MONALISA 2.0 – Activity 3

BBS ICT tool adapted to maritime domain

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## Project

**MONALISA 2.0 Securing the chain by intelligence at sea**

**Founded by**
The Trans-European Transport Network (TEN-T) of the European Union

**Activity**
3 - Safer Ships

**Work Package**
3.1 - *HSQE (Health Safety Quality Environment)*

### History Version Table

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<td>DRAFT to MIT</td>
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1 Introduction

1.1 General

According to the SAP (pages 14 and 25), the aims sub-activity 3.1 are to assess the possibility and benefits of transferring the BBS approach to the maritime sector as a tool to improve operational safety by reducing unsafe behaviors during normal operations. Hence, the goal of the sub-activity is to adapt the BBS methodology and related ICT tools for use in maritime applications and test them as appropriate through suitable prototype(s).

The method used encompasses the following steps:

• adapt BBS practices and ICT tools (widely applied in other industrial sectors) to MoS. The so adapted practices and tools are indicated as “BBS tools” in the following;
• test the BBS tools in at least one realistic pilot application involving suitable operators;
• calibrate/refine the BBS tools based on the feed-back from the field and identify possible obstacles to its voluntary application by the shipping industry;
• assess, throughout the process, compatibility with IMO as well as Class requirements.

Three different organisations co-operate (IB and Ergoproject as implementing bodies of Italian Ministry of Transport and CIMNE from Spain), under the lead of IB, as follows:

• analysis of BBS best practice and success factors in other industries, possibility that the same/similar success factors can be triggered in the maritime sector. Identification of available BBS methodology and certification standard(s) and of their applicability to the maritime sector, identification of possible and meaningful test cases/scenarios for a maritime application (IB and CIMNE). Work completed and reported in D3.1.1: Methodology adapted to marine domain;
• adaptation of the BBS methodology and BBS ICT tools to the selected maritime scenarios (IB and CIMNE). Work completed and reported in this document D3.1.2: BBS ICT tool adapted to marine domain;
• definition, specification, planning, preparation (e.g. tuning of ICT tools to the specified cases) of at least one demonstrator in realistic scenario (IB and CIMNE). Work ongoing and to be reported in D3.1.3: User, task and environmental profiles and developer requirements;
• development of demonstrator(s) including ad hoc (preliminary version) ICT tool for maritime BBS applications. Work ongoing and to be reported in D3.1.5: Customization for pilot applications;
• execution of at least two pilot applications (one in Italy and one in Spain) using the demonstrator(s). Feedback from pilots and application of a Human-Centered Design (HCD) approach, based on current and future regulations (e.g. IMO’s e-navigation), to evaluate its applicability and effectiveness to ICT tools and promote ease of use and acceptance by the target users. Work ongoing and to be reported in D3.16: Execution and Report on pilot applications.

1.2 About this document

This document is organized as follows:
- a short overview of the BBS “process” (BBS flow) is provided in Chapter 2;
- results of a survey on existing ICT tools used in other industrial sectors for application of BBS is summarized in Chapter 3; on the basis of such survey, a reference existing ICT tool was selected;
required additional features needed for a “maritime BBS” ICT tools are listed in Chapter 4; Human centered aspects are analyzed in Appendix A.

1.3 Conclusions

In D.3.1.1, the applicability of BBS maritime operations was confirmed. Based on the work summarized in this document, it is concluded that:

a) an brand new ICT tool for maritime BBS is not necessary since existing ones would cover most of the needs; more specifically the DataBASE® tool\(^1\) emerged to be the best suited for adaptation to maritime applications;

b) the resulting adapted to maritime applications ICT tool, DataBASE 2.0®, in preliminary version is under development and will be delivered ad D3.1.5.

In D.3.1.5 details of the, currently under development, DataBASE 2.0® will be provided.

\(^1\) The DataBase® ICT tool has been designed and developed by AARBA (Association for Advancement of Radical Behavior Analysis) that in Europe acts on behalf og CCBS (Cambridge Center for Behavioral Studies).

AARBA Reference: http://www.aarba.eu/

CCBS Reference: http://www.behavior.org/
2 BBS flow

The BBS process is described in Figure 2.1, where in particular the following are described:

- The Actors:
  - Observer;
  - Safety Manager.

- The Actions:
  - To fill in the observation;
  - To record the observation;
  - To check and to verify.

Fig. 2.1: BBS Business flow
3 Existing BBS ICT tool(s)

ICT tools to enable the application of the BBS approach are available from industrial fields other than maritime. Below a short description of DataBase® which, based on the analysis carried out within Sub Activity 3.1, was judged to be the best existing BBS ICT system (the version of DataBase® analysed is available - as Appendix B – stored in the IB data center).

The BBS methodology requires the execution of the following activities:

- definition of the behaviour to be monitored and how to perform the observations (check list), in the different areas of industrial activity (process) under analysis;
- identification of the observers and what and where they have to look for;
- recording of the observations;
- analysis of observations and related reporting

in the form of high level flow-chart of an ICT system, this is illustrated in previous figure 2.1.

It is noted that decisions and/or recommendations based on BBS analysis’ results are not to be an output of the ICT system; in other words, BBS methodology does not foresee the use of any kind of “expert system”. In fact, according to an “user defined” schedule, the Safety Manager downloads information and/or reports from the BBS data base in order monitor/verify the process under BBS and decide on any necessary actions (see fig. 2.1).

In view of illustration, the main features of DataBase®, which will be retained in the DataBase2.0® are the following:

- log in page (fig. 3.1)
- example of application on a step of an industrial process (fig. 3.2)
- typical output (fig. 3.3)
- synthesis in graphical form of the results (fig. 3.4).

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2 The DataBase® ICT tool has been designed and developed by AARBA (Association for Advancement of Radical Behavior Analysis) that in Europe acts on behalf of CCBS (Cambridge Center for Behavioral Studies). AARBA Reference: http://www.aarba.eu/ CCBS Reference: http://www.behavior.org/
**Figure 3.1:** The user login

**Figure 3.2**

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**B-BS ICT TOOL**

*Industrial domain - Process and Manufacturing*

**LOGIN**

**PSW**

**HOME PAGE**

**APPLICATION**

**ATTRIBUTES GIVEN TO PROFIL**

- USER MANAGEMENT
- ORGANIZATION MANAGEMENT
- CHECK LIST MANAGEMENT
- INPUT CHECK LIST
- DATA ANALYSIS

**Figure 3.1:** The user login
Fig 3.3

Behavior-Based Safety

ANALISI Osservazione - COMPORTAMENTI

CONFRONTO COMPORTAMENTI
PERCENTUALE DEI COMPORTAMENTI SIGURI
01 Lamiera
Gruppo: Turno A Linea 3 Montaggio (SUPERCOLD)
Tutte le aree di osservazione
Dal 01/01/2010 al 31/01/2011

Fig 3.4

Behavior-Based Safety

ANALISI Osservazione - VALUTAZIONE ATTIVITÀ IN CHECKLIST

VALUTAZIONE ATTIVITÀ IN CHECKLIST
PERCENTUALE DEI COMPORTAMENTI SIGURI
01 Lamiera (SUPERCOLD (Gravellona Toce))
Gruppo: Turno A Linea 3 Montaggio (SUPERCOLD)
Area di osservazione: Montaggio (SUPERCOLD)
Dal 01/01/2010 al 31/01/2011
4 BBS ICT tool for maritime application

Due to the specific characteristics of “maritime processes” such as e.g.:

- Language (workers on board the same ship usually have several different native languages, up to 20 in cruise ships);
- High turnover;
- Repetitiveness of working actions;
- High specialization of job;
- Work under stress, far from home and subjected to frequent changes of colleagues;
- Environment potentially harsh (e.g. during a storm)

any existing ICT system cannot be used as it stands in the maritime sector. However, the selected tool DataBase® can be adapted and upgraded accordingly leading to DataBase2.0®.

These adaptations belong to two categories, namely Technological and Methodological as outlined in Tables 4.1 and 4.2. More specifically the Technological adaptations are needed since in maritime application the process is carried out in a “mobile” environment (the ship) and most if not all the analysis is done in a centralized location ashore (e.g. the safety department of the ship operating company).

<table>
<thead>
<tr>
<th>T E C H N O L O G I C A L  S U P P O R T</th>
<th>PLUS</th>
<th>DESCRIPTION</th>
<th>FEATURE FOR MARINE DOMAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEVICE MOBILE</td>
<td>Tablet or Smartphone</td>
<td>The work place of the seafarer is extremely restricted, especially during navigation.</td>
<td>This plus is designed to permit the observations of all the jobs in a ship, in ordinary and extraordinary activities.</td>
</tr>
<tr>
<td>HIGH USABILITY</td>
<td>It has been improved the usability about: Layout, Immediacy, Graphic User Interface (GUI), Reducing text, Streamlining the procedure of compiling</td>
<td>During an observation, the observer (often the seafarer) can directly operate with tablet or smartphone.</td>
<td>This plus is designed to allow to very easily fill out the check list.</td>
</tr>
<tr>
<td>AUTOMATIC UPGRADE OF DATA TO SERVER</td>
<td>Software user: on line (wi-fi), off line (no connection)</td>
<td>Very often ships in general are not connected to the company net (board to shore).</td>
<td>This plus is designed to ensure a continuous updating of data to the server by an automatic upgrade as soon as the connection is available</td>
</tr>
<tr>
<td>MULTI-LANGUAGES</td>
<td>The software manages all languages.</td>
<td>Workers on board the same ship usually have several different native languages, up to 20 in cruise ships.</td>
<td>This plus is designed to allow to each worker to use the software in the own native language limiting errors.</td>
</tr>
<tr>
<td>HELP ON LINE</td>
<td>Support, on line to the ICT Tool</td>
<td>On ships, displacements/shifts are frequent.</td>
<td>This plus is designed to allow to solve ICT problems on their jobs.</td>
</tr>
</tbody>
</table>

Tab. 4.1: technological adaptations
<table>
<thead>
<tr>
<th>PLUS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMMEDIATE FEEDBACK</td>
<td>In BBS protocol, the feedback after the observation of each behaviour must be immediate (both positive and negative).</td>
</tr>
<tr>
<td>AUTOMATIC WARNING «RANDOM»</td>
<td>In BBS protocol, the request of observation is anticipated by a warning (usually an alarm clock) pre-set by hand.</td>
</tr>
<tr>
<td>ATTACHMENTS • PHOTOS • SENTENCES • COMMENTS</td>
<td>In the BBS protocol, it is necessary a detailed description of the behavior, as attachments to the check list.</td>
</tr>
<tr>
<td>VOLUNTARY OBSERVATION</td>
<td>In the BBS protocol, the observation is sampled. To detecting allevents/all verified behaviours it is necessary a voluntary observation during the normal course of the work.</td>
</tr>
<tr>
<td>TOKEN ECONOMY MANAGEMENT</td>
<td>In the BBS protocol, the token economy is a very important pillar. Safe behavior settle with positive reinforcements (token).</td>
</tr>
</tbody>
</table>

Tab 2: methodological adaptations.
Appendix A - HUMAN-CENTERED DESIGN APPROACH (ERGOPROJECT)

The introduction of Human-Centered design (HCD) approach represents one of the outcomes driven by the diffusion of Human Factors methods and principles. For this reason, before introducing HCD, we discuss the origins of Human Factors.

In the last decades, a significant number of accidents fostered the interest in investigating the factors underlying “human error”. Several research found, for instance, that between 70% and 80% of aviation accidents result from some type of human error (Lourens, 1989; O’Hare et al., 1994).

Some authors defined the concept of human error as “an inappropriate or undesirable human decision or behavior that reduces – or has potential for reducing system effectiveness, safety or performance” (Sanders & McCormick, 1993). Although in this report we use the term “human error”, we do not consider human errors as something entirely attributable to the individual. Instead, we support the literature view arguing that the human error causes should be investigated in the people/system relationship (Vicente, 2004). This assumption founds also support in the sociotechnical system model (Koester, 2007), which represents an evolution of the well-known SHEL model originally developed by Edwards (1972) and Hawkins (1987). Compared to other SHEL model versions, the sociotechnical system model by Koester (1997) is specifically conceived for maritime domain and it presents a clear graphic and taxonomic representation of the factors involved in vessel system. In particular, the model describes seven factors (or domains) that determine system performance; each factor is connected to one another (see Figure A1).

![Figure A.1. The sociotechnical system model (Koester, 2007)]

The model also indicates how different factors interact to influence system performance and it conceives the domain “individual” as a factor including individual physical or sensory limitations, human physiology, psychological limitations, individual workload management, skill and...
knowledge. This specific view about the “individual” within a system comes from Human Factors.

Due to different geographical areas of development, the discipline received different denominations. Currently, the term “Human Factors” and the term “Ergonomics” are considered as synonyms but also the term “human element” is often used, especially in maritime domain. In this report, we use the acronym HFE that represents an abbreviation of both “Human Factors” and “Ergonomics”. The different areas of development also produced several definitions of HFE. One of the most validated comes from the International Ergonomics Association (http://www.iea.cc/) that defines HFE as “the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance”. More specifically, HFE focus on the interactions between the humans and other components of a system such as other humans, machines, services and tools. To meet these objectives, the discipline considers the following factors:

- Purpose of the system, product or service;
- Characteristics of the intended target population;
- Goals to be achieved and tasks to be performed;
- Existing constraints;
- Factors of the physical, organizational and social environment;
- Life cycle and any dynamic changes within it.

ISO 26800:2011 offers an example of factors to be taken into account in an ergonomic approach (see Figure A.2).

![Figure A.2](image-url)  
**Figure A.2.** The figure shows a set of factors to be take into account to improve system performance. The activity of a person is central to the functionality of the system.
As mentioned above, an ergonomic approach should consider a set of factors to enhance system performance. With regard to HFE, the definition of these factors result from academic research and military domain that supported its application and development using different tools and methods. Outside the academic environment and other fields of research (military, aeronautical, etc.) those tools and methods appeared unlikely to apply. With the objective to extend the application of HFE principles to other contexts and to simplify HFE tools and methods, a new approach developed in the last twenty years, the Human-Centred design (HCD).

Since 1999 the International Standard Organization (ISO) introduced the concept of Human-Centred design with the publication of ISO 13407 entitled: “Human-centred design processes for interactive systems”. The latest ISO 26800:2011 regarding general ergonomic approach, principles and concepts defines the HCD as follows: “A Human-Centred approach means that all designable components of a system, product or service are fitted to the characteristics of the intended users, operators or workers, rather than selecting and/or adapting humans to fit the system, product or service. This should be done by consideration of: the intended target population; the task, goal or intended outcome of the system, produce or service, and the environment in which design is to function”. Those affected by the design (e.g. workers or users) should be involved throughout the whole design process, including evaluation. This will help to optimize solutions (e.g. by providing specific experience and requirements). Their early and continued participation and involvement is regarded as an efficient design strategy within ergonomics.

In the last years, this approach has been used in various contexts. An important example comes from the United States Department of Defense that published a list of design criteria standard in August 1999. Among the different standards, the Department also illustrates requirements to employ a HCD with reference to anthropometry, displays and layout of controls. Although these standards refer to the military domain, they were applied in various fields, due to their freely available perspective. A more practical example of HCD originates from the web-based platform. A government initiative, for instance, produced one of the most interesting website to provide overviews of the User-Centred design process with particular attention to web usability and design (http://www.usability.gov/). The website also covers the related information on methodology and tools for making digital content more usable and useful. The initiative represents one of most important freely available diffusion of HCD highlighting the significance of the approach and its efficiency.

In this section, we first described some issues that led to a new perspective of individual within a system. Then, we examine the academic background of HCD summarizing the HFE principles. Finally, we discuss the HCD development illustrating some references and applications.

A.1 Human-Centred design for developing ICT tools
The previous section described the development of the HCD approach. In this section, we discuss the reasons underlying the application of HCD in ICT tools development.
As mentioned in the previous section, the first standard referring to HCD was ISO 13407:1999 that concerned HCD processes for interactive systems. In 2010, this standard has been revised by ISO 9241-210:2010 that defines the HCD as “an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques”. More specifically, this part of ISO 9241-210:2010 provides requirements and recommendations for HCD principles and activities throughout the life cycle of computer-based interactive systems.

Another standard regarding the application of the HCD approach is ISO/TR 16982:2002 (complementary to revised ISO 13407:1999). The standard constitutes a technical report providing information on human-centred usability methods which can be used for design and evaluation.

In addition to the standards, there is also some evidence supporting the application of HCD that comes from different fields of application. Since the 1960s, some authors, in the field of product design, advocated the inclusion of users in product design as a solution to the widely acknowledged problem of poor design (e.g., Bayazit 2004; Norman 1988; Sorrell et al. 2006; Wixon, Holtzblatt, and Knox 1990). A study of 310 new product development projects indicated that involving the customer in a professional way in the product development stages of “idea generation, concept development, assessment, and selection of prototypes and market launch” (Ernst 2002, 11) contributes considerably to the realization of commercially successful new products. Maguire (2001a, 2001b) has summarized the benefits of following user-centered design principles in systems.

- **Reduced training and support**: User-centered design and usability principles help reduce smart product provider training time and the need for user support. This is of special importance to novel systems since newly introduced systems most often require dedicated training and support.

- **Reduced errors**: Poorly designed smart systems significantly increase human error due to inconsistencies, ambiguities, or other interface design faults.

- **Increased productivity**: A smart system employing user-centered design and usability principles will enable users to concentrate on the task rather than the interface in order to operate effectively.

- **Improved user population acceptance**: Most users would be more likely to trust a smart system that provides well-presented information that is easily accessed, increasing end user acceptance and enhancing customer satisfaction.

- **Enhanced reputation**: A well-designed system will enhance the vendor’s reputation in the marketplace and guarantee profitability and customer support for future products and services.

There are also other reasons to employ a HCD approach in ICT tools development. First, the heterogeneity characterizing ICT tools (web-based, mobile, etc.) leads to the necessity to consider the context of use, the user’s needs and user acceptance. These requirements can be
satisfied by adopting a HCD approach. Second, the application of ICT tools to a complex work environment requires a specific analysis of job activities to examine tool accessibility and usability that can be carried out only using a HCD approach.

A.2 Human-Centered Design approach in maritime domain
This chapter aims to provide an overview of the presence and the evolution of the HCD approach in maritime domain in the most relevant recommendations, regulations and EU-research projects’ results, which have been published for about two decades. It will possible to notice that the first interventions were based on examining human element issues to minimize or mitigate the effects of human error aboard ship. In the last years, at the same speed of technological progress, the international interest has moved to the implementation of a HCD approach to the development of marine systems.

A.3 Human error and technological development challenges
Maritime accident implies each extraordinary event that causes noxious consequences, putting in danger crews, vessels and working environment. The extraordinary events are divided into those which were “about to” cause harmful consequences, and accidents which indirectly or directly caused the loss of life, endangering health, material damage at sea or ashore, pollution, and other consequences. According to the European Maritime Safety Agency (EMSA)³, about 75% of marine accidents are caused, at least in part, by some kind of human error, meant in a systemic way, as already mentioned in the previous Chapter. It has been specified that human error contributes to 89% of impacts, 75% of explosions, 79% of collapses and 75% of collisions (Hanzu-Pazara, R., Barsan, E., Arsenie, P., Chiotoriou, L., Raicu, G., 2008).³

So, even nowadays, when navigation instruments use advanced technologies, human error is still usually considered the main cause of such casualties. In relation to this, it is pointed out the wrong trend to think that these new and improved technologies can oppose the human limits increasing safety at sea.

As for other application fields (i.e. aviation, military), technological developments have certainly created new opportunities in maritime, but also have presented negative consequences (e.g. the lack proper coordination could bring to lack of standardization on board and ashore, incompatibility between vessels and to an increased and unnecessary level of complexity).

Starting by this, the real challenges for an effective implementation is to ensure that new systems are developed according to users’needs, skills and abilities, as to say according to an approach which considers the centrality of the human element.

³ European Maritime Safety Agency, Maritime Accident Review 2010
A.4 Towards Human Factors & Ergonomics

Over recent years, a growing body of documents, guidelines, and resolutions has become available to focus on the importance and the major role of the Human Element in maritime domain.

These include some international classification societies (e.g. American Bureau of Shipping, Bureau Veritas, Lloyd's Register Group, DNV GL, Registro Italiano Navale, Nippon Kaiji Kyokai), European Commission-funded projects, and the International Maritime Organization (IMO).

On the classification front, the American Bureau of Shipping (ABS) was between the first authorities to intervene, introducing in 1998 the industry standard “Guidance Notes on the Application of Ergonomics to Marine Systems”, which underwent a first revision in 2003 and its last on February 2014.

ABS has contributed to supply a multi-faceted approach to find an answer to the human error issues. The chief virtue of these Guidance Notes has been to introduce an Human Factors & Ergonomics (HFE) approach as necessary in a system design development effort: features which are not developed according to an ergonomic approach could contribute to a greater incidence of human error occurrence.

The main aim of these Guidance Notes and their additional updates is to continue the diffusion and application of ergonomic principles to maritime domain, at the same pace of interface design processes, to integrate humans and systems, and thereby to improve crews’ safety and performance and to lower human error.

From this first model, and considering the increased complexity of ships’ systems and the growing technological sophistication of onboard equipment, also at European level it has been put greater emphasis on the importance of the Human Factor in maritime domain.

A.5 European interest from HFE to a HCD approach proposal

In the years, the European Commission has funded several research projects focusing on the human element in recognition of the crucial importance of this aspect to maritime safety and security.

In addition to considering the attraction, training and retention of seafarers, all the EU-funded projects have and will examine the interaction of the human element in all its facets with aspects of ship operation and design, and the development of enhanced compliance cultures.

These projects represent an extension of ongoing EU level work to share information, to develop best practice guides, and to consider the possible need to request a change in the legislation.

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4 American Bureau of Shipping, Guidance Notes on the Application of Ergonomics to Marine Systems, last updated February 2014
One of the first topics which were analysed is the role of fatigue at the cost of maritime safety. So, when seafarer fatigue was understood to be one of the sector’s biggest health and safety risks, there have been funded projects to help in finding effective and long-lasting solutions.

The first and most important EU project on this topic has been the Cardiff Research Programme about seafarers’ fatigue. Through surveys, analysis of existing databases and field research, it was showed that the fatigue at sea is principally due to seafarers’ exposure to the combined effect of recognizable risk factors, such as operational (e.g. port frequency), organizational (e.g. job support), and environmental (e.g. physical hazards) ones. The main quality of Cardiff Programme has been to pave the way to the investigation of human element related aspects.

Also a part of Project Horizon (ended in 2012), examined seafarers’ fatigue using simulators and electrophysiological recording. The principal achieved goal of Project Horizon has been a deeper and more rigorous understanding of the complex and multiple effects of standard maritime watch schedules on sleepiness and fatigue.

It should be observed, nonetheless, that this was an all simulator-based project that was designed to study some basic aspects of the effects of some of the most common working patterns for seafarers. Although every effort to design realistic simulated working conditions, there were recognised some inevitable practical limitations (e.g. timescales and working environment).

The European Commission is now sponsoring projects which are mostly set in real working environments and that take into account the real users’ central position in maritime systems development through a Human-Centred Design (HCD) approach.

The first in temporal sequence has been the FAROS (Human Factors in Risk-Based Ship Design Methodology) project (2012-2015). FAROS project will use a Risk-Based Design (RBD) methodology to integrate the human element into the ship safety framework. This will be achieved by experimental data, simulations, parametric ship design models and optimisation processes to assimilate HFE into the ship design process since a conceptual stage.

In CyClades (Crew-centred Design and Operations of ships and ship systems) project (2012-end of 2014) there is a more well-defined address to the recourse to a HCD of equipment on board ships to investigate human-machine interaction on ships, and to support the general goal of reducing maritime risk.

According to the criteria of HCD approach, the Cyclades project considers a multi-disciplinary team to focus on all the key steps in the system lifecycle (i.e. from concept, design, application, evaluation and approval, to maintenance), looking continuously (directly and/or indirectly) for stakeholders and users suggestions, opinions and approval.

Fatigue is generally understood to be a state of acute mental and/or physical tiredness, in which there is a progressive decline in performance and alertness.
The most recent (2013 – to end in 2015) EU project, CASCADe (Cooperative and Adaptive Ship based Context Aware Design), is a three years research, which aim is to close the gap between the design of the bridge system and the procedures, optimizing human-machine interfaces on the bridge.

The project uses safety-based scenarios to investigate bridge procedures: it will analyse potential failures due to human errors caused by loss of situational awareness, during the design phase of a bridge. The expected result will be the development of an adaptive bridge system that will identify, prevent and recover from human errors by rising cooperation between crew and machines on the bridge. This goal will be achieved through a HCD approach as a support to the analysis of crew performance at the very early development stages.

The three above mentioned projects prove the general trend in EU’s Seventh Framework Programme for Research to develop a methodology for integrating harmonization tools of system and procedure development and HFE, promoting an affordable HCD approach to maritime systems.

A.6 The most recent application of a HCD approach: IMO’s Guidelines for E-navigation Systems

In the last years, the address to a Human Centred Design approach for the development of maritime systems has been spread at international level, as well, mainly through the interest of the International Maritime Organization (IMO). The IMO work related to Human Factor dated back to the 1990s (Schröder-Hinrichsa, J., Hollnagelb, E., Baldaufa, M., Hofmann, S., Katariaa, A., 2013) often as the result of responses to maritime accidents. The typical reactions to such casualty from the Organization have been a combination of (technical) regulations, procedures changing and workers’ training. The IMO recommended that the study of HFE (and in particular human error) would be an important focus for improving maritime safety. As a result, the IMO started to introduce new regulations that incorporated a human element viewpoint.

Statements made by IMO in recent years claim a shift towards a new approach in maritime safety through systemic evaluations and centralization on seafarers needs.

This plan of action found its way alongside the gradual automation through constant technological advances in maritime systems development. In 2008, the IMO drew up the concept of e-Navigations based on the harmonisation of marine navigation systems and supporting shore services driven by user needs, and it is expected to have a significant impact

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6 The areas of interest between CASCADe, CyClaDes and FAROS project are easily superimposable and there have been and there will be in 2015 some workshops in which there will be discussed the respective achieved results.

7 ‘’e-Navigation is the harmonised collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment’’, International Maritime Organization, December 2008
on the future of marine navigation. In December 2008, the IMO’s Maritime Safety Committee (MSC 85) set the E-Navigation Strategy, which is four year work programme for relevant sub-committees to develop a Strategic Implementation Plan (SIP), which overall goal is to improve safety of navigation and to reduce errors, through modern, proven, optimized tools, according to users’ characteristics and needs.

Within the SIP, Australia has been the most active country in the development of guidelines for the usability of navigation equipment and systems, presenting and promoting a HCD approach.

In 2012 Australia presided at the 58th session of IMO’s Sub-Committee on safety of navigation which produced two reports, which powered up to the definition of the HCD process applied to the maritime sector:

- NAV 58/INF.10 (Australia) - The Human Element Analysing Process (HEAP)
  in e-navigation, that introduces the review and the application of the Human Element Analysing Process (HEAP) to the e-navigation gap analysis.
- NAV 58/INF.11 (Australia) - Human error management in the era of e-navigation, that summarises the human element principles which support the application of the Human Element Analysing Process (HEAP) within the e-navigation gap analysis (i.e. analysis based on data from real-time observation of normal operations, along with risk mitigation strategies based on human error management theory).

Australia’s intervention culminated in March 2013, when the Australian Maritime Safety Authority hosted an e-Navigation Usability Workshop at Kingscliff, New South Wales. The 44 delegates, representing 11 countries and four key stakeholder areas for e-navigation (i.e. maritime administrations, marine electronics industry and users - seafarers and shore organizations such as Vessel Traffic Services and pilots - and research/academia) sat down at the table to compose the draft “Guidelines on Human Centred Design (HCD) for E-navigation Systems”, that has become the Annex 4 of the IMO report “Development of an E-Navigation Strategy Implementation Plan, by the Correspondance Group on e-Navigation”, under the coordination of Norway, which will be released in its latest version in the next months.

The scope of these guideline is to outline a HCD process for ensuring usability and safety in e-navigation systems. They present the HCD approach as the common process to implement usability goals, with the basic premise that designable systems have to be apt to the users’ characteristics and tasks, instead than requiring users to adapt to an already developed system.

This HCD approach employs an Usability Testing, Evaluation and Assessment (U-TEA) process to obtain a formal feedback in each design phase to pledge continued safety and usability.

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8 The HEAP is a practical and non-scientific checklist to assist regulators in ensuring that human element aspects related to the ship and its equipments, the master and crew, training, management ashore and on board, and work environment conditions have been taken into consideration when introducing or amending IMO instruments.
This process should, at least, consist of six activities:

Pre-activity: Conduct Early Human Element Analysis

Activity 1: Understand and specify the context of use (in which the system is/will be used)

Activity 2: Specify the user and stakeholder requirements

Activity 3: Produce design solutions to meet user requirements

Activity 4: Evaluate and test the designs against requirements

Activity 5: Maintain operational usability

These steps propose a possibility to improve user performance, to consider error management and recovery, and to improve time and resources which are necessary for systems maintenance. In the guidelines, it is highlighted in more asides the innate iterative nature of HCD process: each activity may be revisited throughout the system development, with a continuous feedback between each of the activities (i.e. increased definition of the context-of-use could impact on user requirements, or user-requirements may be changed after initial prototyping and evaluation of a design solution).

The main objective of these guidelines is to ensure that the general HCD requirements and criteria have been described in a systematic and effective manner to be applied in a maritime environment.

Most importantly, the intention of this document is to make clear that a HCD approach can actually help in developing systems which support users in low and high stress environments (e.g. during challenging navigation conditions), when they are most vulnerable to make

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9 U-TEA was developed by Japan, which is the responsible for the draft “Guidelines for usability evaluation of navigational equipment”
mistakes. A HCD developed system will optimize learnability and familiarization requirements, as well.

It is very important and realistic that it was specified that the so presented HCD process can be applied to the design of both new systems in development and already existing system to be modified. As such, detailed and prescriptive design requirements which specify design solutions are not included.

The drafting of these IMO guidelines is still ongoing, so their effective applicability could be evaluated only at a later time. It is now possible to examine the discussion topics on which the worktable participants are already confronting. The guidelines on HCD do not refer ever to the necessary recourse to experts (i.e. User eXperience, Usability experts) for a focused and effective support in some activities in HCD process, assuming that the guidelines themselves could be sufficient for the audience of stakeholders\textsuperscript{10}, which have an interest in developing, testing and evaluating e-navigation systems. Similarly, there is no a clear indication and practical examples of the user research methods (i.e. card sorting, contextual interviews, focus groups, heuristic evaluation, personas, prototyping, task analysis, usability testing, use cases).

Till now, there are not relevant examples of practical implementation of these guidelines, so it could be only supposed the probable stakeholders’ difficulties in putting them in practice. These criticalities could easily dissuade the stakeholder through and though in approaching a HCD process for developing systems.

Projects like Monalisa 2.0, which considers the application of a HCD approach to the development of e-Navigation systems in a real working environment (or, more generally, to the development of ready-to-use ICT tools), could be the right test bench to collect information and to check and rearrange, if necessary, the process which was presented in the guidelines.

To be thorough, in mutual cooperation with the IMO, also the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) has planned an intervention strategy for e-Navigation, which principal aims are to develop user-friendly bridge design, to increase reliability, resilience and integrity of bridge equipment and navigation information and to improve Communication of VTS Service. The IALA’s activities are just partially superimposable to the topics of this review about HCD approach in maritime, so it will not analysed here.

A.7 Criticalities in applying a HCD approach in maritime domain

As indicated in ISO 9241, criticalities about users’ acceptance of a HCD approach to systems development could be detected during throughout all the advancement steps of the process. So, in this initial phase of the research activity, it is possible to indicate the general issues about users’ acceptance of a HCD approach.

As illustrated in Chapter A.6, to apply a HCD approach in a working environment it is essential to involve in the process real end-users, such as seafarers, pilots and relevant shore personnel.

\textsuperscript{10} Stakeholders include equipment designers and manufacturers, system integrators, maritime authorities and regulators, shipbuilders, ship owners/operators, Vessel Traffic Service authorities and Rescue Coordination Centres.
In the maritime domain - as in others - the most common users’ reaction to a process implementation could be a general resistance to change. Indeed, it was argued (Baddoo and Hall, 2003) that the most onerous obstacle in introducing any new approach in a system development is the unwillingness of the persons concerned to take it up. This resistance could effectively work even for the HCD approach which intent is to introduce gradual changes, that are based primarily on users’ suggestions. 

Moreover, it could be possible meeting organizational obstacles (Bauer, 1991) in recruiting professionals as participants to HCD activities, both for the intense work rate and for the constricting physical working environment. In the maritime case, the ship owners could not be very willing in offering spaces and time to develop these necessary activities.

As far as the debate about the effectiveness and ease in applying a HCD approach is still in progress (Maguire M., 2011), there are many evidences in other fields (i.e. medical, aviation, aeronautical, transportation) of the positive effect of users’ participation to the development stages, which revealed itself in a more serene changes acceptance by users and a general improvement in working safety and performances (Endsley M.R., Boltè B., Jones D.G., 2003).

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