FFI RAPPORT

SPECIFICATION OF FUNCTIONS FOR THE UNISON UNDERWATER WARFARE DEMONSTRATOR

WEGGE Jon

FFI/RAPPORT-2002/00593

FFIBM/765/116

Approved
Horten 4 February 2002

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE
(when data entered)

REPORT DOCUMENTATION PAGE

1) PUBL/REPORT NUMBER	2) SECURITY CLASSIFICATION	3) NUMBER OF PAGES
FFI/RAPPORT-2002/00593	UNCLASSIFIED	45
1a) PROJECT REFERENCE	**2a) DECLASSIFICATION/DOWNGRADING SCHEDULE**	
FFIBM/765/116	-	

4) TITLE

SPECIFICATION OF FUNCTIONS FOR THE UNISON UNDERWATER WARFARE DEMONSTRATOR

5) NAMES OF AUTHOR(S) IN FULL (surname first)

WEGGE Jon

6) DISTRIBUTION STATEMENT

Approved for public release. Distribution unlimited. (Offentlig tilgjengelig)

7) INDEXING TERMS

IN ENGLISH:	IN NORWEGIAN:
a) Demonstrator	a) Demonstrator
b) Specification	b) Spesifikasjon
c) Anti Submarine Warfare	c) Antiundervannsbåtkrigføring
d) Function	d) Funksjon
e) Computer program	e) Datamaskinprogram

THESAURUS REFERENCE:

8) ABSTRACT

UNISON 2005 is a research and development program supporting the development of the next generation of combat systems for underwater warfare. The UNISON 2005 program is a co-operation between KDA, SIMRAD and FFI.

The UNISON Underwater Warfare demonstrator is intended to include processing of sonar data beyond beamforming and low-level data detection to demonstrate possible solutions to improving the capability and capacity of sonar operators in an ASW-situation. The demonstrator program include among other modules a slightly modified version of the RoNoNavy NAVMATCOM's LYBIN hydro-acoustic model, data from high resolution land and sea floor topography, alternative target trackers and components of an ASW-planning tool. In addition to assimilate data from hydroacoustics, topography and sonar data, the Human-Computer Interaction solution should demonstrate rational and effective operation of the program.

This report contains a description of the new functions suggested for second phase of the UNISON 2005 Underwater Warfars demonstrator. The second phase lasted from January 1999 to September 2001.

9) DATE	AUTHORIZED BY	POSITION
	This page only	
4 February 2002	Elling Tveit	Director of Research

ISBN-82-464-0636-1

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE
(when data entered)

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SPECIFICATION OF FUNCTIONS FOR THE UNISON UNDERWATER WARFARE DEMONSTRATOR

1 INTRODUCTION

UNISON 2005 (Underwater Information and SONar technology) is a research and development (R&D) program supporting the development of the next generation of combat systems for undersea warfare. The UNISON 2005 program is a co-operation between KDA (Kongsberg Defence & Aerospace), SIMRAD and FFI (Norwegian Defence Research Institute). The RNoN (Royal Norwegian Navy) contribute to the project with their technological and operational knowledge about undersea warfare in Norwegian waters as well as navy vessels and personnel during sea trials. The UNISON 2005 program is supported by the Norwegian Ministry of Defence and the Norwegian Industrial and Regional Development Fund (SND).

UNISON 2005 aimed at implementing a demonstrator of a combined sonar operator- and ASW officer station. This station consists of a computer and two displays and demonstrates the use of new algorithms, advanced human computer interface and integration of detailed environmental data with sonar data. The navy's sonar performance prediction model, LYBIN, is also integrated for direct use in the algorithms, but also as a part of the planning tools and in the tools for optimisation of sonar settings. Some of the solution available at early stages of UNISON will be included in the ASW system for the new Norwegian frigates. Other solutions such as the synchronised audio will be further developed by KDA and probably be included in later versions of their ASW combat management system. Feedback from experienced navy sonar operators, tells that the solutions demonstrated in this ASW station will improve the operators ability of doing detection and classification.

Phase 1 of the project lasted from autumn 1998 until January 2000 and phase 2 lasted until the end of the project July 2001.

This document specifies the extra components within the phase 2 UNISON P2005 Underwater Warfare (UWW) demonstrator and does not include the specifications of the components already included in the phase 1 demonstrator. The document is based on a UNISON document by Nordmoen, Tomter and Wegge(1). Not all functions were realised finally due to shortage of time/resources. See Wegge(2) for an overview of functions implemented in the final demonstrator version.

2 GENERAL DIRECTIONS FOR PHASE 2 FUNCTIONALITY

2.1 Need for focusing

The evaluation of the UWW demonstrator after phase 1, revealed that the demonstrator functional content gave only limited support to the ASW problem area. Within a scoring scale of 1 (= no support) to 5 (= extensive support), the highest score obtained was 3. Ref. UNISON document "ASW Demonstrator Components – relevance to Problem Areas" (PD2803) by Tomter and Wegge in (3).

The UNISON project should not be satisfied with such score, and should aim for substantially higher score within phase 2. Due to scarce resources as compared with the complexity of the ASW challenges and problem areas, high score on each problem area is not obtainable.

This report recommends to focus the Phase 2 demonstrator effort on a few functional areas in order to seek substantially improved score on certain problem areas at the cost of other problem areas. The following focusing principles are considered to facilitate best possible level of obtainable results, and are therefore recommended to constitute the basis for the selection of functional areas to focus on:

- Relevance to problem areas
- Rely on established competence and experience within the UNISON organisation
- Avoid direct competition with heavy NATO or other defence projects
- Appreciate feed-back from ASW User Group
- Relevance to KDA's new frigate project
- Include functionality to support demonstrations and scenario runs
- Need for final balancing assessment of focusing

2.2 Relevance to problem areas

When selecting areas to focus on, relevance to problem areas should be emphasised. High priority should be given functional areas having the capability to provide substantial improvement to one or preferably more problem areas, at the cost of functional areas being able to provide limited improvement only. This principle of focusing is considered to facilitate maximum utility value to the overall ASW process resulting from the ASW demonstrator phase 2 effort.

The following major problem areas related to ASW were identified and described as part of the ASW Domain Analysis, ref. UNISON document: ASW – Major challenges and Problem Areas (PD2312) by Tomter in (3):

- Presentation and perception of available information
- The planning challenge
- Employment of sonar
- Indication and classification of contacts
- Torpedo counter measures

For UWW demonstrator Phase 2, this implies that selected areas should have the capability to provide substantial improvement to one or preferably several of these problem areas.

2.3 Rely on established competence and experience within the UNISON organisation

When selecting areas to focus on, the type of competence and experience within the UNISON organisation should be taken into consideration. Areas where the UNISON organisation possesses high-level competence and experience, should be given high priority compared with areas within which the current competence and experience are at ordinary level only. This principle of focusing is considered to facilitate increased uniqueness and utility value resulting from the UWW demonstrator phase 2 effort.

The UNISON organisation is considered to possess high-level competence and experience within the following categories:

- Hydroacoustics, sonar usage and environmental impact
- Sonar processing, signal classification and false alarm reduction
- Multi-sensor correlation and target tracking
- HCI
- General system design and integration
- Specialised ASW system knowledge and experience (MSI 3100)

For UWW demonstrator Phase 2, this implies that selected areas should take full advantage of these categories of high-level competence and experience. This should not, however, automatically preclude effort on other areas where development of new/additional UWW-related competence is considered to be of vital interest for UNISON parties.

2.4 Avoid direct competition with heavy NATO or other defence projects

When selecting areas to focus on, areas on which NATO or other defence bodies (e.g. Euclid, Eurofinder) are conducting heavy analysis or development projects, should be taken into account. The UNISON phase 2 demonstrator effort should not aim at competing with corresponding NATO or other significant defence effort. As compared with competence and resources made available to such projects, competence (except for certain areas) and resources made available to UNISON project organisation are marginal only, and the potential for UNISON to reach results comparable with expected results from such projects, is deemed unrealistic.

If such areas are deemed to be of particular interest for UNISON, UNISON should aim at taking full advantage of and seek appropriate co-ordination with existing effort, with special focus on national bodies engaged in those activities.

This principle of focusing will facilitate increased lifetime of the utility value resulting from the UWW demonstrator effort, and reduce the risk for NATO or other international effort making results obsolete. For UWW demonstrator Phase 2, this implies that such areas, if selected, should be co-ordinated with existing effort being conducted.

2.5 Appreciate feed-back from ASW User Group

First meeting with the ASW User Group was held at Kongsberg 22. and 23. February 2000. See report by Wegge in (3). The UNISON project and the UWW demonstrator phase 1 were presented. Constructive and valuable discussions on ASW problems and desired UWW demonstrator functional content were conducted.

The following were emphasised by the ASW User Group at this first meeting as areas where improvements will provide significant support to major problems within the ASW process:

- Use of hydroacoustic models as well as topographic, intelligence and environmental data
- Functionality supporting audio analysis
- Signal processing and classification – addressing false alarms, reverberation and submarines.

These areas should be considered as potential priority candidates when selecting areas for focusing.

2.6 Relevance to KDA's new frigate project

KDA will develop and deliver the ASW system to the new Norwegian frigates, as a subsystem within the overall combat system to be provided by Lockheed – Martin. One major goal of the UNISON project is to develop new competence and technology within UWW, including ASW, and thus strengthen and develop further KDA's UWW-related current competence and expertise. The new frigate project constitutes the first major project taking full advantage of this competence and expertise.

Including areas relevant for the new frigate project will provide significant contribution to accomplishing the basic goal of the UNISON project. Appropriate attention should therefore be given to the new frigate project when selecting areas for focusing.

2.7 Include functionality to support demonstrations and scenario runs.

Attention should also be drawn to the demonstrator's role as a tool for visualising functionality, run scenarios and evaluate the visualising/scenario sessions. Such sessions are deemed to constitute a key part of the important dialogue with the ASW User Group. Special functions will be needed for supporting such demonstrations, scenarios and evaluations.

Although not directly related to ASW challenges and problem areas, such functions are needed to facilitate constructive and effective dialogue and collaboration with the ASW User Group. Such dialogue and collaboration is extremely important as a measure to assure that the UWW demonstrator phase 2 effort produces results which are relevant, useful, and may provide high-score support to ASW problem areas.
For UWW demonstrator Phase 2 this implies that such support functions should be included in the selected areas.

2.8 Need for final balancing assessment of focusing

It is acknowledged that the total set of focusing principles discussed above may partly be conflicting. The sum of candidate areas of focusing derived from the total set of focusing principles may be well beyond realistic scope as given by the time and resource limitations valid for UWW demonstrator phase 2. Hence, when arriving to a recommendation for focusing presented in the next chapters, this recommendation results from a preliminary overall and balanced assessment taking into account all focusing principles and their implications as well as the UWW demonstrator phase 2 time and resource limitations. At the end this balancing assessment rests on the best judgement of the SA-UWW (System Analysis-Underwater Warfare) interproject group.

3 ASW SPECIFIC FUNCTIONS RECOMMENDED FOR THE UWW DEMONSTRATOR

It was not the intention of this document to discuss the functions of Milestone 4 (end of phase 1) version of the ASW demonstrator. However most of them will be included in the coming versions of the demonstrator following different degrees of modifications. The amount of effort required for this must not be left out when planning the work ahead. These functions are:

- ASW-planner
- Geographical Information Provider (GIP)
- Geographical Information Display (GID)
- HMS Tracking
- Navigation System
- Picture Compiler
- Sonar Processing
- Sonar Simulator
- Sonar Performance Analyser (SPA) (interactive, autonomous, planner)

ASW-planner consists of a route planner in addition to technical tool aiding an ASW-officer in planning an ASW-operation. The GIP offers an access to geographically positioned data in a structured fashion similar to a geographic information system. The GID consists of the geodata model and its presentation on the display. HMS tracking is basically the target tracking algorithm used for an active hull mounted sonar. The term navigation system is used for the organisation and use of three-dimensional position and time in the demonstrator. Picture compilation is a term used for the presentation of data on the display screens in any situation. Sonar processing is the signal processing applied to the sonar signal in order to extract certain information. The sonar simulator is a simulator used to generate sonar data numerically as an alternative to sampling data from the sonar itself. The SPA is a tool for prediction and analysis of sonar performance as a service to many applications.

Based on the recommended direction for phase 2 discussed above, the following subjects should be addressed when developing ASW-functionality for a demonstrator. The list is currently not prioritised. Final balancing this list with available resources and prioritising as required will be done at a later stage before detailed specification commences.

- **Audio analysis** - currently the most important means for target indication.
- **False alarm reduction / Signal classification** - the most central objective for the demonstrator.
- **Sonar usage** - identified as a problem area requiring support. The UNISON-environment possesses important competence covering most of this subject.

- **Tactical Decision Support -** recommended included in order to resemble some completeness as a UWW-station all the way from a sonar operator to an ASW-officer station. Also relevant as an on-ship planning capability.
- **Fusion with external sensors** (acoustic and non-acoustic) - supports the problem areas of Presentation and perception of available information as well as Indication and classification of contacts. Considerable competence covering this subject exists within the UNISON-environment.

In addition to this list, it is assumed that functionality for supporting demonstrations and scenario runs (ref. chapter 6 below) is implemented within the UWW demonstrator phase 2.

3.1 Audio analysis

For the Oslo-class frigates' sonars, audio output is the most trusted means for sonar signal classification. It is therefore natural that this is reflected in some of the UWW-station functionality. This functionality presupposes that audio-output for all sonar beams will be made available from all sea-trial recordings done by the UNISON-project.

3.1.1 Synchronous audio output with visual presentation of raytrace, echo and topography.

Within a sector analysis, synchronous output of audio while the reflected area/position is visualised onto the raytrace, sonar output and topography offers a powerful interpretation tool to the operator. Experienced navy personnel have long requested such functionality. Should audio data not be made available, such functionality is still beneficial as information such as raytraces, sonar echoes and topography may be correlated. For more information about audio functionality, see chapter 5.1 or Wegge and Sundgot (6).

3.2 False alarm reduction / Signal classification

The overall challenge when searching for a submarine is the detection and correct classification. Related to this is the classification or reduction of false alarms (Fas. Some classification functionality not mentioned here, may also be suggested by the Active Sonar System sub-project and later implemented within the UWW-station.

3.2.1 Echo signal structure presentation tool

This functionality is a more comprehensive version of the echo classifier of the version at Milestone 4 (M4), which was not implemented. It is a tool for the analysis of the signal itself and does not address the internal structure of the target. Contributions from Lybin and audio-output will be included.

3.2.2 Tracking applied to kinematic classification

Tracking is based upon the signals from a sequence of pings. Hence it has the capability to take into account the consistency within the signals and correlate with expected behaviour of a submarine or maybe a shoal of fish. For detailed information about the target tracking algorithms, see chapter 5.2.2, Eidsvik and Løland (4) or Løland (5).

3.2.3 Information correlation tool (echo, topography, hydroacoustics, non-sub objects)

This functionality helps the operator to correlate and interpret the information available to him more than he is capable of with only a visual presentation. The geo-correlator as of M4 may be interpreted as a prototype of such a tool. The correct positioning of each of the data is a condition for such functionality.

3.3 Sonar usage

Employment of sonars, is one of the main challenges within ASW. A hydro-acoustic model is necessary in order to more correct predict the performance of the sonars. However, no model is perfect, but it is believed that by the means of continuous research and development it may be possible to arrive at a model which more closely resembles the reality.

3.3.1 Noise and reverberation presentation tool

This informs the operator of areas of substantial reverberation or noise and is based upon modelled data. This may again encourage him to change sonar parameters or advice of the sensor used.

3.3.2 Sonar usage recommendation tool

This functionality is made up of a combination of version M4's autoSPA and interactiveSPA. The information must be presented in a variety of ways for the operator to immediately see the resulting effects and trends if changing the different sonar parameters before taking action.

3.4 Tactical Decision Support

Compiling a good and realistic ASW picture is a complicated and difficult task. The operators depend on a system which provides a picture that keep focus on the issues that really matters in order to make their decisions.
In addition, the operators need tactical support tools which makes it possible to provide more information. It is important to get access to the information of interest for the situation. The operator must understand the situation good enough to be able to evaluate the consequences of a decision.

The operation of the tactical sonar display system which the demonstrator comprises, lacks a completeness without relatively simple handling tools which eases the operation.

3.4.1 Editing tool

This enables the operator to add text and graphics information to the display which give the operator easy access to relevant situational information and which then puts the system into a more realistic ASW-situation.

3.4.2 Track management tool

It is required to have a more comprehensive track management tool. This tool enables the operator to manage tracks within the track store. The operator will be able to initiate, delete and combine old and new tracks. Does not include fusion of tracks from different sensors. For detailed information about the target tracking algorithms, see chapter 5.2.2, Eidsvik and Løland (4) or Løland (5).

3.4.3 Simple calculation tools

The geo-tactical display should also be equipped with simple calculation tools like e.g. the estimation of closest point of approach (CPA) and torpedo danger zone (TDZ), etc. A prioritised selection of tools will be worked out with the UNISON ASW user group.

3.4.4 Tool or on-site planner for search/surveillance

Such a tool is helpful when conducting area surveillance or a search through some geographically limited areas. Effort will be concentrated around the utilisation of hydroacoustic predictions for the sonar sensors. A prioritised selection of tools will be worked out with the UNISON ASW user group.

3.5 Fusion with external sensors (acoustic and non-acoustic)

The contribution from more than one sensor is vital for the correct classification of a submarine. While one platform may possess several different sensors, one may also consider the opportunity to include the possible contribution from other platforms.

3.5.1 Sensor correlation tool

This component presumes the input of other sensors than Spherion, including organic non-acoustic sensors as well as sensors from other ships. Functionality for interpreting the information coming from these sensors in the context of the hull mounted sonar presentation must be included, as information from more than one sensor is needed for a higher classification level.
This functionality includes a means for correlation of both own ship sensory outputs (acoustic and non-acoustic) and other platforms sensory outputs. Such sensors may include radar, ESM, information through LINK 11 and other ships' sensors. It is presumed that such data will be made available and that their relevance is taken into account at sea-trials.

4 ADDITIONAL FUNCTIONS RECOMMENDED FOR THE UWW DEMONSTRATOR

4.1 Experimenting and prototyping

Modern software and hardware has improved visualisation capabilities drastically. This offers the opportunity to more flexibly present the correct amount of information in a more optimal context. Functionality suggested elsewhere may also include their respective presentation/displays.

4.1.1 Sonar signal displays (WINSON-display contribution to UWW-station)

This display offers the presentation of sonar data in a variety of ways. Currently the demonstrator lacks this type of X-Y sonar data analysis diagrams. See chapter 5.6.1 or Andersson (7).

4.1.2 Perspective presentation (sector, area, etc)

This functionality offers the opportunity to analyse/observe the situation within an area or a sector with the help of perspective presentation in which the operator is given freedom to zoom, pan, rotate etc.

4.2 Demonstrator and scenario support

An ASW system is only a part of the vessel, and lacks vital functions to be a complete ”vessel”. The functions not handled by the ASW system has to be simulated in the demonstrator. The demonstrator shall offer full functionality to replay recorded data.

5 DETAILED UWW DEMONSTRATOR PHASE 2 SPECIFICATIONS

5.1 Audio analysis

5.1.1 Synchronous audio output with visual presentation of raytrace, echo and topography

Brief description:
Within a sector analysis, synchronous output of audio while the reflected area/position is visualised onto the raytrace, sonar output and topography, offers a powerful interpretation tool to the operator.

Intention:
Powerful interpretation functionality as it offers a capability to correlate real-time reflected audio and echo data onto raytrace positions in the water column, topography characteristics and tracked targets.

Usage:
When chosen within a mode showing the birds-eye view (not perspective view), the reflected area may be depicted as a transparent area moving away from the sonar synchronously with the audio output.
Within a sector analysis using perspective presentation, synchronous output of audio while the reflected area/position is visualised onto the raytrace, sonar output and topography. The operator may use this functionality to correlated audio output with features of the local topography, established tracks, echoes and other characteristics which may generate some unique audio in addition to being capable of causing an alarm.
A mechanism of navigating the audio channel between the beams is necessary. Also some means of tagging an echo may be useful.

Benefit to ASW operations, impact on problem areas:
- Benefits the presentation and perception of available information
- Indication and classification of contacts

It also ensures trustworthiness of the classification.

Outputs produced:
Sound of real-time audio from a selected beam signal.
Visual presentation of:
- Raytrace/ TL
- Topography and available bottom characteristics and NONSUB objects
- Echoes within the sector (no matched-filter)

- Reflected signal position projected onto the raytrace synchronously overdrawn along with the audio output

Also real-time pulse extent in range within the geo-tactical window.
Optionally presentation of hydro-acoustic model data such as signal excess, probability of detection, reverberation level or transmission loss projected onto the back-wall of the analysis sector box.
Echoes categorised by the operator as being 1)unknown, 2)potential submarine or 3)not submarine and 4)acknowledge this.

Input requirements:

- Sonar echoes correctly positioned with inaccuracies wrt the topography.
- Audio of single selected beam
- Raytrace based on selected bottom profile (time discrete)
- Topography
- Established system tracks (internal tracks wrt the sonar)
- Navigation data of own ship
- Other available bottom characteristics and non-sub information
- Relevant hydro-acoustic model data; SE, PD, RL, TL etc. (option)

Special requirements:

- Time discrete raytrace
- Synchronous audio and visual outputs
- Full flexibility in switching information on/off within the window(s)
- Representative bottom profile

Additional comments:

Should audio data not be made available, such a functionality is still beneficial as information such as raytraces, sonar echoes and topography may be correlated, but this does not require real-time synchronisation. Should perspective presentation not be made available, real-time pulse extent may still be visualised within the geo-tactical window. See example illustration.

Requirements from the recording of data:

- Time (and position) stamped audio-data
- Position recording of nearby ships and submarines
- Echo data
- Own ship position and orientation (heading)

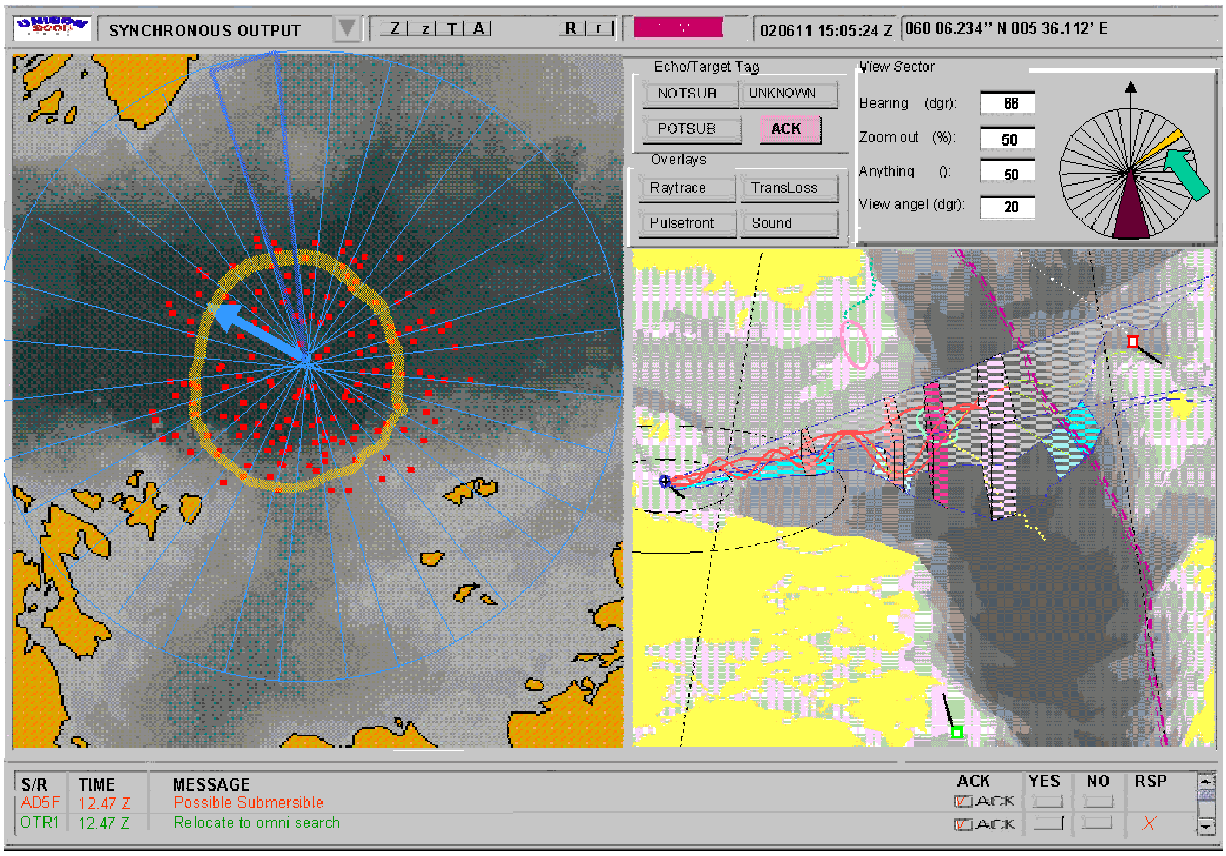

Figure 5.1 *Example is showing two different uses of audio-video synchronisation. On the left side, the real-time extent of the reflected pulse is shown as a circular feature where also the position of the beams including the current audio channel is shown. Also the echoes of the previous ping history are shown as red dots. On the right, the perspective view of the audio beam is shown where also raytraces are shown including any high reverberant areas of the bottom. Real-time extent of the pulse is shown as a transparent volume box. The positions of the echoes, including their positional uncertainties, are also shown as boxes. In the upper right corner there is an agent which shows the angle of view with respect to the ship orientation. Also included is means for manually tagging any echo according to the operator interpretation. He has also some control of what information is displayed within the perspective view.*

5.2 False alarm reduction / Signal classification

5.2.1 Echo signal structure presentation tool

Brief description:

This functionality is a more comprehensive version of the echo classifier intended for version M4, and which was not developed.

It is a tool for the analysis of the signal itself and does not address the internal structure of the target. Contributions from Lybin and audio-output are included.

Intention:
Using this functionality the operator may analyse the reflected signal originating from a beam and range found interesting to analyse.

Usage:
By selecting this functionality within the analysis display/technical display, the operator may view the signal characteristics from a selected position (beam and range window) several ping histories in a row. If made available, the audio may synchronously be output as the signal is highlighted. It may also be desirable to concurrently display the geographic area including the track/echoes and even raytraces within one or several windows at the same display.

Benefit to ASW operations, impact on problem areas:
Benefits the indication and classification of contacts and ensures trustworthiness of the classification.

Outputs produced:
Presentation of:

- time-series matched-filter output drawn as curves
- audio from a selected beam signal
- visual presentation of raytrace
- topography and available bottom characteristics
- echoes correctly positioned

Hydro-acoustic model data (single dB numbers listed in a table) SE, PD, RL, TL etc. (see illustration)
Number of raytrace bottom bounces and surface bounces, range spreading of pulse and possibly depth focus of the sound energy (requires depth discrete ray position information from LYBIN).
Presentation of target or echo selected by the operator positioned at the centre of the analysis window.
A separate presentation of the parameters for a track taken in control.
Echoes categorised as being 1) unknown, 2) potential submarine or 3) not submarine and 4) acknowledge this.

Input requirements:
The geographical area selected for analysis may be chosen by selecting beam and range, selecting an echo or taking a track in control. Then this functionality is selected.

- Sonar echoes correctly positioned with inaccuracies wrt the topography.
- Audio cut of the selected beam
- Raytrace (time discrete) within the analysis range window
- Topography within the analysis range window
- Established system tracks (internal tracks wrt the sonar) for range and bearing selected

- Hydro-acoustic model data; SE, PD, RL, TL etc. for the range and bearing selected (dB numbers)
- Operator specifies the number of sequential pings to be analysed or a default setting may be chosen

Special requirements:
- Two possible modes of operation; 1) automatic mode where signals are presented as they are received from the real-time pinging, and 2) interactive mode where the signal input to the tool is frozen and the operator may himself decide in which sequence data is output.
- Time discrete raytrace
- Storage of the 10 last ping histories for each beam

Additional comments:
See illustration diagram

Requirements from the recording of data:
- Audio of all beams
- Echo data
- Matched filter output of all beams
- Position and orientation of ships
- Position of nearby ships and submarines

Figure 5.2 The illustration shows a possible solution for a echo signal structure classifier. Buttons on the left activates the sound of the time slice of the respective ping. Going to the right, a perspective view of the area selected for analysis is shown including the raytrace and echo positions. In the centre, the time series signal is drawn of the matched filter output for the section selected by the operator. Again, on the top right, a widget showing the angle of view is included. Further down, some data showing the hydro-acoustic model estimations are shown which may tell the operator something about the trustworthiness of the signal. Below this, there is again a dialogue for the operator to make any contribution to the tagging of an echo or track. On the bottom right there is an audio operation dialogue.

5.2.2 Tracking applied to kinematic classification

Brief description:
Determine classification of tracks based on kinematic and temporal behaviour. Tracks will be checked against known submarine behaviours, and shoal fish behaviour etc. Presentation of the track position history/echo history in the Geo-tactical window will contribute to manual classification.

Intention:
Provide support for classification of tracks based on kinematic data over time.

Benefit to ASW operations, impact on problem areas:
Improve the echo/track classification. This will support the following problem areas:

- Indication and classification of contacts.

Usage:
This function is typically a background process, checking all tracks against the "behaviour DB". The track/echo history will be presented, on request by the operator, in the Geo-tactical window.

Output produced:
A recommendation for track classification.
Presentation of track/echo history in the Geo-tactical window

Input requirements:
Tracks. This function requires a tracking system which manage tracking in clutter, which handles splitting and joining of tracks and which gives a stable track solution
Technical track information from technical (Encyclopaedic) DB.

Special requirements:
The function requires information on maximum speed and turn rates for different types of submarines (technical track information)

Additional comments:

5.2.3 Information correlation tool (echo, topography, hydroacoustics, non-sub objects)

Brief description:
This functionality is a more comprehensive version of the geo-correlator functionality of phase 1, which will perform and present to the operator the correlation of information relevant for sonar echoes.

Intention:
Using this functionality the operator may correlate the sonar echo information with any other information capable of causing a sonar echo. Such features may be tracked targets, bottom reverberation, particular features of the bottom such as peaks, wrecks, pipelines or sub-bottom layers. It also is supposed to be used for correlating the echo position with land, behind land or waters more shallow than a specified depth.

Usage:
This functionality visualises the result of the tagging of echoes performed by components as they correlate echoes with features of the topography, hydro-acoustic model output or data within databases or tactical picture. Echoes are assigned correlation values, and the properties which have the highest correlation score dictate the colour of the symbol of the echo or of the circle surrounding the echo.

Benefit to ASW operations, impact on problem areas:
Improve the alarm correlation. This will support the following problem areas:
Indication and classification of contacts
Presentation and perception of available information

Output produced:
As an window within the analysis display, an indication of echo position (possibly including its uncertainty) correlating with:

- Tracked targets
- Sea mounts
- Wrecks and other available information about sea floor installations
- Bottom reverberant areas
- Self noise dominant areas
- Shallow areas
- Land areas
- Behind land areas

A possibility is also to mark an object which may correlate with any combination of the above features.

Input requirements:

- Correct position with position inaccuracies of echoes within analysis sector
- Historic echo positions of 10 last ping histories
- Topography
- Coastline and land areas
- Track positions
- Sea mounts over a specific significance (to be specifies by the operator)
- Hydroacoustic model bottom reverberation
- Self noise dominant sector (blind sectors)

Special requirements:
This functionality is meant as an analysis functionality activated by the operator in order to check the system interpretation of what causes the echoes. Care must be taken if adopting these interpretations in discarding echoes.

Additional comments:
See illustration diagram

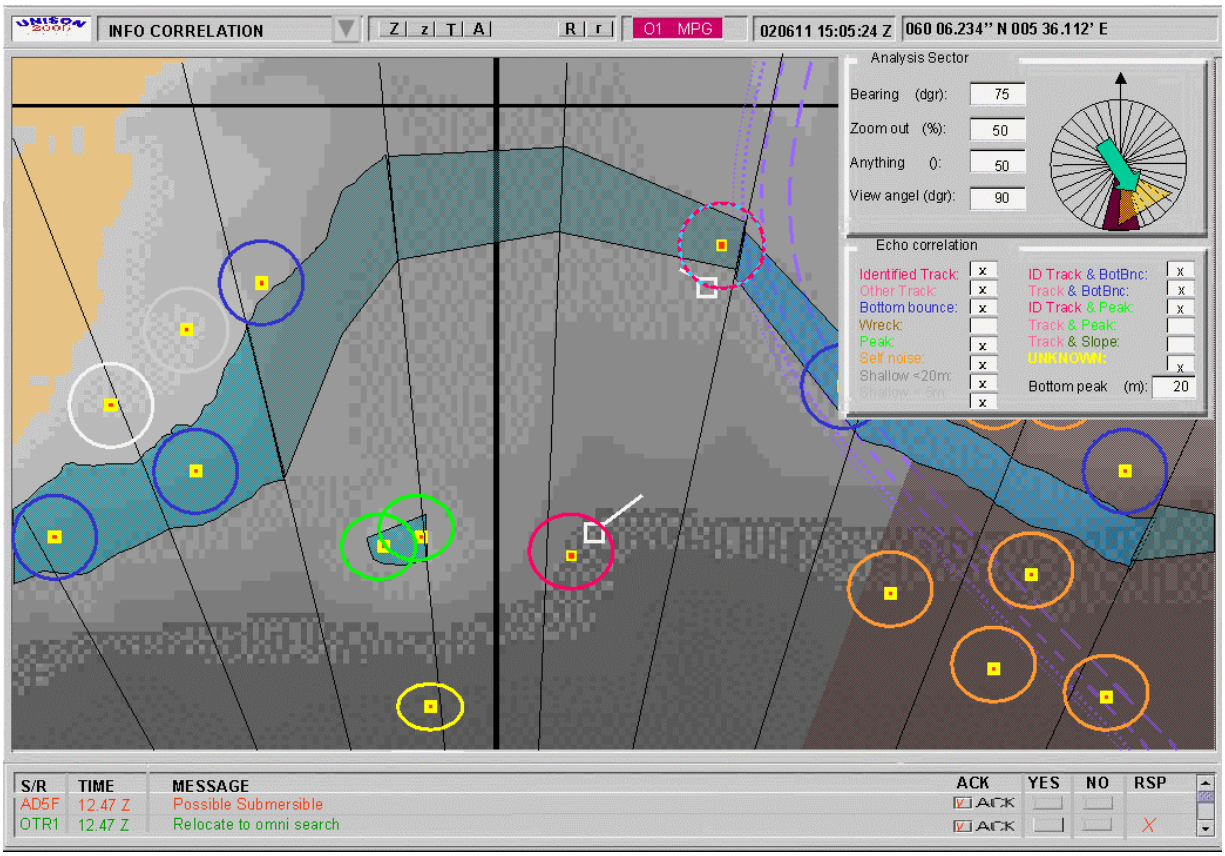

Figure 5.3 *Illustration shows the possible presentation of the information correlation functionality. Surrounding each of the red/yellow echo symbols, there is an ellipse implying the uncertainties of the positions. The colour of an ellipse corresponds the type of information(s) which is the most likely explanation to the alarm. Also specific features e.g. of the bottom is displayed (here: bottom reverberation intensive areas). This diagram also shows the positions of the sonar beams. A dialogue for choosing what information is to be checked in the correlation is included in the upper right display area including a widget for showing the angle of view.*

5.3 Sonar usage

5.3.1 Noise and reverberation presentation tool

Brief description:
Using the hydro-acoustic model and available information about the sea floor topography and ship positions, this functionality estimates and presents the noise and reverberation limited areas at a specified resolution.

Intention:
Using this functionality the operator may determine in which areas the sonar is reverberation or noise limited, and to some extent determine what measures to activate in order to ensure detection or tracking.

Usage:
This functionality would naturally be visualised as an overlay in the geo-tactical window. It tells the operator, to a specified level of details, where the sonar is bottom reverberation limited and where noise is the primary masking effect. Proper measures may thereafter be taken to reduce the effect of high reverberation level by e.g. reducing the source level of the sonar.
This functionality is related to the automatic SPA component, though this version visualises several different effects in the same overlay.

Benefit to ASW operations, impact on problem areas:
Improve the alarm correlation. This will support the following problem areas:
- Indication and classification of contacts
- Employment of sonars

Output produced:
A presentation of noise and reverberation intensive areas. Noise in this case may be ship noise, speed dependent own ship noise, harbour or industrial noise or ambient noise. Modelled bottom reverberation generated from the sound speed profiles and topography should also be displayed. Also areas where there are object on the sea floor (wrecks, pipelines etc) should be marked.

Input requirements:
- Own ship position (or planned ship position)
- Target positions (as correct as possible)
- Echo positions (as correct as possible)
- Sound speed profiles

- Bottom topography and any other information concerning the bottom (as correct as possible)
- Available information about permanent sea floor objects (wrecks, pipelines etc.)

Special requirements:

Additional comments:
See illustration diagram

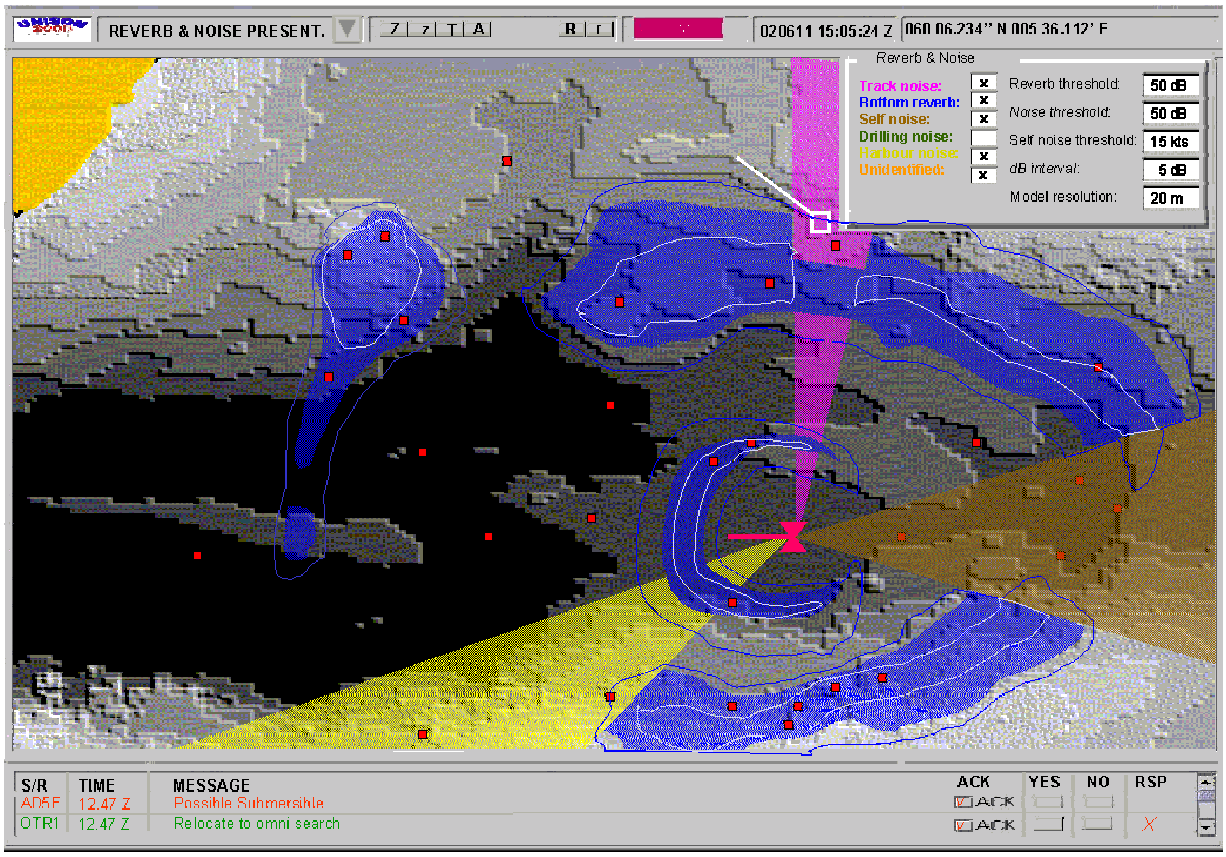

Figure 5.4 *The diagram shows the areas where the sonar is reverberation limited above a specified level (blue), noise limited areas (magenta (other ship noise), yellow (harbour noise) and brown (self noise)). Using lines an indication is included to show the situation when the source level is increased and decreased by e.g. 5 dB. A dialogue for input and display of these parameters are included in the upper right.* The display is intended as an overlay in the geo-tactical window. Echoes are shown as red dots, a track an own ship is also displayed.

5.3.2 Sonar recommendation support

Brief description:
To provide the operator with relevant sonar performance prediction capability. This will increase the operator's ability to employ the sonar in a optimal way for improved sonar performance, and to assess how sonar performance will react on variations in sonar parameters.

Intention:
To provide the operator with relevant sonar performance prediction capability. This will increase his ability to assess how sonar performance will react on variations in sonar parameters, and allow him to employ the sonar for improved sonar performance.

Usage:
This function may be used to support operator assessment of optimal sonar settings in e.g. the following situations:

- The frigate conducts a precursor operation searching an assigned area (mode 1)
- The frigate follows and keeps track of a target (mode 2)
- Sonar conditions are difficult and extensive analysis of performance various parameters are required (mode 3)
- Sonar performance conditions in a new deployment area are analysed as basis for ASW planning (mode 4)

Benefit to ASW operations, impact on problem areas:
Improve sonar performance, allowing for improved capability and trustworthyness of interpreting sonar signals. This will support the following problem areas:

- Employment of sonars
- Indication and classification of contacts

Products produced
All products relate to analysis area identified by selected reference position**.**

1. Presentation of a 360^{o} Sonar performance indication diagram (Omni Analysis, ref enclosure).
2. Presentation of Sonar performance details at selected prediction conditions. Sonar performance details may include e.g: *Echo level (EL), Reverberation level (RL), Noise level (NL), and Transmission loss (TL).*
3. Presentation of Raytrace details at selected Prediction conditions. Raytrace details may include: *Bottom bounces (number), Surface bounces (number), Spread (m), Depth focus (%)*
4. Special diagrams presenting effects on sonar performance factors (operator selected) from combined variations of:

- target depth and range, at Speed, Tilt and Bearing iaw. selected prediction sector
- target depth and bearing, at Speed, Tilt and Range iaw. selected prediction sector
- platform speed and range, at Target depth, Tilt and Bearing iaw. selected prediction sector
- platform speed and bearing, at Target depth, Tilt and Range iaw. selected prediction sector
- sonar tilt and range, at Target depth, Speed and Bearing iaw. selected prediction sector
- sonar tilt and bearing, at Target depth, Speed and Range iaw. selected prediction sector

  Sonar performance is presented as Signal Excess (SE), Probability of detection (PD), Transmission Loss (TL), Reverbation level (RL), Noise level (NL), or Sum of reverberation or noise level (RL+NL), as selected by the operator.

5. Presentation of latest updated details of Target selected by the operator. Target details may include e.g: *Range (m), Speed (m/s), Bearing (dgr), Heading (dgr)*. Range and bearing values shall be relative to geographical area reference point.

Input requirements:

- Reference point of analysis area
- Current environmental data (hydroacoustic, bathymetric, geographic/topographic, weather. Most representative sea floor profile should be used)
- Prediction conditions: Target depth, range, bearing, speed, tilt.

Special requirements:

This function shall have the capability to predict sonar performance effects with respect to the following performance variables: Signal Excess (SE), Probability of Detection (PoD), Transmission Loss (TL), Reverberation Level (RL), Noise Level (NL), and Sum of Reverberation and Noise level (RL + NL). The analysis shall be performed with respect to the particular performance variable selected by the operator.

The function shall be able to run in four modes:

1. Reference point of analysis area is continuously equal to own ship position and is updated accordingly. Prediction conditions are continuously equal to current sonar settings and are updated accordingly.
2. Reference point of analysis area is continuously equal to own ship position and is updated accordingly. Prediction conditions are continuously equal to selected target data, and are updated accordingly.
3. Reference point of analysis area is initially set to own ship position, but is not updated. Prediction conditions are initially set to current sonar settings, but are not automatically updated. They may, however, be changed by operator interaction.
4. Reference point of analysis as well as prediction conditions are initially selected by the operator. Prediction conditions may be changed by operator interaction.

Additional comments:
The following data recordings are required for this function:
- Sea floor topography within analysis area
- Self noise
- Track

5.4 Tactical Decision Support

5.4.1 Editing tool

Brief description:
This tool enables the operator to add text and graphic information to the display, and give the operator easy access to relevant situational information, which again puts the system into a more realistic ASW-situation.

Intention:
Provide a possibility to describe a more realistic picture of the real world to the operator.

Usage:
This function is a collection of tools, used by an operator, to put information in the Geo-tactical window.

Benefit to ASW operations, impact on problem areas:
Provides a drawing tool that can be used as a part of the water space management.
Gives the operator a tool to describe the real world, and put into the system more knowledge about the areas of interest.
This will support the following problem area:
- Presentation and perception of available information
- The planning challenge

Output produced:
Presentation of text and graphics on the geotactical display.

Input requirements:
Operator interaction.

Special requirements:
The graphical information can include the following:

- lines
- polygons
- polylines
- rectangles
- text
- circles

Special symbols can include the following:
- JTAA (joint action area),
- NOTACK,
- SGSA (submarine generated search area),
- MEDOW,
- SAA (submarine action area),
- SLL (submarine safety lanes),
- ASWFA (ASW free area),
- SPA (submarine patrol area),
- Ocean front,
- currents,
- mine fields,
- submarine operating area,
- marine life areas,
- Area Of Responsibility (AOR),
- restricted area

Additional comments:
Not all of these graphical symbols will be implemented in the UWW Demonstrator. The list of graphics can be changed as a result of discussions with the ASW User Group.

5.4.2 Track management tool

Brief description:
A tool that enables the operators to manage the tracks within the system, e.g. classification, alter track data, initiating and deleting tracks.

Intention:
Provide a tool to the operators in order to manage all the tracks within the system, e.g. identification, classification, alter track data, alter track creation and deletion criteria, initiating and deleting tracks.

Usage:

Benefit to ASW operations, impact on problem areas:
The operators are given a complete overview over the tracks within the system, and has a tool for manipulate the tracks.
This will support the following problem area:

- Presentation and perception of available information

Output produced:
Tracks with updated information in the track store.

Input requirements:
System tracks

Special requirements:
Manual initiation of sonar tracks.
Alteration of criteria for creation / deletion of tracks.

Additional comments:

5.4.3 Simple calculation tools

Brief description:
Tools that provide calculation aid to the operators.

Intention:
To provide tools which can help the operator in understanding the real picture in order to make the decisions. The tools can be used for the operators benefit, or as and aid on forwarding information to other friendly units.

Usage:

Benefit to ASW operations, impact on problem areas:

This will support the following problem area:
- Presentation and perception of available information
- The planning challenge

Output produced:
Presentation of calculated data and graphics in the geo-tactical picture.

Input requirements:
System tracks and other objects available in the geo-tactical picture.

Special requirements:
The tools can be the following:
- MPA tool
- Multi Ruler
- Range Rings
- Furthest On Circle (FOC) / Torpedo Danger Area (TDA)
- Torpedo Danger Zone (TDZ) / Limiting Lines of Submerged Approach (LLSA) / Submarine Limiting Course (SLC)
- Future position predictor
- Closest point of approached (CPA)
- Closest point of intercept (CPI)
- Estimated time of arrival (ETA) to TDA
- Attack position (A-POS)

Additional comments:
Not all of these tools will be implemented in the UWW Demonstrator. The tools can be changed as a result of discussions with the ASW User Group.

There have been made PowerPoint slides to visualise some of the tools that can be implemented (see appendix):
- Multi-Ruler tool
- Range Rings tool
- Furthest On Circle / Torpedo Danger Area
- Torpedo Danger Zone / Limiting Lines of Submerged Approach / Submarine Limiting Course
- Disposition 4W

Calculation tools examples:

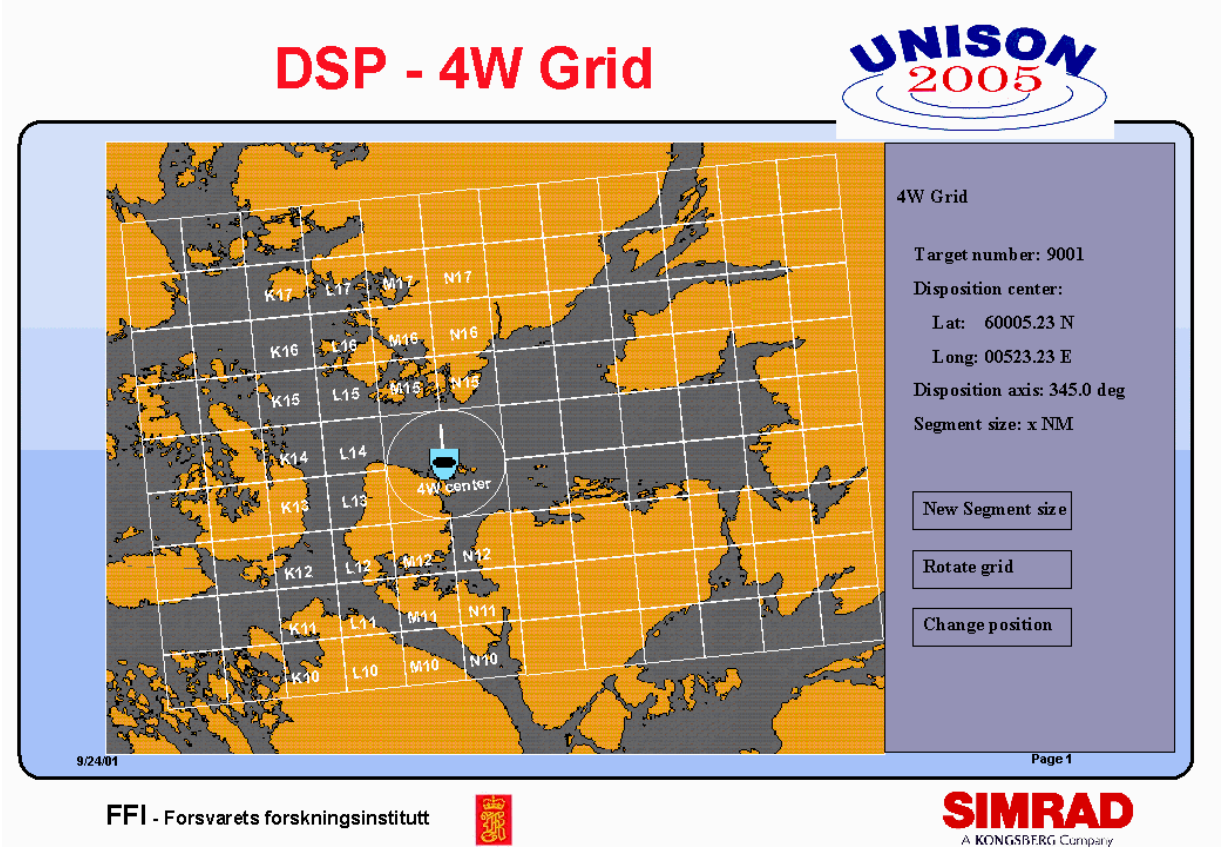

Figure 5.5 An illustration of a 4W-grid tool for use in ASW-planning.

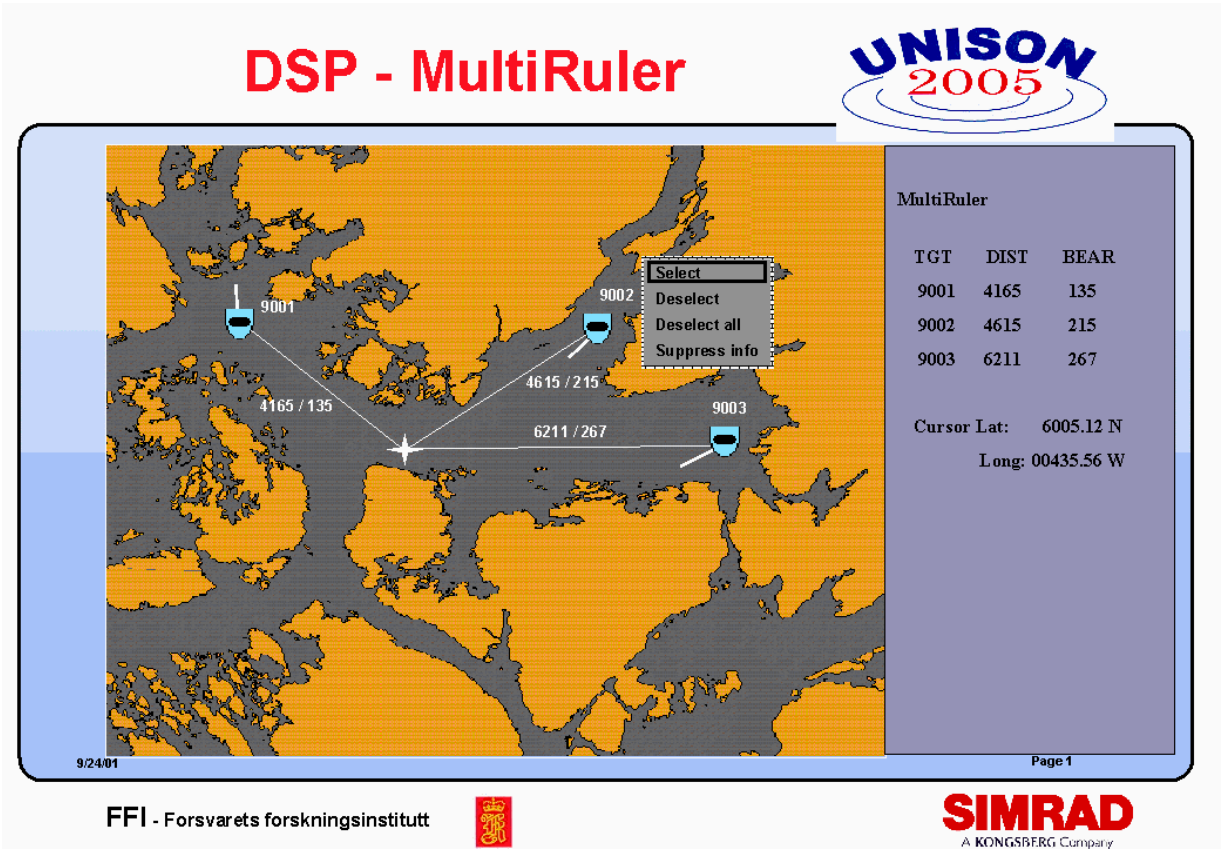

Figure 5.6 An illustration of multiruler graphical tool

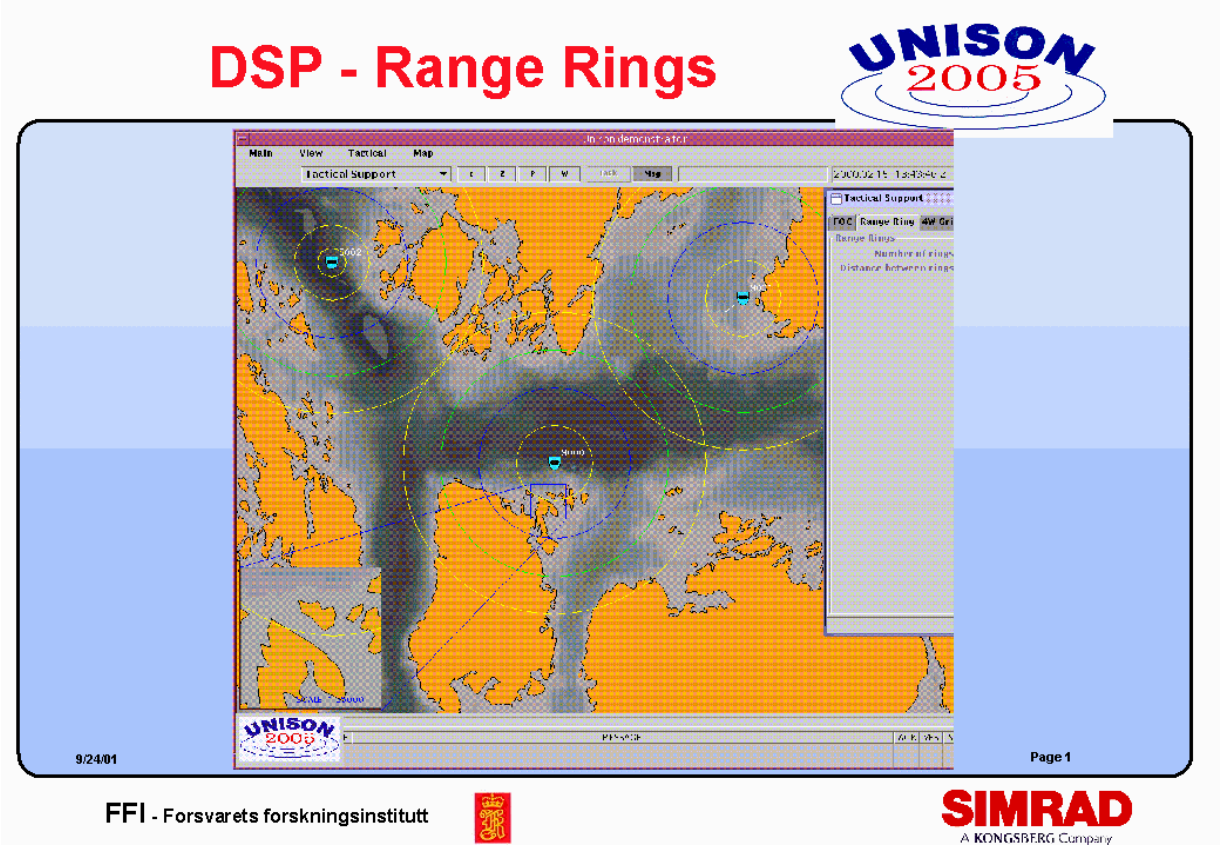

Figure 5.7 An illustration of range rings graphical tool

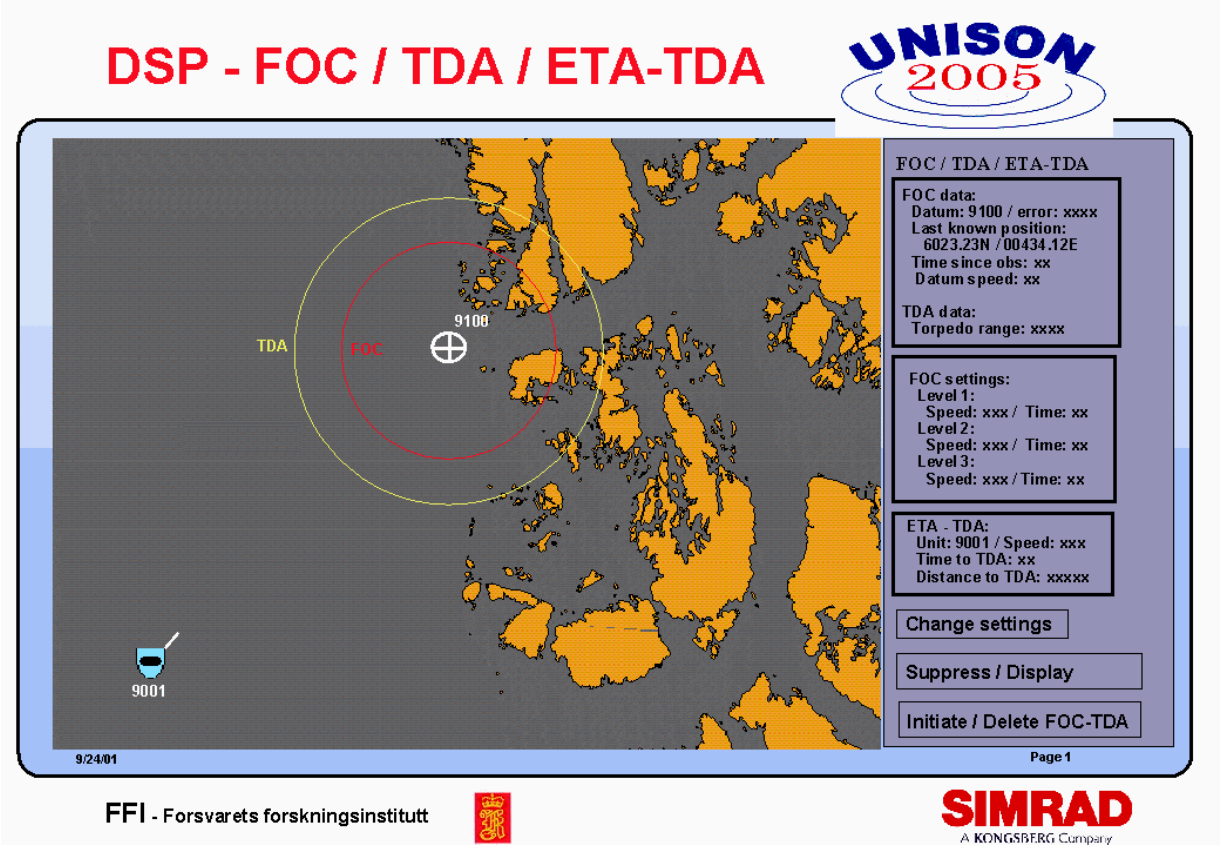

Figure 5.8 A illustration of FOC (Furtherst On Circle), TDA (Torpedo Danger Area) and ETA-TDA (Estimated Time of Arrival-Torpedo Danger Area) graphical tools

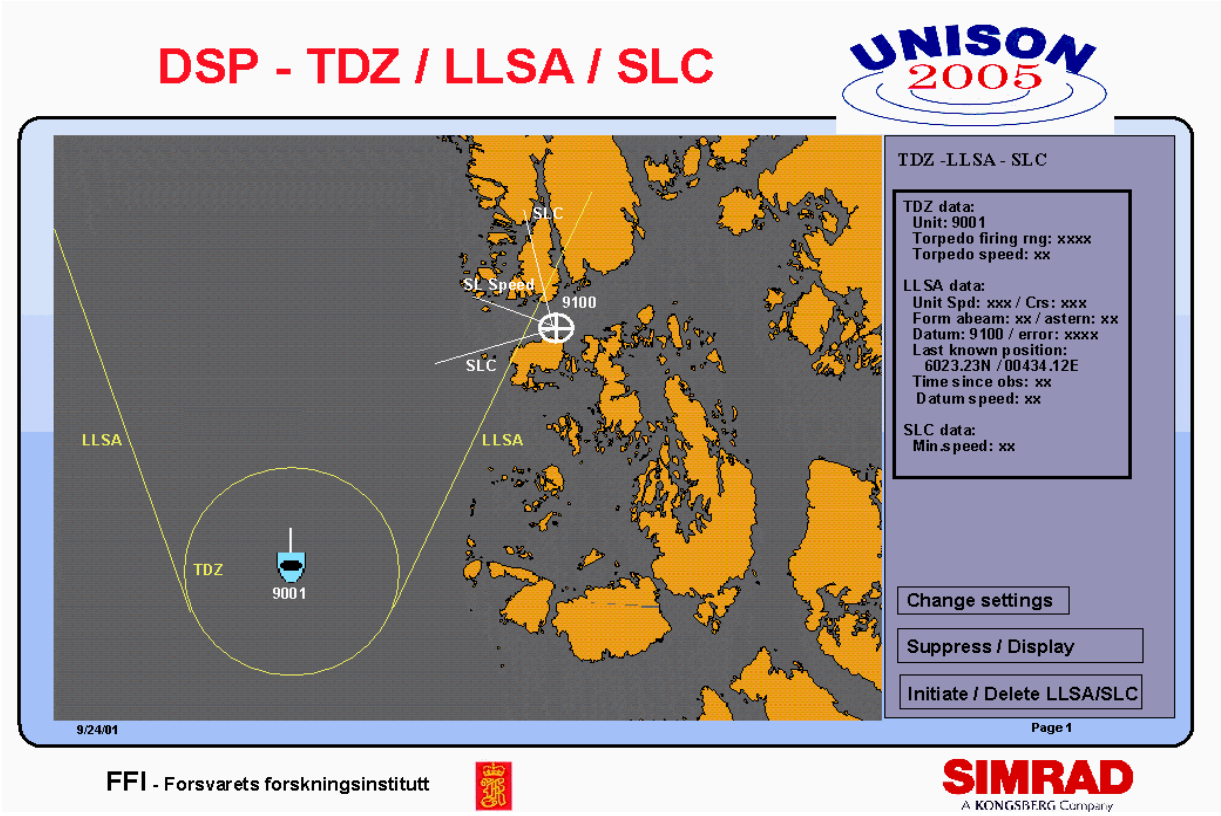

Figure 5.9 An illustration of the TDZ (Torpedo Danger Zone), LLSA (Limiting Lines of Submerged Approach) and SLC (Submarine Limiting Course.) graphical tools.

5.4.4 Planning and support tools

Brief description:
Tools that provide aid when planning and conducting ASW operations.

Intention:
Aid the operator in the planning and conducting phase of the ASW operation.

Usage:
This function is a collection of tools, used by the operator to plan and conduct an ASW operation.

Benefit to ASW operations, impact on problem areas:
Such a tool is helpful when conducting an area surveillance or a search through some geographically limited areas. Effort will be concentrated around the utilisation of hydroacoustic predictions for the sonar sensors.

This will support the following problem area:
- Presentation and perception of available information
- The planning challenge

Output produced:
- Routes
- presentation of information

Input requirements:
- system tracks
- sonar performance

Special requirements:
- Planning and support tools can be the following:
- tool for establishing units, creating and simulate routes – as in the ASW Planner
- presentation of predefined ASW search and attack patterns (ref. ATP 1)
- presentation of sonar performance
- calculation and presentation ASW screen
- handling of ASW DATUM
- presentation of dogbox
- filtering of information
- establishment of disposition 4W

Additional comments:

5.5 Fusion with external sensors

5.5.1 Sensor correlation tool

Brief description:
Correlate sonar contacts (tracks) with information from other organic sensors (radar, ESM, outlook), as as well information provided by non-organic sensors via digital or voice communication.

Intention:
To take advantage of the potential contribution from relevant information provided by own non-acoustic sensors as well as by external sources.

Benefit to ASW operations, impact on problem areas:
Provide a combined overview of sonar contacts together with other sensor information, analyse the sonar and sensor findings with respect to possible correlations, recommend fusion of correlating detections with common targets as well as splitting of fused detections as appropriate. This will add confidence to and improve trustworthiness of the contact classification, and support the following problem areas:
- Presentation and perception of available information
- Indication and classification of contacts

Products produced:
Composite presentation of sensor detections with associated time tags. Sensor detections, include:

- Indicated sonar contacts, (i.e. subsurface tracks.. Common tracks fused by multiple sensor detections should be highlighted. .
- Established datum(s)
- Visually identified objects
- Surface tracks
- ESM bearing(s) and associated platform position(s)
- Riser-sinker detections
- Common tracks (i.e. tracks verified by multiple sensor detections and representing operator aceptance of recommended fusion)

Recommended fusion of sensor detections to common tracks, when correlation strength exceeds specified limit.
Recommended splitting of common tracks (fused sensor detections), when correlation strength decreases below specified limit

Input requirements:
Input requirements include input from own as well as external sensors.

- Indicated sonar contacts (subsurface tracks)
- Surface tracks
- ESM detections
- Riser-sinkers
- Visual observations
- Relevant information received by message or voice

Special requirements:

- The operator shall have the capability to select and deselect layers of information...
- The operator shall accept or refuse a recommendation for fusion of multiple sensor detections to a common target.
- The operator shall have the capability to manually fusion a sonar track and split a common track (fused sensor detections) regardless of recommendations.

Additional comments:
The following data recordings are required for this function:

- Sonar echoes
- Radar tracks
- Riser-sinker detections
- ESM detections
- Own ship data

5.6 Experimenting and prototyping specifications

5.6.1 Sonar signal displays (WINSON contribution to UWW-station)

Brief description:
Integrate the WINSON display in the UWW demonstrator. See Andersson.

Intention:
To present sonar data in a variety type of X-Y analysis diagrams.
Integrate two different platforms together (COM/CORBA).
Develop a platform independent WINSON-display.

Usage:

Benefit to ASW operations, impact on problem areas:
This will support the following problem areas:

- Presentation and perception of available information.

Output produced:
A presentation of sonar data.

Input requirements:

- Sonar echo
- Matched filter

Special requirements:
Sonar echo and matched filter presented in the sonar display, shall be made available for other components in the UWW demonstrator.
The sonar display shall be prepared to display data from different types of active sonars.

Additional comments:

5.6.2 Perspective presentation (sector, area, etc)

Brief description:
Enabling presentation of data windows including the geo-tactical window in perspective view with capabilities such as zoom, pan and rotation around two axes.

Intention:
To present data in a more realistic manner enabling to operator to differentiate between data and to obtain a better perception about data presented without introducing ambiguity.

Usage:

Benefit to ASW operations, impact on problem areas:
This will support the following problem areas:
- Presentation and perception of available information.

Output produced:
Presentation of topography and other data correctly positioned in the 3D-space.

Input requirements:
All data to be visualised in perspective view must come with 3D-positional co-ordinates.

Special requirements:
Requires use of Java 3D compiler for all UI-components utilising perspective presentation.

Additional comments:

5.7 Demonstrator and scenario support

Brief description:
The functions not handled by the ASW system will be simulated in the demonstrator. The demonstrator will offer full functionality to replay recorded data.

Intention:
The functions not handled by the ASW system will be simulated in the demonstrator. The demonstrator will offer full functionality to replay recorded data.

Usage:

Output produced:
- Navigation data.
- Time data.
- Recorded data (echo, raw sonar data).
- Presentation of recorded targets.
- Control tool for running the recorded data.

Input requirements:
Recorded data

Special requirements:

An operator shall be able to start and stop the run.
The operator shall be specify where in the logged data, the run shall start.

Additional comments:

6 CONCLUSION

The report presents the necessity for additional functions of the demonstrator following the evaluation of UNISON 2005 phase 1 demonstrator. From a wide range of alternative functions suggested and considerated at an early stage, the final components recommended for the phase 2 UWW-station were selected in accordance with the major ASW challenges of the RoNoNavy. Other directions also had some influence, but with significantly less emphasis.

At the end of the UNISON-project, only a limited number of the suggested function had been implemented within the demonstrator due to shortage of time and resources. Most of the functions had to some extent been elaborated, but emphasis were finally put on a few to ensure their completion.

The functions completed in the final version of the demonstrator:
Audio analysis
- Synchronous audio output with visual presentation of raytrace, echo and topography

Experimenting and prototyping
- Perspective presentation (sector, area, etc)

The functions worked on separately, but not included in the final version of the demonstrator:
False alarm reduction / Signal classification
- Tracking applied to kinematic classification
- Information correlation tool (echo, topography, hydroacoustics, non-sub objects)

Sonar usage
- Sonar usage recommendation tool
- Noise and reverberation presentation tool

Tactical Decision Support
- Editing tool
- Simple calculation tools
- Track management tool
- Simple calculation tools
- Tool or on-site planner for search/surveillance

Experimenting and prototyping

- Sonar signal displays (WINSON contribution to UWW-station)

Functions on which no significant work had commenced during the UNISON 2005 project:

False alarm reduction / Signal classification

- Echo signal structure presentation tool

Fusion with external sensors (acoustic and non-acoustic)

- Sensor correlation tool

Experimenting and prototyping

- Demonstrator and scenario support

The varying degree of completion of these functions was caused by several matters. To some extent, some of the functions have been worked on even after the end of the project. Some functions are also identified as desirable for the Fritjof Nansen class firgates' ASW-solution

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(7) Toril Andersson (2001): Sonar System Integration (a preliminary study), Simrad AS report.

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