KONGSBERG NORCONTROL

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SIREHNA

EEIG UNITAS

MARITIME BLACK BOX

Waterborne Transport 6.3.2/22

4th Framework Programme – DG TREN – B4

INTRODUCTION OF A MARITIME BLACK BOX

Public Report

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1 Introduction

1.1 The MBB project

The MBB project involves a number of European partners in order to develop a MBB (Maritime Black Box) Demonstrator. Contributing partners are Thomson-CSF Detexis, EEIG Unitas, Kongsberg Norcontrol and Sirehna.

The Work Package 8, directed by Thomson-CSF Detexis, is relative to the Project Management.

1.2 Purpose of the document

This document is the FINAL PUBLIC REPORT.

This FINAL REPORT includes the following items:

- Executive Summary of the MBB Project,
- Partnership Information
- Objectives of the project,
- Methodologies,
- Scientifical and technical description of the project,
- Technical results (WP0-WP7),
- Links with other relevant projects,
- Conclusions,
- List of publications and conferences.

2 EXECUTIVE SUMMARY OF THE MBB PROJECT

The MBB Project is a research contract partly funded by the European Commission's specific Transport R&D Program under the 4th Framework Program.

The MBB Project is managed by DG Energy & Transport, Directorate B. The Project Co-ordination is managed by Thomson-CSF Detexis (France). The partners involved on the program are:

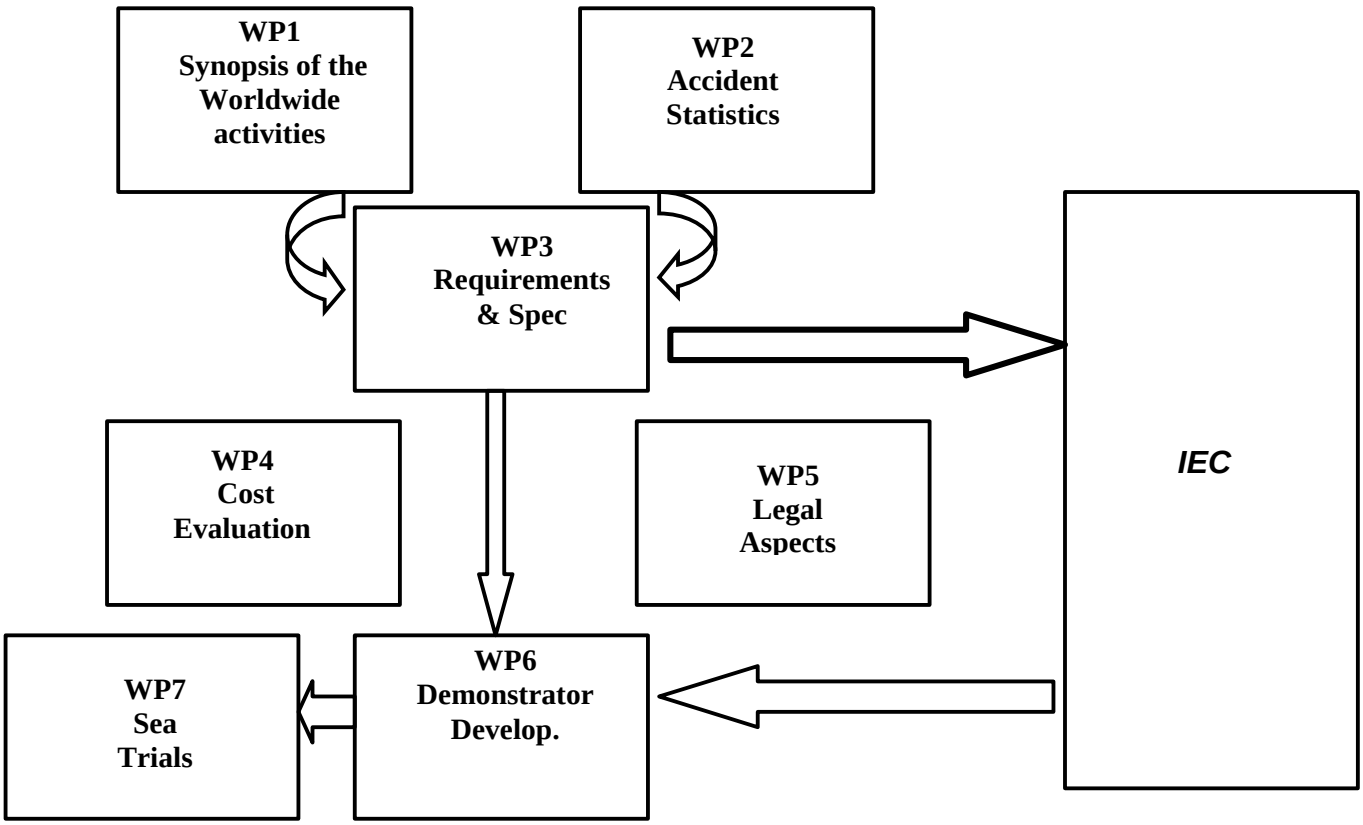
- **Thomson-CSF Detexis** (France): experienced company in the development of solid-state crash voice recorders and flight recorders,
- **Kongsberg Norcontrol** (Norway): pioneer since the early seventies in the field of marine electronics and today's leading supplier in the world of computer-based navigation and automation systems for ships,
- **EEIG Unitas** (Belgium): Co-operative group of the 3 main European classification societies members of the International Association of Classification Societies:
    - Bureau Veritas (France),
    - Germanischer Lloyd (Germany),
    - Rina (Italy).
- **SIREHNA** (France): Contract research company specialized in maritime innovation, subsidiary of the Ecole Centrale de Nantes.

The main objective of the project is to develop and to prove that a MBB Demonstrator installed on board of a ship could help to reconstruct the chain of events during the ship travel. The analysis of the recorded parameters shall permit to clarify the reasons of an accident by giving the appropriate information including radar still images, audio and data recording.

The other objectives of the MBB project are also:

- to provide the authorities with a demonstrator equipment which can be used to gain knowledge on accidental situations, in order to understand them better and to take suitable preventive and regulatory measures,
- to prepare the specifications of requirements for a MBB contributing for the improvement of safety and efficiency in Maritime Transport,
- to propose a legal framework for its implementation.

In order to achieve these objectives, the proposed breakdown structure for the project is:



The IEC VDR Requirements have been taken into account as far as possible on the MBB Demonstrator functionalities.

As reminder, the IEC VDR requirements specify:

- the recording duration of 12 hours minimum for audio (permanently recorded), radar still image (one every 15 seconds) and the data (each second),
- the resistance to severe environment (shocks, fire, penetration and immersion).

The legal aspects study has permitted to obtain the following conclusions as categories of owners are likely to be passive when the VDR will be mandatory:

- the VDR must be extremely reliable,
- the VDR needs a periodical inspection,
- the VDR must include autotests,
- to be worldwide, the VDR must be a safety device to be included in SOLAS Chapter V.

The MBB Demonstrator is composed by a RSU (Retrieval & Saving Unit) and an APAU (Accident Parameters Acquisition Unit). The system has been tested on laboratory by using an accident scenario during the summer 1999 and the tests at sea have been performed on November 1999 on the ship “M/S Kong Harald” .

During the land and sea trials, the MBB functionalities have been checked: recording and replayed chain of events. The quality of radar images have been approved by the Captain of the ship during the debriefing session.

The exploitation plan for the partners consists in the launch of a VDR product complying with the full IEC specifications during the year 2001 and in dissemination actions like exhibitions, conferences, press articles, presentations, demonstrations on board the ship.

All information on the MBB study can be asked through the Co-ordinator E-Mail address:

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3.1.3 EEIG Unitas

Under the terms of an agreement signed in Paris on 27 April 1993, the three international Classification Societies, Germanischer Lloyd (Germany), Registro Italiano Navale (Italy) and Bureau Veritas (France) have established the E.E.I.G. "UNITAS".

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4 OBJECTIVES OF THE PROJECT

The main objective of the project is to develop and to prove that a MBB Demonstrator installed on board of a ship could help to reconstruct the chain of events during the ship travel. The analysis of the recorded parameters shall permit to clarify the reasons of an accident by giving the appropriate information including radar still images, audio and data recording.

The other objectives of the MBB project are also:

- to provide the authorities with a demonstrator equipment which can be used to gain knowledge on accidental situations, in order to understand them better and to take suitable preventive and regulatory measures,
- to prepare the specifications of requirements for a MBB contributing for the improvement of safety and efficiency in Maritime Transport,
- to propose a legal framework for its implementation.

5 METHODOLOGY

In order to achieve the objectives given in the previous chapter, the MBB Consortium has broken down the project into 8 work packages.

5.1 Description of the MBB Workplan

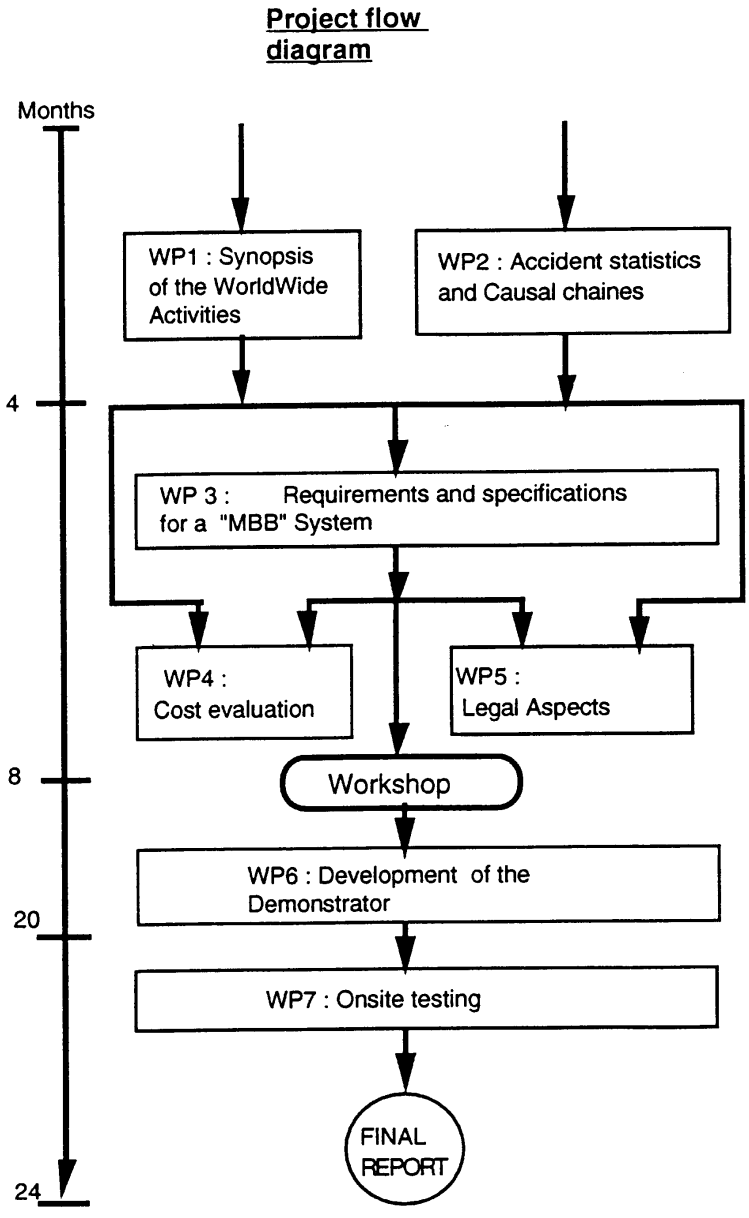


FIGURE 1: Project Flow Diagram

WP1, managed by **EEIG Unitas** and involving **Thomson-CSF Detexis,** is a ***summary of the MBB activities world-wide***. It details the various studies and achievements at the national level, specify their cost and the political and regulatory aspects which contributes to their introduction into the maritime sphere. The background given will help to the future introduction of the VDR (Voyage Data recorder) on ships.

WP2 is also managed by **EEIG Unitas** and 2 experts are involved on the works: **Mr Cockroft and Mr Marchand**. This workpackage is relative to the ***"Investigation of accident / Establishment of causal chains"***. A statistical analysis of the accident occurred over the last few years has been performed. The causes and circumstances have been analysed in order to determine and characterise the main accident parameters to be recorded by the MBB. The technical approach consisted in the use of the large database established by Lloyd's maritime Information Service Ltd and internal EEIG Unitas casuaty data. The use of results of arbitration and legal inquiries led by experts in maritime casualties have help to provide the synthesis report.

WP3, leaded by **Thomson-CSF Detexis,** involves all partners. The workpackage is relative to the ***"Requirements and specifications of a MBB System".*** The objective was to establish the specifications for the design, manufacturing, installation and evaluation of a basic MBB for passenger ships.

WP4 is leaded by **Thomson-CSF Detexis** and all partners participate to the workpackage. The subject is the "***cost evaluation of a basic MBB"*** by considering different configurations, taking into account the mass production effects. The cost estimation has been made for APAU, Interface, Installation and additional protective and recovery devices.

WP5 leaded by **Thomson-CSF Detexis,** is relative to ***"Legal aspects"***. **EEIG Unitas** and **Mr Marchand** are the main participants to the results of this study. It consists to establish the requirements for a legal framework and its various components which will contribute to introduce the MBB at different levels. Investigation and analysis of legal aspects at various level for all the concerned parties (crew, ship owners, type of ships,…).

WP6 is leaded by **Thomson-CSF Detexis** and involves all partners. This WP concerns the ***"design and development of the MBB Demonstrator".*** The technical specifications has permitted the development, the manufacturing and the integration of the different components of the MBB Demonstrator: APAU (Accident Parameters Acquisition Unit), RSU (Recording and Saving unit) and Reading Unit.

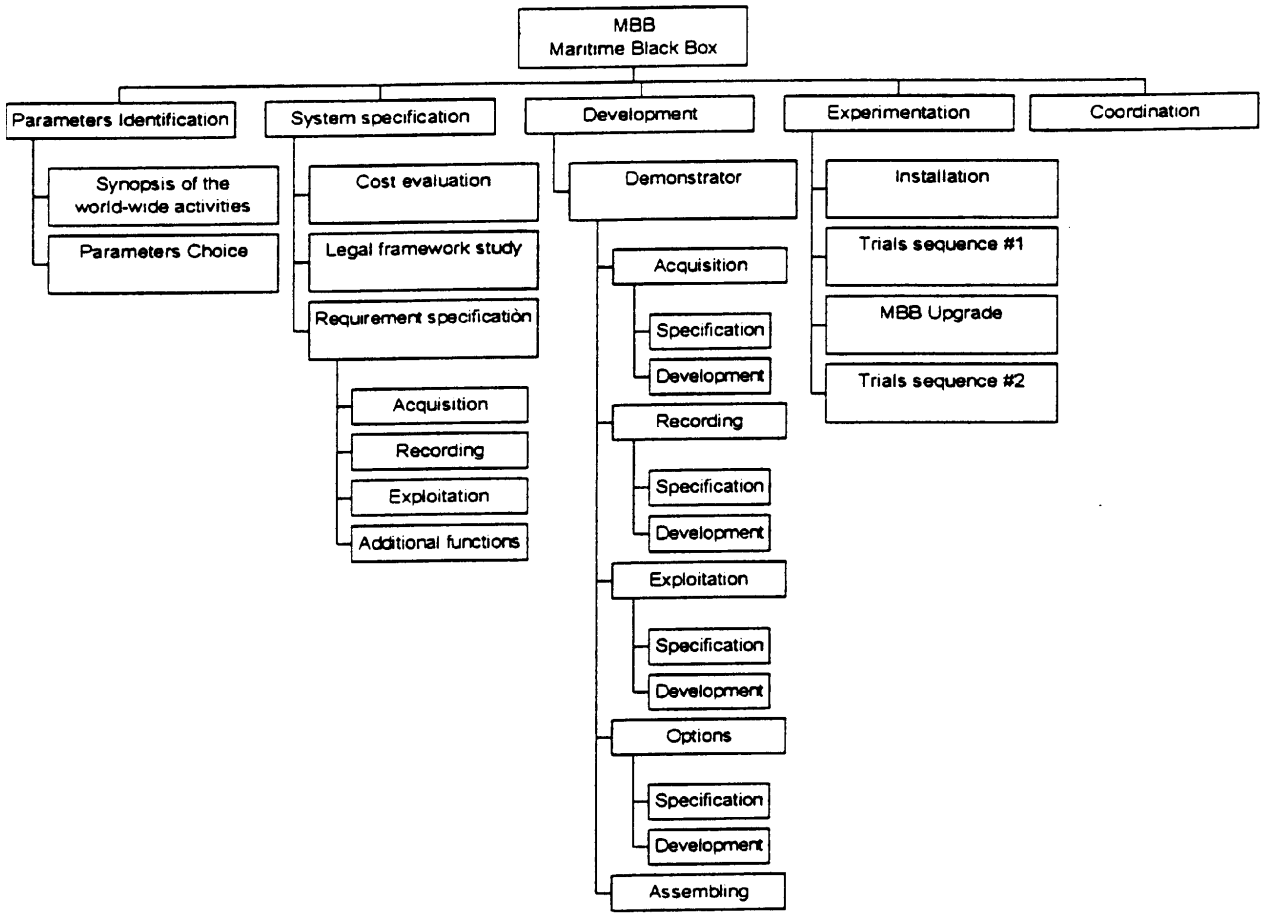
WP7 is leaded by **Thomson-CSF Detexis** and involves all partners. The study is relative to the ***"MBB Demonstrator trials and tests on board a ship"***. The results of the evaluation have been compared versus the IMO/IEC Requirements.

WP8, managed by **Thomson-CSF Detexis**, concerns the "***Project management"*** and covers all co-ordination tasks and issuing the deliverables.

5.2 Project methodology

In order to develop the MBB Demonstrator for use in maritime domain, the methodology followed during the project was:

- Establishment of the state of art of accident recorders activities and similar VDR systems worldwide; the classification societies did a survey of existing systems in many countries like USA, Japan, Europe, New Zeland. This work has permitted to define requirements in better conditions,
- Analysis of the most significant accident by using the public databases (from 1985 till 1995) in order to determine the sequences of failure: a list of accident parameters has been defined for the different type of accident or ships,
- Requirements for a basic version of the MBB in order to meet the needs of passenger ships and also to stick as far as possible to the IMO/IEC Requirements known at the time of the study. The recorded parameters and their characteristics (frequency, duration,...) have been defined.
- Cost evaluation of a MBB product,
- Legal aspects which could arise from the MBB has been examined and requirements prepared: national and international rules, parties involved, certification, inspection, post accident recovery,...
- MBB Demonstrator Development, including hardware and software for the APAU, RSU and the Retrieval Unit,
- Sea trials have permitted the evaluation of the Demonstrator in real conditions and the performance has been evaluated by EEIG Unitas.



6 SCIENTIFIC AND TECHNICAL DESCRIPTION OF THE PROJECT

The project consists in the development of a demonstrator which has to be installed on a ship for an evaluation versus recommendations or requirements coming from the MBB study or from IMO/IEC Working Groups.

The MBB Demonstrator is composed of APAU, RSU and the data stored are read thanks to a reading station. The design of the Demonstrator started with analysis of the accident parameters to consider and also the audio/video capabilities for facilitating accident analysis (audio recorded permanently inside the bridge, radar still image recorded every 15 seconds from the radar system).

The hardware and software solutions used for the MBB Demonstrator are based:

- Either on **standards** from the computing market for the processing, operating systems, communication bus and storage components,
- Either on **proprietary developments** for the recording and evaluation software.

The Demonstrator is composed of a cabinet in which are installed industrial PC, audio mixer, and the RSU includes a FLASH EEPROM non volatile memory. All hardware components are mature and are in phase of large production.

The interface of the APAU to the bridge equipment is flexible and can be adapt to future interface standards.

The knowledge of the MBB development is mainly in the following field:

- Bridge systems interface,
- Algorithms for audio, video and data compression or exploitation,
- Rugged capsule of the RSU for severe environment,
- Selection of mature and reliable hardware and software,
- High technology environment development,
- Expertise on maritime environment: parameters, installation, etc.

7 TECHNICAL RESULTS (WP1-WP7)

The main technical results obtained during the different phases of the project are given hereafter.

7.1 WP1: SYNOPSIS OF THE WORLDWIDE ACTIVITIES

The name Maritime Black Box is the working title of a device which records information and retains it permanently. IMO calls it Voyage Data Recorder. MBB or VDR must not be confused with a Monitoring System which monitor and display specific information on the ship behaviour.

The purpose of MBB is to improve passengers and crew safety, as well as to protect the interests of shippers and ship owners. Therefore MBB is designed to record significant elements in an automatic, inviolable and nearly indestructible process. These information are to be read and processed by approved Authority.

Today everybody agree on the need for such MBB to be operated on passenger ships and on valuable or dangerous vessels. This general agreement is based on previous researches and experiences carried on the maritime world, as well as on the existing and well established aviation recording systems, implemented on every aircraft for public transportation.

In Air transportation field, every aircraft involved in public transportation must be equipped with at least two protected recorders. The recorders are covered by international regulations dictated by the OACI ; all the European texts are unified under the generic name JAR145, in force in 1995. The texts precisely define the features and the survivability of the equipment, such as :

- 1000 g acceleration for 5ms on each axis,
- 1100°C flames for 30 min.
- 30 days sea water immersion.

The Black box technology has more than 50 years of existence and of continuous improvements. The equipment has the same quality standard as those of the airplane itself.

In the road transportation domain, black boxes are made mandatory inside the EU. The main feature is the existence of an extremely structured organisation dedicated to the systematic inspection . The equipment is held simple, rugged ad low cost.

In National marine accident Investigation Systems, the exploitation of the MBB in case of an accident should be made according to international or national regulations. This aspect is twofold:

- Investigations to be carried must comply with the national legislation,
- Investigations must obtain evidences.

The document issued by the MBB Consortium and entitled

WP1 - State of the Art Summary

presents and comments the various Accident Investigation systems in force in the following countries:

- AUSTRALIA,
- CANADA,
- FINLAND,
- FRANCE,
- GERMANY,
- NETHERLANDS,
- NORWAY, SWEEDEN, DENMARK, FINLAND,
- UNITED KINGDOM,
- UNITED STATES OF AMERICA.

7.2 WP2: ACCIDENT STATISTICS AND CAUSAL CHAINES

The developed list of parameters has been evaluated on grounds of technical, sociological, psychological and legal feasibility. This latter evaluation has been performed and documented as part of WP3, WP4 and WP5.

A parameter considered to be useful from the nautical point of view (e.g. visibility) may be technically difficult to measure in a reliable way with the present techniques or of other elements like all bridge conversations, that are not always professional, may lead to legal and psychological problems.

In the development of the parameter recommendations, no attempt has been made to define the possible sources of the recording data. This is strongly dependent of the ship's age and type and the level of interface standardization. It is important to define the interface requirements of the MBB, in order to develop a necessary standardized black box solution.

Many centralized recordings already exist for the control of automated engines, information on safety, and cargo operations, particularly liquid in bulk. This information, even for cargo control, are usually now situated on the bridge, or immediately nearby. These are favorable circumstances for collection in an MBB. Information available, on the same spot, particularly on large and relatively modern vessels, are already at the disposal of the Captain and the ship owner.

The new problem is to select, standardize and secure the parameters for official decoding, without depriving the ship owner of this own information. One difficulty arises from the fact that nobody can predict exactly which incident will occur aboard a ship, even if statistics give probabilities. The precise timing of an occurrence, even if the event is obvious without an MBB, is always a useful fact to substantiate all subsequent events and declarations.

There is a choice to be made between the number of different recorded parameters and the duration, or frequency of successive recordings, for a given memory capacity. Except for even data, the choice could be more information in a shorter period of time (several hours), providing there is a device to stop the recording after an accident, or timed delay after the accident. In the

case of rapid foundering this can be a hydrostatic system in the EPIRB buoy, if the **MBB** is located there. One can also imagine **MBB** recording could be linked to the running of the main engine. However, a ship is not lost because the main engine has stopped at some time, for example after a collision and many subsequent events are of great interest.

Thinking of the variety of possible damages and losses, a manual stop of the recording by the Captain or the responsible person in charge, with a possibly deferred input (one hour ?) has to be considered, because it will be the starting point of the duration of useful recording to be analysed. This whole question is far more difficult than in aviation where an engine stop means a crash. For a marine accident it should be carefully examined, if MBB information should become a useful tool for inquiries, that it covers completely the period of interest.

The EPIRB location of **MBB** is suitable for extreme situations (rapid sinking etc), but may not be appropriate in other cases where EPIRB is not released when abandoning ship in an organized way. In these cases easy removal of the **MBB** is necessary from the EPIRB by the Captain, already legally bound to testify on the circumstances of an accident. If the recording equipment itself is not costly item, a second device, in parallel with the first, easily portable, containing identical information to the first, up to the time of disconnection, should be available to be brought ashore.

In the following Work Packages (3, 4, 5), it has been done the following work: evaluation of the technical requirements, determination of the associated costs and identification of possible legal problems associated with the recording of the **MBB** parameters.

Based on these evaluations, it has been be possible to define the scope of the **MBB** solution that will be developed and tested.

7.3 WP3: REQUIREMENTS AND SPECIFICATIONS OF A MBB SYSTEM

The objective of WP3 is to produce the technical specification of the MBB System.

The works done within WP3 consist in:

- Specification for an APAU
- Interface Specifications
- Ship motion Measurement
- Recording and Saving Unit Protection and Recovery
- Recording and Saving Unit and Evaluation Unit Specifications

The conclusions of the different tasks are given hereafter.

7.3.1 Specification for an APAU

The APAU (Accident Parameter Acquisition Unit) is a part of the MBB System. The APAU is an interface between the ship sensors and equipment, and the RSU (Recording Saving Unit).

APAU provides the reading of signals from the ship sensors and equipment, A/D conversion and formatting, and their transmission via the communication bus to RSU.

The deliverable "SPECIFICATION FOR AN APAU" describes:

- The Functional HW and SW Architecture,
- The specification of APAU interface with the ship equipment,
- The communication bus dialogue protocol,
- The operation and installation.

This specification has been used for cost estimation.

7.3.2 Interface Specifications

The most extensive list of parameters proposed to be recorded cover the group "conventional chips" RoRo, RoPF, passenger vessels, bulk and tank ships. Although none of them will require the maximum configuration, the high priority list still contains approximately 100 parameters to be recorded for a tanker. Some of these parameters will, if they are to be captured from individual sensor require several input channels, for instance digital inputs in case of alarms or open/close type status information.

Therefore the most cost effective solution from a hardware point of view, will be to prepare the system to capture most of its information from existing sub-systems already integrated by means of a vessel wide net work. Only few vessels posses such systems today, and some of these are not used in normal trade (e.g. multipurpose vessels used as FSOP's). Also, even when a comprehensive network exists, it often integrates systems from various suppliers, and only limited amount of data are routed from one proprietary LAN to another, mostly by means of an "intelligent" gate way (i.e. a dedicated PC).

From a software-point of view therefore, the current status is that a great many different proprietary protocols and date formats are in use and the possibility to access almost all vital information through a common system net is a long term prospect. Consequently a significant amount of software development work will be required to cater for the amount of proposed parameters, even if they are available through local area net-works.

During the cost analysis part of the MBB project it is assumed that estimates has to be performed in order to decide what would be the optimum solution in a trade off between handling a great number of individual sensor, with more or less standardized output signals, (which also will require extensive on-board cabling), and "high-level" interfacing through different system net work. In the long term perspective one might expert that a communication standard like MiTS will be generally adopted, in which case in principle all the information asked for would be available by means of a generally communication implemented protocol.

An important high-level approach will use data links on proprietary serial level since the different autonomous sub systems mostly will offer a serial RS-232C output, often with standard pr NMEA like protocols when this is relevant.

Generally the APAU interface options should as a minimum cater for capturing data by means of the following types of inputs :

- Local or vessel wide area net work LAN/WAN – TCP/IP (MiTS)
- Serial line
- Serial proprietary type messages
- Analogue input, most common 0-10 V
- Digital/binary DC voltage an/or potential free contacts
- Audio and video (RGB) type of data

7.3.3 Ship Motion Measurement

A study of ship motion measurement has been done and several measurement systems have been proposed for evaluation of ships motions and their position on the earth:

- Inclinometers
- Accelerometers
- Inertial measurement unit:
  - Gyrocompassing and alignment
  - Inertial measurement unit errors
  - Platform misalignment errors
  - Schuler oscillation
  - Position error growth
- Hybrid inertial measurement unit

Provided information in this study is of great interest for the MBB concept since they could help to reconstruct the causal chain of events which led accident. Hybrid systems seem to be more adapted because position could be a crucial parameter.

7.3.4 Recording and Saving Unit Protection and Recovery

The protection and the recovering of the RSU in case of accident has been analysed.

The following topics have been handled during this study:

- Identification of potential external aggressions,
- Resistance of the box to external aggression,
- Location of the box on board,

- Separation or ejection of the box from the vessel,
- Behaviour of the box after separation/ejection.

7.3.5 Recording and Saving Unit and Evaluation Unit Specifications

The RSU and evaluation unit specifications have been done in 3 steps:

- Requirement description for a basic RSU featuring the minimum functions and services for an operational MBB System,
- RSU fitted with supplementary functions and part of an advanced MBB System.
- Description of the Evaluation Unit and the main characteristics.

The RSU design providing a single interface to the outside world by means of a high speed LAN connection and single power supply increases the security of the system and its protection relative to unauthorised operations. The read-back operation, performed from the Evaluation Unit connected to this unique LAN interface is secured thanks to an access control to prevent access to the data by unauthorised persons and most important to prevent data corruption.

As shown by the above study, the storage requirements for the Recording and Saving Unit mainly depend on a few high bandwidth parameters such as radar image and audio channels. The technical and technological feasibility of such a Recording and Saving Unit, with the technical functional requirements listed in this document in terms of communication and storage requirement is no question. The technical difficulty comes from the need of simultaneously fulfilling the functional requirements and the environmental requirements (see doc. WP3 – RSU Protection and Recovery).

7.4 WP4: COST EVALUATION OF THE MARITIME BLACK BOX

7.4.1 Cost estimation for APAU

When estimating the cost for the APAU, is it important to be aware that no ships are similar. This means that there will be an engineering work related to nearly all deliveries. This estimate tries to estimate this, however in a real project this will be different for each project.

The cost for the APAU is divided into the following groups:

- Hardware Cost, including computers, microphones, net adapters, network hubs, cabinet etc.
- Software Cost, including recording applications, 3rd party software licenses such as Windows NT and Software maintenance.
- Software Engineering Cost, including estimates for work related to interfacing sensors and 3rd party supplier equipment.

7.4.2 Cost evaluation of additional protection and recovery devices

- Additional protection:

Several suppliers were contacted in order to get an estimation of the cost of the complete protection device designed according to the specifications regarding fire protection, shock resistance, pressure, corrosion and so on. The required protection system would in any case need further development to be issued.

- Recovery device

It is assumed here that the RSU has to be released from the ship, and the parameter selected to trigger off the released deals with immersion. The cheapest and certainly the most reliable mechanism for achievement of the release is hydrostatic. Pressure acting on a piston frees a fastening system and separates the Case from the ship.

7.5 WP5: LEGAL ASPECTS

7.5.1 LEGAL ASPECTS

The generalisation of the installation of the Maritime Black Box system on board ships will lead the EU and the International Maritime Organisation to make a legal framework with regulations and rules. Workpackage 5 has the objective to provide the EU with a first draft of requirements for the development and the installation of the legal and mandatory MBB on board ships. This is intended to help the EU as well as the IMO to implement the legal framework and the process of standardisation and of certification for the MBB system.
WP5 considers the following aspects related to the legal framework:

-2- General legal aspects and legal problems, (see Legal Framework part of WP5)
-3- Standardisation,
-4- Maritime certification,
-5- Onboard installation,
-6- Investigation after an accident (see Legal Framework part of WP5).

-3- Standardisation:

The carriage requirements and the performance standards of navigational and radio equipment on board ships are in general developed and required based on resolutions and conventions of the IMO. Concerning the VDR, IMO adopted the Resolution A.861(20) entitled:

PERFORMANCE STANDARDS FOR SHIPBORNE VOYAGE DATA RECORDERS (VDRs)

The Resolution discusses including VDR carriage requirements in the revision of SOLAD chapter V (Safety of Navigation), which might become effective in 2002.
Then IMO requested the assistance from the IEC to establish an international standards to specify the minimum requirements, technical characteristics and methods of testing, with

required test results. The relevant document was drafted by the IEC, TC80, Working Group 11 and submitted to vote in August 1999, under the title:

IEC 61996
SHIPBORNE VOYAGE RECORDER (VDR),
PERFORMANCE REQUIREMENTS / METHODS OF TEST
AND REQUIRED TEST RESULTS.

7.5.2 LEGAL FRAMEWORK

The generalisation of the installation of the Maritime Black Box system on board ships will lead the EU and the International Maritime Organisation to make a legal framework with regulations and rules. Workpackage 5 has the objective to provide the EU with a first draft of requirements for the development and the installation of the legal and mandatory MBB on board ships. This is intended to help the EU as well as the IMO to implement the legal framework and the process of standardisation and of certification for the MBB system.
WP5 considers the following aspects related to the legal framework:

-2- General legal aspects and legal problems,
-3- Standardisation, (see Legal Aspect part of WP5)
-4- Maritime certification,(see Legal Aspect part of WP5)
-5- Onboard installation,(see Legal Aspect part of WP5)
-6- Investigation after an accident .

The Legal Framework aspects have been extensively discussed in the WP5 document entitled **Legal Framework.** This document should be considered, along with the implementation of the demonstrator, as the major result of the MBB Project. Due to the variety and the complexity of the subject, it is recommended to refer to the document itself in order to gain a complete and exact understanding.

The initial questions, the findings and the conclusions of this document are multiple and can be summarised as follows:

"A MBB would be used for investigating maritime accidents from the technical, penal and even civil liability points of view".
"The implementation of such a system would raise legal problems in various areas:

- Who can make a MBB mandatory ?
- Which bodies would be responsible for standardisation, certification and survey of such a system ?
- How would a world-wide recovery organisation of MBBs be possible after accidents, with or without Captain's control ?
- What would the following process be ? delivery of the records to a Readout and Interpretation Centre (RIC) under Flag State or Port State responsibility ? conditions to release information so obtained ?

State control is absolutely necessary :

- for technical purpose and/or for the avoidance of similar accidents in the future,
- for apportioning blame or liability, if any, according to national legislations,
- what would the MBB status be ? Among MBB recorded data it is obvious that voice recordings and radio-communications have not the same nature as simple facts such as position, course or speed at the time of accident. Furthermore, is a Magistrate and/or an Investigator the only authority who legally could retain recorded data ? Could MBB data be used as an evidence reference whereas other 'unprotected' sources could give information (survivors, logbooks ...) ?

Therefore, a legal MBB framework concerns many aspects related to:

- a routine regime before accident,
- the destiny of the MBB and data recorded, after an accident."

One of the most interesting findings come from the comparison with the civil aviation experience, in relation with possible reactions of the unions and/or ship owners:

"Habits have to be acquired and after the starting period, MBB existence will be quite ignored if:

- ship owners abide by provisions related to confidentiality of voice recording; severe limitations have to be fixed,
- Maritime Administration investigators distinguish nautical and private exchanges on technical grounds; the role of Readout Centers and the participation of accredited parties will be decisive,
- A conclusion on the routine regime can point out the following items:
  - regarding necessary wiring and sensor modifications, a MBB implementation amendment would mainly apply to ships under construction; for the existing ships a 2/3 years delay would be needed,
  - ships over 3.000 GRT could be concerned, with a lower limit for ship potentially dangerous (HSC, tankers, chemicals), at the first stage,
  - MBB should be considered as a safety device for inspection and its malfunctioning as a possible retaining safety cause at a calling port, depending on the local facilities and proposed voyage,
  - MBB would not be a disturbing device after a test period if confidentiality rule is strictly observed for the voice recording."

The Report presents several proposals, one of them concerning a progressive implementation :

"whether or not IMO discussions prove it would be worthwhile to wait patiently since the concept and the primary standards are no longer criticised, some other steps can be contemplated:

- an experiment with the financial support of EU,
- a EU directive for types of ships on regular crossing lines or for some EU Flags registered types of ships,
- the adoption of an IMO common general position on MBB by a EU Ministers of Transport's Council and other EU targets."

(It is worthwhile to note that this WP5 Report was delivered in 1996).

7.6 WP6: DEVELOPMENT OF THE DEMONSTRATOR

The development and the test of the demonstrator have been done within WP6 with the following steps:

- System Specifications,
- Integration of the APAU and the RSU units,
- Definition of a scenario for simulating and testing the demonstrator in laboratory,
- Land based tests .

7.6.1 System Specifications

The MBB demonstrator design includes:

- system outer specification, that is system general requirements and outer-seen behaviour (see "VDR general requirements", page 9),
- system inner specification, limited to:
  - the distribution of the MBB demonstrator into functional components,
  - the functional specification of each MBB component, that is the set of services each component is assumed to provide to all or part of the system components,
  - the interactions between the functional components (hardware links, communication protocol, exchanged messages).

The Maritime Black Box is a system composed of:

- a shipborne Voyage Data Recorder (VDR),
- an ashore data Retrieval and Evaluation Unit (REU).

The aim of the shipborne Voyage Data Recorder is defined by the IMO Resolution A.861(20) as follows:

The purpose of a Voyage Data Recorder (VDR) is to maintain a store, in a secure and retrievable form, of information concerning the position, movement, physical status, command and control of a vessel over the period leading up to, and following, an incident having an impact thereon. This information is for use during any subsequent investigation to identify the cause(s) of the incident.

During this phase of specification the goals of the demonstration was to demonstrate:

- the usefulness of having means that enable the recording and analysis of the temporal evolution of a collection of data related to ship's equipment and ship's movements/activity, in order to:
  - analyse incident/accident causes,

- analyse structure ageing and embedded equipment failures, for maintenance purpose.

This demonstration is addressing police officers in charge of maritime accidents investigation, maritime insurance companies and ship's managers.

The demonstration purpose is to show:

- the relevance/useness of the recorded-data,
- the correctness of the recorded-data values and time stamping,
- the efficiency of the REU.

7.6.2 Integration of the APAU and the RSU units

The APAU and RSU units have been integrated on early June 1999, using a connection between the two units, enabling the APAU to directly write data to the RSU.

7.6.3 Definition of a scenario for simulating and testing the demonstrator in laboratory

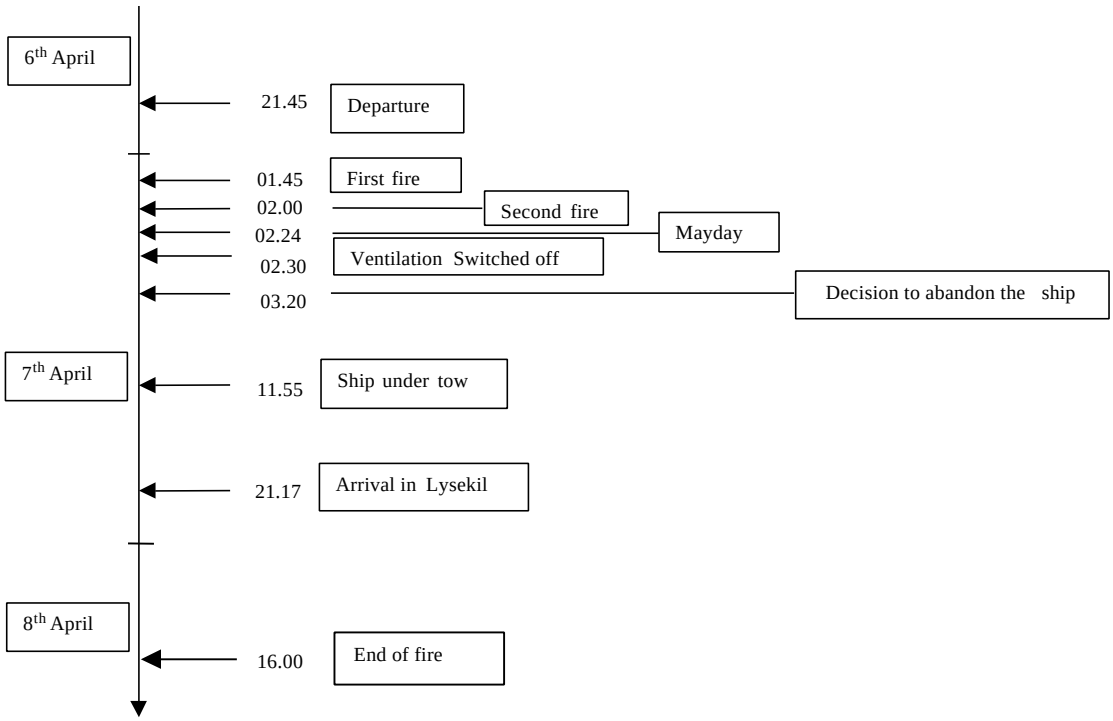
The deliverable produced within this task thoroughly describes one of the major maritime disaster over the last decade, which occurs in 1990 when a passenger ferry caught fire during a voyage from Norway to Denmark : at 21.45 hours on 6 April 1990, the ship left Oslo (Norway) bound for Frederikshaven (Denmark). Several hours later, while the ship was crossing, a fire broke out that was to claim the lives of 158 people onboard. After an enquiry, it was found out that most people have died of smoke inhalation within meters of exits : they were unable to locate themselves in the blinding, choking smoke.

A scenario issued from this disaster was used as practical exercise to demonstrate the Maritime Black Box (MBB) capability to reconstruct the chain of events leading to an accident. This case was regarded as particularly relevant since the wrecked ship was a 10500 Grt combined passenger ship and ferry for cars with nine decks, built according to SOLAS 1960 requirements, specially with respect to fire protection. Furthermore, it had been shown that neither the weather condition nor the environment was responsible for this disaster since the fire got deliberately put on. So this is a chain of events due to human failures only that led to the catastrophe.

7.6.4 Land based tests

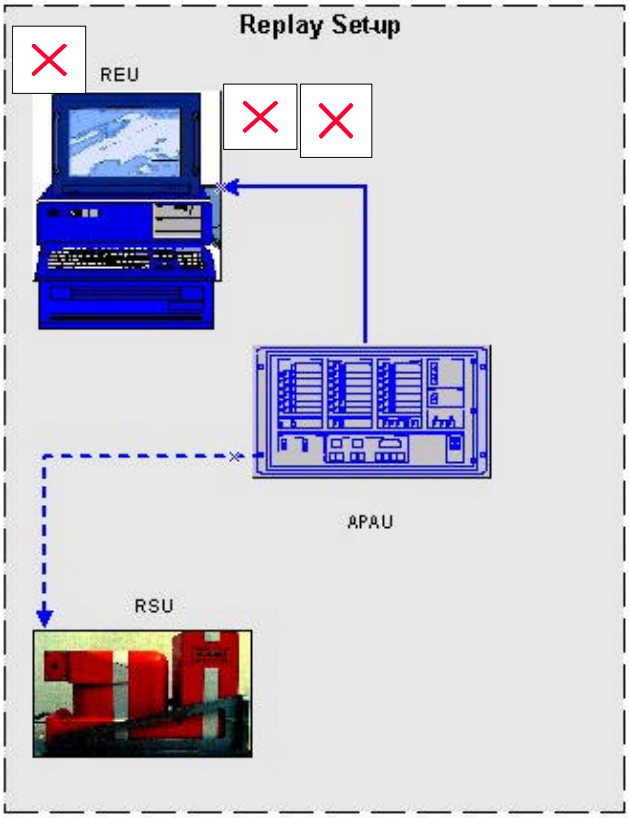
The Land Based Test (LBT) is a test to verify that the Accident Parameter Acquisition Unit (APAU) is able to record events specified in a scenario. The test includes simulation of a scenario where the APAU records a chain of events, and after recording; replay the recorded events and see that the recorded information is sufficient to rebuild the actual chain of events.

The Land Based Test shall simulate the scenario described by Sirhena. The figures below show the actual events.



The purpose with the Replay of the simulation scenario is to verify that the events recorded during simulation is of such quality so that it is possible to rebuild the actual chain of events, as it occurred during simulation.

The figure below shows the Replay set-up:



Limitations:
In case of a real accident, the APAU would be damaged and unavailable. During the Land Based Test the connection to the APAU is maintained. This is done in order to reduce time necessary to perform the test.
The technical solution in a real accident would in principle be the same.

7.6.4.1 Recording Applications

The radar recorder is an application that is continuously running on the Navigation system Radar (ARPA). The Radar Recorder captures the image of the radar screen every 15 second and stores each image as a compressed file on the RSU.

Technical Specification:

Recording frequency:	15 Seconds
Connection to APAU:	LAN Network connection, TCP/IP.
Information Lost in Compression:	None

7.6.4.2 Recording application

Parameter Recorder application is running on the APAU Computer and collects information from the Kongsberg Norcontrol Alarm Monitoring and Control System, DataChief. The parameter recorder collects information related to fire alarms, speed, heading and other mandatory alarms. In the LBT the following parameters will be recorded:

Description	Number of parameters

Fire alarms	>100
Conning Information	>10
Alarm History	All alarms continuously

Technical Specification:

Recording frequency: Every Second

Connection to APAU: LAN Network connection, TCP/IP.

7.6.4.3 Audio recorder

The Audio Recorder is an application, which only records audio from a number of different channels. For the MBB project and the LBT One channel will be recorded:

- Microphone on Bridge

Due to restrictions for use of VHF the VHF recording will not be simulated.

Technical Specification:

Recording frequency: Continuously operation 3 Channels.

Connection to APAU: Recording Card installed on APAU.

7.6.4.4 Replay Applications

The Replay applications can be run separately or simultaneously with time co-ordination. The replay control panel is common for all replay applications.

In the replay control panel, the user can set the required time and date for replay.

The playback of data stored has been made for radar images, parameters and data

7.7 WP7: ON SITE TEST

The Sea Trials of the MBB Demonstrator was the last step of the MBB project and were organised in Norway at the end of November 1999. All partners participated during the one and half day of the sea trials onboard the M/S Kong Harald which is a 122 meter long luxurious passenger ship travelling along the west coast of Norway between Bergen in Southern Norway and Kirkenes in Northern Norway, which is known as the Coastal Express Route.

The circumstances of the recording proved to be very relevant with regard to what may happen on a ship at sea, for the following reasons:

the recording included a departure from and an arrival at a harbour including the various manoeuvres they require,

the ship sailed both on close and open seas, which gave a very varied navigation including narrow passages between islands and crossings with other ships which generated special warnings on the radar display that were recorded by the VDR,

the weather conditions were very rough,

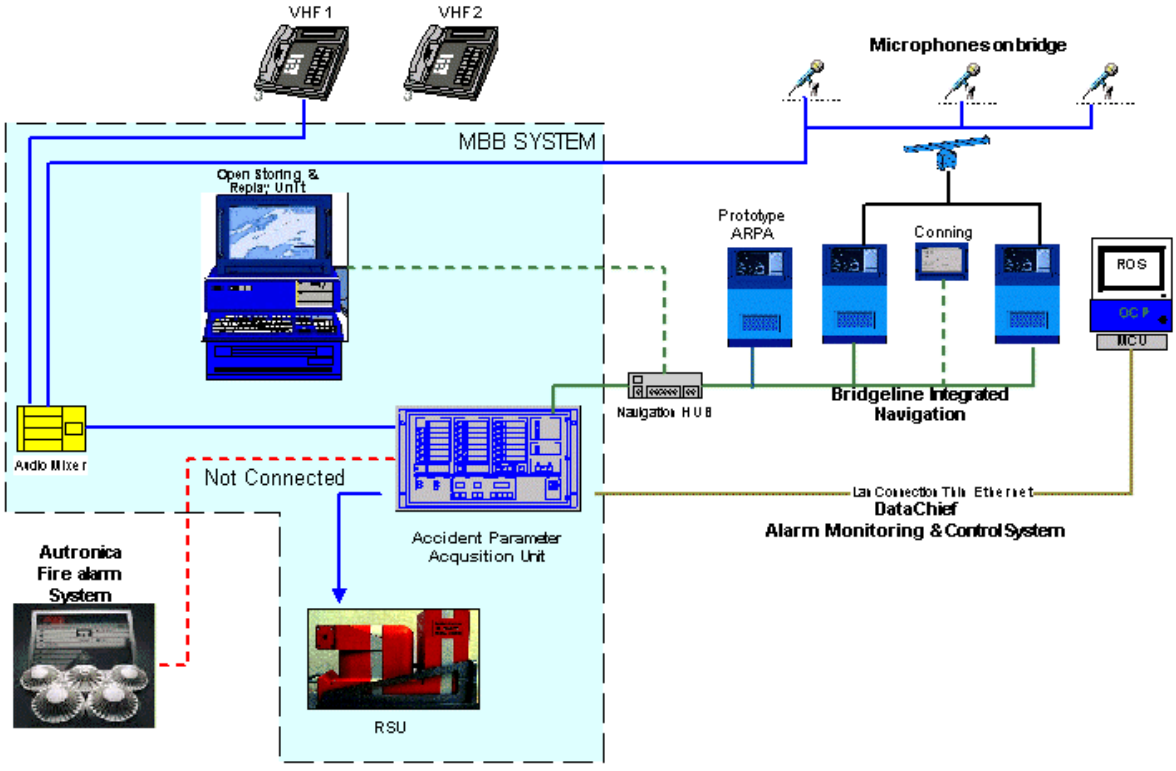
the ship was on a real commercial journey.

7.7.1 Installation

The demonstration proved that it was possible to interface a ship in operation, without having to go into a shipyard, however the RSU was mounted in the same cabinet as the APAU. The MBB prototype do not comply with all the IEC specifications.

The installation proved that it is a great advantage for the ship owner to have integrated navigation and automation systems, with the possibility to interface through network interfaces. This reduces the required cabling and the number of suppliers to interface, thereby reducing the installation cost.

MBB Installation onboard Kong Harald



7.7.2 Operation

The operation of the MBB System proved to be stabile during the sea trial, with no interference to the process systems or shut downs with this configuration.

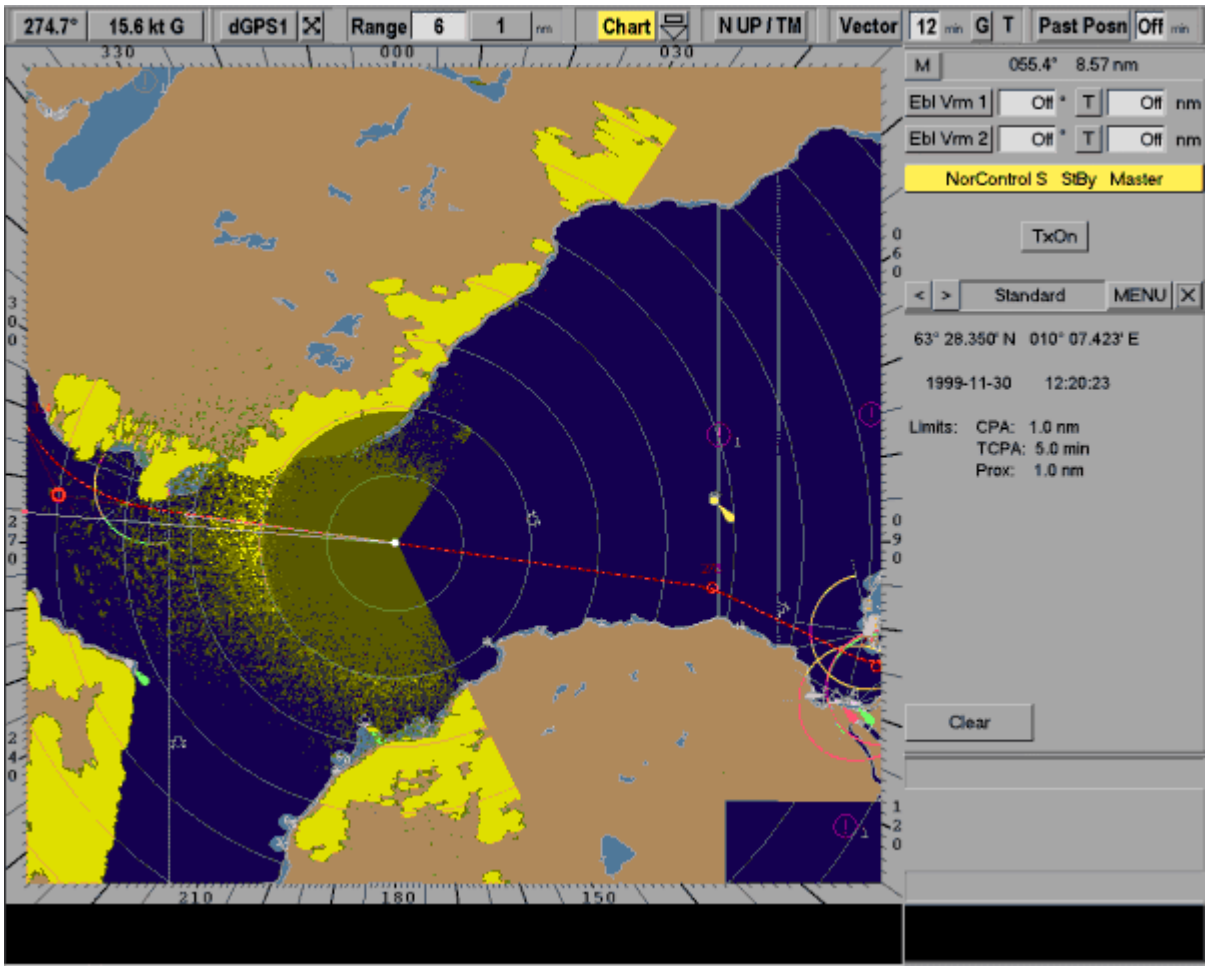
7.7.3 Replay

The replay of the recorded data worked fine. Data from each of the recordings was co-ordinated and presented enabling evaluation and reconstruction of the journey, however the applications is still on prototype level and will need refining before commercial use.

7.7.4 Further development

The demonstrator ship Kong Harald will be used as a pilot ship for further development and testing.

7.7.5 Radar image stored in the RSU: Leaving the Port of Trondheim



8 LINKS WITH OTHER RELEVANT PROJECTS

8.1 DISC II

The MBB project is interconnected with the DISC II Programme. DISC II (Demonstration of Integrated Ship Control) is a research programme under area 6.3.3 of the Transport Research.

The DISC Consortium is a joint venture between four major contributors to the European ISC research:

- ATOMOS III Consortium,
- MiTS Consortium,
- COMFORT Consortium,
- MBB Consortium.

The objectives of this project is to demonstrate feasibility, validity, safety level and cost/benefit issues of the European/International ISC standard developed in DISC II.

Kongsberg Norcontrol are supplying the “Gateway” utilising the new Pisces protocol, designed for communication between ship equipment in this project. The same “Gateway” is being used in the APAU. When the Pisces Protocol is completed will it be automatic updated so that the Maritime Black Box MBB® will be “DISC II” compatible.

9 DELIVERABLES LIST

WP	Document
WP0	Management Plan
WP1	State of the Art Summary
WP2	Definition of recording parameters
WP3	Specification for an APAU
WP3	Interface specifications
WP3	Ship motion measurement
WP3	Recording and Saving Unit Protection and Recovery
WP3	Recording and Saving Unit Evaluation Unit Specifications
WP4	Cost evaluation of additional protection and recovery devices
WP4	Cost estimation of Interfaces and Installation
WP4	Cost estimate for APAU
WP5	Legal aspects
WP5	Legal framework
WP6	System Specifications
WP6	Definition of a scenario for simulating and testing
WP6	Land-based Test
WP7	Sea trial Report
WP8	Final Consolidated Progress Report

10 DISSEMINATION ACTIONS

The dissemination actions are given hereafter:

10.1 ARTICLES IN NEWSPAPERS

- A software of risk simulation due to High Speed Craft has been presented to the "Journal de la Marine Marchande" in October 1997.
- Press release for LISBON EXHIBITION (April 1998)
- Article in "Science Research Development" (May 1998)
- Article in "INFOCEAN" (1998)
- Article in "LE MARIN" (July 1998)
- Article in "TRANSPORT ADVANCE" (Springs 98)
- Dassault Electronique newspaper: "CINQ SUR CINQ" about MBB exhibition in LISBON (1998)
- "Journal de la Marine Marchande" (October 1998),
- "Fairplay Solutions" N°25 (1998)
- Dassault Electronique newspaper: "CINQ SUR CINQ" about MBB to EURONAVAL 98.
- SAFERT AT SEA (February 1999)
- MARITIME JOURNAL N°133 (April 1999)
- REVUE DE L'ELECTRICITE ET DE L'ELECTROMECANIQUE N°4 (April 1999)
- JEUNE MARINE N°142 (May-June 1999)
- LA TRIBUNE (June 23, 1999)
- MER (Maritime Engineers Review) (June 1999)
- ELECTRONIQUE INTERNATIONAL HEBDO: presentation of MBB EUREKA Project, in September 1999.
- L'EXPRESS dated on 1/6/2000

10.2 Conferences on MBB

- LISBON EXHIBITION (1998)
- EURONAVAL-Paris (October 1998)
- SMM-Hamburg (November 1998)

- ITS-DG7 in ROTTERDAM (March 1999)
- INSTITUTE OF MARITIME ENGINEERS in LONDON (May 1999)
- IMDEX in SINGAPOUR (May 1999)
- NORSHIPPING in OSLO (June 1999)
- « Learning from Maritime Accidents » organised by the « Royal Institute of Naval Architects (RINA) » in association with the « Marine Accident Investigation Branch (MAIB) », in LONDON, 20-21 October 1999
- UTE Meeting on 21 September 1999 in Fontenay - aux – Roses
- Transport Research Conference on 8-9 November 1999 in Lille: a MBB RSU unit will be exhibited on the DISC II booth
- EURONAVALE 2000 (Paris-November 2000)
- ITS (Torino-November 2000)

11 CONCLUSIONS

The MBB study results have permitted to validate the Requirements of an Accident Recorder thanks to the tests of a MBB Demonstrator installed on board a ship and also to propose a legal framework for implementation of a VDR. These 2 aspects (one on a technical point of view, the other on legal aspects) have really permitted to improve significantly the maritime accident investigation capability.

On the technical point of view, the SYSTEM ARCHITECTURE including the MBB Demonstrator has been validated during sea trials. The 2 units of the Demonstrator are:

- The APAU (Accident Parameters Acquisition Unit) which collects all parameters generated by the navigation equipments (Bridgeline Navigation, DataChief Monitoring and Control System),
- The RSU (Retrieval & Saving Unit) which stores all parameters in a ruggedized box.

The integration on board a ship has been validated: the integrated networks reduce installation costs.

The data stored (parameters, radar images according IEC Specifications, audio from microphones installed on board) have been retrieved successfully and the quality validated by the Captain of the ship. The image is enough good for interpretation of the collision warnings recorded during the sea trials in Norway.

On the legal point of view, the study has permitted to collect valuable information for checking how the Voyage Data Recorder could be used for investigation on maritime accident. The main results are related to:

- An unquestionable set of data collected during an accident,
- Some obstacles have been referenced as well as the possible solutions (WP5):
    - Adoption of standards for the equipment,
    - Maritime certification and periodical survey,
    - Procedures for the investigation after an accident.
- Major key points:
    - During normal ship operation:
        - Recording and use of the audio
        - Who may access the other stored data?
    - In case of an accident:
        - Possibility or not to allow to stop the MBB
        - Float free or bolted
        - Extraction of the MBB in an unquestionable way
        - Readout and data validation

- LEGAL KEY POINTS need action from Administrations, Authorities, Flag States
- MBB Project partners have no influence on IMO Level.

The general conclusion of the MBB Project is that the legal and technical study of a MBB Demonstrator has permitted to validate the concept in theoretical and practical fields thanks to an experimentation on a ship. The results of the study will facilitate any future actions in the field of VDR in technical aspects as well as legal ones. A VDR product can be launched based on the MBB study for answering the needs of accident investigations.