projects, staffing, training and qualification for personnel, advanced technologies and the future of VTS but the literature is very limited for the effectiveness of VTS systems. Major studies related to this subject are mentioned below.

1- COST 301:The COST 301 project was a program established by the European Community (European Union) in the early 1980 s to asses the risk to marine traffic in European waters and to promote safety through shore-based navigation aids including VTS systems. Opinions of experienced mariners and VTS operators were collected by a questionnaire. The maximum benefit to be obtained through the introduction of a VTS system is 60 percent on collisions and the maximum benefit which is likely to be obtained through the introduction of any VTS system is estimated to be 55 percent on groundings.

2- National Vessel Traffic Service Study, Canadian Coast Guard, 1984: This study, performed to asses the benefits and costs of the Canadian VTS, is one of the primary documents specifically addressing the effectiveness of VTS. The study focused on developing effectiveness measures for four different waterway configurations and a number of alternative VTS systems configurations. VTS effectiveness was estimated to range from 15 to 70 percent. The study found that the casualty rate reduction factor for a radar surveillance VTS with automatic track analysis would be expected to range between 0.50 and 0.70 depending on the type of waters. The average VTS effectiveness was estimated to be 43.3 percent. Estimates of VTS effectiveness were developed using the knowledge and experience of a team of personnel with marine related background. These persons included former mariners, VTS regulators and consultants, as well as Canadian Coast Guard management.

3- Vessel Traffic Systems, Analysis of Port Needs, USCG,1973: The purpose of this study was to rank 23 ports of U.S. in order of their VTS needs using a cost—benefit algorithm. The estimated reduction in vessel accidents was found 30 to 32 percent for a mix of collisions, rammings and groundings and collisions alone 60 to 65 percent.

4- Dover Strait Research, 1978: In this study the annual rate of collisions was used to measure variations in the level of safety. After the introduction of Channel Navigation Information Service there was a 54.7 percent reduction in the number of collisions.

5- Safety Assessment of Waterway Network in Tokyo Bay Area,1990: The time trend of the number of traffic accidents in the Tokyo Bay was studied to evaluate the effectiveness of the Tokyo Bay Traffic Advisory Center. The percentage reduction in accidents due to the VTS was found to be 52 percent.

6- Port Needs Study, USCG, 1991:This study was performed by USCG to determine the benefits and costs of potential U.S.C.G. vessel traffic services in selected U.S. deep water ports on the Atlantic, Gulf and Pacific

Coasts. Casualty rate reduction factor for collisions was found to range between 0.52 and 0.68 and for grounding between 0.25 and 0.46

4. Methodology

In this study Synthesis of expert opinion method was used to estimate VTS effectiveness at congested waters. Questionnaire technique was used for collecting data about the perceptions of officers and masters who have direct experience on these systems as users. A non-probability convenience sampling method was used during the sampling process. The questionnaire was applied to respondents at a terminal on the south coast of Turkey, Pilot Associations in Izmir and Istanbul and maritime education institutions. It was aimed to reach respondents from different nations having oceangoing licenses. 150 questionnaire were prepared and total 61 replies were received in two months period. The questionnaire was designed within two stage and these stages will be discussed at next section.

5. Findings

Respondents were from 9 different nations including Turkey, India, Pakistan, Greece, France, U.S.A., Norway, Romania; 48 % of the respondents have ocean going master, 19.7 % of them have oceangiong chief officer license; 87 % of them have sea experience more than 6 years; 70 % of them are at an age of 30 and above; 70 % of them were active on board, 15 % of them were maritime lecturer with sea experience and 13 % of them were pilot.

The study was performed at the two stages. At the first stage, ten major casual factors of two major accident types at sea were chosen. In general more than 80 percent of major vessel accidents are collisions and grounding (including stranding). Collision involve physical contact between two or more vessels, where there is an interactive decision making process for the vessels concerned and groundings involve the crossing of the boundaries of navigable space by the ship concerned, therefore, the decision process only for that ship, were chosen as accident types. Respondents were asked to rank the role of casual factors of casualties with regard to their experiences and perceptions from 1 (min) to 5 (max). And results were shown as Casualty Effect Level (C.E.L) in the table 1and 2.

Casual factors of groundigs and collisions

1- Hydrographique features : current, tide etc.
2- Meteorological features: fog, wind, rain etc.
3- Geographic conditions: narrow, shallow etc.
4- Traffic intensity
5- Crew conditions: motivation, training etc.
6- Non-compliance with COLREG
7- Defective ship
8- Commercial pressure on the crew
9- Beyond human control
10- Insufficient infrastructure of the waterway

At the second stage, respondents were asked to rank from 1 (min) to 3 (max) the role of Vessel Traffic Services (VTS) on preventing the marine accidents which are caused by the factors listed above. These values were called VTS Effect Level (VTSEL). And these two sources of data were analyzed together and the weighted average of VTS Effectiveness Factor (WEF) was found for both collisions and groundings for each casual factor (see table 1 and 2). At the end of the analysis the maximum benefit which is likely to be obtained through the introduction of any VTS system is estimated to be 51.7 percent on collisions and 52.7 percent on groundings. The results were found to be parallel with the studies that were done by different institutions and at different levels. Term VTS Addressable Casualties and factors effecting the VTS effectiveness are described according to the results of this study at the next sections. The results of the researches related to VTS effectiveness are also shown in table 4.

Table 2. VTS Effectiveness on Collisions

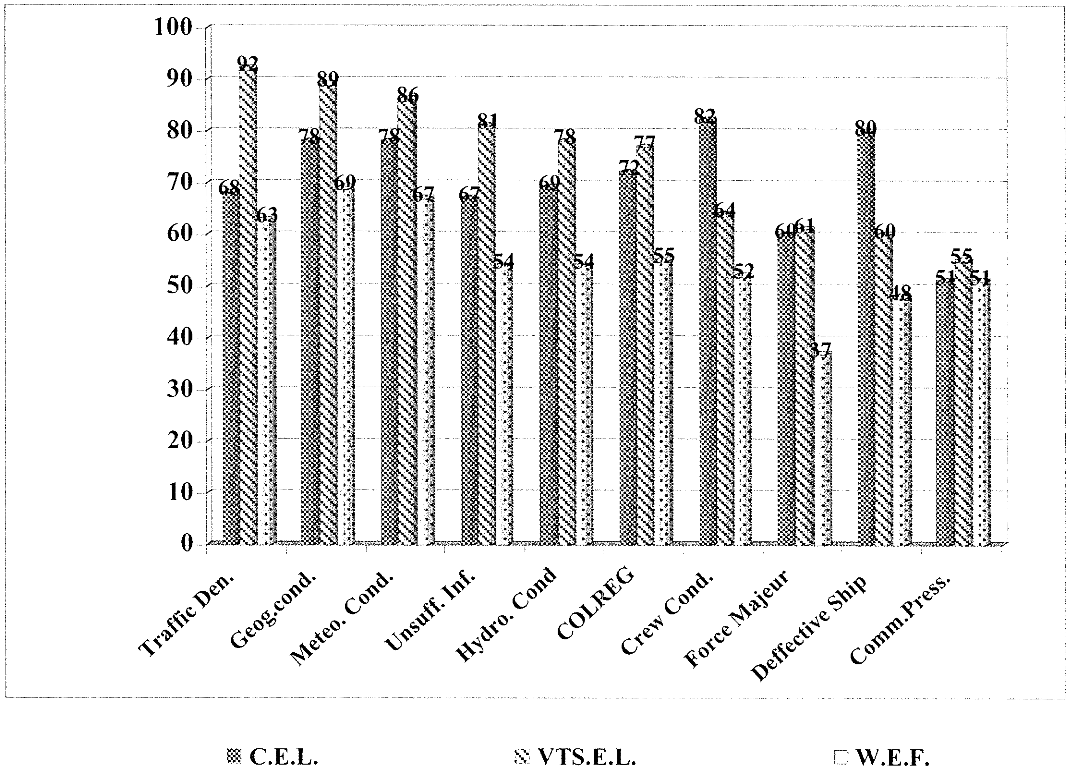
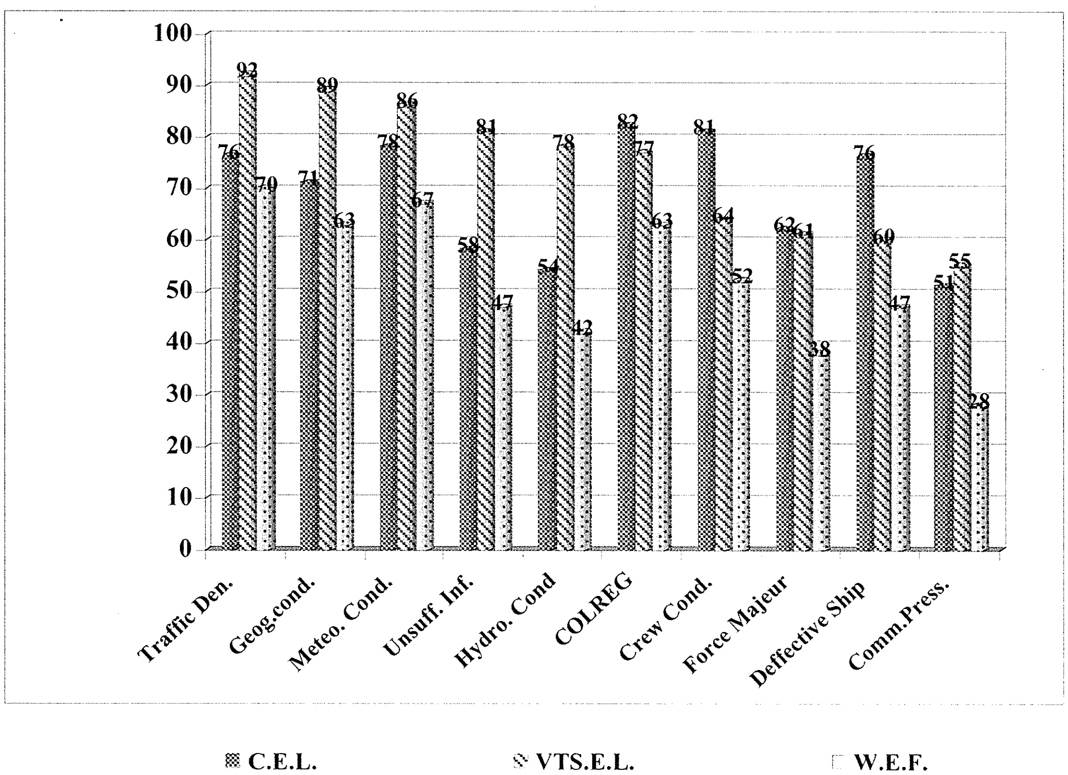


Table 3.VTS Effectiveness on Groundings



5.1 VTS Addressable Casualties

VTS addressable casualties are the ones that may be prevented directly or indirectly by a VTS system. For instance; open water collisions between two vessels caused by surprise, poor visibility, severe weather, or simple miscalculation on the bridge; certain overtaking situations; casualties at dredging operations or at similar work activities in a waterway; some casualties involving vessels at anchorage; casualties caused by traffic density, geographic (narrow, shallow etc) and meteorological conditions (fog, wind, rain etc), hydrographic features (current, tide etc), and insufficient infrastructure.

Also there are some incidents where effectiveness of VTS systems are limited. Incidents which are not addressable by VTS include mechanical and technical failures, fire or explosion, non-participating vessels (i.e., fishing vessels or other vessels less than 20 meters in length), casualties outside of the VTS range of surveillance, groundings or collisions in close quarter situations such as docking, undocking, maneuvering in crowded anchorage, incidents which occur with insufficient warning or lead time. Also it was found that VTS systems have limited effectiveness in reducing the accidents caused by human error and commercial pressure.

5.2 Factors Effecting the VTS Effectiveness

During the research and the literature survey it was found that effectiveness of VTS systems depends on many factors. These factors can be classified as follow;

1- Type of encounter: Meeting, crossing, overtaking
2- Technological level of VTS system
3- Waterway types: Open sea, open approach, convergence area, open harbor or bay, enclosed harbor constricted waterway, river, or open waters and confined waters
4- Traffic pattern: Simple ,complex
5- Dynamic changes in VTS area: Varying port volume, types of cargo, regulatory actions, improvements in the harbor, improvement accident reporting accuracy
6- Accident types: Collision, grounding, ramming
7- Types of services to be provided : Information, navigational assistance, traffic organization
8- Density and the character of the traffic: Local, transit traffic
9- Participation type and level : Voluntary, mandatory
10- Competency of VTS operators

Table 4. Results of the Researches Related to VTS Effectiveness

Related Studies	Methodology		Results (VTS Effectiveness Factor) (%)		
	With and without VTS analysis	Synthesis of expert opinions	Collision	Grounding	General
COST 301 Project		X	60	55	**55-60**
Canadian Coast Guard Research		X	-	-	**50-70** [1]
USCG (1973) Study		X	60-65		**30-32** [2]
Dover Strait Research	X		54.7	-	**54.7** [3]
USCG (1991) Study		X	52-68	25-46	**36-60**
Safety Assessment of Waterway Network in Tokyo Bay Area	X		-	-	**52**[1]
Ender Asyali (2001)		X	52	53	**52-53**

Note: Values are for advanced VTS systems active at congested waters
(1) Casualty types were not examined
(2) Total factor for collisions, groundings and rammings
(3) Only collisions were examined

6. Conclusions and Recommendations

VTS systems will play a more active role for enhancing navigational safety in the close future. The level of cooperation between the bridge team and the VTS operators will determine the effectiveness of these systems. Both the quality of ship s crews and that of VTS operators limit the effectiveness of VTS operations.VTS authorities should be aware that well-trained VTS operators may have a positive effect on the quality of participation by ship in VTS. VTS systems have limited effect in reducing the accidents caused by mechanical and technical failures on board, human factors, non-complience to COLREG, and also commercial pressure on the crew.Also when we consider the related VTS studies, the effectiveness varies in large ranges depending on many factors related to waterway types, traffic pattern, participation conditions and technological level.But in general overall accident reduction rate expected to range between 0.50 and 0.60 depending on the factors mentioned above. The effectiveness of shore based systems in offsetting human errors such as those found in collisions and groundings is limited. The results of this study give an overall idea about the VTS effectiveness in general and can be used to evaluate the effectiveness of an existing VTS and a planned VTS and to make a cost and benefit analysis for VTS projects. But to gain precious results for a special VTS area, an on-field study must be performed. Such information can be useful in determining how VTS could be improved for existing systems.

Endnotes

1 VTS Guidelines A.857(20) (article.1.1.1)
2 VTS Guidelines A.857(20) (article 1.1.2)
3 VTS Guidelines A.857(20) (article 1.1.3)
4 VTS Guidelines A.857(20) (article 2.3.2)
5 VTS Guidelines A.857(20) (article 2.3.3)

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