MONALISA 2.0 - Activity 3

Safer Ships
– Executive Summary

MONALISA 2.0_Deliverable 3

Co-financed by the European Union
Trans-European Transport Network (TEN-T)
Document Status

Authors

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federico Coscia</td>
<td>Federico Coscia</td>
</tr>
<tr>
<td>Barbara Terrosi</td>
<td>IB</td>
</tr>
<tr>
<td>Simon Mastrangelo</td>
<td>Ergoproject</td>
</tr>
<tr>
<td>Francis Campa</td>
<td>Cimne</td>
</tr>
<tr>
<td>Anders Tammelin</td>
<td>Sjofartsverket</td>
</tr>
<tr>
<td>Elia Rodriguez</td>
<td>Ferri</td>
</tr>
</tbody>
</table>

Review

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flavio Marangon</td>
<td>D'Appolonia</td>
</tr>
</tbody>
</table>

Approval

<table>
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<tr>
<th>Name</th>
<th>Organisation</th>
<th>Signature</th>
<th>Date</th>
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1 General Information

Activity 3, led by the Italian Ministry of Infrastructure and Transport (MIT) focuses on how to increase maritime safety in a variety of different ways by implementing services, based on available technology. Focus is on providing services to large passenger vessels but without modifying existing rules and regulations.

Activity 3 addresses maritime safety from the ships’ perspective by considering the existing fleet where results can be achieved in a relatively limited time by retrofitting rather than new buildings thus avoiding lengthy deployment of suggested measures. Ships’ needs have been addressed by studying safe operations on board and/or with ships in port. The former would reduce the likelihood of an accident to occur and the latter would result in more efficient evacuation and/or rescue in case an accident occurs.

Focus for the work within Activity 3 has been the RoPax and Passenger vessels due to:

- An accident on a RoPax or a passenger vessel can lead to a large number of casualties and would thus would be laying the ground for the perception of passenger vessels as a dangerous means of transportation with potential shift back of passenger traffic from sea to land,
- There is a large number of persons on board – the passengers – who are not used to ship operations and thus cannot be expected to behave adequately in case of an emergency,
- Several activities are running while the passenger ship is travelling (e.g. theatre or cinema, restaurant, gym and spas, etc. on a cruise ship) involving hundreds of persons, hence increasing the risk of improper behaviour from a safety point of view.

The aims of Activity 3 are to:

- Improve onboard (operational) safety for large passenger vessels;
- Introduce ship operators to the safety improvements, achievable through the use of ICT and new technologies;
- Assess usability and crew acceptance matters;
- Address existing ships.

2 HSQE - Behaviour Based Safety (Sub Activity 3.1)

2.1 The reason of this innovation

The global objective of Activity 3 is to improve safety of navigation on board large vessels with support of ICT and in particular the aim of Sub-activity 3.1 is to assess the possibility and benefits of transferring the B-BS approach to the maritime sector as a tool to improve
operational safety by reducing unsafe behaviours during normal operations. Therefore, the goal of the Sub-activity is to verify that B-BS methodology and related ICT tools are adaptable in maritime applications and to test them as appropriate through suitable prototype(s).

The reason for this innovation is the fact that B-BS is the most effective method to reduce accidents at work through the reduction or the elimination of “dangerous” behaviours and actions, and that is the first application in a maritime environment.

2.2 The status of the art

Further details are available in the following documents:
- Deliverable 3.1.1: Transfer and adoption of B-BS best practices from land based domain to the marine domain.
- Deliverable 3.1.2: BBS ICT tool adapted to the maritime domain

The B-BS, Behaviour-Based Safety or Security Based on Behaviours, is the application of the science of applied behaviour analysis to issues of safety in the workplace. The issues include all employees from the front-line to the boardroom and involve architecture, equipment, management systems, work processes and management and employee behaviours. Those “well over 80% of the accidents” occur because of inappropriate behaviour and not due to lack of equipment or unsafe conditions; it is evident that there is an enormous potential of a methodology designed to obtain the execution of a constant behaviour safety.

Now B-BS represents the most effective method to reduce accidents at work, through the reduction or the elimination of dangerous behaviours and actions. However, a single classification criteria does not exist even though there have been numerous attempts over the years to frame the various methods of error analysis. Heinrich studies have shown that a serious accident at work is preceded by an average of 29 minor personal injuries and 300 near-misses.

Generally the expected result is a high reduction in injuries. The average result in any industrial domain of application of B-BS is a reduction of injuries by 40% (first year) and by 20% (following years) until reaching an asymptote of 0 (zero).

The right application will lead to a positive scenario:

<table>
<thead>
<tr>
<th></th>
<th>40% INJURIES REDUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST YEAR</td>
<td></td>
</tr>
<tr>
<td>SECOND YEAR</td>
<td>20 % INJURIES REDUCTION</td>
</tr>
<tr>
<td></td>
<td>(Over the first 40%, progressively in addition)</td>
</tr>
<tr>
<td>THIRD YEAR</td>
<td>100% INJURIES REDUCTION</td>
</tr>
<tr>
<td></td>
<td>(ZERO INJURIES)</td>
</tr>
</tbody>
</table>

Standard B-BS results in industrial domain.

In order to manage a B-BS process in a company, in the market are available several ICT tools coming from industrial fields and as result of our analysis, the DataBase® was judged to be the best existing B-BS ICT system.

The B-BS process, managed by DataBase® ICT tool, is described below:
2.3 The proposed solution

Further details are available in the following documents:
- Deliverable 3.1.3: User, task and environmental profiles and developer requirements
- Deliverable 3.1.5: Customisation for Pilot Application

We studied the application of BBS as highest Standard on Health and Safety at work and the related need for a tool. The model that we implemented in the pilot application is characterised by the B-BS application to be developed in a pilot form and then to be tested in a many different scenarios for its validation and for its collecting data/information.

The new developed ICT tool for maritime application, named DataBASE2.0®, incorporates and upgrades DataBASE®. The following upgrades have been made:
- Improved logical flow
- Revised components to allow for the use of mobile infrastructure (particularly important for use on a “mobile” environment as ships);
- Allowing for an “almost” paperless approach;

Allow
ing real time (i.e. “on the field”) data reporting.

The applied Mobile Infrastructure Scheme is described below:

2.4 The pilot applications

Further details are available in the following documents:

- Deliverable 3.1.6: Report on Pilot application: usability and crew acceptance issues
- Deliverable 3.1.7: Pilot applications: feedback from pilot results and proposed improved operations

The selected marine scenarios are the following:

A. Roll-on/Roll-off passenger (Ro-Ro Pax);
B. Cruise ship;
C. Offshore Plant installation.
A. 1 - The first pilot application was carried out on-board a Ro-Ro Pax Italian Flag on 17-18 June 2014. Some sub-areas were examined and for each sub-area:

<table>
<thead>
<tr>
<th>SUB AREAS</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIVITIES ON BOARD (With particular emphasis on the activities defined as &quot;dangerous&quot;)</td>
<td>A common result was achieved: using an ICT tool the operator could reduce:</td>
</tr>
<tr>
<td></td>
<td>• Data recording time</td>
</tr>
<tr>
<td></td>
<td>• Redundancy of data, because the information on paper are often redundant</td>
</tr>
<tr>
<td>CREW ON BOARD (With particular emphasis to the training and professional required certifications)</td>
<td></td>
</tr>
<tr>
<td>WORK ENVIRONMENT (Defined as a place where the seafarers carried out the tasks assigned and the places for the rest/refreshment and hygiene/health)</td>
<td>• Duplication of data, because different standards require the same information, even if in different format.</td>
</tr>
</tbody>
</table>

The proposed solution related to that pilot application is the using of ICT tool, unique standard format based on an agreed upon and compliant taxonomy.

A. 2 - The second pilot application was carried out on two Spanish vessels, one from Transmediterranea and the other one from Balearia.

With the following steps and previous interviews, it has been created the Checklist for risk prevention, starting from the two Ro-Ro Pax procedures and activities on board:

- Step 1 - Planning work: who will be involved in the task.
- Step 2 - Check safety equipment: Officer checks that crew wear safety equipment.
• Step 3 - Development of work and notes of the observer: the observer checks crew behaviour and takes some notes.

An example of General Checklist for Risk Prevention follows:

The interview results have been shown that the proposed B-BS methodology is the correct strategy to prevent accidents modifying crews’ behaviours.

If the B-BS methodology on board could be mandatory, the application on a maritime environment will be more effective.

B. The pilot application in a cruise ship scenario has been carried out. The selected ship has installed on board an ICT solution for asset management intended for the maintenance purpose and also for the injury reporting. The on board installed ICT tool is capable to record all the injuries in a standard format, according to the principles of B-BS methodology (i.e. the pyramid of risk). The following activities have been carried out:

• How the “injury” process is performed on board;

• The Non Conformities (NC) management (record and follow up), coming from behavioural observations (near miss).

From this pilot application, the following considerations have been stated:

• An average 90% of the “injury” audit is realised by a documentary process (ex post analysis).
• The existing ICT tool detects previously (not on board) “Non Conformity” but not all the occurred Near Miss, that are at the basis of the risk pyramid of Heinrich, the true warning that something doesn’t work.

Therefore, Near Miss are detected only with a daily on board behavioural observation, using the proposed Database2.0® and that is the only strategy to reduce injury.

Because a cruise ship is a very crowded environment, we developed in Database2.0® a self-observation component, which has been added to guarantee a “spontaneous observation” because crew activities are often carried out alone.

C. The pilot application on an offshore installation was carried out by a selected staff, who have been on board of the regasification terminal “FSRU Tuscany”, located about 22 km off the coast between Pisa and Livorno to observe different activities, characterised by high risk, performed by crew members, to acquire some data needed to prepare a check list to implement the B-BS ICT software tool, developed by IB. Preliminary activities in order to finalised and generalised the developed ICT tool for a general maritime environment:

• Interviews to Spanish crews (Transmeditarranea, Balearia): deck staff (six workers) and engine room staff (eight workers).
• Questions ranged from habitual tasks to attitude to new technologies and to care for workplace and activities safety.
• Developing “personas” and “scenarios” to understand and specify users and context of use of the B-BS ICT tool.

<table>
<thead>
<tr>
<th>PERSONAS</th>
<th>“I use the Internet for everything, from talking to my parents home to searching the last news bulletins”.</th>
</tr>
</thead>
</table>
| Personal information: | Age: 28 years old  
| Residence: La Coruña  
| Position: Second Deck Officer  
| Education: Bachelor of Engineering  
| Character: exuberant, curious |
In my opinion, computers have not simplified so much our job, they have just papers got reduced.

Personal information:
Age: 52 years old
Residence: Malaga
Position: Engine Room Supervisor
Education: High School Diploma
Character: commanding, reserved

**SCENARIOS**

**Deck - mooring**
The crew is involved in mooring procedure and the captain asks for everybody’s special attention since just a month before a third officer injured the fingers on his left hand, crushing them between the tug’s line and the vessel’s fairlead when trying to let the tug go.

**Engine room – night shift**
Two out of the four hours of the night shift have passed. The youngest between the workers are showing the first signs of boredom.

With the previous steps, it has been analysed the terminal procedures and it has created three checklists, one for each activity/related job:

1. Load lifting,
2. Restricted enclosed space entry,
3. Working on electrical equipment.

Six participants were selected on the basis of their main working area, two of them for each activity. They have seen observed during their job, in order to verify the compliance with the previous agreed procedures. Finally we recorded on mobile device of the observed data.

After we did the usability testing, in order to determine B-BS ICT tool effectiveness, as to say users’ ability to achieve a task, through each task success (user achieved or failed the task) and error (user committed at least 1 error or no errors at all) rates.
Users’ and context profiling influenced deeply the use of the tool, since it spreads a new safety procedure in a digital way to users with different levels of digitalisation (according to age and job position), which are usually involved in fragmentary work activities. The user acceptance evaluation suggested that seafarers’ opinions about the introduction of the B-BS tool are not clear and need to be deepened again with users.

2.5 The final outcomes

Further details are available in the following documents:

- Deliverable 3.1.4: Deployment road map – ICT aspects
- Deliverable 3.1.8: Deployment road map – learnt, usability and crew acceptance aspects

Regard to the success factors, it is possible to identify a hierarchy of importance. Each application of B-BS methodology in industrial sector shows its scale of success factors, which is important to analyse in order to organise the protocol and decide where concentrate the action of the change.
We analysed one by one the industrial success factors, comparing with the marine ones:

<table>
<thead>
<tr>
<th>SUCCESS FACTOR</th>
<th>INDUSTRIAL DOMAIN</th>
<th>MARINE DOMAIN</th>
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</thead>
<tbody>
<tr>
<td>Language</td>
<td>FIXED</td>
<td>CHANGING</td>
</tr>
<tr>
<td>Turnover</td>
<td>LOW</td>
<td>HIGH</td>
</tr>
<tr>
<td>Repetitiveness of working actions</td>
<td>PREVAILING</td>
<td>MISSING</td>
</tr>
<tr>
<td>Specialisation of job</td>
<td>LOW</td>
<td>HIGH</td>
</tr>
<tr>
<td>Working in team</td>
<td>PREVAILING</td>
<td>MISSING</td>
</tr>
<tr>
<td>Environment</td>
<td>FIXED-ORDINARY</td>
<td>CHANGING-STRESS</td>
</tr>
</tbody>
</table>

Success factors (from industrial to marine domain)

We expect a percentage reduction, but lacking the whole of the success factors like in land domain. Getting to the point, we could think in a reduction, even though almost certainly it will be lower in marine domain, which is known as more risky, hazardous, stressful and more exposed to extra-ordinary situations.

It is confirmed that in the marine domain, B-BS gets the same positive already verified and spotted in industrial domain, where the methodology begins. Our studies point out that, due to the heterogeneity of the jobs and the hyper-skill of the seafarers, it’s required a strong characterization of the methodology for the application on a vessel. To remedy this, a major adjustment of the B-Bs methodology has been made and a self-observation component has been added.

2.6 The next steps

On the basis of the considerations and results achieved, we deem that the next steps for fully introducing B-BS methodology in a maritime scenario are:

- Re-engineering the process of B-BS in maritime field.
- Customised the B-BS process on the basis of the commercial mission of the ship and the crew skill (job/activities).
- Adapting the mobile device to a maritime workplace (i.e. introducing ATEX devices and improving the on board connectivity, i.e. working off line).
- Sensitise ship-owner to adopt B-BS methodology on board in order to significantly reduce the number of major injuries and to generate benefits in term of safety time and resources.
3 ICT-Tool for Search and Rescue (Sub Activity 3.2)

3.1 The reason of this innovation
The old system for Search and Rescue used by the Swedish Maritime Administration has been used for 10 to 15 years and is in-house developed. It is based on older Information Technology that can no longer be maintained or developed. It also lacked important functions for efficient rescue operations. The system has also become unreliable over the years.

Currently there are a number of SAR systems of different brands on the market and information contained within these systems cannot be integrated. The new has developed a new graphical interface that will provide the SAR coordinators with all available information and the ability to communicate simultaneously with all parties.

Swedish Maritime Administration began a project to replace the old system and started the process of writing system specifications. The project became part of the MONALISA 2 project in early 2013. The contract to develop the new system was appointed to Swedish company Carmenta AB. The system development and cooperation started in May 2013.

3.2 The status of the art
As of November 2015 the new system, including new hardware and algorithms, has been implemented by the Swedish Maritime Administration and is used in parallel with the old standard system.

The system is designed for JRCC (Joint Rescue Coordination Centre) and can handle both Maritime and Aeronautical incidents and accidents.

“\nThe idea is to provide the persons who are coordinating the SAR operation with an interface that will make all information available and easily interpreted and acted upon. It will allow the people who lead the SAR-operation to quickly get the full picture, which translates to better and more precise decisions. The solution will also facilitate communication as messages can be written in a box on the screen and instantly shared with involved organisations and resources.\n\n"
“The new system will provide a more accurate prediction of how an accident will unfold and as it is presented on a large touch screen display it allows groups of people to interact and work together.”

“All calls and interventions can be recorded and good results can be analysed and shared with others. We can use reality to define best practice.”

### 3.3 The proposed solution

The new system developed is a multi-user emergency response system designed for JRCCs (Joint Rescue Coordination Centres) that can handle both maritime and aeronautical incidents and accidents. The system has been designed to meet all the requirements of demanding search and rescue operations, and its combination of user friendliness and hi-tech features ensures that operators are able to locate incidents and direct resources quickly and accurately.

#### 3.3.1 New functions and features specified for the new system

Integration from many sources:

- Maps on-line – combined with essential maps locally stored
- Address registers
- Persons and people databases
- Flight Radar Information
- AIS and recorded AIS-data
- Ship database
- Aircraft Database
- Aircraft Route information
- Ships Route information (MONALISA Routes)
- Radio and Location Beacons Certificates
- Weather forecasts
- Weather observations
- 112 emergency operators
- Mobile Phone positioning
- Drift calculations at sea, Leeway
Output data:

- Rescue operation information to participating resources
- Press information
- Web-sites and Social medias
- Police and other government organisations
- MONALISA and future STM route monitoring and generation

3.4 The application

The system provides SAR (Search and Rescue) coordinators with an accurate, easy-to-interpret common operational picture including maps, resources, cases, weather forecasts, drift calculations, findings and search areas, etc. – thereby helping operators to make better, faster and more informed decisions. In addition the new system improves overall communication, as all new data is instantly shared with the other operators and can be easily distributed to any relevant organisation or resource.

There is an advanced search planning function, including support for probability calculations and IAMSAR procedures, for example, calculation of POC, POD and POS. It also has support for large touch screens, which means that several people can interact and work together at the same time, resulting in efficient teamwork and effective operator cooperation.

3.5 The final outcomes

A lot of the functions has been developed which will increase the efficiency in rescue operations and thereby shorten the time before s person in distress is saved.

3.5.1 Efficient Information Sharing

Instead of sharing information by spoken word using telephones and radio most of the relevant information in a rescue operation will be shared by digital means which result in reduced work and more reduce misinterpretation. This applies both to information from 112-service to JRCC and from JRCC to participating Rescue Recourses such as helicopters and vessels.

3.5.2 History from earlier rescue incidents

In a Search and Rescue Operation mission coordinator can use previous knowledge and data within the same geographical area. In shorter time this result
will gave relevant contributions to speed up the decision process and shorter rescue operations.

3.5.3 Flight Transponder Information

The new system will provide flight transponder information in the same way as AIS information for vessels in the same display and with either or both flight charts or sea charts in common picture for an efficient operational overview. This simplifies the rescue operations for both aircraft and maritime rescue operations.

3.5.4 Mobile Cellular Phone Positioning

By using new techniques available in Smart Phones as most people are using these days it is possible to use the built in GPS in these phones to accurately determine the position and the person in distress. This position can be directly sent from the Smart Phone to JRCC in be displayed on the map in the new system. It only requires a minimal interaction on the Smart Phone using SMS. This can significantly reduce the time for the rescue operation, as many people do not know their current position.

3.5.5 Some other new functions developed

- OGC-WMS layers as overlays
- Create Case from context menu in Map
- Tie a Case to a Map Window
- Vessel and Aircraft tracking using Transponders
  - AIS & ADS-B data and socket communication
- Engage a Transponder as temporary Resource
- Weather input from meteorology Agency (Sweden SMHI)
- Drift Leeway calculations
- Search Areas creation
- Integration with MONALISA Routes and STM
- Case Journal in text form with actions and decisions
- Replay Mechanism
  - It will be possible to replay all entries in the Case Journal synchronised and together with transponder and resource movements on the map
- Generation and sending of Mission Description
- Knowledge Database
- Makes it possible to systematically collect and evaluate experiences drawn from actual cases.
  - Search Area Handling - Based on the drift calculation the POC, POD and POS for the search can be calculated.
  - Aircraft maps
  - Voyage plans for aircrafts
  - Mobile (Cellular) Phone position integration

### 3.6 The next steps

The new system is fully operational during the first weeks of January 2016 and replaces the old system.

In the new STM (Sea Traffic Management) system the system will be used as a test bed for STM functions and evaluate possible methods to cooperate with a rescue centre.

In the future further integration with chart systems on board helicopters and maritime rescue vessels will be investigated and developed.

![Image: 60" touch screen](image)

Figure 3: a 60" touch screen

The system in use at JRCC using a 60" touch screen
4 Networked Vessel - Indoor Positioning (Sub Activity 3.3)

4.1 The reason of this innovation

Real cases happened in the past showed us how complex and chaotic people movement in a large vessel can be during emergency situations. A lack of appropriate coordination of passengers and crew behaviour during an emergency scenario can easily lead to tragic consequences.

Vice versa, if the safety team could rely on an accurate and pervasive positioning system for crew members, a so called People Tracking System (PTS), integrated with state of the art Safety Management Control System (SMCS), it would be possible, for example, to:

- Quickly react to fire accident on critical rooms releasing immediately CO2 and avoiding risks for crew members;
- Monitor crew members in real time and effectively drive them out of dangerous zones;
- Locate injured people and support rescue operations.

4.2 The status of the art

The purpose of locating people on board of a ship could be fulfilled, in principle, by means of many locating technologies available on the market and successfully utilised in other field These technologies utilise different medium to sense the presence of a person: Light, Sound, Radio Frequency signal.

The most widely utilised approaches have been evaluated, such as the Time-of-flight devices; the Vision based technologies, Ultra sound technologies, the Wi-Fi technologies and RFID technologies.

In the Time-of-flight, the same approach of a RADAR system is used; it is possible to measure the distance of an object measuring the time needed for a light pulse to reach that object and flight back to the emitter (LIDAR). If many light pulses are sent from the same emitter in different directions, and the travel time of back reflected pulses coming from various directions are measured, then it is possible to capture a 3D model of the environment, or in other words it is possible to take a true 3D picture of the room. The Wi-Fi and the RFID results the most promising technical approaches.
4.3 The proposed solution

The technology that has been selected as result of a deep evaluation phase is a multi-frequency active RFID.

The main reasons that motivate this choice are the Precision, the Performances and the Localisation Reliability. All those factors have been taken in account.

<table>
<thead>
<tr>
<th>Precision</th>
<th>The systems based on active RFID use an active TAG type that has a very wide area of coverage. It follows that the accuracy in these systems is extremely complex and totally delegated to the middleware software.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>This technology has no limit of the speed with which the TAG moves</td>
</tr>
<tr>
<td>Localisation reliability</td>
<td>With this technology it is extremely difficult to ensure a reliability of 99.9%</td>
</tr>
</tbody>
</table>

Main components in the system are:
The Active Tags that is a transponder equipped with a battery, able to emit a RF signal; The TAG must be carried by the tracked person.
The Reader, mounted in a fixed position, able to decode the signal emitted by the tag and to route it to the People Tracking Software
4.4 The pilot application

The People Tracking System demonstrated its good performances in a pilot installation realised on the cruise ship “Ruby Princess”.

The installation evidenced that the People Tracking People can ensure a quick response to ship emergencies in terms of rapid automatic detection of crew.

Figure 4: Ruby Princess
presence in sensitive areas. It will also help with evacuating crew before extinguishing fires with CO2, for example.

4.5 The final outcomes

The latest IT solutions in People Tracking have captured the interest of Carnival Corporation and the Italian Navy.

The Italian Navy is significantly inclined to advanced technologies, especially if they are nationally and internationally recognised for their excellence, said Admiral Pellegrino, talking about installations used on board of their ships to ensure crew safety.

"The need to know with certainty, for safety reasons, the crew presence in hazardous areas is a challenge that the Navy has always dealt with using available technological solutions. In compliance with the new Naval Law, the Defence Administration would like to adopt the consolidated version of the People Tracking System developed by Martec onboard all naval units, taking into account the benefits of functional integration with the platform damage control, the homogeneity of the configuration of the installed systems and, not least, by the uniformity of logistical support."

Captain Casarini, Marine & Safety Director Newbuilding of Carnival Corporation, pointed out: "The ships are getting bigger. We went from 1,000 people 30 years ago to over 6,000 today with important repercussions and effects on security management on board.

“The giants of the sea are true floating countries, thus requiring a new approach that can benefit from new technologies. The People Tracking System is a clear and good example. The ability to locate people on board is fundamental in certain situations and that's why Carnival Corporation and Princess Cruises made the Ruby Princess available for a trial that has been successfully underway for three months coordinated by Piero Susino, Technical Operations Director of Princess Cruises."

4.6 The next steps

Some clear directions for future developments are emerging from the experiences of use of the People Tracking System. One direction is that of enforcing security aboard trough the integration of the Tracking People System with the People Counting technology for better control of unauthorised accesses.
Another direction of future development will be the integration of the Tags with smartphones. This can be extended to newly developed services, based on the localisation of people, to all passengers and not only to the crew.

The evolutionary vision of the concepts developed in MONALISA 2.0 goes to the direction of a more intelligent future Decision Safety System with powerful algorithms for the interpretation and management of data coming from Tags and companion phones.
5 Safe Evacuation System (Sub Activity 3.4)

5.1 The reason of this innovation

The Safe Evacuation System (SES) is a safe, effective, efficient and reliable system for performing evacuation operations on board passenger ships in extreme sea, weather and stability conditions, especially with high wind speed and high heel values. Such a system is capable of working in situations where conventional ones cannot work properly and it is conceived to be compatible with existing lifeboat launch appliances and to be easily installed on different types of vessels.

5.2 The proposed solution

The proposed system focuses on the major problem that appears when the heel of the damaged vessel is over the 20º, considered the limit in the IMO rules, but that could be greater for most of the modern passenger vessels before final sinking. With the vessel in such a dangerous situation, the safest course of action would be to launch the lifeboat from the opposite side of the heel. Considering all the requirements that launching appliances must satisfy, and after an in-depth study of evacuation methods, and the main problems existing during such operations on passenger vessels, all the specific technical features that the system SES must meet, have been defined:
• It must reduce the friction between the hull of the lifeboat and the passenger vessel side during evacuation, in order to maintain the angle between the hook and the davit throw at small values. This critical factor is usually responsible for preventing the release systems working at heel angles above 20º.

• The system must guarantee that the lifeboats can be positioned along the shipside in order to launch them freely.

• According to commercial issues, the system should be compatible with small adaptations, with commercial launch appliances for lifeboats, and be able to be installed on different sorts of vessels.

• The system must be capable of operating in heel conditions either way, but mostly to the opposite side, at much higher angles than conventional limits (> 20º).

• The system should be compatible with both telescopic and tilting launching devices.

• The system should be able to work also with empty lifeboats.

• The hull of the lifeboat will be supported on the ship's hull with a force 45% higher than what the law requires, due to the increased angle of heel at which the SES will work.

At this point of the explanation, in which all the requirements that the SES system satisfies are already known, two equally valid solutions were proposed:

• One to prevent the boat being lowered over the deck, and so guide it to the hull/vessel side. This with two options: one based on straps, and the other based on telescopic arms.

  o A system based on straps:

    This system essentially consists of 2 or 3 straps that tighten at the time that the davit tilts/or its boom makes a telescopic movement (depending on the sort of davit), in order to push the lifeboat out, to prevent it from falling on the deck of passenger vessel but rather directly on the shipside.

    Those 2-3 straps (depending on the lifeboat) must have their ends anchored to the edge of the deck before starting the launch operations. On the deck of the vessels they special clamp devices will be already placed for an easy clamp operation when an evacuation is needed.
A system based on telescopic booms:

This system essentially consists of 2 telescopic arms that make a telescopic movement in order to push the lifeboat out, to prevent it from falling on the deck of the passenger vessel but rather directly on the shipside.

• Another with a technical proposal slide-system, for minimising the friction between the hull of the lifeboat and the shipside of the passenger vessel, the slide system.

Once the lifeboat is below the deck level and against the shipside, it starts to slide down. To facilitate this part of the launch operations, sliding pads will be fitted on the lifeboat hull, in order to minimise friction between the two surfaces. With lower friction, the angle formed by the hook and davit throw is minimised, down to design values.

Sliding pads are also designed to distribute the effort on the lifeboat hull (45% more than the design one). These sliding pads will be placed in such way that damage the lifeboat hull surface and adapt to the specific hull shapes for each type of lifeboat. They will also be placed so they have a minimum effect on the hydrodynamics of the lifeboat in navigation.
5.3 The pilot application

During 2014, Compass has studied, in a 3D FEM sea-keeping simulation, the launching conditions of a lifeboat down the side of a ferry ship (ROPAX) in an emergency situation with a simplified analysis of the dynamic equilibrium of the lifeboat on the shipside. A RAOs (Response Amplitude Operators) study of the ship has been undertaken, in two different conditions: at a heeling angle of 0º and at a heeling angle of 20º. As a result, the analysed condition of the damaged ship, without propulsion, in which the ship is put abeam to the waves (90º waves), with a heel angle of 20º to port and for 2 meters wave height with a period of 11 seconds, the accelerations observed (75% of gravity) in the lifeboat’s launching zone, it will surely be very difficult to execute the launching safety.

Considering all this, Industrias Ferri S.A. has developed a system based on straps mixing it with the slide system, in order to obtain the most reliable system. Straps fitted at the deck recess aligned with the shipside guide the boat to the proper position to continue slipping down along the side of the vessel’s hull. Soft fenders glued to the boat hull protect the surface from the excess pressures. These same
fenders have a hard surface to reduce friction and allow the boat to lower without swinging towards the outside at an excessive angle.

In the first week of June 2015, Industrias Ferri tested their prototype models in the facilities that SASEMAR has at the Jovellanos Training Centre in Gijón (northern Spain). As a result of the tests, the design of the transition between straps and hull has been improved with a new end component on the straps in their connections to the deck’s edge; and the boat fenders external surfaces have been hardened to further reduce friction between boat and vessel in order to increase passenger comfort while lowering.

### 5.4 The final outcomes

![Figure 8: Safe Evacuation System – Test Phase](image)

The SES system has been tested and validated. It is now ready to be used, and a marketable reality to be installed on board passenger vessels.

### 6 Cost Benefit Analysis (Sub Activity 3.5)

The proposed innovations have been evaluated in terms of Costs Benefits. The Activity 3 has been completed with the evaluation of the sustainability of the of the innovation studied in previous Sub Activities 3.1, 3.2, 3.3 and 3.4. This evaluation has been done in terms of Costs Benefits (CBA – Cost Benefit Analysis).

CBA is an essential instrument for estimating the economic benefits of projects. In principle, all impacts should be assessed: financial, economic, social, environmental, etc. During this activities will be also evaluated the benefits that
can contribute the economic viability of the investment (new services for passengers, based on indoor positioning system and/or more attractiveness of the services due to higher safety and security, etc.).

The objective of CBA is to identify and monetise all possible impacts in order to determine the costs and benefits; then the results are aggregated (net benefits) and conclusions are drawn on whether the project is desirable and worth implementing.

Costs and benefits will be carried out on incremental basis, by considering the difference between the safer ship scenario and an alternative scenario without the identified safer ship applications.

The analysis considers both economic and financial aspects. The main purpose of the analysis is to use the project cash flow forecasts to calculate suitable net return indicators. The indicators will be:

- The Net Present Value (NPV);
- The Internal Rate of Return (IRR), respectively in terms of return on the investment cost;

The Benefits evaluated for each activity are summarised in the following scheme:

<table>
<thead>
<tr>
<th>Pilot application of Behaviour Based Safety</th>
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<tr>
<td>• Minor injuries</td>
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<table>
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<tr>
<th>ICT Tool for Search and Rescue</th>
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</thead>
<tbody>
<tr>
<td>• Number of deaths prevented</td>
</tr>
<tr>
<td>• Serious injuries reduction</td>
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<tr>
<th>Indoor Positioning System</th>
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</thead>
<tbody>
<tr>
<td>• Damages reduction</td>
</tr>
<tr>
<td>• Number of deaths prevented</td>
</tr>
<tr>
<td>• Serious injuries reduction</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Safe Evacuation System</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Number of deaths prevented</td>
</tr>
<tr>
<td>• Serious injuries reduction</td>
</tr>
</tbody>
</table>

The sub-activities 3 are working in the perspective of reducing the negative impacts and instead producing benefits to health, and fatalities saved. For this reason these sub-activities will not get a positive financial return on investment,
because they intend to implement the above mentioned activities with the only objective of getting benefits for passenger and crew.

The result of the economic analysis shows a positive ENPV, which means that the value of the benefit (cash inflows) is greater than the costs (cash outflows) and the beneficiaries of the activities make a social profit in terms of reduction of fatalities and injuries.

6.1 Activity 3.1 - HSQE - Behaviour Based Safety

The B-BS implementation, for example with a crew with 300 workers, impacts mainly on the reduction of minor injuries. The use of Behaviour Based Safety allows obtaining a considerable reduction of minor injuries for year, obtained a benefit, by the second year of € 223,600, thanks to a decrease of 5 minor injuries. The value of minor injuries has been calculated with a precautionary approach based on the value of 43,000 € per minor injuries as established by the Italian National Institute for Insurance against Accidents at Work.

The Cost Benefit Analysis has been very positive impact, showing a very high ERR (141%).

6.2 Activity 3.2 - ICT-Tool for Search and Rescue

The main benefits generated by the Information and Communications Tool for Search and Rescue are in terms of fatalities and serious Injuries saved. To estimate the value of fatalities and injuries saved, have been considered the statistics data reported in the “Official Statistics for Swedish SAR operations for 2014”. It seems to be correct "conservatively" to have saved at least 1 fatality and
5 injuries per year. Considering a total of fatalities of 22 (2014), it is like saying that there is a reduction of 4% of fatalities thanks to the system. The system has a Benefit Cost Ratio equal to 7, i.e. that profit is seven times the investment done. The Information and Communications Tool for Search and Rescue Discounted Cash Flow (following figure) show by the second year a pay back of the investment.

It is important to highlight the positivity of the CBA results, (ERR 138.23% and ENPV 21.525 k€) despite that the analysis excludes other important benefits not easily quantifiable, but certainly of great importance such as energy saving in the research or the reduction of any major damage.

6.3 Activity 3.3 - Networked Vessel - Indoor Positioning

The Pilot application of RFID Technology for indoor positioning of crew and passenger and guidance in an emergency has the following benefits:

- Number of fatalities reduction; (with time frame of 10 year amount to € 240.000);
- Accident/injuries reduction; (with time frame of 10 year amount to € 45.000);
- Damages reduction. ((With time frame of 10 year amount to € 1.000.000);

The monetisation of Benefits have been done with a precautionary approach based of the value of a human life as established by the Italian insurance company.

The serious injuries are monetised using as reference the EUROPEAN COMMISSION Directorate General Regional Policy: Guide to COST-BENEFIT ANALYSIS of investment projects.

The damage evaluation has been done considering the economic damage done in similar fire events.

The probability of fatalities has been calculated according EMSA report on the Risk Level and Acceptance Criteria for Passenger Ships Thanks to the indoor positioning system is possible have benefits saving for € 150.000 at year. The cost benefit analysis has highlighted a good payback period, by the third year, with an ENPV of € 658.136.
6.4 Activity 3.4 - Safe Evacuation System

The Safe Evacuation System studied, aims to primarily reduce:

- Fatalities;
- Serious Injuries.

The probability of each event has been calculated according EMSA report on the Risk Level and Acceptance Criteria for Passenger Ships.

The benefits generated by the Safe Evacuation System demonstrate how the investment has a positive social economic impact. The economic indicators like **ERR and ENPV are very positive: 19% and € 73,364**; demonstrating a return on investment after five years.

6.5 The Discounted Cash Flow

The next figure shows the discounted cash flow (DCF) for all of the proposed innovation. The purpose of discounted cash flow (DCF) analysis is simply to estimate the money an investor would receive from an investment, adjusted for the time value of money.

Therefore the DCF analysis is a method of valuing a project, company, or asset using the concepts of the time value of money. All future cash flows are estimated and discounted by using cost of capital to give their present values (PVs). The sum of all future cash flows, both incoming and outgoing, is the net present value (NPV), which is taken as the value or price of the cash flows in question

Using DCF analysis to compute the NPV takes as input cash flows and a discount rate and gives as output a present value; the opposite process—takes cash flows and a price (present value) as inputs, and provides as output the discount rate—this is used in bond markets to obtain the yield.
The figure demonstrates like in few years the investments have a positive return.

Figure 10: Discounted Cash Flow

7 Publications

8 Reference Material

D3.1.1 Technical report on BBS methodology adapted to passenger ships
D3.1.2 BBS ICT tool adapted to passenger ships
D3.1.3 Technical report on user, task and environmental profiles and developer requirements
D3.1.4 Deployment road map – ICT aspects
D3.1.5 Pilot application: customisation of MARBBS to the users selected for the use case
D3.1.6 Report on Pilot application: usability and crew acceptance issues
D3.1.7 Report on Pilot application: feedback from pilot results and proposed improved operations
D3.1.8 Deployment road map – training, usability and crew acceptance aspects
D3.2.1 System Design,
D3.2.2 Interface with STM components,
D3.2.3 System Delivery,
D3.2.4 Test Plan,
D3.2.5 System validation.
D3.3.1 Report on Requirement Definition,
D3.3.2 Report on PTS Design,
D3.3.3 Report on PTS Pilot Development,
D3.3.4 Report on PTS onboard Installation,
D3.3.5 Report on PTS onboard Validation.
D3.4.1 Report on Requirement specification,
D3.4.2 Report on Launch and Recovery System Design,
D3.4.3 Report on System simulation,
D3.4.4 Report on Pilot Application in Port,
D3.4.5 Report on System Validation.
D3.5.1 Report on Methodology Approach to the CBA Analysis,
D3.5.2 Report on Cost-Benefit Analysis.

9 References


European Commission, DG Economic and Financial Affairs, 2007, Evaluation of the performance of network industries providing services of general economic interest, Brussels


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39 partners from 10 countries
taking maritime transport into the digital age

By designing and demonstrating innovative use of ICT solutions
MONALISA 2.0 will provide the route to improved

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