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PROPOSED USE OF LYBIN IN PROJECT SIMSON

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8) ABSTRACT

Previous and present versions of the acoustic ray trace model Lybin are described briefly. The use of Lybin in FFI project Simson can be divided into three categories: simulation of submarine detection coverage, simulation of sonar response for operator training and simulation of sonar response for scientific analysis. The work needed to develop these tools is discussed and outlined. The tools will have the same mathematical kernel, but different user interfaces reflecting the users' level of understanding and the desired functionality.

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PROPOSED USE OF LYBIN IN PROJECT SIMSON

1 INTRODUCTION

One of the goals of FFI-project 849 SIMSON is to develop a realistic sonar simulation tool for the sonar suite of the Fridtjof Nansen-class frigates. The simulation tool should be valid for the complex coastal environment of Norway. The basis of this tool will be the sonar prediction model LYBIN, developed by the Norwegian Defence Logistic Organisation / Sea (NDLO/Sea).

To fulfil its purpose in project SIMSON, LYBIN as it is (version 4.0) needs to be modified and extended. These modifications will be co-ordinated with FFI-project 795 and with NDLO/Sea.

This report specifies the necessary changes in LYBIN. First we give a brief history of the model and presents the status of the different versions of LYBIN, chapter 2. Then we describe how the acoustic model will be used in the project, chapter 3. Description of proposed modifications are given in chapter 4, and a more detailed description of the software changes is given in chapter 5, and finally a crude work breakdown structure is given in chapter 6. Conclusions are given in chapter 7. The main changes needed are the ability to compute in a fully range dependent environment, extended resolution in bathymetry, and estimates of time-of-arrival and multipath structures. Software changes are also necessary to permit extensive batched computations and to integrate LYBIN in other software. The issue of maintaining and updating the official version of LYBIN, assuring easy update of all applications using LYBIN is not addressed in this project.

This report also serves as the deliverable for milestone 1.5.1 – Give a plan for the LYBIN work in project SIMSON, see project agreement, ref (6). The detailed text of this work package is given in A. This report also covers the initial thoughts for milestone 1.1.2 – Describe properties of acoustic model.

2 THE HISTORY AND STATUS OF LYBIN

A brief overview of LYBIN is given in ref (1).

2.1.1 The history

- Developed and used as standalone program since 1980. Originally developed on HP-Basic. Several C++ version exists for windows based Pc's and also for UNIX.
- At KDA early versions were used in MSI90U and in SPHERION active sonar trainer. These versions have later been modified by KDA, but have never been updated with new releases from NDLO/Sea.

- Version 2.0 implemented and documented by Nansen Environmental and Remote Sensing Center, NERSC and NDLO/Sea1999.
- Version 2.0 used in project UNISON 2005, and integrated in the UWW demonstrator (1999-2000)
- Version 2.0 tested at SACTLANTCEN, Supreme Allied Commander, Atlantic Undersea Research Centre, after some small modifications done by FFI (2001).
- Version 2.0 extended with passive module
- Version 4.0, sep 2002 (by FFI) includes many error corrections and extensions to the program, but has not the Passive Module. Delivered to NDLO/Sea, to be delivered to KDA.
- Version 3.0 computational part integrated in the operational simulation model OSCAR II. Extraction of bathymetry from maps included in this implementation

2.1.2 The use of LYBIN

LYBIN is used in the Navy on standalone computers on different ships and offices. It is used for estimation of sonar detection range and for aid understanding the acoustical conditions influencing sonar performance.

2.1.3 The status of LYBIN today.

2.1.3.1 Version 4.0 (sep 02)

LYBIN 4.0 was delivered from FFI to NDLO/SEA September 2002. This version contains all revisions, modifications and extensions done by FFI project 795, New Frigates, since the source code of LYBIN was delivered by NDLO/SEA in 2000.

The major improvements in LYBIN 4.0 compared with LYBIN 2.0 are:
1. Improvements in ray tracing.
2. Introduction of volume reverberation.
3. Error correction in the probability of detection calculation.
4. Bottom topography can be saved and read from file.
5. Bottom loss can be saved and read from file.
6. Calculated transmission loss, probability of detection and reverberation can be saved to file.
7. Possibility to simulate with different vertical beam response in transmitter and receiver.
8. Plotting of reverberation and noise curves.
9. Pre measured reverberation and noise can be saved and read from file.
10. Bottom backscattering coefficients can be saved and read from file.
11. Various minor improvements.

All the improvements mentioned above are described in more detail in LYBIN 3.0 preliminary release notes and LYBIN 4.0 Release Notes – Preliminary.

2.1.3.2 Version integrated in OSCAR II

The integration of LYBIN in OSCAR is described in ref (7).
This integration is based on Version 3.0 of Lybin, but updated with some of the modifications listed in chapter 2.1.3.1.

2.1.3.3 Version 4.0 integrated in MSIFC by KDA

We do not know much about this version. Since in MSIFC the GUI of version 4.0 is not used and that some input has to be read automatically from other processes, and MSIFC is implemented on a unix based computer, we know there are modifications done. We don't know how easy updates of the PC-version can be incorporated. This version is put in a "framework" were bathymetric profiles are extracted from maps. This version is probably similar to the Lybin version implemented in the UNISON 2005 UWW demonstrator.

2.1.3.4 Latest version of LYBIN at FFI (oct 2002)

Continuous work is done to improve LYBIN at FFI. Since the delivery of LYBIN 4.0 in September 2002, several improvements have been made by project 795 and 849:

1. The source code has been improved in order to run in Microsoft Visual Studio .NET.
2. Memory leaks have been corrected.
3. User interface improvements introduced in Windows XP have been incorporated in LYBIN.

2.1.3.5 HP-Basic Version in use by NDLO/Sea

This version is continuously extended and updated and contains a lot of features not available in the other versions. It functions as a reference and a "lab" for the originator of LYBIN, Svein Mjølsnes.

2.1.3.6 Version 2.0 included Passive Module

This version was made by NERSC after FFI started debugging 2.0. The passive module is therefore not implemented in version 3.0 and 4.0.

The Passive Module computes the range at which own ship/sonar is detected by an enemy passive sonar at different depths.

2.1.4 Planned work in other projects

2.1.4.1 Project 795 New Frigates

- Calibration of Lybin in a nearly range independent environment.(includes comparison with sea trial data).

- Implementation of range dependence in oceanography, volume scattering strength, sediment parameters and wind speed. Not prioritised, but probably necessary to investigate sensitivity to range dependence (in the SAT2 tests)
- Finalize integration in OSCAR II
- Implement batch mode version to ease the effort of running studies.

2.1.4.2 Project 861 METOC

The goal of this project is to establish meteorological and oceanographic forecast to the operational units of the navy. The details of the oceanographic forecast will influence the computational accuracy of LYBIN and vice versa. Through METOC, realistic oceanographic field will be available for LYBIN, and through sensitivity studies with LYBIN, necessary requirements of resolution of oceanographic forecast is established.

2.1.4.3 Project 836 SWASI III

This project represents a valuable knowledge of the geophysical parameters important for acoustic propagation. Their main interest is in low frequency propagation, but they collect and analyse information important for active sonar performance, for instance bathymetric data.

2.1.4.4 Project 821 RUMBLE

This project aims at estimating bottom properties using the operational low frequency sonar. In addition to establishing a method for instant estimation, the project establishing models for bottom scattering in some test areas. These estimates and models will be used as reference when calibrating LYBIN.

2.1.4.5 AESS

LYBIN is recommended for inclusion in the Allied Environmental Support System, AESS, by SACLANTCEN, see conclusion of ref (3). Some modifications are necessary. These are the inclusion of range dependent bottom characteristic, oceanographic structure and wind speed/wave height. Norwegian Navy has given their intention to include these changes and SACLANT will then incorporate LYBIN AESS within the Maritime Command and Control Information System (MCCIS) Ref letter of 12 oct 01 from director, Norwegian Naval Training Establishment to SACLANT, and their reply of 2 nov 01.

2.1.4.6 NORCCIS II

At the moment there are no plans of including a sonar coverage module in NORCISS II, Norwegian Command and Control Information System II, but this must in our view be an essential part of a CCI system for maritime operations. There are plans of including bathymetric data and meteorological and oceanographic forecasts in NORCCIS II.

3 THE USE OF ACOUSTIC MODELS IN SIMSON

A description of the simulation and analysis tool to be developed in SIMSON will be given in ref (8). The mentioned document is written in parallel with this one, and some inconsistencies may occur.

The use of an acoustic model in SIMSON can be divided in three cases:

1. Simulation of detection coverage (signal excess) around the sonar platform.
2. Simulation of sonar response for operator training and tactical training.
3. Simulation of sonar response for analysis of measured data. Includes sonar data at hydrophone level, two-way impulse response, detailed reverberation and transmission loss.

The version in point 1 is similar to the current version of LYBIN. We need a measure of the probability of detecting a submarine in every position. The results are to be used in visual inspection of detection coverage or in comparison of the effect of different parameter settings of the sonar. Since coverage prediction over a large area is required (50x50km) and these predictions need to be updated with new parameters/positions frequently, the computations need to be fast. This use of LYBIN is needed in a future planning and decision aid tool.

The aim of the version from point 2 is to generate realistic sonar data for a sonar operator consol and an anti submarine warfare, ASW, training system. When the sensor platform moves through an (artificial) environment with targets, the operator should hear and see a realistic picture on the console. This simulation has to include the audio channel, normalised beam response, echoes (with position, snr, and other characteristic), track and classification information. The same that the operator has available on the real operator console (from KDA). Real time performance is essential. It is important to simulate also false contacts, stochastic variations in signal level, position and noise. The simulations should reflect the environment from specific areas, making special area-planning possible.

Version 3: To perform detailed analysis of physical phenomena and effects in the processing chain it is important to be able to simulate with extreme resolution and accuracy in all dimensions; time, range, bearing. Precision is here more important than computational speed. If some effects can be predicted, they might be compensated for in the processing. It is also important to have a detailed model, to validate the simplifications done in version 2. Examples could be simulation of time series on hydrophone level, two-way impulse response, 3-D scattering.

4 PROPOSED EXTENSIONS AND MODIFICATIONS TO LYBIN

Here we give a description of what we think are the changes needed to LYBIN. We don't know at the moment that all these changes will be included in a "final" version of LYBIN, but some of the changes have to be implemented to perform sensitivity analysis. Before starting implementing any changes, we will coordinate the effort between NDLO/Sea, FFI project 795 New Frigates and this project, Simson.

4.1 Batch version

The current version of Lybin is attached to a graphical user interface, GUI. The GUI gives a fast way of specifying the physical data and parameters, and promptly displays the results. Unfortunately it limits the possibilities of running batch-mode and doing in depth studies of the computed data. In order to batch Lybin the computations must be separated from the GUI.

4.2 Range Dependence

To represent the acoustic environment the model should consider not only range dependence in bathymetry, but also in oceanography, wind speed/wave height, sediment type, and volume scattering strength. Project 795 has this modification on the action list. Considering the dependence of this in SIMSON and project METOC this task should be given higher priority, and SIMSON will also contribute to this task.
In reference (9) a study has been made on Lybins sensitivity to changes in sediment types, n order to confirm the importance of range dependent sediment types.

4.3 Pseudo 3d scattering

With simple modifications Lybin can be turned into a pseudo 3d ray trace model. Currently Lybin computes the reflection angle as the difference of the ray`s grazing angle and the angle of the one-dimensional bottom in the models plane. By introducing a bottom angle for the terrain perpendicular to the present bottom used by Lybin, the calculations of both bottom loss and reverberation may be improved. Unfortunately the actual reflection of the ray is not easily modified. The ray would in most cases be reflected out of the models plane. There are no obvious method to solve this problem without turning Lybin into an actual 3d raytracing model. Thus, only bottom loss and reverberation can be modified.
The effect of 3d scattering in Lybin has been studied in reference (9).

4.4 Impulse response (or timespread)

The current version of Lybin does not compute the ray's time of passage. There are no eigenray search implemented either. Both time of passage and eigenray search are essential in computing the impulse response. Time of passage can easily be implemented. The eigenray search can be circumvented, by using high resolution and high ray density. In which case all rays hitting the cell containing the submarine are dubbed eigenrays. Some or all of the eigenrays are reflected back to the receiver and add their contribution to the impulse response.

4.5 Clutter prediction

To predict clutter from bathymetry, we need high resolution in range and bearing. We need a good way of balancing resolution of bathymetry, with computational resolution and number of rays. In a "real time" clutter prediction, a high resolution LYBIN will probably be too slow. We therefore need to investigate different ways of prediction clutter. One way could be to use a low resolution version of LYBIN to find sonified spots on the sea floor, and then fold the intensity of these spots with the detailed bathymetry gradients of these areas.

4.6 Representation of wide sectors

A sonar has a certain beamwidth, which is the angle between two lines defined by a reduction in the intensity of 3 dB compared to the center of the beam. Lybin on the other hand models in a single direction of infinitesimal width. We need thus to compute and integrate the transmission loss and backscattering for a number of bottom profiles within the sector sonified by the sonar. This sector could simply be approximated within the beam width, but in some cases, especially in fjords and other undulating terrain, side lobes must also be taken into account. This method will increase the computational load drastically, and we will therefore in project Simson look into possible ways of reducing the angular resolution of the simulations. One method that is presently studied is to let a single bottom profile represent the whole of a sector.

4.7 Computational speed

When used as a sonar simulator for a operator trainer or tactical trainer LYBIN must deliver output in real time or faster. It will be important to do trade offs in accuracy, resolution level and speed. The version used in the simulator might be a different version than the others, or it might be the same version but running with different parameters, and less detailed input parameters. It might even be necessary to generate sonar input without LYBIN.

5 SPECIFICATION OF INPUT/OUTPUT FOR AN UPDATED LYBIN

In this chapter we give a description of input / output needed in an updated LYBIN, and also a definition of a batch mode Lybin, where all i/o will be done through files. This is necessary to perform many of the sensitivity studies and to integrate LYBIN in other software systems.

It is possible to include higher sophisticated algorithms in LYBIN, but we concentrate on what we think is feasible and necessary. Again something that will be subject to discussion.

5.1 The physical environment

The physical environment is described by:

1. Bottom profile with roughness. (Full world coverage is needed, supplied with details in certain areas, roughness could be taken from very coarse measurements or estimates)
2. Range dependent bottom reflection loss coefficient. (It could be stored in database as physical parameters of bottom, but need conversion to suitable values for model.)
3. Range dependent bottom backscattering coefficient. (This will probably be available as a function of bottom type)
4. Range dependent sound speed profile. Need sample data for whole world, and measurements and forecasts and corrections based on remote sensing techniques.
5. Thermal volume absorption.
6. Range dependent wind speed, wave height and bubble layers.
7. Range dependent volume reverberation.
8. Ambient noise.
9. Directional noise, due to powerful sources, stationary or in motion.

5.2 The target

The target is described by:

1. Course, Speed, Heading, Depth
2. Target strength (aspect and frequency dependent)
3. Highlight structure. There are target scattering models out there. FFI has received one from NRL.

5.3 The sonar

The sonar is described by

1. Waveform
2. Source level
3. Beam pattern of source
4. Platform induced self noise
5. Signal processing and Human computer interface
6. Platform course and speed and other movements.

5.4 Results/Output files.

For definition of case 1, 2, and 3, see chapter 3.

For case 1 the result will be values for echo levels as a function of range, depth and bearing, and also values of reverberation and noise as function of range and bearing. Signal excess can then be computed when target strength and detection parameters (system loss and detection threshold). To compute Probability of detection the required false alarm rate and signal fluctuation should be given. Today's resolution in depth (50 cells) and range (50 cells) is probably sufficient to represent a average picture of sensor coverage. A logarithmic range step should also be considered, in effect decreasing the resolution at longer ranges where the number of rays is fewer and fewer.

It might also be of interest to estimate the time-spread or multi-path structure of the pulse in each range cell/depth cell.

To compute signal excess for Doppler sensitive pulses, the reverberation Doppler spread should be estimated. This spread depends on surface waves, vertical and horizontal beam pattern and own platform speed.In case 2 for every ping, we need files with echo positions, echo signal to noise ratio, track included parameters, normalized and decimated result of coherent processing, audio-files in selected bearing. At every ping there can be from none to 5 (or more) real targets, and as many as 200 false targets. It is important to use stochastically variations in echo characteristic to avoid very deterministic and long lasting tracks. E.g. fluctuation in signal level from probability density functions with different time constants.

In case 3 the results/output will be approximately the same as in case 1, but the level of detail/resolution is much higher.

All the input data should be saved together with the output calculations. This would make the calculations more available for later use.
For a detailed analysis, calculations should be saved in as many steps in the calculation series as possible. The output should have option to save the following:

- All input parameters
- Raytrace
- Transmission loss
- Echo level
- Surface reverberation
- Volume reverberation
- Bottom reverberation
- Noise after processing
- Signal excess
- Probability of detection
- Vertical beam response

5.5 Input and output files

The coding structure of the input data in the current versions of Lybin is disorganized. This has complicated the efforts on analysis of the numerical data. In order to lessen future efforts an attempt to improve the structure of the input data has been made. The table in appendix B lists thirteen different sets of parameters that will be available as input in future versions of Lybin. This data will also be available as output data. Each parameter is listed with a data type and a dependency on other parameters and their data type. All the sets of parameters will be available in input files for manual modifications if necessary.

Regarding the before mentioned cases of Lybin use; they will all use the same input files, but the parameters will be accessed differently.
The first case will be limited to the same options and parameter setting as the current version of Lybin. The input files will be modified according to changes set in the GUI and need never be accessed directly.
In the second case, Lybin will be a fully automated model. Lybin will be an invisible component dependent on the physical environment chosen in the trainer. The other input data are preset and constant.
In the third case all input files can be accessed and modified. This version may also be run in batch mode. A GUI will be attached to this version containing all parameters in all the data sets. Editors for the different physical profiles will also be available, e g sound speed, bottom and wind speed profiles.
Note that the input files will be available for manual modification by text editing in all three cases. Although it is not recommended unless the user has sufficient understanding of the model.

6 WORK TO BE DONE

The previous sections describe three different versions of Lybin needed by project Simson. The work necessary to develop them is described in chapter 6.1. Chapter 6.2 lists work that must be done to ensure the quality of Lybins results. How the Lybin software is planned to be maintained is described in chapter 6.3. Chapter 6.4 includes a preliminary timeline on this work.

6.1 What has to be done?

- Adapt resolution of the model to input data and to real time requirements. (What effects are included when coarse resolution is used)
- Find a way of predicting clutter (even with coarse resolution)
- Implement computation of travel time/time spread. The purpose is to identify distinct multipath when possible, and give a general hint of the multipath spread. This to support classification and simulations and estimates of gain.
- Perform sensitivity studies to establish trade offs between accuracy, resolution level and computational time.
- Create a batch version of LYBIN. I/O from file.
- Establish interface to other software
- Establish interface to databases.
    - Platforms and sonars
    - Environment
- Make sure that some makes those databases
- Benchmarking of LYBIN (some is done at SACLANTCEN, but not reverb yet)
- Keep good software
- Check other products available
    - Models at Saclantcen, Hodgsen, Almost, …
- Where do we find good input values for volume reverberation.

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6.2 Quality assurance/ Sensitivity studies

We need to:

- Check model output with benchmarks
- Check with CAPTAS measurements and Spherion measurements.
- Check sensitivity to resolution of bathymetri (Performed in reference (9))
- Check sensitivity to range dependent wind, oceanography and bottom type
- Check sensitivity to 3-D effects (Performed in reference (9))
- Check sensitivity to azimuth variations (how dense do we need to sample in azimuth – are there ways of cheating).

6.3 Maintainance of software

6.3.1 Development tools

When FFI received LYBIN the programming language and development tool used was C++ and Microsoft Visual Studio 6.0. The graphic user interface (GUI) is based on the class library called Microsoft Foundation Class. After the completion of LYBIN 4.0, the LYBIN source code has been moved to the newest Microsoft development tool, Microsoft Visual Studio .NET. With minor changes LYBIN now compiles with the new version of Microsoft

Foundation Class. Microsoft Visual Studio .NET will be the development tool used in future development of LYBIN.

The main platform for LYBIN should be Windows. The GUI will be made only for the Windows platform.

One reason for dividing LYBIN into components is to separate the platform dependent parts from the platform independent parts. This could give the opportunity to run the calculating kernel and the XML files on an UNIX based platform. The adaptation for UNIX is not a prioritised task.

6.3.2 Version control

Today Visual Source Safe is used for version control. To ensure the flexibility for programmers on different sights, other version control programs have to be considered. One alternative is Rational Clear Case LT, another is an extension to Visual Source Safe.

6.3.3 Software testing

There exist programming tools especially made for software testing. The benefits in using these types of programs have to be investigated.

The revision of LYBIN should ensure optimisation of the code concerning execution speed, modularisation and user-friendliness.

6.3.4 Some guidelines to follow:

- There should always exist a PC-based stand alone LYBIN.
- The computational kernel of LYBIN should be the same in all applications.
- Format of file I/O should be standardized (to assure backwards compability, one could label all files with reference to version number and supply converters?)
- A potential work including LYBIN in MARIA should be coordinated with the work in SIMSON.
- A potential work including LYBIN in AESS should be coordinated with the work in SIMSON.
- The LYBIN “kernel” should be separated from the GUI and input data databases.
- Norwegian Navy wants a “caps and lims” document. A basis will be a user interface allowing the operators to investigate the “gain” of different settings in different situations.

6.4 Timeline:

Tentative dates:

Feb 03	File i/o version of Lybin specified.
Mar 03	File i/o version of Lybin ready.
June 03	Implement clutter generator based on LYBIN reverb and Signal Excess, test on Bjørnafjord and Vestfjord
June 03	File i/o version connected to the "standard" GUI of LYBIN.
2004	File i/o version connected to MARIA for input of geodata and output of graphics. 3-D graphics important (refer to FFI report from 1996). How do we extract environmental data from MARIA (hint: how is this done in Hodgson or AESS?) Could we put the standard "datasets" into MARIA (Define areas/regions/boxes, grided datasets, datapoints, vectorbased areas given characteristics to sediment. Timestamped forecasts, historical data.

7 CONCLUSION

To fulfill the needs for acoustic simulation in project Simson, we describe three different modes or version of the Lybin model:
One that predicts sonar detection coverage. This version will be very similar to the existing stand alone version of Lybin, but it must be possible to run the model from other software.
Another version is needed to simulate realistic sonar response for tactical training and operator training. This version must be optimized on speed.
A third version will be tailored to detailed analysis of physical effects and will be optimized on high resolution and accuracy.
All versions should be based on the same computational kernel.

The main changes needed are the ability to compute in a fully range dependent environment, extended resolution in bathymetry, and estimates of time-of-arrival and multipath structures. Software changes is also necessary to permit extensive batched computations and interface the model to other software. The issue of maintaining and updating the official version of LYBIN, assuring easy update of all applications using LYBIN is not addressed in this project, but we will do our best to assure compatibility to the official version of LYBIN.

APPENDIX

A DETAILED TEXT OF WORK PACKAGE 1.5 LYBIN

"*849 SIMSON –*
Arbeidspakke 1.5 LYBIN:
a) Utarbeide prioritert liste over nødvendige oppgraderinger av LYBIN
Milepæl 1.5.1 (30.06.02): Utarbeidet detaljert plan for arbeidet"

V3.1.1.5 Arbeidspakke 1.5: LYBIN

Arbeidet omfatter

a) *Utarbeide prioritert liste over nødvendige oppgraderinger av LYBIN*
b) *Implementere og teste modellering av impulsrespons*
c) *Implementere og teste ut 3-D scattering og sektormodellering*
d) *Implementere og teste ut modellering av clutter fra batymetriske strukturer*

I forbindelse med aktiviteten i delprosjektet, er akustisk modellering kritisk for å oppnå resultater. LYBIN er et naturlig valg for deler av disse aktivitetene, Det er nødvendig med noen utvidelser utover de som gjøres i prosjekt 795 og utover de endringer som planlegges gjort for å kunne integrere LYBIN i AESS.

For prediksjon og analyse av sonarforhold i kuperte kystnære områder og fjorder, er det nødvendig å ta hensyn til en 3-dimensjonal representasjon av refleksjon og tilbakespredning fra bunn. For å analysere hvor godt sonarprosesseringskjeden virker, vil det også være viktig å modellere sonarpulsens forvrenging gjennom mediet mellom sonar og mål. Det vil også være nødvendig med en mer detaljert modell for å kunne modellere tilbakespredning fra geografisk strukturer.

Arbeidet gjøres i nært samarbeid med FLO/Sjø Teknisk Divisjon og FFI prosjekt 795 Nye fregatter.

B PROPOSAL TO INPUT PARAMETERS

The input parameters are listed in thirteen different groups. Each listed with its data type and the parameters of which it depends and their type. All of these parameters will be available for modification and also be available as output. This will simplify the analysis work considerably and also give way to new possibilities.

Sonar:

Parameter	Type	Dependent parameter	Type
Sonar name	String		
Depth [m]	Double		
Tilt, transmitter [deg]	Double		
Tilt, receiver [deg]	Double		
Sidelobe, transmitter [deg]	Double		
Sidelobe, receiver [deg]	Double		
Beam width, transmitter [deg]	Double		
Beam width, receiver [deg]	Double		
Beam weight, transmitter [dB]	Double	Angle [deg]	Double
Beam weight, receiver [dB]	Double	Angle [deg]	Double
Relative bearing [deg]	Double		
Calibration factor [dB]	Double		
Effect level [dB]	Double		
System loss [dB]	Double		
Frequency [Hz]	Double		
Source level [dB]	Double		
Directivity index [dB]	Double		
Pulse form	String		
Pulse length [dB]	Double		
Filter bandwidth [Hz]	Double		
FM bandwidth [Hz]	Double		
Processing gain, noise [dB]	Double		
Processing gain, reverberation [dB]	Double		
Envelope function	String		

Platform:

Parameter	Type	Dependent parameter	Type
Ship name	String		
Ship type	String		
Course [deg]	Double		
Speed [knots]	Double		
Latitude [deg N]	Double		
Longitude [deg E]	Double		
Self noise [dB]	Double	Frequency [kHz]	Double
		Ship speed [knots]	Double
		Depth [m]	Double
		Measuring ship	String
		Measuring sonar	String
		Measuring data	String

Target:

Parameter	Type	Dependent parameter	Type
Target strength [dB]	Double		
Target speed [knots]	Double		

Ocean:

Parameter	Type	Dependent parameter	Type	Dependent parameter	Type
Wind speed [m/s]	Double			Range [km]	Double
Wave height [m]	Double			Range [km]	Double
pH	Double				
Ship density	Double				

Sound speed profile:

Parameter	Type	Dependent parameter	Type	Dependent parameter	Type
Sound speed [m/s]	Double	Depth [m]	Double	Range [km]	Double
Temperature [deg C]	Double	Depth [m]	Double	Range [km]	Double
Salinity [ppt]	Double	Depth [m]	Double	Range [km]	Double

Volume back scattering:

Parameter	Type	Dependent parameter	Type	Dependent parameter	Type
Volume back scattering strength [dB]	Double	Depth [m]	Double	Range [km]	Double

Bottom back scattering:

Parameter	Type	Dependent parameter	Type	Dependent parameter	Type
Bottom back scattering strength [dB]	Double	Angle [deg/rad]	Double	Range [km]	Double
Bottom reverberation type	Double			Range [km]	Double

Bottom loss:

Parameter	Type	Dependent parameter	Type	Dependent parameter	Type
Bottom loss [dB]	Double	Angle [deg/rad]	Double	Range [km]	Double
Bottom loss type	Double			Range [km]	Double

Bottom topography:

Parameter	Type	Dependent parameter	Type
Depth [m]	Double		
Range [km]	Double		

Measured reverberation and noise:

Parameter	Type	Dependent parameter	Type
Reverberation and niose [dB]	Double	Cell number	Integer
		Max range [km]	Double

Specification of calculation:

Parameter	Type	Dependent parameter	Type
Max range scale [km]	Double		
Max depth scale [m]	Double		
Range cell size [m]	Double		
Depth cell size [m]	Double		
Transmission loss rays	Integer		
Termination intensity [dB]	Double		
Max border hits	Integer		

Visualisation:

Parameter	Type	Dependent parameter	Type
Ray trace rays	Integer		
Surface reflections	Integer		
Bottom reflections	Integer		
dB min [dB]	Integer		
dB step [dB]	Integer		
Number of steps in POD plot	Integer		

Probability of detection:

Parameter	Type	Dependent parameter	Type
Signal excess constant	Double		
Detection threshold [dB]	Double		

C LIST OF ABBREVIATIONS

AESS	Allied Environmental Support System
ASW	Anti Submarine Warfare
CCI	Command Control Informasjon
GUI	Graphical User Interface
KDA	Kongsberg Defence & Aerospace
LYBIN	A ray tracing model for estimating sonar coverage
MCCIS	Maritime Command and Control Information System
METOC	Meteorology and Oceanography, also an FFI project
MSI-90U	Submarine Combat Management System for ULA-class submarine
MSIFC	Anti submarine warfare system for the new Norwegian frigates
NDLO	Norwegian Defence Logistic Organisation
NERSC	Nansen Environmental and Remote Sensing Center
NORCCIS II	Norwegian Command and Control Information System II
OSCAR II	Object-oriented Simulation for the Combat Assessment of Requirements
SACLANT	Supreme Allied Commander, Atlantic
SACLANTCEN	SACLANT Undersea Research Center
SAT2	Sea Acceptance Test 2
SIMSON	Simulation and evaluation of sonar systems and ASW operations
SPHERION	The hull mounted sonar on the Oslo class frigates
UNISON	Underwater Information and Sonar Technology
UWW	Under water warfare

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