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NEW APPLICATIONS SESSION

Qualification of a SIMOPS Management Tool

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Abstract

This paper describes a new decision making tool for Simultaneous Operations (SIMOPS). The enabling technology for this tools and results from a full-scale Qualification program run during the summer of 2011 are presented.

In the context of this paper, SIMOPS are addressed from the perspective of the need for precise positioning and maneuvering of vessels. This is very challenging since large vessels are operating in near vicinity of each other. Distribution and visualization of relevant information in a multi-vessel scenario is also very important.

In this perspective, several conceptual elements are described, such as: SIMOPS Safest Mode of Operation (green, blue, yellow, red states), Responsibility Areas, Standby Areas, Safety Zones, Proximity Zones, Escape Sectors and No-Go Zones. The role of these elements in SIMOPS navigation is elaborated.

A main target for the SIMOPS Management Tool is to provide a <1m, steel-to-steel distance accuracy between any vessel with SIMOPS equipment onboard. The key technology elements to achieve this are relative GNSS, precise motion monitoring, utilization of AIS, utilization of 3D vessel models and a novel Maritime Broadband Radio. These technology elements, or building blocks, are integrated to provide a SIMOPS Management Tool.

Results from several months of operation of the SIMOPS Management Tool in the Gulf of Mexico during the summer of 2011 have verified that the technology elements and the integration of these have been successful. This has been verified both through analyzing logged data and following the operation remotely via a real-time, encrypted Internet connection.

Introduction

Simultaneous Operations (SIMOPS) involving the navigation of large vessels or structures in close vicinity of each other provide great challenges to the personnel and equipment involved. Better management concepts and tools need to be developed to increase the safety and efficiency of such operations. Furthermore, it is crucial that such tools are qualified through full scale operations in a realistic environment.

This paper is going to present SIMOPS Management Tool based on a new concept for SIMOPS navigation and the respective qualification program run in the Gulf of Mexico during the summer of 2011.

Figure 1: The SIMOPS at Macondo 2010 (illustration)

In traditional DP positioning the main concern is to reduce all navigational data to a point in the vessel, usually denoted Centre of Gravity (CG). For large and complex installations this can be a challenging task. Lever arm transformation over long distances needs to be carefully taken care of to avoid errors being introduced in the position data fed into the DP.

With large modern, multi-purpose vessels, there is an increasing need to monitor the position and the dynamics of not only the CG, but several other points, such as e.g. the moonpool, a crane tip and the helideck. Using several monitoring points on a vessel increases the navigational complexity significantly.

In a SIMOPS, several monitoring points on different vessels moving more or less independently of each other constitute the navigational challenge. One primary interest is the "steel-to-steel" distance between the vessels involved. Hence, the navigational challenge includes reliable communication between the vessels and the physical topography of the vessels and their environments.

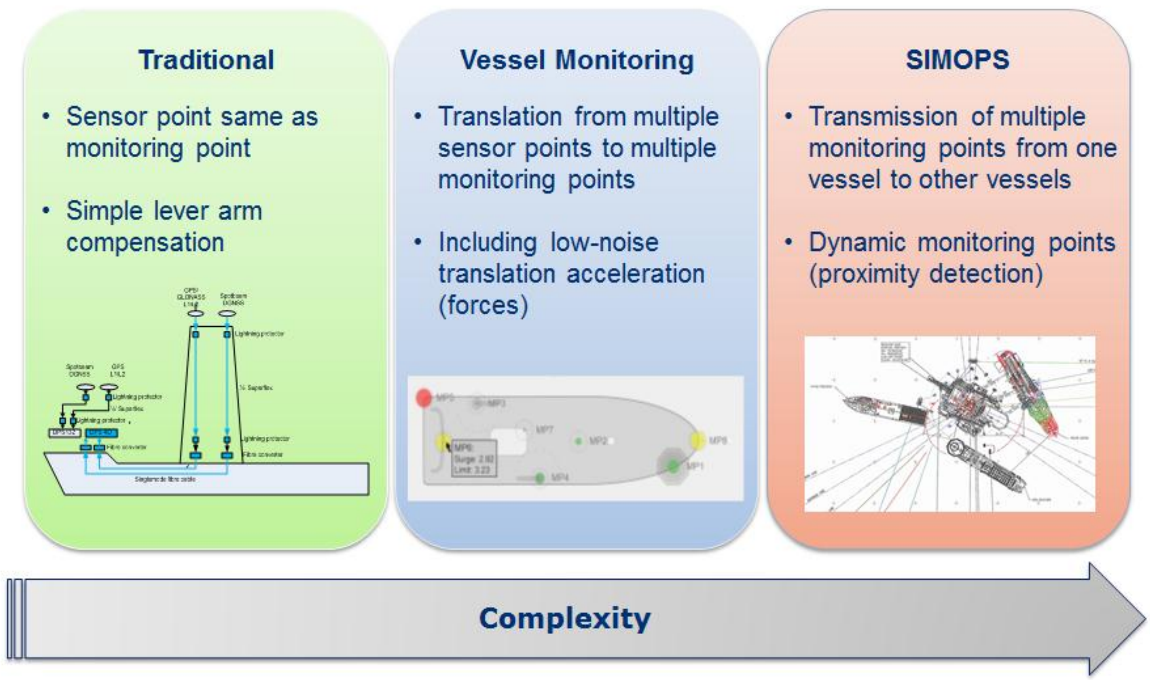


Figure 2: Complexity of SIMOPS navigation

SIMOPS concept

A key element of the SIMOPS Management Tool is the concept of "Safest Mode of Operation". This concept is based on four different possible conditions for the vessel as described in the following figure. The Safest Mode of Operation will be transferred in real time between the vessels with the SIMOPS Management Tool installed.

Condition	Green	Advisory	Yellow	Red
Notify Master, Chief Engineer and SIMOPS Control Room	No	Yes	Yes	Yes
Action	Continue Normal Operation	Informative/ Consultative status (risk assess)	Cease operations - and be ready to move off	Cease operation – leave 500m zone immediately

Figure 3: SIMOPS Safest Mode of Operation

There are three main SIMOPS vessel categories

1. **Operation Centres**
    - SIMOPS equipment installed
    - Hosting the SIMOPS Coordinator

2. **Project/Construction Vessels**
    - SIMOPS equipment installed
    - On-board AIS utilized by the SIMOPS Management Tool

3. **Vessel of Opportunity/Logistics**
    - No SIMOPS specific equipment
    - On-board AIS utilized in the SIMOPS concept

Further the SIMOPS Management Tool relies on the following operational definitions:

- Responsibility Area
- Standby Area
- Safety Zone
- Proximity Zone
- Escape Sectors
- No Go Zones

The SIMOPS Responsibility Area represents the authority area of a SIMOPS coordinator. Several vessels of different kinds can operate within this area but are expected to follow the advices given by the SIMOPS coordinator.

The Standby Area will be allocated for vessels waiting to enter a specific operation as advised by the SIMOPS coordinator.

The Safety Zone is usually represented by a 500 m circle centred at the SIMOPS Operation Centre.

A Proximity Zone is a guard zone following the outer contour of any vessel involved in a SIMOPS. Overlapping Proximity Zones of two vessels will mean a potential risk for both vessels and should be followed by the uttermost caution by the SIMOPS coordinator. Vessels with specific SIMOPS equipment installed can operate with close Proximity Zones, while AIS only vessels will need larger Proximity Zones to maintain the same level of safety.

For each vessel operating within the Safety Zone, an Escape Sector should be defined. The Escape Sector will indicate the planned route if it should be necessary to cease the operation and move away from the Safety Zone. It will be the responsibility of each vessel to define its Escape

Sector in co-operation with the SIMOPS coordinator Overlapping Escape Sectors can then be monitored by the SIMOPS coordinator or any of the operating vessels.

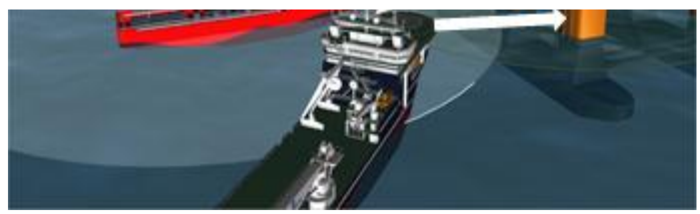
The No Go Zones are identified and defined in the SIMOPS Management Tool by the SIMOPS coordinator. The No Go Zones are distributed to all involved vessels; identifying areas where no vessel is expect to enter.

Specifications

Some key target specification elements of the SIMOPS Management Tool are listed in the following bullets:

- All vessels with the SIMOPS Management Tool installed should have access to consistent real-time visualization of the SIMOPS situation. All SIMOPS data should be transferred between the vessels carrying SIMOPS equipment with little latency (< 1 second) including but not limited to:
    - Safety zones
    - Responsibility area
    - Standby area
    - Escape sectors
    - No go zones
    - Safest mode of operation

Figure 4: SIMOPS communication and visualization



- Communication between vessels carrying SIMOPS equipment need to be reliable under all conditions even when a large vessel is located between two other vessels and when flat sea surface might cause signal fading effects.
- The SIMOPS equipment should be able to find the closest distance between any points on any vessel and calculate this with a “steel-to-steel” accuracy of < 1 m.
- The SIMOPS Management Tool should have the ability to automatically allocate proximity zones to any vessel involved in the SIMOPS.
- It should be possible to follow the SIMOPS remotely from any location by utilizing Internet based access to the operational data.
- The SIMOPS Management Tool should exchange information between any vessels carrying SIMOPS equipment to support decision making.
- All relevant information should be presented to optimize execution of the SIMOPS.

Building blocks

The implementation of a solution like the SIMOPS Management Tool is based on several technological building blocks.

Relative GNSS
For a SIMOPS the relative distance and heading between the vessels is crucial. To meet the < 1 m steel-to-steel requirement, it is necessary to calculate this distance with an accuracy of < 20 cm. Therefore, the concept is based on combining GNSS (GPS +Glonass) measurements recorded on each vessel in real-time. The required accuracy can be achieved without any use of differential corrections.

Motion Measurements
To be able to calculate steel-to-steel distances, accurate measurements of the following parameters are necessary:

- Heading
- Roll, pith, yaw
- Surge, sway, heave

These measurements need to be integrated into the navigation solution with minimum loss of accuracy and integrity.

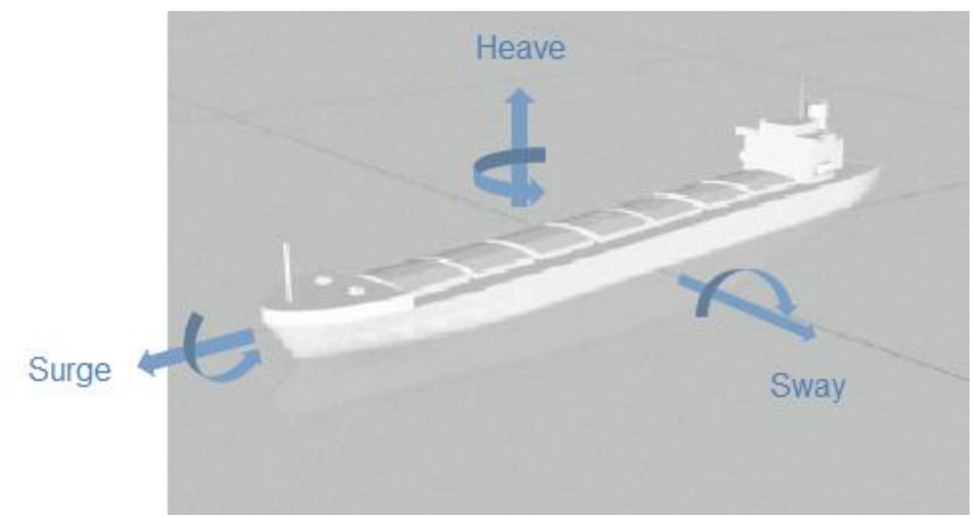


Figure 5: Parameters in SIMOPS navigation

AIS

The capabilities of AIS are closely integrated into the SIMOPS Management Tool. One of the obvious reasons is that most vessels already carry an AIS unit. Another is that AIS is providing SIMOPS with some reliable communication capability.

The SIMOPS Management Tool is capable of receiving and displaying AIS data from all vessels within VHF range. At the same time, AIS is utilized to transmit some SIMOPS relevant data to vessels within the SIMOPS Responsibility Area. This can be done by utilizing the AIS capability of transmitting both broadcast and addressed safety messages.

Another utilization of AIS is the capability for the SIMOPS coordinator to reallocate AIS bandwidth capacity in the SIMOPS Responsibility Area. This means e.g. that the AIS reporting rate from vessels of special relevance can be increased.

3D Vessel Models

To provide realistic visualization in all relevant scales in a SIMOPS, it is important to be able to utilize 3D vessel models and to convert these into high quality 2D models for certain purposes. This is also important in order to achieve the < 1 m steel-to-steel accuracy requirement.

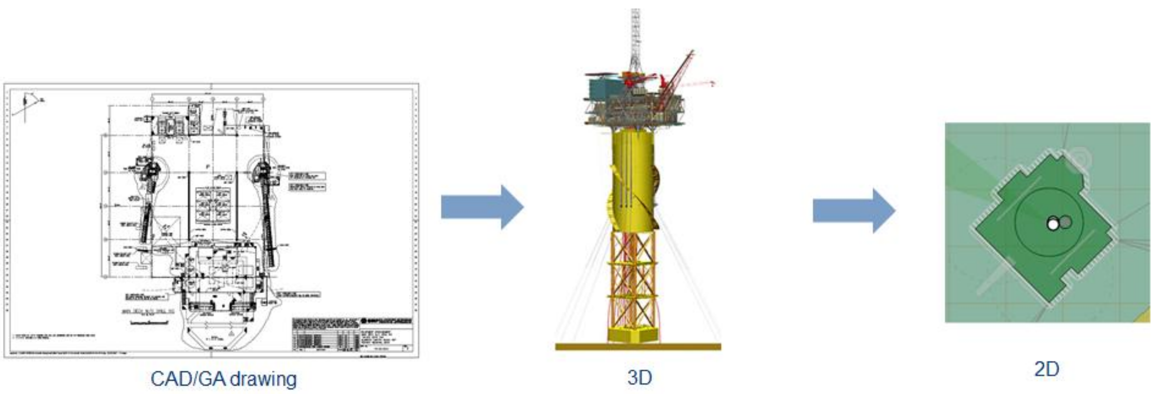


Figure 6: Conversion of CAD/GA drawings to 3D and 2D models

The SIMOPS Management Tool allows the exchange of such 3D and 2D data in near real-time between vessels involved in the SIMOPS.

Maritime Broadband Radio

SIMOPS requires communication bandwidth for:

- Transferring accurate sensor data in real-time
- Supporting multiple vessel operations
- Exchanging operational data and vessels models (3D/2D)
- Automatic real-time distribution/across-vessel transfer of operational data

Tests of several existing solutions like Wi-Fi and WiMAx have not been able to meet the requirements for reliability and functionality. It has, therefore, been necessary to develop new technology for maritime broadband radio communication with the following overall capabilities:

- > 10 km range over sea, close to large steel or concrete constructions
- > 1 Mbs effective transfer capacity (sufficient for video)
- Capability of handling multiple far and near range communication simultaneously
- Meshed network configurations

The Maritime Broadband Radio has been developed as an integrated or embedded communication solution in the SIMOPS Management Tool.

Qualification program

The SIMOPS Management Tool qualification program was run in two stages during the summer of 2011:

Field Qualification Trial I

- Scope: Real-time visualization of a SIMOPS
- Operation centre: Noble Danny Adkins (NDA)
- Project/construction vessels:
    - C-Clipper
    - Nicki Candies
- Remote monitoring:
    - Encrypted data channel via Internet
    - Remote access via KSX Services
- Timeframe: June – September (3 months)

Field Qualification Trial II

- Shell Serrano Project
    - Two vessels carrying a riser
    - Moving at 0.2 m/s with 20 m increments for 2 miles
    - ROV operation to check riser
- Vessels:
    - HOS Achiever (heavy lift)
    - HOS Iron (heavy lift)

Figure 7: Field Qualification Trial I

- Ocean Intervention 3 (ROV support)
- Scope: Real-time visualization of a SIMOPS
- Remote monitoring:
  - Encrypted data channel via Internet
  - Remote access via KSX Services
- Timeframe: September, 3 weeks

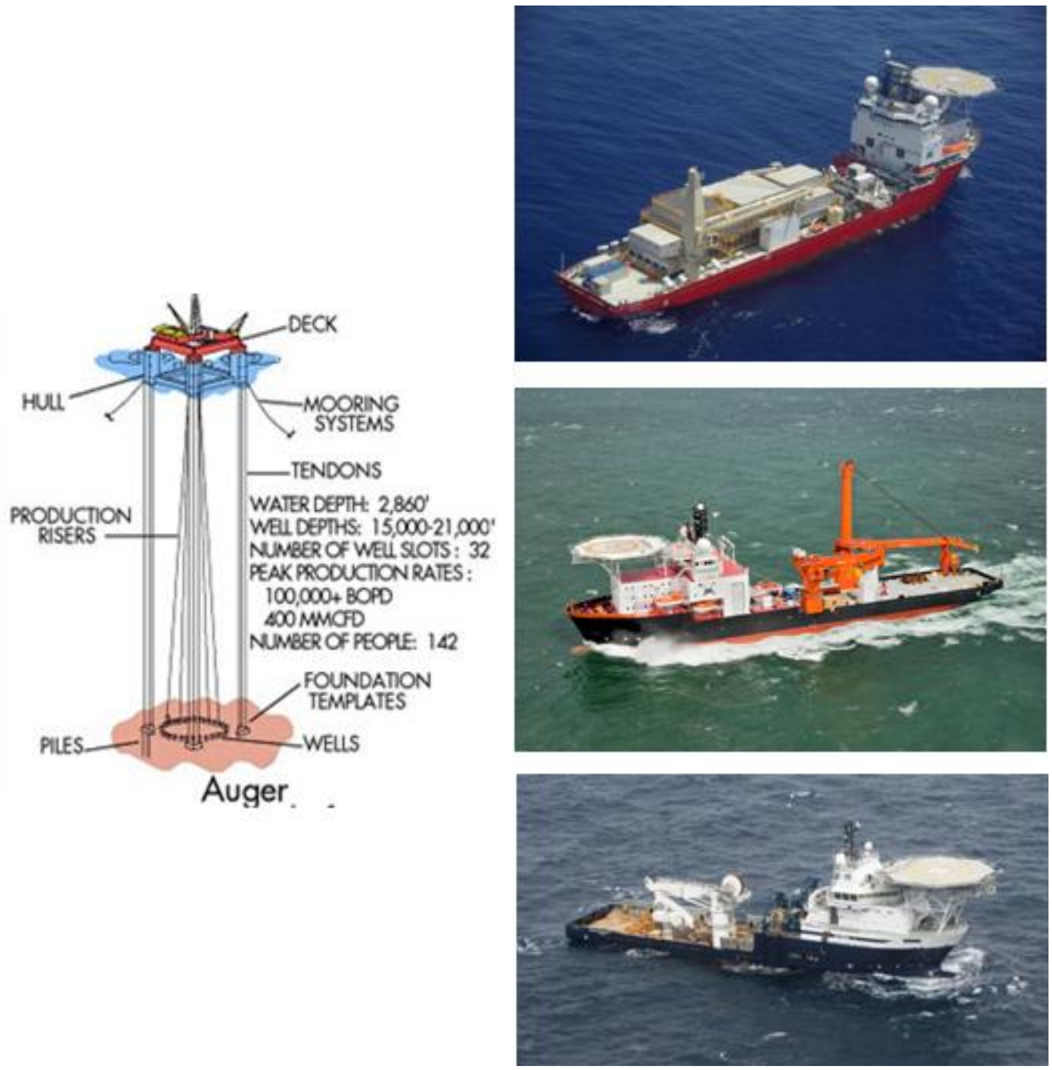


Figure 8: Field Qualification Trial II

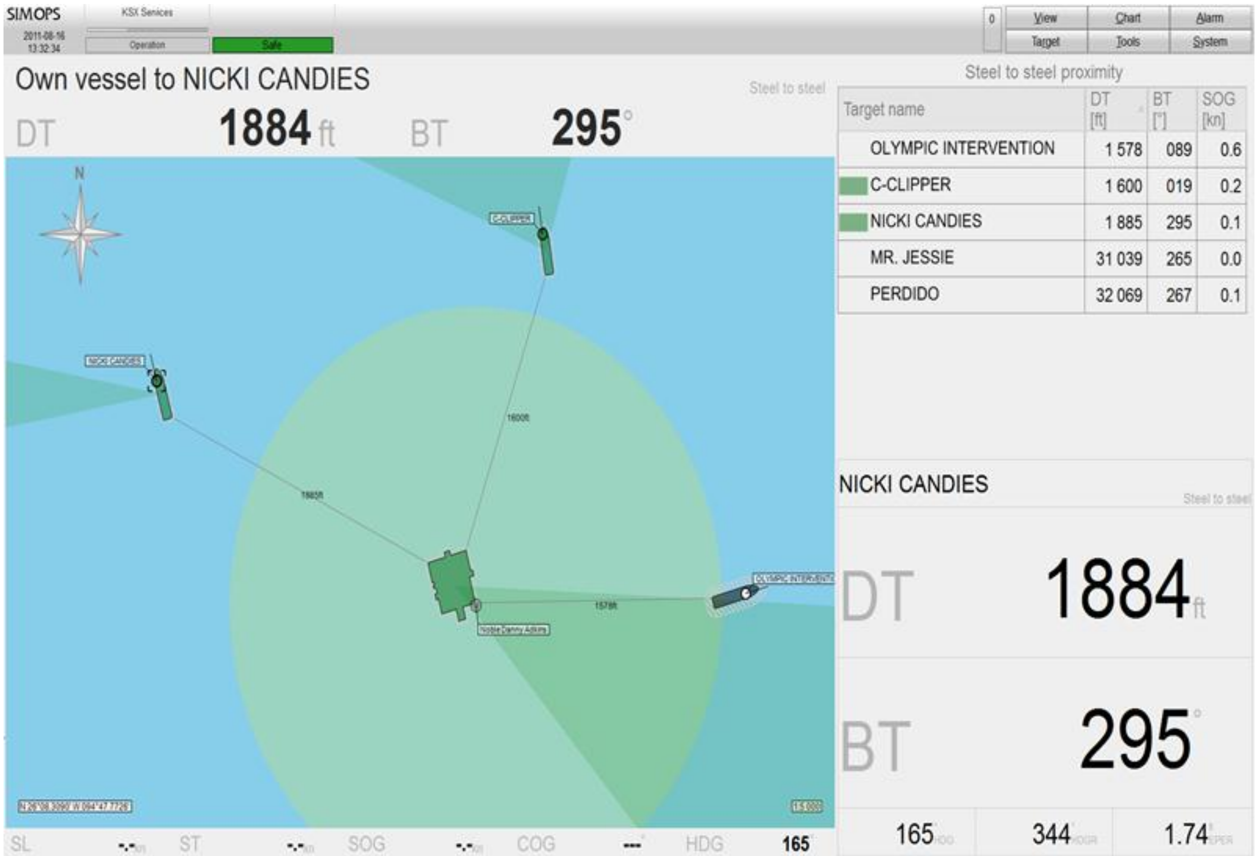


Figure 9: Screen-shot Operational Scenario Trial I

Figure 9 illustrates a screen-shot taken during Operational Scenario Trial I. The same screen-shot was available at all SIMOPS capable vessels, Noble Danny Adkins, C-Clipper and Nicki Candies simultaneously.

The screen-shot demonstrates the concepts of Safety Zone, Proximity Zones and Escape Sectors.

The steel-to-steel distance between the SIMOPS Operation Centre and Nicki Candies is 1884 ft (574.2 m) with an estimated accuracy of 1.74 ft (0.53 m) based on relative GNSS measurements.

Three AIS vessels are also observed: Olympic Intervention, Mr Jessie and Perdido. Olympic Intervention is approaching the Safety Zone and is displayed with a larger Proximity Zone than the vessels with SIMOPS equipment, C-Clipper and Nicki Candies.

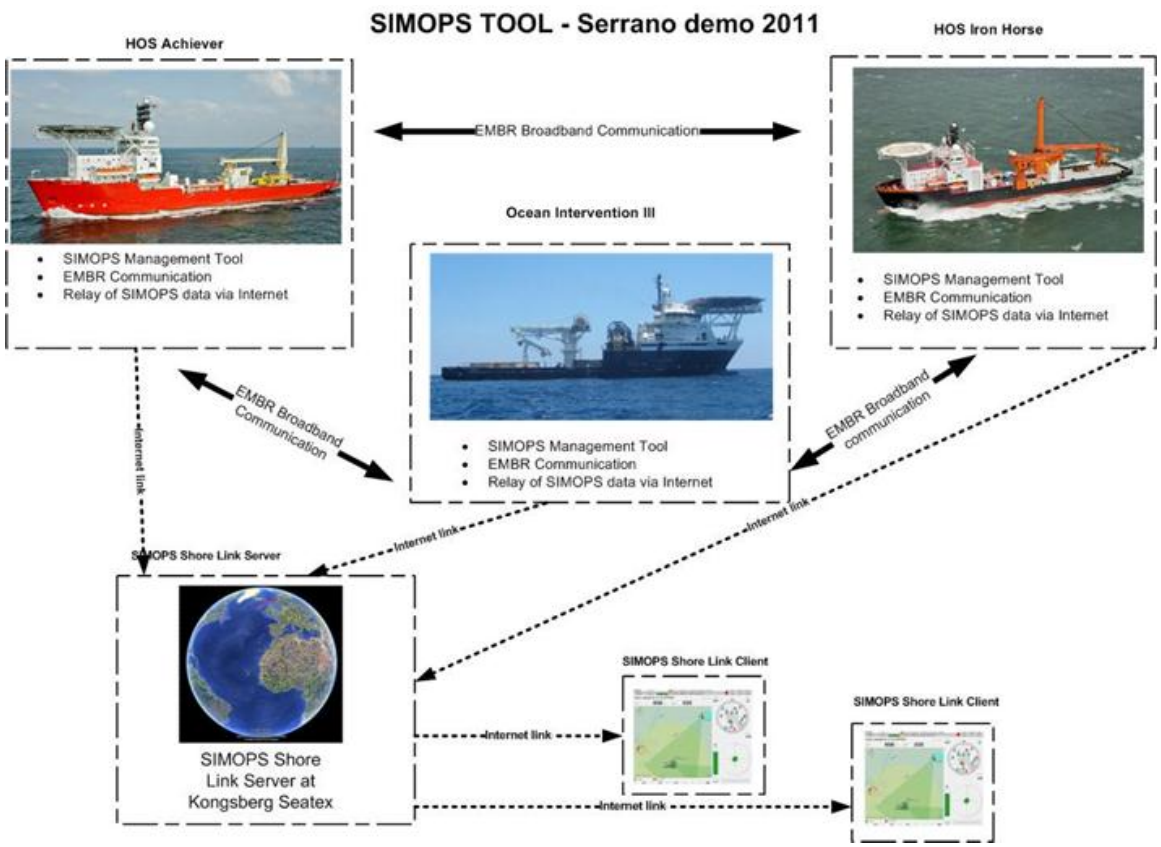


Figure 10: Solution for Remote Monitoring

Figure 10 shows the configuration for remote monitoring during the SIMOPS Management Tool Qualification. All vessels with SIMOPS equipment are communicating in real-time using the Maritime Broadband Radio link. An encrypted Internet link is established with one of the vessels by connecting to the standard Satcom solution onboard. The SIMOPS data is stored in a database and can be accessed by authorized users by encrypted Internet communication from anywhere in the World. The internet based remote access enables shore-based support by presenting the same display as seen on the SIMOPS operation center.

Lessons learned (TBC)

Conclusion

All technology elements and the integration of these have performed excellent during the 2011 SIMOPS Management Tool Qualification program.

The SIMOPS Management Tool has also demonstrated its capability of providing real-time visual information both to the SIMOPS capable vessels involved and remote monitoring sites.

The SIMOPS Management Tool will improve decision making, increase safety and enhance the speed and effectiveness of a simultaneous operation.

Awareness of the situation by all involved is the key to success of any simultaneous operation. It is of great importance that the vessel captains and the SIMOPS coordinator have the same information so they can communicate and work together.

Having the same display onboard all involved vessels ensure that during the operation everyone have access to consistent information. This allows for better communication and a clearer understanding of the situation.