2019 IMEKO TC-19 International Workshop on
Metrology for the Sea
Genoa, Italy, October3-5, 2019

SINDBAD: a new operational service for a safer leisure and boating navigation

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***Abstract* – The SINDBAD- Leisure and Boating Safety Navigation – project goal is the development of an advanced operational service to support navigation in a specific area. The first prototype covers the Ligurian Sea (a very busy touristic area in the North Mediterranean Sea) It develops an ICT Service Infrastructure to provide innovative intelligent automation functions and to develop customized services, accessible by your mobile device, for conducting a boat and avoiding any kind of risk ensuring the best degree of comfort.**

I. INTRODUCTION

Sea Situational Awareness (SSA) is defined as the capability to provide information about present andfuture sea conditions to support people during their activitiesat sea. SSA is very important for a pleasant and safer navigation. The lack of knowledgeand awareness about sea conditions induces a degree of incertitude in leisure activities at sea, with an impact of tourist industry.

Leisure navigation and boating are usually excluded from SSA high-end services, devoted to commercial navigation, and the available traditional weather bulletins do not fully match this typology of users. The SINDBAD project seeks to bridge this gap by integrating high reliability data and models with high spatial and temporal resolution, in order to produce weather-marine forecasts for the target area, together with a web-based Decision Support System(DSS) able to analyze the impact of these forecasts on different type of boats, thus leading to customized navigation operational suggestions.

The DSS integrates heterogeneous weather and boat seakeeping data to provide specific tasks that may be of immediate utility for users, like the generation of comfort and risk maps and the delivery of boat-specific alerts and advices. The ultimate goal is to provide yachtsmen, fishermen, port authorities etc. with affordable and boat-specific highly detailed information.

II. NAVIGATION SERVICES AND TOURISM

Maritime voyages are significantly influenced by the environmental conditions encountered along the route. In the recent years, the everincreasing availability of reliable weather forecast data has significantly improved the safety of ship voyages, allowing shipmasters to select convenient routes to avoid rough weather and to better estimate ship times of arrival, as well as the associated costs. Nowadays, increased attention is paid to seakeeping abilities of ships, thus increasing the ship safety also in rough weather conditions. On the other hand, medium intensity weather conditions do not impair ship safety but affect fuel consumption and comfort on board. The concurrent addressing of ship efficiency, ship routing, ship safety and comfort issues can be handled numerically, in real-time, providing a relevant decision support tool.

In the framework of maritime safety and efficient transportation, situational sea awareness through the operational distribution of oceanographic and meteorological information is a key enabler of technological applications. In fact, the use of marine weather forecasts for route recommendations has been since long recognized. However, due to the limited spatial and temporal resolution of the oceanographic forecast products, so far applications have dealt mainly with large ocean-going motor vessels or racing and leisure sailboats, mainly in a regime of open sea navigation. In recent years, the operational availability of coastal observatories and high-resolution ocean forecast products have paved the way for applications to be used even in enclosed seas and coastal waters.

Leisure and boating navigation operators cannot afford to use the available weather routing navigation tools and they use bulletins that are not fitting their specific needs. In the Mediterranean Sea, only a few services provide detailed weather maps, anyhow these services are delivering data without customized suggestions about the impact of meteocean conditions on a specific boat type. A widely used one is SeaConditions, (www.sea-conditions.com). A complementary service providing route advices for several ship classes is VISIR (www.visir-nav.com). Both of them originated from the research work of CMCC (Centro Euro-Mediterraneo sui Cambiamenti Climatici). However, apart from weather maps and weather routing, no alerts about safety of uncomfortable navigation are available.

Already existing professional routing services (e.g. Navimeteo www.navimeteo.com, MeteoNautica www.meteonautica.com) are not implementing full automation, a staff of technicians who operates the systems usually provides navigational advice directly to the customers, with consequent high costs that are not sustainable for the average boaters. While having so many potentially usable weather services, often available through "apps" for mobile phones, it is not easy for a yachtsman to obtain low cost, affordable and boat-specific routing information. This is even truer for the critical phases of port landings that requires highly detailed weather information and complex maneuvers to avoid any risk of accidents.

III. DATA SOURCES

SINDBAD foresees a first phase of activity aimed at the characterization and integration of heterogeneous components able to provide sea-weather data, including:

a. a forecast component for surface waves and currents, with high levels of detail and reliability, complemented by an high frequency (HF) oceanographic coastal radar system, for the development of nowcasting of sea-weather conditions;
b. a numerical component with dynamic downscaling techniques for processing high-resolution wind and wave data forecasting;
c. a high-resolution modeling of the sea-weather conditions near the landings, to ensure safe access to ports.

The first pillar of the project is made by the data sources to be integrated. These data should be operational, reliable and cover the identified area. For these reasons SINDBAD integrates a broad set of data sources, briefly reviewed as follows.

A. Atmospheric data

Global Forecast System (GFS), a weather forecast model produced by the National Centers for Environmental Prediction (NCEP), has been used as boundary/initial conditions for the operational forecast simulations, based on WRF model; WRF Simulations are then performed over three one-way nested computational domains in Lambert Conic Conformal projection, covering Western and Central Europe and the entire Mediterranean basin with horizontal resolution of 10 km, Northern Italy with horizontal resolution of 3.3 km and the Eastern part of Liguria region with a grid spacing of 1.1 km. The number of terrain-following vertical levels adopted was 35, with higher resolution close to the surface. Every day two operational simulations are performed, initialized with the data provided by the 00 UTC and the 12 UTC GFS runs, respectively. The forecast horizon is 5 days for simulations over the coarser domain and 2 days for the other domains..

B. Wave data

Detailed information about wave conditions have been provided by means of dynamical downscaling from regional data on the basis of the meteorological data obtained through the WRF model (CMEMS and CDS data and in-house forecast system). Wave characteristics are defined through a un-structured mesh to local resolution in order to cover the specific area of the project with a fine resolution not available today. Resolution has been pushed up to some hundreds of meters close to the coast and in shallow water regions. High resolution modeling provides unique information to be conveyed to leisure and local maritime traffic not operating in long routes or open water navigation. This kind of information will be useful not only for leisure and small-range navigation but as well for all the operational maritime activities of small-medium-enterprises that have limited budget in order to buy dedicated services from professional operators, such as small-medium size aquaculture farms and many others.

Detailed information about waves characteristics, such as spectral partitions and integrated quantities,can be employed in order to identify dangerous areas due to crossing seas, and hazardous areas for navigation depending on ship/boat characteristics, providing then a different alert messages for different boat typology than in a future could be included within official AIS messages

The activities related to wave forecasting are developed by the University of Genova (Environmental Engineering Dept, DICCA) which is maintaining an operating forecasting system which has been proved to be highly reliable in the Northern Tyrrhenian Sea that has been exploited either for operational scopes, either for re-analysis activities (www3.dicca.unige.it/meteocean).

C. HF Radar data

Wave field parameters derived from historical data measured by Codar SeaSonde HF radars, operated in the area by CNR-ISMAR, are firstly analyzed in order to identify an effective strategy for their integration with wave models and atmospheric data and for calibration and operational optimization of the HF radars acquisition parameters in the region of interest. Sea surface currents derived from HF radar acquired by the CNR-ISMAR stations located in Monterosso al Mare (SP), Tino Island (SP), Viareggio (LU) have been made available in real time to the SINDBAD platform for nowcasting. To be efficiently integrated into the SINDBAD workflow, HF radar data will be calibrated with respect to ground truth data and completely gap-filled.

New HF radar stations deployments are expected in the same region thanks to the Interreg projects SICOMAR Plus (in western Liguria by 2019) and SINAPSI (near Genova by 2020, with higher potential for wave field measurements). Integration of these new data sources into the SINDBAD infrastructure will be straightforward.

IV. OPERATIONAL ADVICES

A second phase of activity involves the development of an easily accessible web portal able to provide services aimed at the safety of navigation, based on simulation techniques and numerical optimization developed in the project. These services will include:

a. the assessment of the degree of risk and the comfort of navigation by the type of boat;
b. the provision of timely operational suggestions for each user such as: optimal landing, course changes, suggested speed, possible critical sea conditions;
c. the supply of warnings according to the different types of boats and the meteorological data (waves, currents and wind);
d. the forecast of drifting trends in the event of a possible failure.

The second pillar of the project is made by the algorithms and the specific access functions allowing their use by a suitable user interface.

Based on the integration of meteo-marine data, specific algorithms have been developed to provide information on the interaction between weather situations and vessels of different types (e.g. boats, yachts, small cruises, ...). This in order to evaluate the risk and safety conditions for navigation in the selected area and the circumstances for safe tourist and commercial port landings, providing precise operational indications customized for different types of boat.

This latter aspect is particularly innovative because tourism navigation today has very few tools to ensure safety while approaching a port and especially the existing solutions are general and not “boat specific”. The detailed knowledge of the impact of expected weather and sea forecasts on a specific vessel is the key to a personalized alert management service.

A. Seakeeping computation

SINDBAD service relies on an efficient seakeeping computation able to evaluate, for a broad range of typical hulls, the forces and then the acceleration induced by the sea conditions.

The behavior of a floating structure (ship or boat) subjected to waves can be calculated through physical model and then verified on board the vessel. Detailed calculations are performed by computer and the results are specific transfer functions called Response Amplitude Operators (RAOs). For a floating structure we need to calculate the responses for all six rigid motions and for all relative wave headings. SINDBAD server hosts an increasing number of hulls, whose RAOs have been computed in advance. The affine modification of an existing hull allows a fine tuning on a specific boat.

B. Modeling of sea effects on humans

Ship motions are important for determining dynamic loading on the crew, passengers, ship system components, secured cargo, and structural elements. Excessive ship motions may hinder the vessel's ability to complete its journey. A measure of an individual's ability to complete a specific task while on board a moving ship is the Motion Induced Interruptions (MII). It counts the number of events in which a standing person needs support in order to be balanced, measured in occurrences per hour.

Ship motions have obviously strong effects on passengers and crew. It is well known that vessel accelerations (mainly the vertical one) have adverse effects like sea sickness and this reduces the ability of crew to work and distresses passengers. Smaller vessels and tourist boats are more sensible to this effects due to their lower stability.

A good way to estimate the possible occurrence of sea sickness is the Motion Sickness Incidence (MSI) computation. MSI has a standard numerical definition [3] in terms of accelerations, and it quantifies the percentage of people who experience sea sickness during a given amount of exposure time. A commonly accepted limit of MSI is 20% occurrence of sea sickness over a four-hour exposure period.

Today preventive MSI evaluation in different sea conditions is one of the essential issues in order to assess the comfort of passenger on board of cruises and yachts.

C. Dynamic advice generation

Customized operational advices consider explicitly the fact that a given sea height (e.g. one meter) can create enough chop to swamp a small boat, while the same height could not affect sensibly a larger boat. Moreover, the wave period may have a very different impact on different type of boats. For the Mediterranean, we need to consider even mixed scenarios with swell and sea waves. Swell waves can be of considerable danger near port entrances or breakwaters. Swell waves don't enter enclosed waterways, but they may have a strong effect on entrances to these areas. The combination of sea and swell heights indicates the wave conditions experienced by a boat, and its impact is not simply obtained adding one to the other. So, the estimation of the impact of mixed sea conditions on a given boat and the following safety or comfort index calculation is the result of a complex analysis, which justify a subscription to the service in order to get a more specific operational advice.

Given the RAOs and the forecasted sea conditions, SINDBAD platform is able to compute boat accelerations and produce detailed MSI maps for the next hours, so it is possible to inform the user with a reliable estimate of the risk of sea sickness on board in the near future, given the expected trajectory of the boat, and to suggest possible diversions in order to reduce the risk.

The advices will be provided mainly in graphical form, showing a map with the expected risk condition (safety or comfort indexes) specific for the defined/selected boat type in the current navigation path. The user will specify the level of warning on the base of his/her experience, and the alerts will be produced according to the affordable values of the expected indexes.

D. Drift estimation

A specific vertical application inside the SINDBAD server is devoted to the drift estimation in case of a propulsion failure or for the reported loss of a loaded equipment. The availability of sea current nowcasting estimates allows a probabilistic computation of the possible location of the boat itself or of the equipment, expressed as a geographic map at a given time horizon.

V. SINDBAD SERVER AND SERVICE SETUP

An early prototype of the service is expected to be online by the end of 2019 at http://www.sindbad-liguria.it. The SINDBAD portal page will provide the users with the general information about the service as well as it will permit to access the real operational service. The operational version will be online by Spring 2020.

SINDBAD server will provide the users with two main interfaces: the web site and a mobile APP. The web service and the mobile APP have to be very responsive, guarantee good level of availability, and support multiple parallel users sessions.

To this end the back office infrastructure is designed and deployed in order to use the most recent standards in terms of hosting and data access services (i.e. cloud services) and data dissemination tools (e.g. THREDDS, ERDDAP, GeoServer catalogues) and viewing technique (WMS/Leaflet/etc.).

The SINDBAD operational routing advices and the forecasted risk maps for navigation are going to be made available from dedicated pages. Only registered users (subscribers) would be able to access the operational service in which they, once defined/selected the boat size/typology, will be able to interact with the customized version of the service.

Stats on the users and the use of the service will be tracked and made available in compliance with the GRDP. The SINDBAD service adapts and evolves the service infrastructure that the consortium is developing for a local action (Ligurian Sea), but it is intended as a repeatable service for other locations with the same touristic vocation.

VI. ACKNOWLEGMENTS

The SINDBAD Consortium is composed by both public and private bodies. The scientific contents are provided by University of Genova (Environmental Engineering, DICCA, and Naval Engineering, DITEN) and by the Marine Sciences Institute of the National Research Council (CNR-ISMAR).

The service being developed and managed by three research-oriented SMEs (OnAIR, ETT/XEDUM and PM_TEN). The project received funding from the Regional Development Fund POR-FESR 2014-2020 Axis 1 "Research and Innovation" managed by the Ligurian Regional Authority.

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