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Service Description: Harmonised Data Exchange with Inter-VTS Exchange Format (IVEF)

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Executive Summary

The pilot showed the interchange of traffic images between VTS's and between vessels and coastguard/VTS centres (vice versa), making use of the IVEF standard.

To share information between parties is of great importance to reduce misunderstanding between parties and to enlarge/enhance the information coverage of the individual parties. Examples of tasks which benefit from the information exchange are:

- SAR tasks
- VTS / Monitoring tasks
- VTS outside territorial waters
- Port entry by vessels

Sharing the picture build up by your own sensors and shared with other parties in the same area has several advantages:

1. Saves money on installing and maintaining sensors like radar and AIS stations;
2. Possibility to verify your data with data of partners;
3. Track smaller targets than possible from shore only;
4. Share a common harmonized picture over a specific area with partners (shore and ships);
5. Ability to look and search further than your own sensors farm;
6. Backup system for your shore based system;
7. Ability to have data available when needed in areas normally not covered.

Some disadvantages or points that have to be solved are:

1. Quality assurance of the data;
2. Responsibility of the data;
3. Legislation about sharing data;
4. Communications costs;
5. Implementation costs for current (proprietary) systems.

Growing from coverage only on the shore site as shown in figure 1 to a coverage on need and current shown in figure 2:

Figure 1: Current sensor (radar) coverage

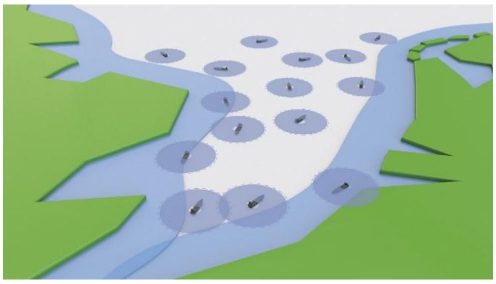

Figure2: Possible sensor (radar) coverage

Implementing the pilot showed that not all shore based systems are already IVEF compliant, due to different reasons, what makes the connection between these systems more difficult. This problem is even greater on ship site but some standardization helped already making use of the same sensors on board.

The organisation of the pilot was the greatest challenge: getting everybody involved and enthusiastic, getting permissions and cooperation. Cooperation with the German EMS VTS and the British coastguard was planned, but is not realised due to the fact that both organisation were dealing with a redesign of their systems and were not able to deal with adjustments on their systems for the pilot at the same time In the last case special thanks goes to the Dutch Coastguard and the crew of the Barend Biesheuvel.

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1 Introduction

1.1 Background

"What is your status?" misunderstanding is often caused by miscommunication, particularly when information used is different, not complete or not clear for the parties involved. What may result in unsafe hazardous situations for ship, crew and environment?

It is well understood that the availability of reliable and accurate information is essential for the (future) traffic management, logistics and decisions for the operational processes both on board and on shore.

Liu and Wu (2003) studied 100 collision reports from the maritime authorities of the UK, USA, Australia, Canada, New Zealand and Sweden. They found that communication problems were one of the most prominent causes of accidents at sea. The most frequently identified causes were lack of communication and misinterpreting information. Underlying human factor issues, they concluded, were the reluctance of navigators to exchange information.

In the passing years information gets more important every day for enabling a safe passage on the same waterways as before. Bigger ships, more ships, other use of the waterways (i.e. windfarms, oil platforms and environmental areas) reduces the accessibility of the area.

With all these threats for the "freedom of the Sea" the ports situated alongside the waterway (Sea) wants to have an even greater accessibility of their ports. Therefor knowing what is happening in your port and on the fairways towards your port, is essential. All measures supporting the processes that enable a safe and reliable infrastructure are welcomed.

Sharing harmonized traffic images between partners is essential to enable this goal. Sharing this information supports services like:

- port logistics, planning services (port and fairway);
- port entry of vessels, Having this information ships could decide on their own or on advice of a VTS operator to adjust their intentions. VTS services (INS/NAS/TOS);
- SAR services;
- monitoring and management services (including the provision of "future" route advising;
- enforcement of (inter)national/regional maritime laws and regulations);
- it could even enable the possibility to provide VTS services on difficult areas like VTS outside territorial waters;

At the ship site a huge part of the same data, next to her own data, can be used for:

- the operational processes on board for a safer, faster and more reliable journey. Saving money on fuel and harbour fees.
- In case of an incident, taking part in an on-scene command procedure

Traffic images must be accurate, reliable, up-to-date and covering the area of responsibility and the area of interest.

Most waterways authorities already have a complete image/coverage of their area of responsibility, but this may not be the same as the area of interest. This area of interest is often covered by an adjacent authority and therefore could be provided by this adjacent authority. Sharing a harmonized image gives all parties the same and more reliable picture of the current status of the waterway and the object they will encounter.

Areas where the information is unavailable or not accurate enough, mostly further away from shore, and most difficult cover with radar or receiving AIS data. These areas are still sailed by ships and could share there sensor data (radar/AIS) with other ships or the shore.

By this way the shore and ship side sharing information on a structured way could save investments costs for information services supporting services for all parties involved.

1.2 Scope/goal of the pilot

To obtain a (more accurate) image of the southern part of the North Sea is very costly and seems not always necessary at all times. Therefore a solution could be a temporarily extra (more accurate) coverage of an area by radar and/or AIS when necessary, e.g. during SAR operations or the establishment of temporary VTS outside the regular VTS areas.

The goal of the pilot was to obtain and share a traffic image of the whole of the North Sea area and share this with all partners (cross-border/cross-responsibility) around the North Sea for their tasks. This implicated connecting the shore based systems of these partners to each other and share the data. This will give each partner next to its own area of responsibility a verified picture of the area of interest covered by a partner.

But some part of the area of interest is not covered on the North Sea by shore systems but will, when this is available, help for safety and logistics on. The main interest will be where ships are sailing. If these ships could share their traffic picture with others (ships and shore) a common shared traffic picture of the areas of responsibility and interest would be available for every partner (ships, shore, planes, oil-rigs etc.).

Better and more accurate information about an area of interest by using on-board radar images and/or AIS. Particularly in case of an incident the on-scene command is in some cases on board of a vessel nearby the location of the incident. The on-board radar/AIS information may provide very useful information for the SAR Authority to handle the incident. Because when there is more distance between the radar sensor and the target, the accuracy will get less, what will result in smaller objects not being detected.

1.3 Current status

At the moment, the Netherlands Coastguard is connected with several domestic VTS systems providing the Joint Rescue Coordination Centre (JRCC) at the Coastguard a real-time picture of the complete Exclusive Economic Zone (Netherlands part of the Continental Shelf). This picture consists of fused radar and/or AIS data. It should however be noted that only the coastal waters are covered by radar, which of course makes this part of the overall picture more accurate and reliable, the rest is only based on AIS data.

Figure 3: Current sensor (radar) coverage

In case of incidents or with the extension of VTS outside radar coverage, it will be very useful to have on demand access to on board radar image of vessels navigating in that area.

A larger image, exceeding the boundaries of the Dutch Exclusive Economical Zone, could help to fulfil the objectives, like:

1. safe navigation (cross border SAR operations), accessibility of ports and maritime waters, sustainability;
2. accessibility of maritime waters (planning and the prediction of traffic intensities);
3. future management of traffic in order to enhance (or at least maintaining the same level of) maritime safety;
4. to guarantee the accessibility of ports in the region;
5. protection of the environment.

Collaboration between all relevant stakeholders in order to defy the identified future challenges and risks for the North Sea Region is considered to be inevitable.

Sharing data and information with the relevant parties on shore and ship side in the Netherlands and abroad like the UK (VTSs, MRCCs) could enhance the effectiveness of the separate bodies. Sharing of information will improve their tasks.

1.4 Description of the Harmonised Data Exchange Service

The IVEF Service is intended to provide a common framework for the exchange of real-time Vessel Traffic Image[1] information between shore-based e-Navigation systems, such as VTS systems, e-Navigation stakeholders and relevant external parties. The IVEF Service is described in IALA recommendation V-145 and may be revised based on the results of the ACCSEAS test.

Figure 4 shows a situation, where VTS centres share information about the common operational area and also to relevant other users and authorities.

[1]The consolidated information about vessels and their movements in a particular area of interest. This information may be presented in different ways according to the task at hand.

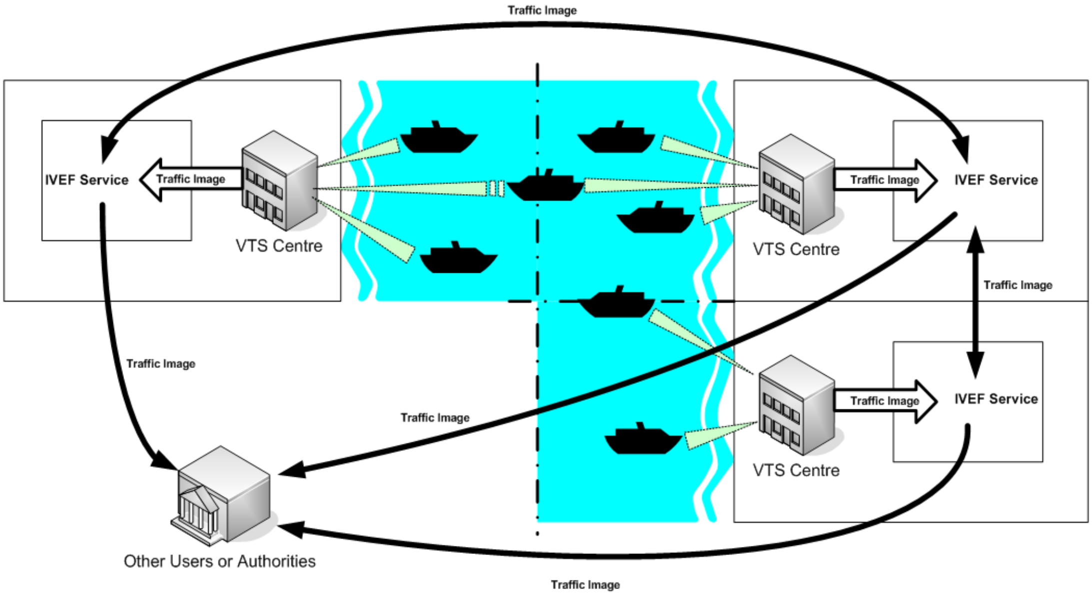

Figure 4: The IVEF Service in operation

The current Harmonised Data Exchange Service is client/server-based on the IVEF (IALA V-145) protocol. Clients make a connection to a server, running the IVEF Service and receive traffic image data according to their specific preferences and authorisations (Figure 5). It should be noted that different clients may specify different data requirements, such as the area of interest, the update frequency and the particular traffic objects that are relevant to them. Based on the client credentials, the IVEF Service will enforce restrictions on the data that is being provided to the client. These restrictions can be specified by the data provider.

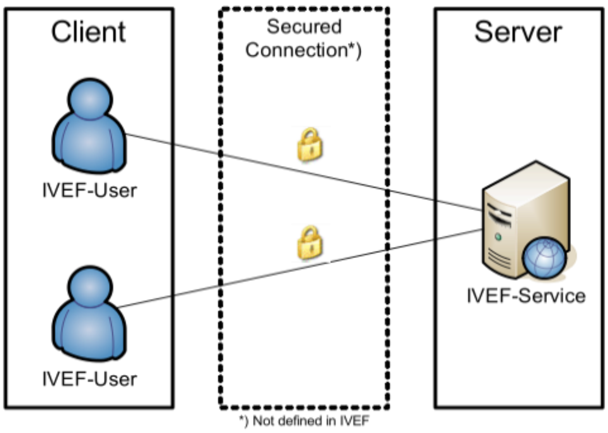

Figure 5: The IVEF Service Client/Server Model

The previous text gives the current situation as installed and operational in the Netherlands.

Essential is the means of communications for connecting all stakeholders (Coastguard centres, vessels, SAR-units) what can be done through the “Maritime Cloud”.

This situation is shown in Figure 6 below.

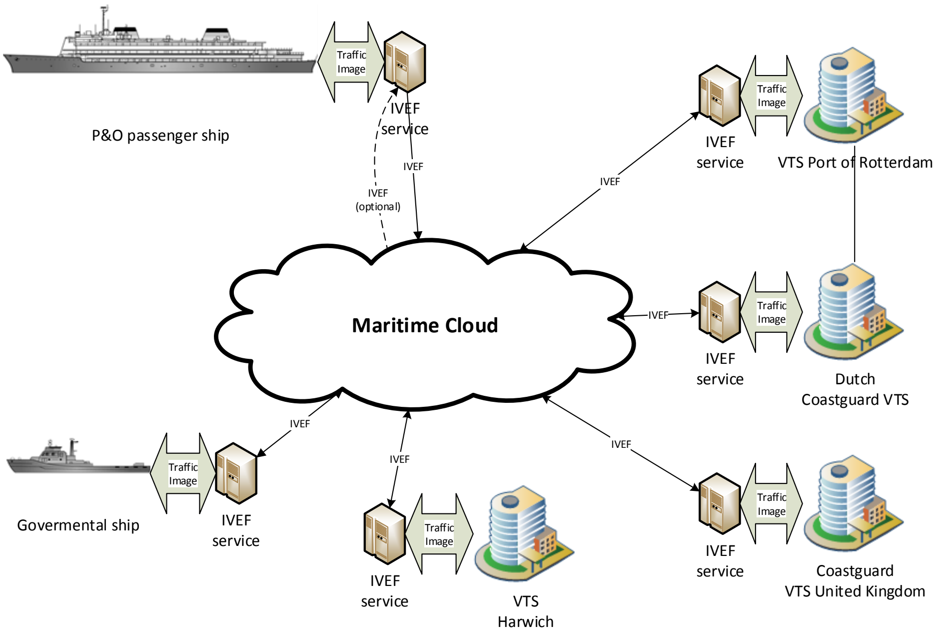

Figure 6: IVEF Maritime Cloud

1.5 Considerations

During the project there were several considerations for testing and using the IVEF service in combination with the Maritime cloud. The following considerations were taken into account:

1. The maritime cloud makes it possible to manage the subscription/use of the traffic image exchange service;
2. The maritime cloud makes it possible to switch between different communication channels. In this way always the most efficient communication channel can be selected;
3. The IVEF service is already in use (shore to shore)and is a recommended service by IALA (V-145);
4. The IVEF service is tested and used in the Netherlands to connect VTS centres and the Coastguard centres with each other.

New technology, like the “Maritime Cloud”, may make it easier to share data transnational between VTS centres and/or vessels. Using this gives other opportunities than available when the IVEF protocol was invented but also gives new challenges with privacy laws.

Unfortunately, due to lack of time, sharing the data through the Maritime cloud could not be tested but it has a great potential for sharing this data.

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2 Description of Developed Service

2.1 Pilot setup

For the pilot due to time the possibilities were limited for reaching the ultimate goal. Therefor a smaller pilot was eventually emphasized where available possibilities were used. As described before we used the already installed connection of the shore systems and fed this data into a separate environment, not to influence the operational system.

Next to this also the data (radar/AIS) from the ships sensors was fed into this system. The system fused both data streams to one complete traffic picture. This picture was shared on the shore and ship side.

On the shore side it was send to the VTS operators at the Coastguard. The ship also received a part of the picture approximately 50 nautical miles around the ship (could have set larger if the data communications connection would allow this.

By sharing the data to the VTS operators they would get better and more accurate information than with only the shore based system. The VTS operators used this information for their VTS tasks like INS, NAS and TOS. But also the law enforcement users from police, customs could use this information plan their actions.

On the ship side the information was displayed on a extra screen and officially (due to the pilot state and dependencies) could (not) be used for navigation. But it could be used for law enforcement tasks performed by the ship and when assisting with SAR operations.

During the test a comparison of the VTS picture from shore side (left) was made with the same picture but enriched with the information of the vessel (right side). In the next picture (Figure 7) on the right side extra targets can be seen mainly in the red circle. Where the Barend Biesheuvel has a label.

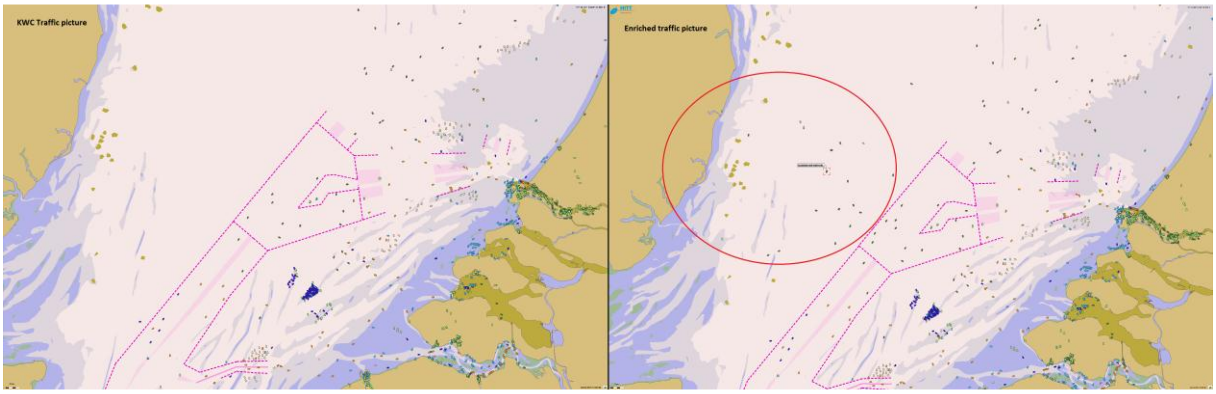


Figure 7: Comparison screens

2.2 Starting point

The drawing (Figure 3) gave the possible theoretical overview of the *ultimate* solution for conducting the tests. This solution had the following starting points described:

1. The test systems will re-use data of the systems already in place. The re-use of data may never interfere with or influence the operation of the existing systems. Therefore data will not incorporate in the systems already in place. This to ensure that the systems will not be influenced by the test systems of ACCSEAS;

2. For all the tests within ACCSEAS the same equipment/environment will be used unless this is not possible. By this it will be more cost effective and unnecessary use/placement of equipment will be minimised;
3. All tests will be conducted on the same ships/infrastructure unless this is not possible. This is also a result of the previous item.

To perform the tests the following conditions were needed:

1. Availability of vessels;
2. Communications between systems;
3. Connection between the ACCSEAS test systems and the on-board or local systems when needed;

Due to several reasons these starting points were not solid and were adjusted during the tests.

2.2.1 Radar

The next picture (figure 8) gives an overview off the range and detection of radar. The picture makes is clear that ship further away from the sensor are only detected if big enough, so small vessels are best detected nearby the radar sensor.

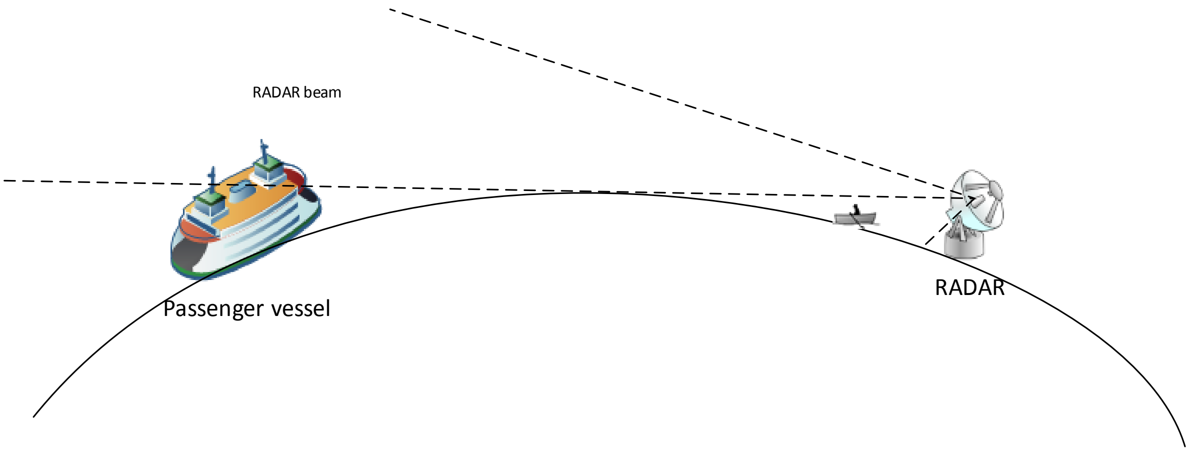


Figure 8: Radar coverage

During the tests all present on-board (radar/AIS) sensors were used. But to make these sensors usable for the test adjustments/expands had to be made on the technical installation to make it usable for the pilot. This installation differs from the shore site installation, due to the technical requirements defined by IMO and the restrictions on board regarding space available .

For the tests we used the on board systems and forwarded the data from these systems. The next picture (Figure 9) gives an overview of the sensors needed for generating the on board picture.

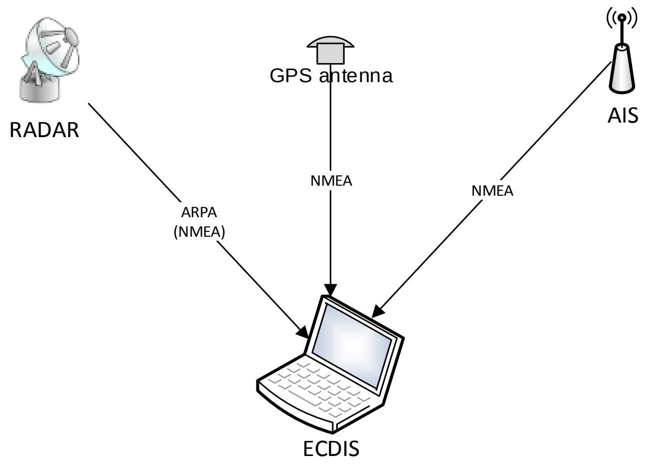


Figure 9: on board sensors

Radar data can be transmitted in different ways between parties. In principal there are three ways to transfer the data:

1. Raw video; this is the raw data received from the different sensors like radar, AIS and GPS.
2. Extraction (plots); These are the interpreted RAW radar picture to a defined description of this radar image with an absolute position of the ship
3. Tracking (tracks); this is the fused picture from radar and AIS with the exact position in the envelope (IVEF).

These have all their advantages and disadvantages which are summarized in the next table:

Description	Sources	Advantage	Disadvantage
Video	1. ARPA (radar) 2. GPS	Optimal fusion at shore side	Most bandwidth
Extraction	1. ARPA (radar) 2. GPS	1. Absolute position to the ship 2. Fusion at shore side	Less bandwidth
Tracking	1. ARPA (radar) 2. GPS 3. AIS	1. Smallest bandwidth needed 2. No extra interpretation of “image” 3. Fusing at source	Possible information loss from RAW radar

Concluding from the table sharing of track data is the most efficient way and is supported for instance by IVEF services.

Next to the IVEF service there are also other possibilities to share this information. A possibility is using AIS. During the project it was decided to use IVEF and not to use other services like AIS, based on the following reasons:

1. The data shared with AIS is only within the range of the ships, so the shore could miss this information. This could off course be received by shore infrastructure but the start point was that this was not available;
2. The AIS VHF Data Link could be overloaded in high density areas;
3. Due to privacy laws sharing this information with non-governmental agencies is difficult/not allowed and could not be encrypted with AIS;
4. In case of an accident based on the (wrong) information shared parties could be hold responsible especially if they are non-governmental bodies.

These reasons in combination with the time to solve some of the issues, was the reason that the IALA standard IVEF was chosen with other combining standardised products. This suite of product could protect (encrypt) the data and was transferred by other means than over the AIS VDL.

2.3 System Setup

The following figure 10 shows the physical implemented test system:

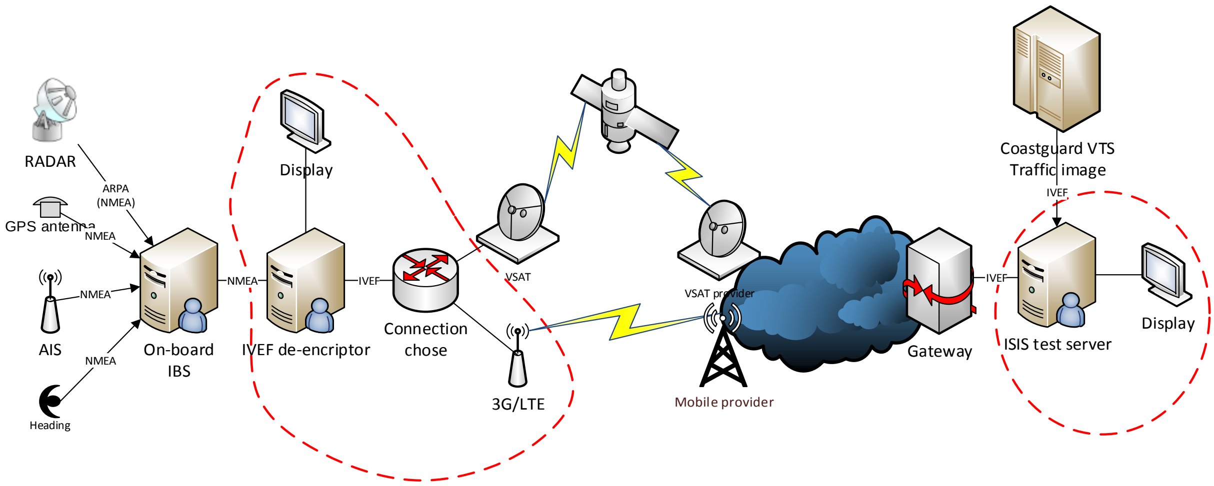


Figure 10: Implemented

The main hardware components (already present, within red line= extra) are

- Sensors (radar, AIS, GPS and heading)
- The on-board IBS system
- A converter RS322 (IBS NMEA) data to TCP/IP (not shown);
- A device for converting and fusing sensor data from the IBS to IVEF;
- A screen to present the Harmonised VTS picture
- A router determine the preferred connection and to limit the throughput;
- A mobile 3G/LTE data unit;
- A VSAT infrastructure;
- An HITT ISIS server. This server merges the KWC traffic image with the received on-board traffic image and send it back to the ship.

The software components are displayed in figure 11:

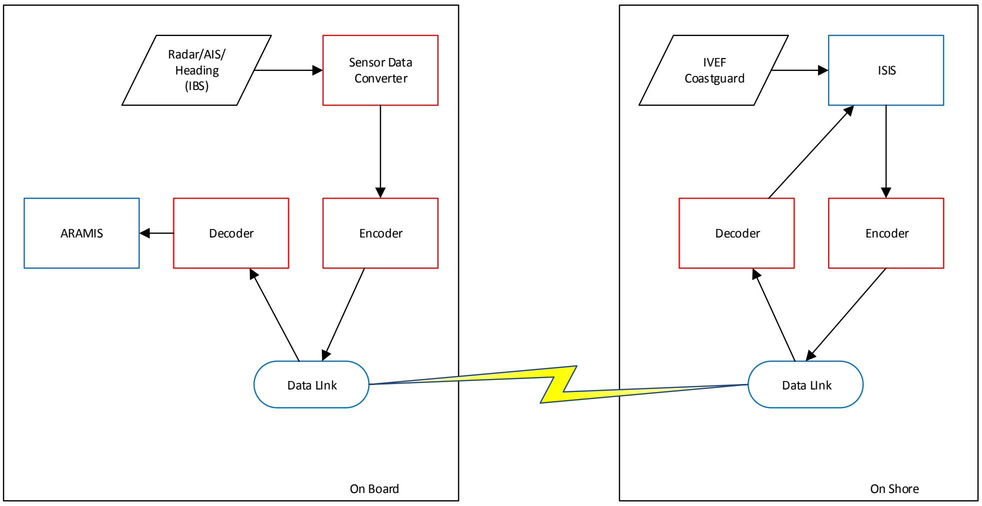


Figure 11: Test system software components

The main software components (Blue = off-the-shelf, Red = development) are

- A converter from the sensor data in IBS data format to IVEF;
- An encoder/decoder from IVEF to compress data and link format also vice versa. For efficiency reasons, the data link format will not be the IVEF xml text format. It will be compressed;
- An ARAMIS display on the ship;
- An HITT ISIS server. This server merges the KWC traffic image with the received on-board traffic image.

Figure 11 show that mostly standardised products are used for realising the pilot system with the on-board Integrated Bridge System. What resulted in a faster process of realisation of the pilot system. Another solution was a ship without a suitable IBS but should need more components to accomplish the same result. Two other vessels where investigated for the pilot. They had the right sensors on board to use off-the-shelf products, but not suitable for this first test in case of traceability.

2.4 Connection between ship and shore

There were two options for communication between the shore systems and the ship systems. The “old” point-to-point connection type or the new *Maritime Cloud.*

The *Maritime Cloud* is a digital Information Technology framework consisting of standards, infrastructure and governance that facilitates secure interoperable information exchange between stakeholders in the maritime community using the principles of Service Oriented Architectures (SOA). For a detailed description of the Maritime Cloud, which is also open source, please refer to http://maritimecloud.net.

The intention was that IVEF should use the *Maritime Cloud Messaging Service* (MMS) for sharing its real-time picture like services such as intended route exchange, route suggestions, MSI-NM and text messaging. A vessel will broadcast its own real-time picture periodically via MMS, and all interested parties (i.e. vessels, VTS centres, etc.) will hook up as listeners for this message type and receive the real-time picture.

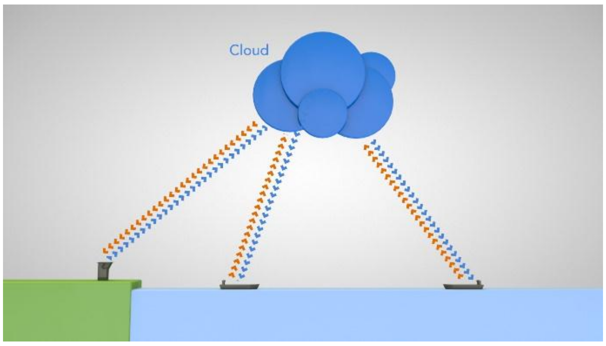


Figure 12: Broadcasting through the Maritime Cloud

The *Maritime Cloud* and the “old” point-to-point connection both needed a internet connection at all times to operate. Internet connections on a ship going outside of the mobile networks are expensive and the bandwidth is limited. Next to this the primary tasks of the ship also used internet connections and could not be interfered by the pilot.

To realise an internet connection that would reduce costs and not interfere with the primary tasks, a combined connection type was introduces with bandwidth management. (See figure 9) This solution makes use of LTE/GSM network when available and the VSAT connection when outside of the LTE/GSM networks. Also when operation on the VSAT communication bandwidth was maximised to 200Kbit.

To detect, switch and apply bandwidth management an extra router was placed whom had these features. After configuring the router switching from LTE/GSM network to (on-board) VSAT and back was detected and managed by the router. This router is in this pilot system the single point of failure but could be fixed in a permanent solution.

As mentioned before the pilot should have used the *Maritime Cloud* but was impossible to realise in the time frame. Therefor a point-to-point solution was chosen by building an secure tunnel between the ship pilot system and shore pilot system using the realised internet connection.

This seemed to work fine but after some tests we found out that during the network switch (VSAT – LTE/GSM) the secure connection did not reconnected. After investigation the server process seemed to be crashing due to the switch and additional functionality was build. Changing the “old” point-to-point connection to the *Maritime Cloud* would solve this problem.

The *Maritime Cloud* has no centralised system where every client has to connect to is has a common architecture to connect to and if one part fails another part takes over.

3 Observations and Feedback

There were several positive observations at the end of the project.

3.1 Reactions of the end users:

The involved persons on board of the coastguard vessels and at the Coastguard centre were very enthusiastic about the usefulness of the information. Some of their reactions were foreseen but others came when the project progressed.

Ship side:

1. The functionality gave the possibility to see further than their own sensors could detect. Therefor they could locate ships earlier what gave them more time to plan;
2. They had the same picture as on shore as on the ship what gave no information gap between ship and shore side. This resulted in less (mis)communication;
3. Drifting buoys or other drifting material without AIS could be identified and transferred to the shore side
4. vessels without AIS (like pleasure crafts) coming into the area were detected earlier in the area where shore based radar images are available;
5. Extra data not present on the ship added on the shore side became available on the ship.

Shore side:

1. Smaller targets further away from the shore infrastructure could be tracked due to the higher accuracy of the information from the on-board radar systems;
2. AIS targets with transmission problems could in some cases not be received by the shore system due to distance to the closest base station. These were received by the ships AIS mobile station and then transferred to the shore side;
3. Targets only detected by one of the shore infrastructures sensors could be verified by the sensors on-board of the ship.

3.2 Organisation

Doing a pilot in an operational environment, like is done with the IVEF pilot encounters several organisational problems and challenges. These organisational issues gave restrictions to the technical solutions and had a large influence on the realisation of the pilot set-up.

A big issue when doing a pilot also involving a ship is that the ship is at sea several days in a row what makes planning very important. In a (large) organisation like Rijkswaterstaat, you have to deal with several departments, each with their own responsibility. When you have the agreement of the coastguard to take part in the pilot, your still not ready to go forward. You need to deal with the sections responsible for planning, for the technical systems on board, technical systems on the shore side, PR department, etc.)

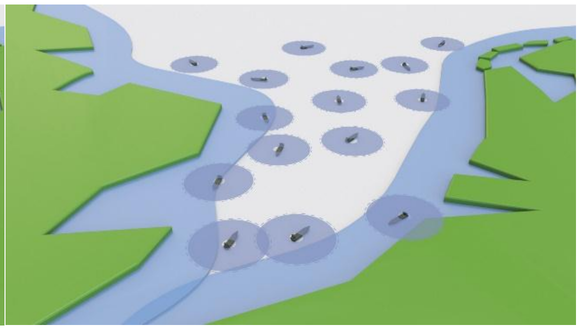
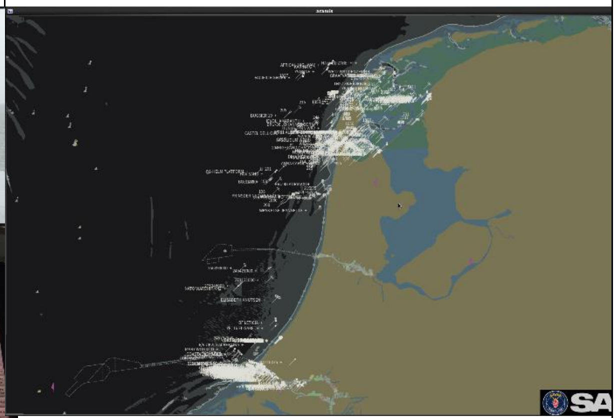
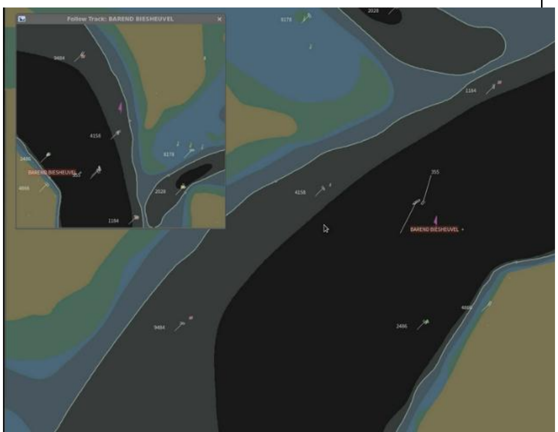
 *Current sensor (radar) coverage*	 *Possible sensor (radar) coverage*
 *View from ships bridge*	 *Harmonized view on ship*
 *Harmonized view on ship (zoom)*	 *Small ship used during test*

Figure 13 – Results from the trial in ACCSEAS.

3.3 Technical

3.3.1 Shore side

During the technical installation of the pilot the problems at the shore side were mainly getting access to the Coastguard network on a safe manner. Problems with different contractors was not an issue because both systems (ship and shore side) were build and maintained by the same contractor.

The connection between the Coast Guard system and the pilot system was easy because the products were the same, and both capable of sending and receiving IVEF. Regarding the connection between the ship and pilot shore systems the main problem was the change of the transmitter (IP) address, due to switching between mobile network and VSAT network. This was solved by a VPN network connection.

3.3.2 Ship side

During the selecting of the pilot ship, there were several issues to take into account:

1. Difference in equipment on board of ships;
2. Finding the right maintenance company of the on board systems;
3. Changing of the maintenance company of the on board systems;
4. Capability of the equipment on board of the ship;
5. Which communication systems are present on board of the ships (mobile/VSAT?)

By connecting the ships sensors there were two options one was connection to an IBS system and another was connecting to the sensors directly (radar). The first option gave the possibility that the operator could fine tune the reception of targets. The other was that there is no human interference but fine tuning would not be possible. In case of the test and the traceability, the first option, connection to the IBS system was chosen.

3.4 Overall Advice

During this pilot several issues were encountered what resulted in the following advice.

Organisational:

1. Find the right contacts on all sides (make a stakeholder map) whom are interested and motivated to help;
2. Make an inventory of possible problems the parties could encounter. Like:
    a. Operational;
    b. Legal;
    c. Organisation;
    d. Political;
    e. Goals;
    f. Technical.
3. Explain the importance of sharing data for their process but also explain the possible problems and project them on their goals and problems it would fix;
4. Make clear that “Cloud” thinking (sharing data instead of collecting it on your own) will fullfill the user need better, faster and cheaper;
5. Make clear that possible future budgets cuts will empazise the need for sharing and collecting data because there is not enough money to realize your own system.

Technical:

1. The Maritime Cloud could in the future solve problems with sharing data to all stakeholders. For making use of the Maritime Cloud some issues should be solved:
    a. Legal matters for privacy and responsibility matters;
    b. Fusing process where should that be done;
    c. Rights whom can see which data.
2. Technical connection through the IVEF protocol is a good solution in cooperation with the Maritime Cloud. Most functionality is incorporated in the protocol. Secure connections and compression if the data is not incorporated. This was done intentionally because these are evolved more rapidly than the IVEF.

3. Sensor data from and to systems should be more standardized and should be held mandatory by official bodies like IMO, IHO and ITU.

4 Material Investments

4.1 ACCSEAS Legacy: IVEF Hardware

For the ACCSEAS IVEF demonstration, the following equipment was purchased to provide the functionality that was required:

Table 1 - Equipment purchased for the trial under ACCSEAS.

Quantity.	Equipment purchased	Description
1	Console	Consists of a display and a processing unit to process the ship sensor data to IVEF and display the received harmonized picture
1	ISIS	A centralized CVE that processes and fuses the data received from the ship and the shore systems.
2	Datacom equipment	To enable a seamless switch between different operators and bandwidth management
1	MoXo converter	Converting signals to a network enabled connection signal.

This equipment was purchased by RWS, to carry out the tests in the Netherlands on the test bed areas. The tests will be carried out during and beyond the end of the project to emphasize the potential to several stakeholders

The tests during the ACCSEAS project have already shown that IVEF using is feasible. Further tests will be required after the project has ended to determine the potential. These tests should show that a full position solution is possible with the technology, providing harmonized picture on-board vessels and shore. This would be a very significant legacy outcome for ACCSEAS.