



**EMBARC**

## **High Lights of EMBARC**

### **Final Policy Report**

**Version 1.0**

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## Final Policy Report EMBARC

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Contents:

<b>1. Introduction .....</b>	<b>7</b>
<b>2. EMBARC in coastal waters .....</b>	<b>9</b>
<b>2.1. Introduction .....</b>	<b>9</b>
<b>2.2. RTIS, HRVs and the combination of SAR and VTM centres .....</b>	<b>9</b>
2.2.1. Research results .....	9
2.2.2. Policy implications .....	12
<b>2.3. Legal instruments for proactive monitoring of HRV .....</b>	<b>12</b>
2.3.1. Research results .....	12
2.3.2. Policy Implications .....	14
<b>2.4. Electronic reporting and AIS .....</b>	<b>14</b>
2.4.1. Research results .....	14
2.4.2. Policy implications .....	17
<b>2.5. High Risk Vessels .....</b>	<b>17</b>
2.5.1. Research results .....	17
2.5.2. Policy Implications .....	28
<b>3. EMBARC in ports .....</b>	<b>29</b>
<b>3.1. Introduction .....</b>	<b>29</b>
<b>3.2. AIS networks and capacities.....</b>	<b>30</b>
3.2.1. Research results .....	30
3.2.2. Policy implications .....	39
<b>3.3. Validation of VTMISS.....</b>	<b>40</b>
3.3.1. Research results .....	40
3.3.2. Policy implications .....	43
<b>3.4. AIS in a port environment.....</b>	<b>44</b>
3.4.1. Research results .....	44
3.4.2. Policy implications .....	46
<b>3.5. Vessel Position Prediction.....</b>	<b>47</b>
3.5.1. Research results .....	47
3.5.2. Policy implications .....	48
<b>3.6. Navigation Support Services in Ports .....</b>	<b>49</b>
3.6.1. Research results .....	49
3.6.2. Political implications .....	52
<b>4. References.....</b>	<b>53</b>

**List of figures:**

FIGURE 2-1: THE REPRESENTATION OF VTM AT SEA AND THE CONTEXT OF FSA .....	10
FIGURE 2-2: A VESSEL DEPARTS FROM PORT A AND IS HEADING FOR THE PORT OF DESTINATION B .....	15
FIGURE 2-3: EFFECT OF AGE ON THE MULTIPLICATION FACTOR.....	21
FIGURE 2-4: THE FATE OF THE OIL SPILL AND A MODEL FOR MECHANICAL OIL REMOVAL .....	24
FIGURE 3-1: INDICATIVE PLOTTING USED IN “VALIDATION OF VESSEL TRAFFIC, CARGO HANDLING AND RELEVANT STAKEHOLDERS”. .....	42
FIGURE 3-2: COSTS OF DIFFERENT ALTERNATIVES AS FUNCTION OF WEATHER .....	51

**List of Tables:**

TABLE 2-1: USE OF THE BLACK, GREY AND WHITE LISTS OF PSC TO DETERMINE THE EFFECT OF FLAG...	20
TABLE 2-2: THE MULTIPLICATION FACTORS FOR THE DIFFERENT AREAS FOR DIFFERENT TYPES OF ACCIDENTS .....	22
TABLE 2-3: MULTIPLICATION FACTOR OF WIND AND VISIBILITY AS FUNCTION OF ACCIDENT TYPES .....	23
TABLE 2-4: NUMBER OF VESSELS THAT SINK WHEN THEY ARE INVOLVED IN A GIVEN ACCIDENT .....	23
TABLE 2-5: ANNUAL RISK OF VESSEL IN EUROS .....	25
TABLE 2-6: VESSELS BELONGING TO THE 20% RISKY VESSELS .....	27
TABLE 3-1: REPORTING INTERVALS FOR CLASS A SHIP BORNE MOBILE EQUIPMENT .....	30
TABLE 3-2: REPORTING INTERVALS FOR EQUIPMENT OTHER THAN CLASS A SHIP BORNE EQUIPMENT ....	31

## Final Policy Report EMBARC

### **List of Abbreviations:**

AIS	Automatic Identification System
ATD	Actual Time of Departure
EEZ	Exclusive Economic Zone
EMBARC	European Maritime project for Baseline and Advanced Regional and Coastal traffic management and information services
EMSA	European Maritime Safety Agency
ETA	Expected Time of Arrival
FSA	Formal Safety Assessment
GDC	General Dry Cargo vessel
GT	Gross Tonnage
HRV	High Risk Vessel
IALA	International Association of Lighthouse Authorities
IMO	International Maritime Organisation
LNG	Liquid Natural Gas
LPG	Liquid Petroleum Gas
LR	Long Range
LRIT	Long Range Identification and Tracking
MAS	Maritime Assistance Service
MCA	Maritime and Coast guard Agency
MRCC	Maritime Rescue Co-ordination Centre
OBO	Oil-Bulk-Oil vessel
PPU	Personal Pilot Unit
PSC	Port State Control
RTIS	Regional Traffic Information System
RVTS	Vessel traffic service with a reduced Traffic Image (only AIS)
SAR	Search and Rescue
SSN	SafeSeaNet

## Final Policy Report EMBARC

TSS Traffic Separation Scheme

UNCLOS United Nations Convention on the Law of the Sea

USCG United States Coast Guard

VHF Very High Frequency

VTM Vessel Traffic Management

VTMIS Vessel Traffic Management and Information Services

VTS Vessel Traffic Services

WTC World Trade Centre

## 1. Introduction

This report reviews the more important achievements of EMBARC. The report is divided in two parts. The first part concerns the achievements in Coastal waters. The second part is oriented to ports.

EMBARC's proposal was made in 2001 and the official date of commencement was Dec 1<sup>st</sup>, 2002. In the period between the proposal and the start of the project the world changed. On Sept 11<sup>th</sup> 2001 an attack on the WTC in New York was made and security issues came to the forefront. This attack also instigated a change in vision with respect to data exchange and Public/Private usage thereof, thereby having an effect on the intended work towards improving efficiency through the promotion of the VTMIS concept. When a part of the original proposal needed to be changed because of redundancy (fusion of radar and AIS signals was already addressed by a number of other European projects) the choice was to study maritime security. This was, however, not approved by DGTREN due to the extreme sensitivity of the subject. In a later stage the potential impact of AIS on resource management and on incident and calamity abatement, as well as the awareness of VTS operators for AIS information was selected as a replacing subject, but the negotiations stretched over more than one year before a final approval was obtained.

The unfortunate accidents with the Prestige but certainly with the Erika pushed the Union into a fast track of taking maritime measures and taking initiatives for an Erika package. One of the major results was the establishment of EMSA. Another initiative taken by the maritime policy unit of DGTREN was SafeSeaNet.

It appeared that EMBARC had to renew its focus and the research that was planned should take into account the new innovations that were planned.

It took a long time before the necessary adaptations were agreed and implemented. This was one of the reasons why the project was delayed to 3.5 years rather than the original planned 3 years.

The turmoil in maritime safety matters may also have positive effects. EMBARC was able to develop a new regime for the enhancement of safety at sea. The major achievements are: electronic reporting, VTM centres at sea, a proposal for a new regime for intervention in relation to the numerical concept of High Risk Vessels. In the first part of this report these achievements are briefly described.

EMBARC is also concerned with marine traffic in ports. The concept of VTMIS has been reviewed and conclusions drawn. The event of AIS in relation to port VTS has been studied in

## Final Policy Report EMBARC

relation with information provision and it was shown that the addition of AIS implies a need for extra training of VTS operators.

EMBARC has also made an attempt to determine the required Navigation Support Services based on risk reduction. Again risk of individual vessels is an important issue. The stakeholders found the method interesting but they feel that such a risk based method should be improved before practical applications can be considered.

## **2. EMBARC in coastal waters**

### ***2.1. Introduction***

This chapter addresses several aspects of safety in coastal waters. It is based on a new concept of Vessel Traffic Management at Sea centres. These centres combine SAR as well as a special way of managing traffic. This management is based on Intervention and the interests of the coastal State. Section 2.2 addresses briefly the function of these centres. These centres may have pro-active capabilities for the so-called High Risk Vessels. These capabilities are to reroute these vessels or to send an escort tug. The legal background of becoming proactive for these vessels is based on international law. This will be explained in section 2.3.

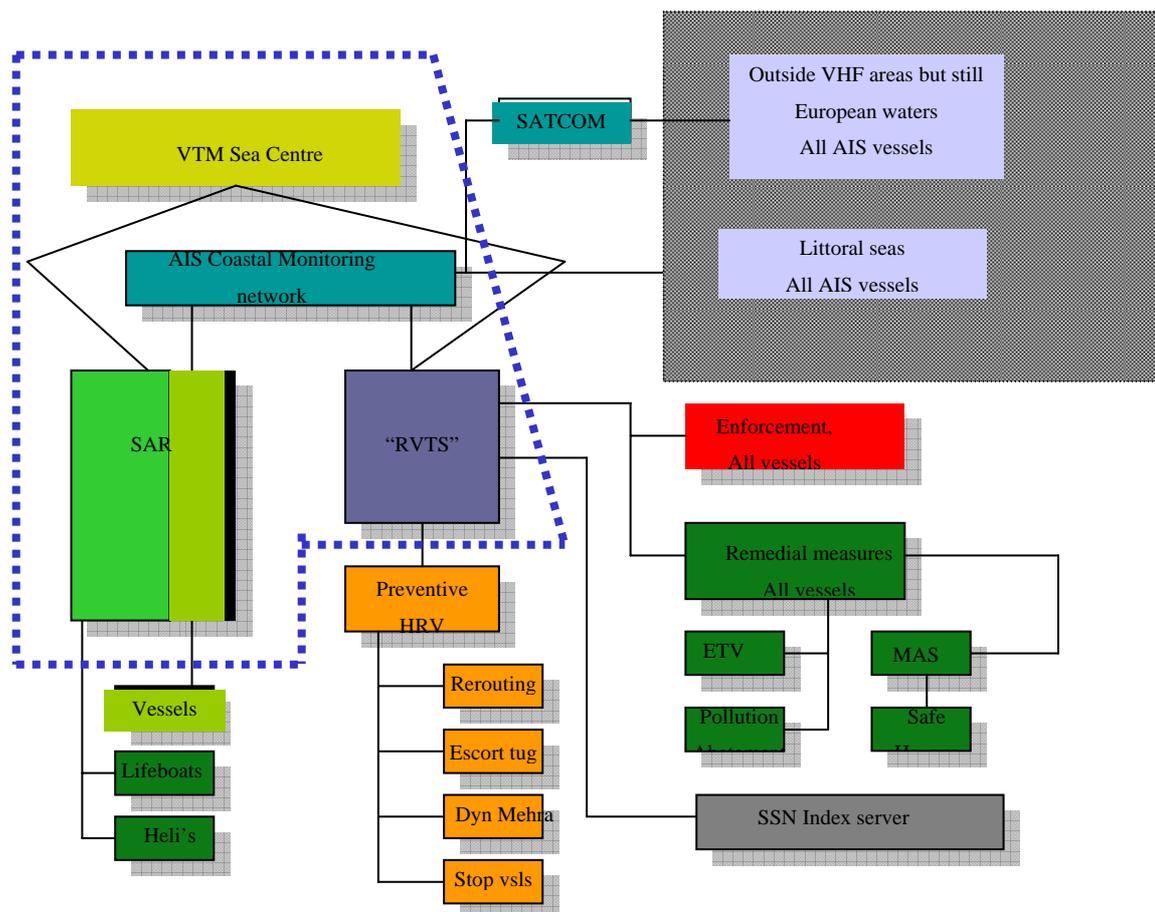
The AIS systems which are an integral part of these VTM centres are also assisting in receiving reports of vessels in the range of the AIS systems. The use of AIS systems and the definition of one European reporting area consisting of the SAR areas of the member States assist in easy reporting of the masters of vessels. Section 2.4 illustrates this reporting scheme.

High Risk Vessel definition and the calculation of the risk in monetary terms is explained in section 2.5.

### ***2.2. RTIS, HRVs and the combination of SAR and VTM centres***

#### ***2.2.1. Research results***

In order to have a common context for the understanding of the results of EMBARC, the following Figure is helpful, see Figure 2-1.



**Figure 2-1: The representation of VTM at sea and the context of FSA**

Figure 2-1 indicates that SAR and “RVTS” (VTS with an incomplete Traffic Image) can be combined in one centre such as is the case, among other member States, in France and Italy. The MRCC part of this VTM at Sea centre is responsible for the Saving of Life at Sea. The resources to do this are Lifeboats along the coast of Europe and in many cases Helicopters are used to save crew and passengers in perilous conditions. The AIS coastal monitoring systems can be used to determine the location of vessels that might be in a better position to assist in the evacuation of crew and persons. If the characteristics of these vessels are easily retrievable the SAR coordinator might well come to the conclusion that a vessel in the vicinity of the vessel in distress may be the first resource. The AIS network may be an important resource for the SAR coordinator. AIS networks have a restricted range. Although many ideas have been launched to develop some kind of LR-AIS, the events of 9/11 have caused a somewhat different approach. The security aspects are becoming more important. The USCG have initiated through IMO proposals for a LRIT (Long Range Tracking and Identification). In a special workshop of IALA [1] the principles have been discussed. There is a large pressure from the US to come to an international system. The functional requirements of the system

## Final Policy Report EMBARC

are that each vessel reports its position and identity every 10 minutes (or comparable time period) to a global clearing house. All commercial vessels should be then tracked. The global clearing house provides then to an Administration the position and identification of the vessels in its own territory and of the vessels under its flag. As soon as a vessel disappears this might be reported and an investigation might be started.

The European countries desire that these data will also be used for safety reasons. This would allow that the SAR coordinator will also have data about ship positions and identities outside the area that is covered by AIS.

The RVTS part of the VTM at sea centre has four goals:

- Enforcement
- SSN server
- Remedial measures
- Preventive measures

Enforcement tasks are tasks which are normally executed by the competent authorities of a Member State with respect to, among others, the behaviour of vessels in Traffic Separation Schemes (TSS's) and coastal zones.

The Safe Sea Net connection requires updates of positions to the Index Server of any vessel that can be observed using the AIS network when the vessel enters and leaves the area of responsibility.

The remedial services are the services that are provided in case an accident has happened. A FSA might be undertaken to determine the best level of resources for responses but this requires additional data which were not available. What is available in the Member States at the moment are the present risk levels in the area of responsibility of Belgium, the Netherlands, UK and Germany.

The preventive services are not services which are available in present day MRCCs or VTSs. In EMBARC a special idea has been developed to deal with High Risk Vessels. This is explained in section 2.5.

### **2.2.2. Policy implications**

The concept of VTM centres seems to be an important one. It combines a number of functions such as SAR and VTM in a way that:

- It fully exploits the potential of AIS in SAR and VTM; responses to calls of distress may be faster when the SAR coordinator possesses a traffic image of the vessels which are in the vicinity of the vessel in distress;
- It comprises remedial functions such as calamity abatement resources including Maritime Assistance Services for guiding the vessels to a Place of Refuge;
- It sends a message to the Index Server of Safe Sea Net when the vessel enters and departs from the area of responsibility;
- It may be able to take pro-active traffic measures in relation to High Risk Vessels.

## **2.3. Legal instruments for proactive monitoring of HRV**

### **2.3.1. Research results**

EMBARC is concerned with the development of an RTI Simulation System that will be tested in the North Sea, Western Approaches and the Mediterranean Sea. The RTI Simulation System's principal objective is to investigate the possibilities of combining SAR with monitoring, and the benefits that this may bring to maritime safety agencies and coastal States.

This part of the research in EMBARC is linked to methodologies to identify High Risk Vessels. The overall policy of EMBARC is indeed to explore possibilities of proactive monitoring by coastal States, or put in other words Vessel Traffic Management.

The RTI simulation system is also linked to the FSA Model, which determines the levels of risk of navigation routes in European waters on the basis of historical data on accident.

In order to develop a product in line with the requirements of end users, i. e. maritime safety agencies, a survey among 7 coast guards in Europe was held. Data for the design of scenarios was obtained from the results of the survey.

By monitoring vessels, maritime safety agencies will be able to detect High Risk Vessels, and to assess the kind of measures they need to take in order to control the risks posed by such ships to life at sea, to the marine environment and to the interests of coastal States in general.

Therefore an appraisal of the legal powers of coastal States towards High Risk Vessels in the territorial sea and in the EEZ is required.

The survey conducted in November-December 2004 among maritime safety agencies in Europe indicates that coastal States are willing to explore possibilities to proactively monitor foreign ships in their coastal waters. Reacting to recent oil pollution disasters, European States and the European Commission have adopted packages of legislative measures, the Erika I and II packages, to attempt to reduce the risks of maritime casualties in European coastal waters<sup>1</sup>. The most important piece of this spree of European legislation is the Directive on Vessel Traffic Management and Information Services (VTMIS), adopted in 2002, which seeks to implement in Europe reporting obligations on foreign vessels on the basis of AIS<sup>2</sup>. The Commission and the Member States are setting in place an information system called Safe Sea Net<sup>3</sup>, which will form a comprehensive database of information on all ships sailing in European waters<sup>4</sup>. Safe Sea Net will be a three level system: local maritime authorities, national maritime authorities and a central maritime authority. The system will therefore collect information through this structure. It will also be linked to the databases on port state control<sup>5</sup>.

These European initiatives seem to indicate a political willingness by the European Commission to become more protective of Europe's coasts against threats of damage by international shipping by providing more practical and legal means to the Member States to control and monitor the movements, the identity, the cargoes and the crews of all ships sailing in European waters. A question arising from this new situation is just how far can European coastal States go?

This new context is calling for an assessment of coastal States' current enforcement jurisdiction, and its future prospects. Coastal State jurisdiction is set out in the 1982 United

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<sup>1</sup> Significant pieces of legislation include: regulation (EC) 417/2002 of the European Parliament and of the Council of 18 February 2002 on the accelerated phasing-in of double hull or equivalent design requirements for single hull oil tankers and repealing Council regulation (EC) 2978/94, OJ L064, 07.03.2002, p1; Directive 2001/106/EC of the European Parliament and of the Council of 19 December 2001 amending Council Directive 95/21/EC concerning the enforcement, in respect of shipping using Community ports and sailing in the waters under the jurisdiction of the Member States, of international standards for ship safety, pollution prevention and shipboard living and working conditions (port State control), OJ L019, 22.01.2002, p17; Directive 2001/25/EC of the European Parliament and of the Council of 4 April 2001 on the minimum level of training of seafarers, OJ L136, 18.05.2001, p17.

<sup>2</sup> Directive 2002/59/EC of the European Parliament and of the Council establishing a Community vessel traffic monitoring and information system and repealing Council directive 93/75/EEC, OJ L208, 05.08.2002, p1, hereafter referred to as the VTMIS Directive.

<sup>3</sup> For more information on Safe Sea Net, go to: <http://www.emsa.eu.int/end801.html>.

<sup>4</sup> The Commission decided on 15 December 2004 to institute proceedings against France, Belgium, Greece, Italy, the Netherlands, Austria, Finland and the United Kingdom for failing to implement key provisions of Directive 2002/59/EC on VTMIS, EMSA Press release IP/04/1488, 15.12.04.

<sup>5</sup> Sirenac and Equasis.

Nations Convention on the Law of the Sea (UNCLOS<sup>6</sup>). The 1982 convention acknowledged the necessity to allow coastal States to protect their marine environment, and therefore provides legal grounds for request for information to foreign ships in the territorial seas and EEZ, as well as rights of inspection, detention, instituting proceedings and expulsion. Intervention is also dealt with by the convention. However the limit to the powers of coastal States is the guarantee of the rights of flag States. UNCLOS established a balance between the powers of the former and the rights of the latter, and this balance is the framework in which coastal States' jurisdiction must be assessed.

### **2.3.2. Policy Implications**

The research is important with respect to the interpretation of the Intervention Convention. UNCLOS may be interpreted in a way that it may enable the competent authorities of the member States in such a way to implement measures that are:

In the interest of the coastal state by minimizing the potential environmental impacts when the vessel is outside the territorial Seas.

## **2.4. Electronic reporting and AIS**

### **2.4.1. Research results**

The monitoring directive 59/2002 indicates that monitoring (AIS) systems should be installed along the European coasts. The fast introduction of AIS by IMO regulations speeded up as a result of the events on the 11<sup>th</sup> September 2001 enables vessels in the littoral seas of Europe to report them selves.

Generally the following requirements are set:

The master should only make one report if he leaves a port in Europe and is destined for another European port. The remainder should be done by electronic reporting by AIS;

The areas of interests should be the search and rescues area of the member states. If electronic reports are made these reports would assist a SAR coordinator in assessing the best options available to rescue crew and passengers of vessels in distress. A vessel in the vicinity may assume the responsibility of on scene commander in taking the survivors on board quickly before helicopters or lifeboats arrive on the scene, but the response time will have negative effects on the number of remaining survivors;

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<sup>6</sup> UN Convention on the Law of the Sea (Montego Bay), 21 *ILM* (1982), 1261.

## Final Policy Report EMBARC

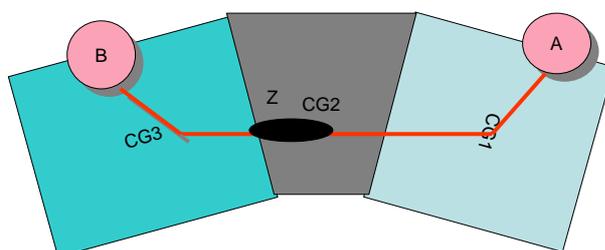
Some SAR areas are extremely large, such as the SAR areas of the UK, Malta and Portugal. It is unfair to let them manage the vessel traffic in such a large area.

When a vessel enters a new SAR area of a member State, a report should be made to the SSN index server to enable other authorized stakeholders to obtain information on the approximate whereabouts of the vessel.

The principle of subsidiarity requires that the member States' authorities have full jurisdiction over their territorial seas and reduced jurisdiction over the EEZ. This rules out that a central authority can take over the responsibility of those areas. Directives may indicate that certain regulations should be harmonised and be included in national law.

During the first part of the project Long Range AIS was a viable option. In a later stage under the pressure of the USA much emphasis was put on LRIT. This is a measure to pinpoint vessels from a security point of view, but the European states wish LRIT information be also used for safety and SAR purposes. The fact that the charge for these reports using satellite communication systems need to be paid by the authorities made it essential to reach an agreement on the division of costs. These issues are not yet solved.

The following graph indicates a vessel that departs from a port and is destined for another port and moves in the SAR areas of three countries.



**Figure 2-2: A vessel departs from port a and is heading for the port of destination B**

## Final Policy Report EMBARC

The reporting sequence is as follows when the vessel Z sails from port A to port B:

- Vessel Z asks permission to leave the port A and the VTS of port A informs the port B, the port of destination;
- The VTS of port A gives permission to depart;
- When the vessel is about to leave the port A, the VTS of port A reports to its national competent authority responsible for the SAR area;
- The national competent authority informs the national competent authorities of the coastal States that vessel Z is on its way to port B with the associated ETA;
- When the vessel is outside of the port it starts to report automatically its identity and position to the competent authority of the member State in which port A is located using its AIS;
- As soon as the vessel Z leaves the SAR area of the member State where the port A is located, this authority sends a message to SSN and to the competent authority of the SAR area in the adjacent member State;
- The competent authority sends a report to SSN that the vessel has entered its SAR area;
- The vessel Z continues to report automatically its position and identity
- The competent authority of the SAR area reports to SSN when the vessel Z has left the SAR area.
- The vessel Z continues to report automatically its position and identity
- The competent authority of the SAR area where the port B is situated reports to SSN and the port of destination B that the vessel has entered its area of responsibility.
- The port of Destination B will get the ETA as it is displayed in the AIS messages.
- When the vessel Z changes its ETA the port of destination will be informed of the change.
- When the vessel comes into the range of the AIS of the port the vessel Z is automatically taken over by the VTS of port B.

## Final Policy Report EMBARC

- The VTS B gives permission to enter port B and indicates a berth.
- The Vessel Z reports to VTS of port B that it is safely berthed

The sequence that is indicated doesn't include LRIT messages since it is not clear that they may be used for safety purposes. When vessels are outside the VHF range other methods need to be used.

The sequence as presented above needs to be changed when a vessel enters a European SAR area having departed from a port outside the European Union, but the principles remain the same.

### ***2.4.2. Policy implications***

The political implications of this reporting procedure are, among others as follows:

- The master of the vessel only reports once;
- The SAR authorities know what vessels to expect and they know the position of these vessels once they have reached the own area of responsibility;
- The same is valid for the monitoring authorities that also act as authorities for VTM at sea to implement possible measures according to the intervention convention;
- SSN knows when vessel change of SAR area since reports are going to SSN;
- SSN is not heavily burdened since they globally know where vessels are and the national authorities know precisely where vessels are using their coastal network;
- The burden of the many reporting schemes can be removed since the European area is one reporting area.

## ***2.5. High Risk Vessels***

### ***2.5.1. Research results***

The risk index has the following form:

$$RI(t) = \frac{\Sigma Risk(t)}{\Sigma Exp(nm)} \quad \text{Equation 1}$$

The following symbols have been used:

*Exp* = Exposure in the appropriate dimension, such as encounters, nm etc

*RI* = Risk Index

The risk in the preceding equation is calculated as the product of the frequencies and of the consequences of an accident. The multiplication factors are seen as factors that will increase the frequency of accidents.

#### 2.5.1.1. *Determination of parameters*

The following types of parameters are included in the Risk Index:

- Static (type and size of ship)
- Semi static (flag, age, crew)
- Geographical characteristics
- Route
- Traffic intensities
- Weather conditions
- Wind, current waves
- Visibility
- Risk reducing measures (probability of casualty)
- Persons at risk
- Oil spills

The following remarks are made in relation to these parameters:

## Final Policy Report EMBARC

Ad 1): Each ship type and size class has each own casualty rate that is the relation between. the probability of a specific accident and the exposure. These casualty rates are determined from casualty and traffic statistics. The World Wide casualty database form 1990 -2002 has been used. For traffic data has been used of Lloyds and Fair-play Intelligence Services.

Ad 2): Flag and crew statistics have been determined using the following Table.

List 2003	Data	Total	Cas/100 ship years	Normalized	Factors applied
VHR	Sum of casualties	382	1.28	1.18	2.1
	Sum of ships	2317			
HR	Sum of casualties	320	2.43	2.24	1.6
	Sum of ships	1019			
MHR	Sum of casualties	104	0.88	0.81	1.2
	Sum of ships	918			
MR	Sum of casualties	1555	1.41	1.30	1
	Sum of ships	8551			
GL	Sum of casualties	340	0.57	0.53	0.9
	Sum of ships	4615			
WL	Sum of casualties	2473	0.98	0.90	0.85
	Sum of ships	19502			
Total Sum of casualties		5174	1.09	1.00	1
Total Sum of ships		36922			

**Table 2-1: Use of the black, grey and white lists of PSC to determine the effect of flag**

The Table displays the number of casualties in each group. The States are belonging to one of the lists: black, grey and white of the Memorandum of Understanding (MoU) of Paris. The black list is divided in four parts:

- Very High Risk
- High risk
- Medium High Risk
- Medium Risk

The procedure is as follows: for the States that appear on each list the number of casualties and the number of ships is being determined. The numbers of the States on the same lists are added. Then the number of accidents per 100 ship-years is calculated. These numbers are smoothed and the results are given in the last column of Table 2-1. These values are used as  $F_{flag}$ .

Ad 3): Effect of age of vessels

Figure 2-3 shows the effect of age on the casualty rates.

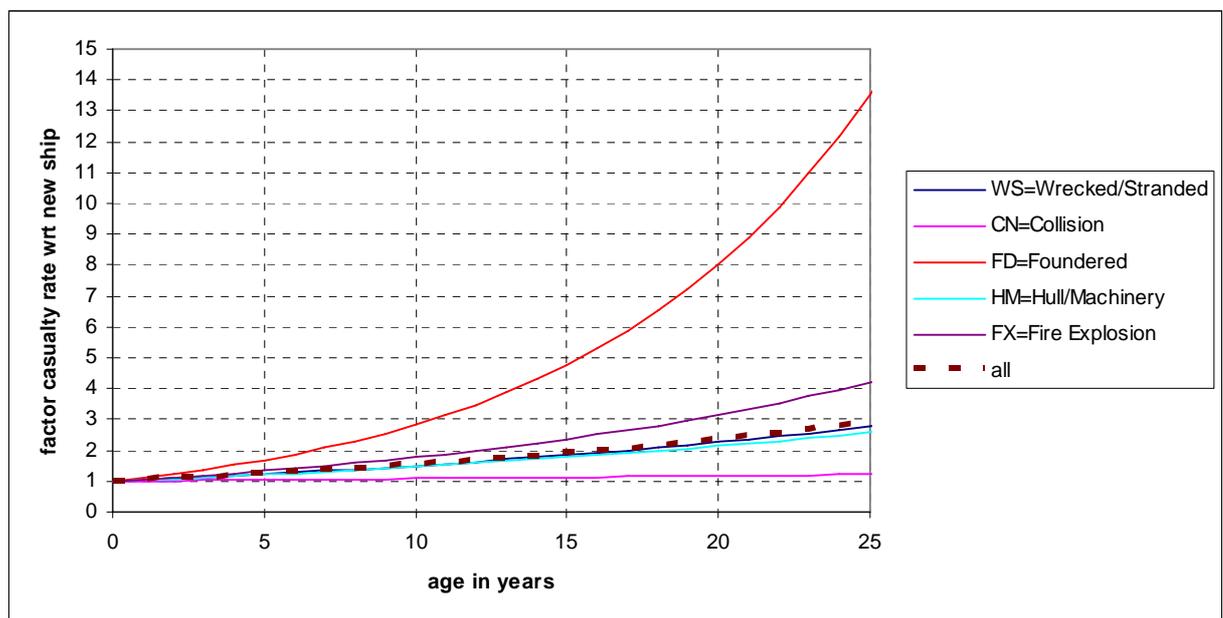


Figure 2-3: Effect of age on the multiplication factor

SRR	average ships at sea	frequency per type per year						Total
		Ships involved in collisions	Stranding by naviga- tional error	Stranding by techni- cal failure	Foun- dered	Hull Failure	Fire- Explo- sions	
UK-East	81.5	1.09	0.57	1.56	1.10	1.00	1.02	1.01
Belgium	20.8	3.31	14.31	8.15	0.88	0.97	1.03	4.56
Netherlands	155.5	1.41	1.75	1.81	1.16	0.97	0.99	1.33
Germany- North-Sea	71.4	1.52	2.03	1.59	1.23	0.93	1.00	1.40
Total	329.2	1.00	1.00	1.00	1.00	1.00	1.00	1.00

**Table 2-2: The multiplication factors for the different areas for different types of accidents**

The multiplication factors for the different geographical for different types of accidents are displayed in Table 2-2.. The last column expresses the average multiplication factor. The effect of a focal point and a port is clearly visible. The Belgian SRR is an exception. Here the densely trafficked NW lane and the approach to Antwerp play a role. It is the reason for a relative high base level for the risk.

Ad 6, 7 and 8): The effects of wind and visibility are depicted in the next Figure. For different types of accidents different effects were calculated. It is important to note the effects of weather on foundering. In this case an interrelation between age and weather may well be present. This is not investigated in detail in this project. It should be done in following projects in order not to exaggerate the effects of weather and age and describe them properly.

As could be expected only collisions and contacts are dependent of the visibility.

## Final Policy Report EMBARC

Weather factors	Storm 8-12 Bft	bad visibility <1500 m
Collision/Contact	1.6	6.9
Wrecked/stranded	12	1.2
Foundered	80	1
Fire/Explosion	3.3	1
Hull failure	23	1
Machinery failure	3.8	1

**Table 2-3: Multiplication factor of wind and visibility as function of accident types**

	Casualty type	Fraction without serious damage	fr_foundered  damage	%foundered
1	Collision	0.800	0.140	2.8%
2	Fire-Explosion	0.807	0.565	10.9%
3	Hull failure	0.382	0.024	1.5%
4	Foundered	0.000	1.000	100.0%
5	Wrecked/Stranded	0.596	0.140	5.7%

**Table 2-4: Number of vessels that sink when they are involved in a given accident**

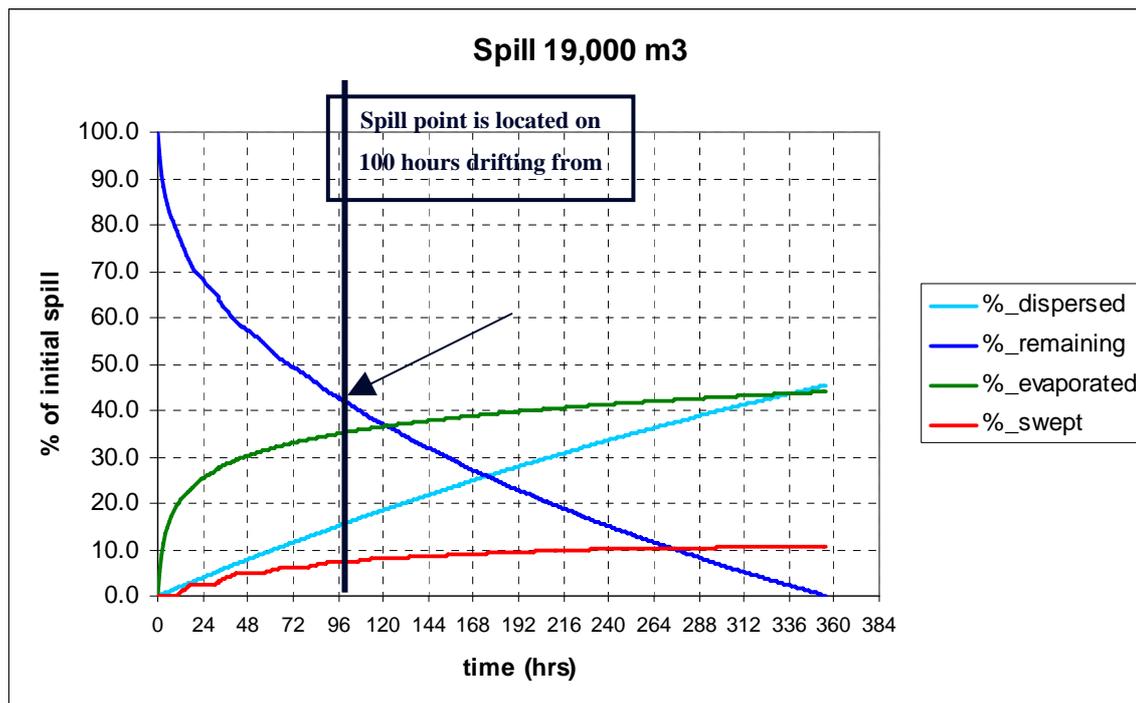
The probability of fatalities is now 50 % of the number of foundered people. Even in case of foundering, SAR services may be so effective and the vessel may remain afloat for such a long time that the persons on board could be rescued. For passenger vessels, the number of passengers and the seasonal influence of the number of passengers are taken into account.

Ad 11): Oil spills are discussed in the following Table. The Table shows that after a collision about 18% of the cargo oil will flow out. The Table shown concerns collisions but for each accident such a Table has been prepared. The percentages given are calculated with a model

and a “standard” lay out of tankers. The second column indicates the size class of the vessel.(Size class 6 is 30,000<GT< 60,000, size class 7 is 60,000<GT< 100,000 and size class 8 is GT>100,000).

The probabilities of outflow are based on the damage cards of IMO where the frequencies of hull damage were recorded.

Eight outflow classes are defined. They range from very small to very large (13 m<sup>3</sup>) to large (150,000 m<sup>3</sup>).



**Figure 2-4: The fate of the oil spill and a model for mechanical oil removal**

Figure 2-4 represents the fate of oil using a mathematical model for oil spills. This model is rather simple, since the major reason to use the model is for risk assessments and FSA studies.

The spills are now located at 100 hours drifting from the coast for the purpose of the calculation of the risk of High Risks Vessels (HRV). After 100 hours for the oil type selected (light crude) about 35 % of the oil is evaporated, 16 % is dispersed and 7 % is removed when sufficient removal equipment and vessels are available. The remaining part is 42 %. This remaining part will beach in the form of a mousse. The total volume of that mousse is about 5 times larger. The oil beached is about 37,500 tons. It is assumed in the calculations that the average cleaning costs are 8 k€/m<sup>3</sup>.

The total number of oil beached using the local wind distribution is given in Figure 2-4. The distance is still 100 hours, say 35 nautical miles from the coast. It is clear that from the smaller spills only small percentages will beach. If the oil spill is larger the final percentage of oil beached becomes larger.

It is assumed that the cleaning up costs are constant and 8 k€m<sup>3</sup>. It is to be remarked that the values relate to the oil contents on the beach and is not the value that is related to the mousse, which has a larger volume.

The coastal sensitivity should also be taken into account. This hasn't been implemented in this study. Other costs are also apparent. These costs concern the environmental cost, third party claims and penalties. It might well be that the cleaning costs only represents a smaller part of the total costs of an oil spill.

#### 2.5.1.2. Risk of vessels

For all vessels that are calling in European ports, the calculation has been made according to equation 2. The number of vessels that has been identified in a European port is about 15,900. However, in the areas that are studied the number of vessels that are present at any one moment is 2,701. This is logical since not all vessels stay in European waters at all times, and some of the vessels are in European ports. These vessels are not included in the figure given.

The risk values have been expressed in Euros/year.

% of ships	number of ships at sea in EMBARC area	limit value	average risk costs / year at sea	average risk costs for selected ships	% of risk costs
top 1%	27	€1,900,450	€78,261,677	€2,861,354	16.6%
top 2%	54	€1,312,311	€119,663,898	€2,222,042	25.4%
top 10%	270	€354,063	€247,476,605	€915,039	52.5%
top 20%	540	€173,362	€314,259,928	€581,715	66.7%
all	2701		€471,349,827	€174,445	100.0%

**Table 2-5: Annual Risk of vessel in Euros**

## Final Policy Report EMBARC

The values of the risks are sorted from a high to a low value. Then the first 1% is taken, respectively the 2% 10% and 20% is taken. In Table 2-5 the top 1% (27 vessels) has an average risk value of M€2.8. The limit value to qualify for this first 1% is M€1.9. The total amount of risk for these 27 vessels is M€78.2. In the same way the Figures for the top 2%, top 10% and the top 20% can be determined. It is to be remarked that we have considered average European navigation area. The geographical multiplication factor is set on 1 for all accident types.

If this is compared with the risk of all 2701 vessels, the total risk is M€471.3 and the average risk costs are k€174. Even more interesting is that the first 1% of the risky vessels take nearly 17.5% of the total risk and the top 2% 25%. The top 20% is responsible for 66.7% of the total risk.

If we are able to take preventive measures for these 20% of vessels and we are able to reduce the risk, we are in a very good position, since we are dealing with 67% of the risk.

Which vessels fall under the 20%? The following Table provides an answer. Table 2-6 shows these vessels. Nearly all Oil-Bulk-Oil carriers are belonging to the group of 20% risky vessels. The same is true for all larger oil tankers. Only larger product carriers are risky.. Interesting is the fact, that all LNG gas carriers are not risky (in “at sea” environment). The normal size LPG carriers are sometimes risky. This will depend on age and flag. Against popular belief, none of the bulk vessels are belonging to the risky group. The studies that are undertaken by IMO and MCA are studies to improve bulk carriers, but on a monetary footing these vessels can not be characterised as highly risky. The Ro-ro vessels are according to this calculation all belonging to the high risk class. Container vessels are not. This may be explained by the number of people that are transported on a Ro-ro vessel and the larger probability that it sinks as a consequence of an accident, due to its construction and lay-out.

General Dry Cargo vessels are for a large extent belonging to the first 20%. There is a reason for this. Large GDC carriers are replaced by new container vessels. Some smaller new GDC vessels are able to transport containers without guides (as multipurpose vessel) but can also be used for the transport for dry bulk. Larger dry cargo vessels which are still in service are often rather old and are in the ownership of the third owner. These vessels are often bought by sub-standard owners, who are not willing to spend sufficient money to maintain their vessels. This is the reason of the high percentage of risky GDC-vessels, despite that these vessels have a small crew and don't carry dangerous goods in bulk.

Ferries can be seen to belong to the risky group, no matter age or flag. This is due to the precious cargo these vessel transport and the high figures for the value of life.

Final Policy Report EMBARC

		Size class								Grand Total
		1	2	3	4	5	6	7	8	
1	OBO crude/product				27%		100%	100%	100%	70%
2	OBO crude oil						100%	100%		100%
4	OBO unclassifiable					100%	100%	100%		100%
13	OIL crude/product	0%	0%	0%	0%	0%	41%	100%	100%	29%
14	OIL crude oil						100%	100%	100%	100%
15	OIL product					0%	0%	0%	100%	2%
16	OIL unclassifiable					0%	59%	100%	100%	64%
18	LNG independ atmos					0%	25%	23%	40%	22%
22	LPG independ press	0%	25%	60%	2%	0%				4%
24	BULKERS ore				0%	0%	0%	2%	0%	0%
25	BULKERS remaining	0%	0%	0%	0%	0%	0%	1%	0%	0%
26	UNITISED container			0%	1%	0%	3%	0%		1%
27	UNITISED roro	33%	0%	90%	98%	100%	100%			98%
28	UNITISED barge				0%	7%	0%			3%
29	UNITISED vehicle				11%	7%	29%			23%
30	GDC dry cargo	52%	45%	42%	38%	12%	25%			40%
31	GDC dry c./contain.	63%	24%	9%	12%	6%	10%			11%
32	GDC reefer	56%	27%	31%	17%	3%				14%
33	Passenger	85%	100%	100%	100%	100%	100%			99%
34	Ferries	100%	100%	100%	100%	100%	100%			100%
35	Miscellaneous	3%	7%	6%	4%	2%	0%	0%		4%
Grand Total		45%	30%	25%	20%	10%	18%	36%	88%	20%

Table 2-6: Vessels belonging to the 20% risky vessels

**2.5.2. Policy Implications**

The policy implications of the concept of High Risk Vessels are already shown in one of the preceding sections. The important issue here is that it can be shown that about 70% of the risk in monetary terms is caused by 20% of the vessels. It is not surprising that many oil tankers and vessels that transport passengers are part of this group. A smaller bit of the risky vessels is formed by the so-called rust buckets of Port State Control.

It is not difficult to understand the differences. PSC is inspecting and detaining vessels using a different scheme than according to the definition of risk as used in EMBARC. Consequences of accidents are not taken into account in PSC considerations. It seems that PSC is inspecting vessels in order to reduce the accident proneness.

Vessels that are not very accident prone but may have large societal consequences such as loss of life and pollution might become risky. Only vessels that are very accident prone despite the smaller consequences appear on the list of HRVs.

The definition of risk that is taken in EMBARC is the formal definition of risk. It is recommended to continue to use this definition and propose a common standard for accident proneness in the determination of HRVs and PSC.

### **3. EMBARC in ports**

#### ***3.1. Introduction***

This chapter addresses several aspects of Vessel Traffic Management in Ports. The emergence and accelerated implementation of AIS as a SOLAS carriage requirement raised in itself many opportunities for VTM stakeholders. After EMBARC began many events led to the increased awareness and need for measures to increase safety in ports by almost any means possible. EMBARC needed to adapt to the changing environment and was able to respond through answering topical questions such as AIS capacity concerns, the potential role of AIS in resource management and incident and calamity abatement, as well as the potential impact on the human operator.

In addition to this there was much discussion on the potential role of Vessel Traffic Management towards overall Transport Management. Considering the previous research and concepts developed EMBARC was able to identify the key considerations when determining to what extent different levels of authority may be able to influence the traffic and transport markets. Through so-called Validation of VTMS, these key differences were literally mapped in order to bring better understanding as to the organizational political and influences on how a port operates.

Further work conducted related to ports was that of vessel position prediction, an issue that was relevant to much of the work conducted in EMBARC. The final major issue dealt with was that of Navigation Support Services in Ports. This work sought a uniform method for all European ports to determine the level of Navigation Support Services required. This contributes to a level playing field on safety matters for European ports. Safety should not be an issue for competition between ports.

### 3.2. AIS networks and capacities

#### 3.2.1. Research results

During many discussions on AIS and for each design of an AIS environment the question arises: what will be the capacity of the system. Within EMBARC a general solution for the capacity question was found.

##### 3.2.1.1. Requirements

The standard use of AIS has 2250 time slots per minute for each VHF channel, which results in 4500 time slots per minute effective. These 4500 time slots are available for:

- position reports of mobile AIS stations (both Class A and the future Class B stations),
- static and voyage related messages,
- Base station and/or AtoN reports if available in the area,
- special messages as text and data messages,
- messages for controlling the VHF data link.

The IMO Performance Standards gives mandatory reporting intervals for dynamic information for Class A stations (table3-1).

<i>Ship's Dynamic Conditions</i>	<i>Nominal Reporting Interval</i>
<i>Ship at anchor or moored and not moving faster than 3 knots</i>	<i>3 minutes</i>
<i>Ship at anchor or moored and moving faster than 3 knots</i>	<i>10 seconds</i>
<i>Ship 0-14 knots</i>	<i>10 seconds</i>
<i>Ship 0-14 knots and changing course</i>	<i>3<sup>1</sup>/<sub>3</sub> seconds</i>
<i>Ship 14-23 knots</i>	<i>6 seconds</i>
<i>Ship 14-23 knots and changing course</i>	<i>2 seconds</i>
<i>Ship &gt; 23 knots</i>	<i>2 seconds</i>
<i>Ship &gt; 23 knots and changing course</i>	<i>2 seconds</i>

**Table 3-1: Reporting intervals for Class A ship borne mobile equipment**

Others, carrying or installing AIS on voluntary basis, have recommended reporting intervals as given in table 3-2.

<i>Platform's Condition</i>	<i>Nominal Reporting Interval</i>
<i>Class B Ship borne Mobile Equipment moving &lt; 2 knots</i>	<i>3 minutes</i>
<i>Class B Ship borne Mobile Equipment moving 2-14 knots</i>	<i>30 seconds</i>
<i>Class B Ship borne Mobile Equipment moving 14-23 knots</i>	<i>15 seconds</i>
<i>Class B Ship borne Mobile Equipment moving &gt; 23 knots</i>	<i>5 seconds</i>
<i>Search and Rescue aircraft (airborne mobile equipment)</i>	<i>10 seconds</i>
<i>Aids to Navigation</i>	<i>3 minutes</i>
<i>AIS base station</i>	<i>10 seconds</i>

**Table 3-2: Reporting intervals for equipment other than Class A ship borne equipment**

Static and voyage related information need to be updated every 6 minutes and after amendments of the data or on request. Safety related messages would only be broadcasted as required.

### 3.2.1.2. Assumptions

For all calculations and definitions in the research, the standard default settings of AIS were used:

- AIS 1 and AIS 2 as operating frequencies (VHF channels 87B and 88B),
- channel spacing 25 kHz,
- transmitter output 12.5 W.

The AIS behaviour is described in ITU-R Recommendation M.1371-1 and in IALA's Technical Clarification on M.1371-1. Because of the developments in Class B AIS stations a description of the behaviour of CSTDMA with respect to the access to the VHF Data Link and the capacity was also provided. Uncertain was whether all Class B AIS stations will operate with CSTDMA. CSTDMA based AIS stations are intended to be used on the lower end of the market. For other, more professional users, there are two options:

- Class B stations based on SOTDMA
- Class A stations not carrying all required facilities (sometimes called Class A derivatives).

### 3.2.1.3. *Access to the VDL*

There are different ways to transmit a message on the VHF Data Link (VDL).

#### Mobile AIS stations (Class A and non-CSTDMA Class B)

In principle AIS is designed as a 'Self Organised TDMA' system. Normally Time Domain Multiple Access (TDMA) communication is organised by a service provider who dictates via its network every mobile station the use of designated time slots. Because mobile AIS stations cannot make use of service providers organising the use of time slots, a 'Self Organised' mechanism was designed to regulate the proper use of available time slots. Synchronised by timing signals from GNSS all AIS stations will follow the time division very accurately. Important to know is that each AIS mobile station will maintain a so-called 'slot map'. This is an overview of all reserved time slots in the near future. Every time an AIS mobile station transmits its message, a reservation of the next time slot to be used will be broadcasted as well. All receiving stations store the reservations in the own slot map and will choose, at the moment of transmission, a free time slot for its own future reservation. This self-maintaining system is called SOTDMA.

#### AIS Base stations

Base stations will reserve fixed time slots for each frame (one minute) over a longer period of time. These time slots can be used for the own transmissions but also for assigned transmissions of mobile stations. It means that a mobile station should transmit in a time slot reserved by a Base station. This will be done when a mobile station is interrogated by a Base station or if a mobile station must report in another sequence than given in the tables 1 or 2. In that case, the mobile station was not able to reserve a slot, so it can use one or more of the assigned slots of the Base station. This way of access to the VDL is called FATDMA (Fixed Access TDMA).

The next way of entering the VDL can be used if unexpected (no slot reservation) non-scheduled messages, e.g. text messages, must be transmitted. This can only be done by using non-reserved time slots. This is called Random Access TDMA (RATDMA). Because the message to be transmitted need free time slot(s) (up to 5 consecutive slots for some messages) a delay in transmission of such messages can occur.

In ship-to-ship communication at open sea, only SOTDMA and RATDMA are available.

## Final Policy Report EMBARC

In shore-to-ship communication FATDMA will be used, in ship-to-shore all modes can be used for transmitting messages.

The access methods described above are defined in ITU-R M.1371-1

### Mobile AIS stations (Class B using CSTDMA)

During the standardisation process of AIS Class B stations, a new access to the VDL is developed for several reasons. They will use free slots only, with other words, they will not reserve a slot for future broadcast but will sense the VDL on its occupation and once a free slot is detected, the station can decide to use that particular slot for transmission. This is called Carrier Sense TDMA (CSTDMA). One of the profits of this method is that Class B (intended to be used for recreational crafts with limited speed only) will have access to the VDL only if free time slots are available. It will act as a self-regulating method if many small recreational ships are sailing in a relatively small area.

The access methods described here is not yet defined in ITU-R M.1371-1 but will be included in the revision to ITU-R M.1371-2.

#### *3.2.1.4. Developments on VDL access*

To protect the availability of mandatory reporting on the VDL some developments need to be made in order to avoid eventually overload caused by additional non-SOLAS users.

### Non-SOLAS mobile AIS stations

The reporting intervals for Class A is defined and mandated by IMO as given in table 1. For all other mobile AIS stations reporting intervals are recommended as given in table 2. In the exceptional situations that many non-SOLAS ships with AIS are in a limited area, some measures have been proposed, to reduce the reporting interval of those stations.

The reporting interval will automatically be reduced by non-SOLAS mobile AIS stations, if less than a pre-defined number of free time-slots are available for slot reservation (see later) (35% is proposed now). This is important in a non-controlled area (no AIS Base stations).

In a controlled area (e.g. VTS with AIS Base stations), there is a new AIS message 23 defined for non-Class A stations only. This is a Group assignment message which can define an area where a group of AIS mobile stations (non-SOLAS only) can be addressed to reduce the reporting interval of that particular group for a given time period.

### Class B stations using CSTDMA

As described earlier, Class B stations using CSTDMA can only use free time slots and will automatically not be a threat for the VDL.

All the measures as described here are taken to protect the use of the VDL and to guarantee the throughput of AIS messages of Class A mobile stations. The effect will only be the reduction of reports from non-SOLAS stations, never to make the 'others' silent.

#### *3.2.1.5. Slot reservation and slot re-use*

Base stations will reserve fixed time slots for longer periods of time. This will be done by transmitting Message 20 (Data link management). It is not allowed to reserve these time slots by other stations within a distance of 120 nautical miles.

Mobile Class A (and if applicable Class B) stations in SOTDMA mode will announce the next time slot for the next message during its transmission. This will be done for both periodical messages (position reports and static/voyage related messages). Because mobile stations are expected to randomise the transmission scheme, the reservation must be made within a certain range of slots (candidate slots). If no free time slots are available within that range, already reserved time slots must be re-used in order to guarantee the transmission as scheduled by table 1. The re-used slots should be taken from the most distant stations from the candidate slots. No FATDMA reserved slots may be used. Once a distant station is subject to slot re-use, that station will be excluded by further re-use from your own station during one minute to ensure the next messages of that station will be received.

Remark: It can happen that two ships on a long distance not receiving each other are reserving the same time slots. This is not defined as slot **re-use** (this is only done aware). For a receiving station in between however, it will manifest as **double use** of time slots and both messages can be disturbed.

#### *3.2.1.6. AIS cell (ship-to-ship)*

The normal receiving and transmitting distance of mobile AIS stations is defined by the height of the antennas (mostly), the used transmitting power (less important) and the sensitivity of the AIS receiver. Also the propagation condition (weather) is playing an important role in the range of AIS. Each AIS mobile station has its own circle or cell defined by the actual range of transmission. By slot re-use, the cell seize is reduced in a dynamic way and fully automatically because the most distant station will not be received for a moment in time. The more AIS mobile stations there are, the more the own cell will be decreased.

## Final Policy Report EMBARC

Under normal conditions, the cell size of a mobile AIS station is about 25 nautical miles (about 40 kilometres).

For an open sea situation, with only ships sailing with an average speed of 14-23 knots (position report (1 slot) every 6 seconds, static/voyage report (2 slots) every 6 minutes), the average number of required time slots per time frame (1 minute) for X vessels will be

$$N_{\text{reqslots}} = X*10 + X*2/6$$

within the available 4500 time slots per minute.

The maximum capacity without re-using slots is than 435 ships. Taking some spare and some other types of reports into account, one can say that more than 425 sailing ships within the range of about 25 nautical miles will lead to slot re-use from the most distant ships. Even than, the positions of those ships will be known at own ship, however with a reduced reporting interval. In practise one can say that at open sea there are no problems with capacity.

In a port environment, with a huge number of AIS users, the situation can occur that in principle time slots of distant ships will be re-used by many other mobile AIS stations in your own vicinity. That will in theory result in not receiving the distant mobile AIS stations for longer periods of time. As a matter of fact, the actual cell size will be reduced. This can be acceptable as long as the cell size is such, that it will not hurt your manoeuvring space. You must be informed about the traffic situation as far as it affects your manoeuvring decisions and the speed of the objects (and your own speed) is part of that. It is not expected that the 425 sailing ships, as calculated before, are sailing within ships manoeuvring space inside a port area. However, there can be a lot of ships moored or for anchor in such an environment. To illustrate this, 50 sailing ships and 500 moored ships with working AIS can be a realistic scenario within ship's VHF range. The load on the VDL per frame (1 minute) can be calculated as follows:

$$N_{\text{reqslots}} = (50*10 + 50*2/6) + (500/3 + 500*2/6)$$

which results in 851 required time slots. Compared with the available 4500 time slots, there rests a lot of free available time slots for Base station reports and safety related messages in each frame.

In an area with a lot of Class B stations (e.g. much inland navigation, being Professional Class B users), say 200 extra ships with an average speed of 14-23 knots, it will generate an extra required number of time slots of:

$$N_{\text{reqslots}} = 200*4 + 200*2/6$$

or 867, giving the total number of required time slots in such an environment of 1718.

With these calculations it will be clear that the capacity in a port environment is sufficient and slot re-use will seldom appear. Exclusion of users to the VDL is not expected.

The calculations before are assuming an averaged speed of the vessels between 14 and 23 knots. In a port environment however, many ships will move slower than 14 knots, which results in a larger capacity of the VDL.

### 3.2.1.7. *AIS Base stations*

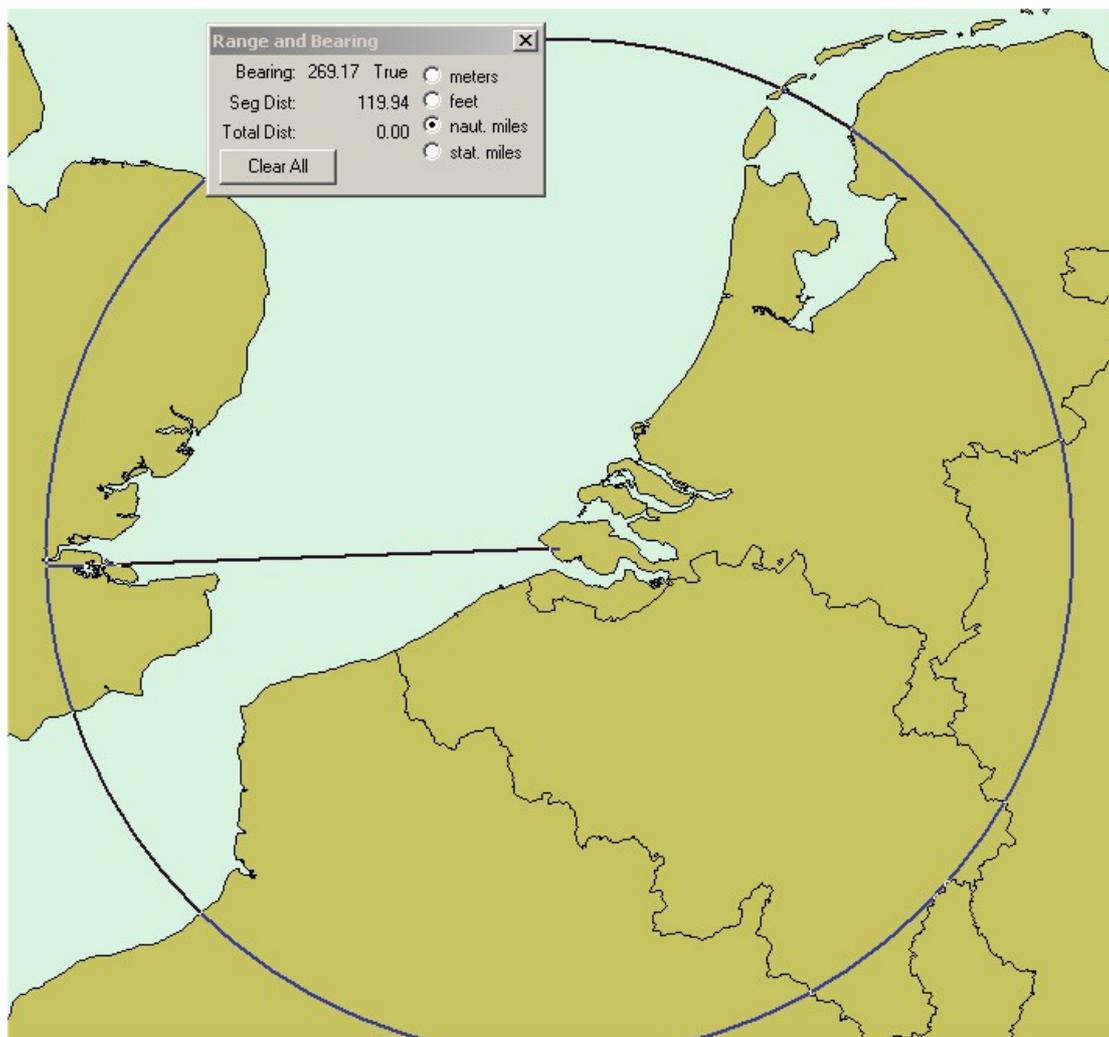
AIS Base stations will be installed in a VTS area or a coastal network and the number of them will be planned to cover at least the whole area of interest. Landscape, buildings, propagation conditions and redundancy are playing a role in planning an AIS base station network. Based on the installation one can calculate the required number of time slots to receive all ships in the covered area. This will be based on the maximum expected number of AIS equipped ships in the covered area of one particular AIS Base station and this must be done for each individual AIS Base station of the network. Important principle for VTS based AIS is that all ships in the area must be received with high reliability, with other words; there must be sufficient free time slots to receive all ship reports without double slot use (including slot re-use). The problem with slot re-use for AIS Base stations is that one, or may be even both transmitted messages will not be received by the Base station. If slot double-use appears from a Base station point of view, it is time to install additional AIS Base stations and to reduce the dimension of the Base station's cell. This can be done by using directed antennas, lower the antenna height or reduce the Base station receiver sensitivity.

Base stations will normally use FATDMA slots, reserved by the Base station itself. RATDMA for Base stations is also possible. The use of FATDMA has consequences for slot reservations for other users. FATDMA reserved time slots can not be re-used by any other

user within a radius of 120 nautical miles. In areas with many Base stations within a circle of 120 nautical miles (see map) all reserved FATDMA slots by all Base stations are protected by other users. The following picture gives an example of an area with many Base stations in potential. A rough estimate yields possible 30 AIS Base stations. Each Base station requires at least 6 time slots per minute to transmit its own report (every 10 seconds and only one slot per message): 180 time slots. Furthermore each Base station needs to transmit its FATDMA schedule (Data link messages are transmitted periodically, maximal every 7 minutes (1 slot, for each channel separately)) and will certainly reserve slots for assignments and special messages. So may be 400-500 slots will be the minimum in such an area for Base station reservations. The conclusion can be, that taking into account the available slots and what is required by ships (see previous calculations), the capacity of the VDL is sufficient.

### 3.2.1.8. *Remark*

The reservation of the required slots by Base stations must be co-ordinated by the Administrations involved (who are reserving which time slots) because Base stations in that area are not allowed to reserve the same slots and the required slots must be spread over the time frame. For this a guideline for slot reservations will be drafted by the IALA AIS Committee in the near future.



### 3.2.1.9. *Other type of messages*

In the discussion before, only ship position report messages and ship static and voyage related messages of mobile AIS stations were discussed and Base station usage of the VDL. The following messages are not involved in the calculations and this paragraph will discuss the impact of other types of messages.

- Text and Binary application messages. These messages need 1 to 5 consecutive time slots, depending on the content of the message. Mobile stations can transmit such messages using RATDMA (they are not scheduled and not repeated, so they are not reserved in the slot map). During heavy load of the VDL it will take some time before the requested number of consecutive slots is available. Mobile stations can also transmit such messages using pre-defined FATDMA slots from a Base station. Base stations will always use FATDMA slots, reserved by the Base station itself. Because Text and Binary application messages will be transmitted only once or may be every 5 minutes or so, the load on VDL in each time frame will be marginal. If every Base station transmit one such a message (max size) per frame (minute), only 5 slots will

be needed per Base station. Mobile stations are only allowed to transmit safety related messages and this will be very rare, so hardly any extra load on the VDL is to be expected.

- DGNSS corrections via AIS messages will form a relatively heavy load and this is not recommended in a traffic dense area. In such area one can better broadcast DGNSS information by the regular (and IMO standardised) radio beacon DGNSS service.
- All other messages will be broadcast incidentally and will not give heavy load on the VDL.

### *3.2.1.10. Conclusion*

In ship-to-ship operation the capacity of AIS is flexible by dynamic cell seize. Re-use of time slots can happen if many ships are on receiving range of the mobile station which practically results in a smaller cell. Normally spoken, the capacity in the ship-to-ship mode is unlimited.

In a Base station situation, where all messages need to be received in the area of interest, capacity can be enlarged by reduction of the receiving range and the installation of additional Base stations.

Special measures are available for a large concentration of Class B stations in a relative small area to avoid limited throughput of Class A stations.

### *3.2.2. Policy implications*

Conclusions regarding AIS capacity:

- In ship-to-ship operation the capacity of AIS is flexible by dynamic cell size. Re-use of time slots can happen if many ships are on receiving range of the mobile station which practically results in a smaller cell. Normally spoken, the capacity in the ship-to-ship mode is unlimited;
- In a Base station situation, where all messages need to be received in the area of interest, capacity can be enlarged by reduction of the receiving range and the installation of additional Base stations;
- Special measures are available for a large concentration of Class B stations in a relative small area to avoid limited throughput of Class A stations;
- The AIS capacity in the port environment (even in very busy ports) is sufficient and slot re-use will seldom appear. Exclusion of users from the VDL is not expected.

### **3.3. Validation of VTMISS**

#### **3.3.1. Research results**

Within the validation task, WP02 of EMBARC sought to detail the relationships between stakeholders and services in differing port situations in order to place the setting in which information is generated and used. So as to provide an overview of current practice in various European ports a series of interviews were planned whereby the potential stakeholders and services were “placed” within a grid. A tool was developed and used to raise the awareness of organisations as to where they “sit” within the VTMISS principle (Public/Private and Nautical/Logistic). It provides the means to visualise both the current state of affairs and the situation being worked towards, especially following privatisation activities.

It was clear that the “status” of information/data collected by the stakeholders depends on the intended use of that information. The moment a third party wishes to make use of that data it should be verified as to whether it is fit for the purpose.

Further, operational procedures are formed to meet requirements as set out on an international, national, regional and/or local basis. The procedures within the port area set out how the relevant regulations are to be implemented for a particular local environment. Considering operational procedures together with the mapping of the stakeholders and services, it is noted that procedures are necessarily different in each port, if the public/private balance is to be maintained. Whilst generic procedures can be met for International aspects, the public vs. private makeup heavily influences local procedures. This “living” situation is dependant on the local organisational structure / environment. Working towards common standards will require close scrutiny of local solutions for public vs. private cooperation related to the role and responsibility of the said organisations.

The Data Flow Diagrams developed from previous research captured the principles as laid down for VTMISS. They were shown to be valid for the generic processes within the port environment however comparing this to the relationships between the stakeholders it can be seen that necessary differences in procedures are required. This is to reflect the public/private relationship, as well as the differences in services provided by the same category of stakeholders in the various ports.

Whilst it can be said that elements of the VTMISS principle were to be found in each port visited, it should be noted that local solutions and the procedures therewith, taking into account local peculiarities, lead to the conclusion that generic VTMISS is not a definable entity

## Final Policy Report EMBARC

on a European level for all aspects of Vessel Traffic Management. The variation in local procedures reflects International, European, National and Local legislation as well as the public/private make-up. In addition this is linked to the varying roles and responsibilities of identified Stakeholders through the type and level of services provided. It was shown that the VTMS principle can only be held to a generic level with respect to input/output requirements and not internal processing and local distribution.

Whilst ports, and thereby Traffic and Transport Management, may be subject to differing regimes (based on type of port) and may require individual, often unique, solutions in order to optimise the level of co-operation between the two sectors, it could be seen that there was sufficient coherence between the two sectors.

The aspects identified above need not hinder the development of generic reporting procedures on a European level for certain requirements. All ports visited demonstrated the ability to collate, qualify and distribute data on a local level (i.e. within the port community) and provide links to the relevant external bodies (i.e. national coordination for Search and Rescue).

Links with the Transport Management were not prevalent; however where close Public/Private working relationships were present it was seen that the availability, and ultimately the quality, of information flow led to more efficient operations.

A generic tool has been developed and tested to obtain insight in which way the public and private stakeholders operate with respect to the available logistic and nautical information flow. This tool creates a higher level of awareness where overlap of data exists and where improvements could be achieved. This tool is supported by a research report about the interoperability of the information flow associated to the physical flow regarding automatic identification systems of cargo, equipment and vehicles that handle cargo (tracing/tracking).

The tool developed is considered a “living” instrument which means it provides the means to visualise both the current status quo and the situation being worked towards, especially following e.g. privatisation related issues and subsequently changes in the Public-Private-Partnership and their responsibilities in the span of control. It is used to raise the level of awareness of organisations as to where they operate within the Vessel Traffic and Cargo Handling (Public/Private and Nautical/Logistic) environment.

With respect of the need for, and use of, information the following steps were and are to be considered:

1. Identification of need for information, e.g. ETA, ATD, Dangerous Goods;
2. Identification of available attributes (Information Processing Systems, Automatic Identification Systems, Vessel Traffic Management tools etc) required within the information flow process;
3. Identification of potential sources. There is often a choice of more than one, e.g. radar observation, AIS derived data, radio communication, through an agent;
4. Identification of status of information. This is often linked to the source and original purpose for gathering that information and may indicate whether this information is freely available or not, also taking into account security issues. This could be seen as a “matching” process;
5. Identification and assessment of the level of data and information quality.

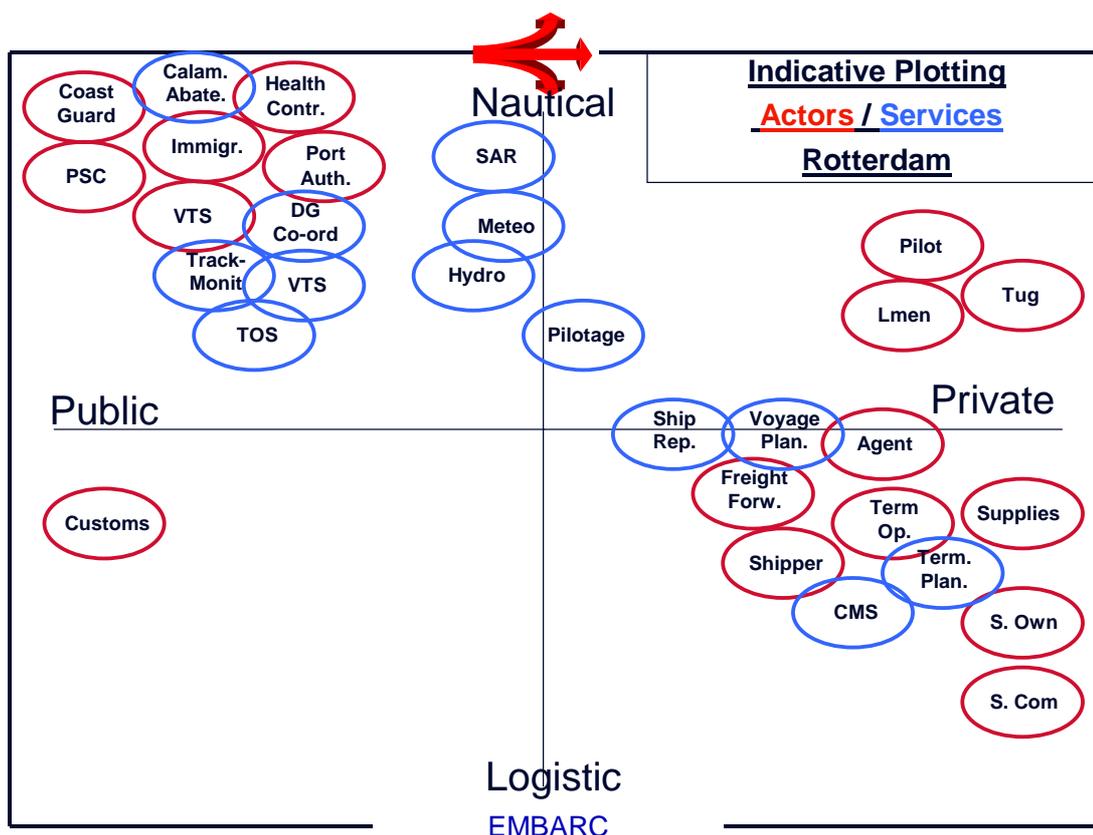


Figure 3-1: Indicative plotting used in “Validation of Vessel Traffic, Cargo Handling and relevant Stakeholders”.

The “status” of information collected will depend on the user, the intended utilization of this information, as well as the quantity and quality of the available data. The moment a third party wishes to make use of that available information, it should be verified as to how this party fits in the information chain in order to ensure security aspects and prevent the possibility of scrutinizing the information flow.

Utilizing of this tool in wider context throughout Europe will result in faster insight in the (local) information flow amongst the various stakeholders and the hereto, related level of quality of services. Finally it will lead to a more cost effective, efficient and safer use of the available resources in Vessel Traffic Management and Cargo Handling related activities and raises the level of awareness amongst the key players in this process.

### **3.3.2. Policy implications**

Whilst ports, and thereby Traffic and Transport Management, may be subject to differing regimes (based on type of port) and may require individual, often unique, solutions in order to optimise the level of co-operation between the two sectors, it could be seen that there was sufficient coherence between the two sectors.

Where elements of VTMISS have been implemented it was reported that improvements in the availability, quality and access to information had assisted in the overall effectiveness of the services provided within the port environment.

Further, operational Procedures, in response to the various levels of legislation to be implemented, are influenced by the stakeholders acting within the port and the services they provide, either as a public task or commercial activity. This creates differences in information flows within the ports due to local requirements however is open for procedures required to be fixed on an inter port or European level.

However, it was shown that the VTMISS principle can only be held to a generic level with respect to input/output requirements and not internal processing and local distribution.

It was noticeable that there was a definite need for awareness within the Transport Management sector with respect the potential added value of closer cooperation with the Traffic Management sector.

In the ports studied, with respect the links between resource and cargo management, the public bodies and the private bodies developed technological tools to satisfy their local needs for improving their tasks and the services.

### **3.4. AIS in a port environment**

#### **3.4.1. Research results**

The potential of AIS for resource planning/ resource management in the port environment has been investigated. In the context of the study this concerns the *planning of the resources* of nautical service providers i.e. the Port Authority, pilots, tug companies and linesmen. The ETA or ETD notification forms the starting point for planning of most port activities including planning of resources. Consequently the study focuses on the potential of AIS for obtaining and improving ETA/ ETD information.

The capacity of AIS in a port environment has been investigated and the results have been incorporated into this report in chapter 3.2.

Position data, including ETA information (provided by AIS), will be available in Coastal Authorities' databases of EU countries within the SafeSeaNet initiative. This information might be made available to the VTS/ Port authority, which may be seen as the logical node for receiving/ sending AIS information and making in turn this information available to the nautical service providers. The potential benefits of introducing AIS in a port for the purpose of resource planning will differ depending on the facilities already in place in the port concerned:

- Ports without radar based VTS might benefit substantially from information made available by AIS for planning purposes. This information can be obtained by means of own AIS base station(s) and/ or AIS (coastal) networks;
- In ports equipped with radar based VTS including an information processing system the added value of AIS information for planning purposes will be limited. The AIS information could be seen as an additional source of information for improving ETA information; not as a replacement of existing systems.

The legal framework within which AIS data is to be received and managed by State authorities is not yet entirely ascertained. Various considerations must be taken into account, legal and political. Whether AIS data should be protected by data confidentiality laws largely depends on whether it can reveal information about individuals, such as ship owners,

or crews. It will be necessary to exactly determine the purpose for which AIS data is to be processed and/or distributed in order to determine the applicable law.

Incident and Calamity Abatement (ICA) will always benefit from more accurate data to build up situational awareness. AIS is expected to contribute to this. The minimum requirements for an appropriate strategy in European waters was studied and discussed.

Main emphasis of the study was laid on the identification of those AIS specific data and the integrity therewith to determine required *essential* and *additional desired* data (supplementary) for ICA. The potential benefits of AIS were identified by performing a case study using a slightly modified collision scenario, thereby assuming that AIS was available. Potential benefits were identified for both *shore based ICA authorities* and for *ships in need of assistance*. The use of AIS allows for quick data access of the shore based ICA authorities and makes it possible to have information about and from the concerned ship(s) in need of assistance. In this way the decision for e.g. a suitable place of refuge for the ship in need of assistance might be facilitated. Nevertheless, in order to integrate AIS into existing information chains during ICA, it is necessary to modify the AIS - HMI on board ships by developing user-friendly facilities for the input and the display of data, whereby AIS should not replace existing systems (e.g. GMDSS), but should be used as an additional means.

Introduction of AIS will have an effect on the work in the port environment. The Human Factors effects of AIS information for new technologies, new task environments and different work conditions of Vessel Traffic Management operators have been addressed.

A test-bed has been developed to illustrate the effects of AIS information on VTS work and to study the potential benefits and constraints in application of AIS information for VTS. The test-bed consists of an interactive portable VTS simulator, on which traffic scenarios are run. Reactions of the VTS operator are assessed through a number of assessment methods, including performance measurements and interviews. This test-bed has been used in a field study to determine recommendations with respect to the presentation and monitoring issues of AIS derived data on traffic images in order to ensure common interpretation. For this study visits were conducted to a number of European ports in different countries, and with different characteristics. Visits have been made to the ports of Cork in Ireland, the ports of Rotterdam and Flushing in the Netherlands, the port of Genoa in Italy and to the port of Helsinki in Finland.

The tests and discussions show fairly consistent results, even though the differences in ports and traffic that the VTS operators are used to are large. Operators from ports all over Europe are well capable of handling the test-bed and the traffic presented in the scenarios. The main conclusions are:

- Potential advantages of AIS information for VTM are generally recognised, but reliability of AIS data is a widespread concern. Reliability issues need to be resolved before AIS can be a source of information that can be trusted by VTS operators;
- When managing traffic, operators do not question the reliability of AIS information. The information is integrated in the situation awareness of the operator with information from other sources, such as radar, without distinction;
- Presentation of information in VTS displays should not be fundamentally different from that on board ships (e.g. advanced processing of data);
- The test-bed is an excellent tool for raising awareness. It can be used for visualising issues such as the consequences of AIS and for invoking discussion with VTS operators on issues such as the effect of AIS for VTM.

### **3.4.2. Policy implications**

- Real life tests should continue to be carried out in order to determine the usefulness of AIS as an additional source of information for among other things service providers. The reliability of AIS data, the effects of possible abuse of the system and the possibilities for channel management among other things should continue to be addressed in these tests;
- It is recommended to speed up the development of standardised safety related text messages with respect to also support shore based ICA measures;
- It is recommended to speed up the development of AIS binary messages and to ensure its harmonised use;
- Man Machine Interface of AIS installations on board vessels should be (urgently) further improved in order to allow for quick and easy handling of data in particular for emergency situations;
- Maintain presentation of both radar and AIS data in the VTS display, with clear distinction between the two, even when AIS data are not reliable;
- Avoid taking the VTS operator out-of-the-loop by solving the problem of reliability of (AIS) data with technical means without informing the operator;
- Designate an area at the border of the VTS area where reliability of AIS data on board ships is addressed;

- To ensure adequate awareness training programs during the transition by VTS authorities towards AIS;
- It is recommended to review and assess on a European level the legal regime governing the management of AIS data, concerning data protection, freedom of information and the re-use of information. This review should take into account European law and the domestic law of the Member States.

### ***3.5. Vessel Position Prediction***

#### ***3.5.1. Research results***

The investigations carried out under WP05 delivers a set of interesting results. Vessel position prediction has a deep impact on the effectiveness of traffic monitoring. The knowledge of the estimated time of arrival (ETA) of a vessel at a certain port of destination, reporting position or another waypoint of a voyage are of great importance especially in cases of emergency, when quick help is needed and co-ordination and planning of resources have to be performed. On the other hand the ETA is an essential data for shore based resource planning in ports, e.g. tugs, locks, berthing places etc.

Achievements and results of this SWP are the overview on the actual state of VTS passage planning and position prediction and the description of the potential benefits of AIS use for this specific purpose.

During the investigations within SWP 5.2 it became clear that tidal and traffic planning, e.g. to avoid dangerous encounter situations, is presently done separately and subsequently. Therefore a suggestion was developed how to combine different solutions. The outcome is the draft of a concept for the extension of the use of the electronic way time diagrams by integrating vertical tidal information. The additional display option is an absolutely new function to support VTS operators by planning a safe and efficient traffic flow in linear fairway sections. The idea is based on the temporary display of speed functions belonging to the relevant tidal windows of vessels and to detect critical encounter situations on the basis of a certain value of added ship's breadth.

Further achievements of this work package are the results of statistical field studies into the present state of the reliability of AIS data. With respect to shore based traffic monitoring the analysis shows that e.g. the ETA data provided by AIS are often invalid or cannot be used because they are not updated. The partition of negative ETA data of the analysed spotlight was nearly 20 %. It is assumed that these are cases either of incorrect data input or of not updated AIS data..

Finally further outcomes of these field studies are also the clear identification of shortcomings and failures of present AIS installations, which have to be overcome to realise the potentials and benefits of AIS for traffic monitoring. Suggestions how to solve the problems are given as recommendations. It is shown that shore based authorities presently cannot rely very much on received data because they might be often poor, faulty or invalid.

### **3.5.2. Policy implications**

From the gained results of this WP further steps of necessary research activities to overcome the identified problems, were derived. Within the following list these outcomes are summarised as political implications and recommendations:

1. ETA and ETP is essential information to all public and private, commercial and non-profit institutions and bodies dealing with the vessel traffic.
2. Reliable ETA / ETP information is one basis for more safety in the maritime transport.
3. Managers of terminals or ports need ETA information to plan cargohandling activities in their port or terminal. ETA information can also optimize the planning in relation to the vessel's passage through locks and/or bridges.
4. With respect to the potential usage of AIS data for the planning of operations following the sea trail of a vessel as e.g. lock, pilot, tug and berthing operations through any private or public service provider seems to be a bit too early. Presently it is much more necessary to train the users onboard how to use the new tool for their work.
5. Furthermore it has to be decided and clearly defined which waypoint is related to the ETA, when inserting the AIS data. It is strongly recommended to the Commission to support the quick review and refinement of the relevant standards.
6. Way - time diagrams are a suitable mean for passage planning in linear fairways.
7. The use of AIS for the additional exchange of planning data (shoreship) should be considered (e.g. necessary rules and procedures for that are missing) for future use.

8. Effective passage planning in a harbour approach (especially with long and narrow linear fairways) seems to be necessary by a centralised shore station.
9. The uses of suitable computer-based planning tools are recommended.
10. Efficient use of AIS data for shore based traffic monitoring and planning activities needs further detailed research and developments especially into the enhancement of the reliability of the data and policy activities regarding the existing AIS and also for training standards and IMO model course respectively.
11. AIS data are very helpful to support the prediction methods presently in use, e.g. the radar based speed function used for the position prediction in linear fairways could significantly be enhanced by using the current speed over ground information of AIS equipped vessels. These are especially valid in case of big vessel dependent on the tides and for the avoidance of critical encounter situations.
12. Additional AIS data on dangerous cargo on board may be added to traffic rules and traffic organisation and planning algorithm as well to reduce the traffic risks, as e.g. by shifting critical encounters between Ro-Ro passenger vessels and tankers outside linear fairways or at least to wider fairway sections.
13. The results gained during the investigations into the reliability of AIS voyage related data shows, that the process of updating these data through the responsible navigating officers is not yet sufficient and has to be optimised and to be integrated in a suitable manner into the voyage preparation phase as well as to the bridge procedure which in fact an ISM related subject.

### ***3.6. Navigation Support Services in Ports***

#### ***3.6.1. Research results***

This report describes the execution of a FSA in a port environment with respect to the required Navigation Support Services. The first part of the project deals with a description of the roles and responsibilities of the different stakeholders in a Vessel Traffic Management System in a port. These roles and responsibilities are used to determine the functions that need to be performed. The information that is required to fuel these functions is described. These issues, functions and information, are the basic requisites to perform a Formal Safety Assessment on Navigation Support Services. These services are defined as services that are required to safely and efficiently enter and depart from a port. These services comprise, VTS and pilotage, but tugs and mooring gangs are also important and are addressed in the FSA.

## Final Policy Report EMBARC

WP6 has developed a FSA to determine the level of nautical assistance of a vessel that calls in a port. These nautical services normally comprise VTS services, shore-based pilotage, pilot on board and pilot on board with a PPU.

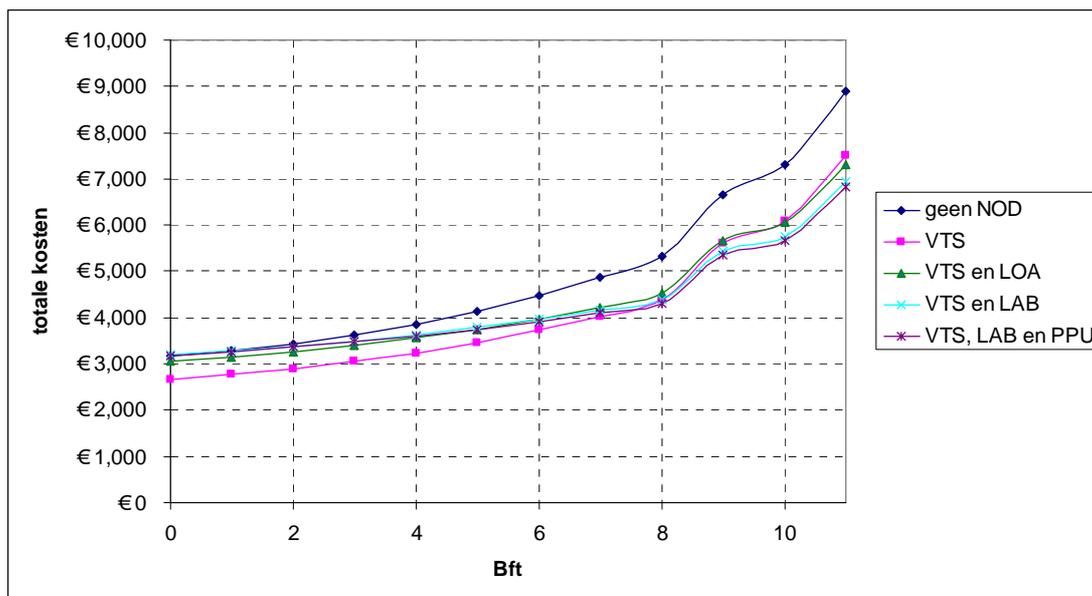
The FSA consists of the determination of the risk of a vessel that will enter a port without any assistance. The risk is based on the determination of frequency of an accident and the average consequences of an accident. Seven types of accidents are distinguished. Each has its own accident rate. The frequency of accidents is dependent on distinct factors, such as age, classification society, flag and type. Weather and fog are time dependent factors which are also taken into account.

The nautical services are seen as Risk Control Options. Pilots and other experts have determined the risk reduction factor, and also the multiplication factors that need to be applied on the average risk level.

For each vessel dependent on the distance sailed in a specific port a monetary value of the risk is determined. The effect of wind and fog are considered as time varying risk increasing factors. These effects will also be apparent in a longer time needed to navigate to or from the berth and the time required for berthing and unberthing. In order to optimise i.e. to determine the optimal nautical support for each arriving or departing vessel, the costs of each form of assistance in monetary terms is calculated. That form of assistance is chosen that minimises the monetary values of risk the ship's time and the costs of assistance rendered as function of the wind force.

The method has originally been programmed for the port of Rotterdam, but many improvements have been made. The method is also being used in Genova and Göteborg.

The results so far show, however, good agreement with the present day practices in the port of Rotterdam. See figure below.



**Figure 3-2: Costs of different alternatives as function of weather**

The following explanation can be given of the figure above.

For each risk option (O) such as VTS, Pilot on board etc all the costs are summed up as follows:

$$Risk(ship, O_i, BF_j) + Shiptime(ship, O_i, BF_j) + costresource(ship, O_i) + costtugs(ship, O_i, BF_j) = C_{i,j}$$

The graph of  $C_{i,j}$  is given above. The option with the lowest costs is the best choice. In this case, a container vessel of about 150 m and of slightly above standard can enter the port of Rotterdam alone under VTS guidance until BF7. When there is more wind than indicated by BF7 than a pilot on board with a PPU is the best choice under severe winds. One can also see the effect of tugs by the sudden increase in the graphs. It should be remarked that using tugs, the risk is reduced by a factor 5 but the costs are high and sometimes the costs of the tugs are higher than the risk reduction due to tugs.

For each vessel such a graph can be constructed. Each port has its own accident pattern which requires a customizing of the figures to each port's accident pattern related to the traffic.

**3.6.2. Political implications**

The political implications are important:

Firstly, the method might provide a uniform method for all European ports to determine the level of Navigation Support Services. This contributes to a level playing field on safety matters for European ports. Safety should not be an issue for competition between ports.

Secondly, it will help reduce costs for those ship owners that really take care of their ships, their crews and their equipment. If vessels are above medium standard, the ship risks will decrease and as a consequence often less costly Navigation Support Services need to be provided.

Thirdly, it also provides a framework for pilot exemption policy of smaller vessels with the same masters that are regularly callers in a port.

Fourthly, it assists in reduction of call costs making European ports more attractive and affecting transport costs to make the “motorways of the sea” more attractive.

#### **4. References**

- [1] LRIT workshop  
Organised by IALA in Victoria, Vancouver, Canada, October 2004