2.4 WP4000 High Speed Passenger Craft

2.4.1 WP4100 HSC Requirement for Near Real Time Data

Introduction

A major problem in the management of High Speed Crafts (HSC) is their vulnerability to rough seas. In the operational case analysed for the COMKISS project (sea crossings between France, or Italy, and Corsica) we were advised that the HSCs operated by Corsica Ferries are able to sail in comfortable conditions for passengers in sea states with significant wave heights less than 4°metres. This limit was set in accordance with regulations from Certification Authorities and confirmed by Corsica Ferries experience.

Hence, the operational problem is to receive accurate advanced knowledge of sea states that will be encountered in future crossings. From a commercial perspective, the ferry company must be able to inform all its passengers with enough advance notice that the HSC crossing will not be possible because of weather conditions. When this is the case, passengers are transferred to conventional ferries. If the marine weather forecast underestimates the sea conditions, and if very rough seas are encountered, the ship will sail slowly, the journey will be uncomfortable and the passengers dissatisfied, with commercial consequences. On the contrary, if the weather forecast overestimates the conditions, the ferry company will cancel the HSC crossing, which in fact would have been possible; again having commercial consequences.

To face these problems, ferry companies are asking for an improvement in the weather forecasts, based on more reliable observations of sea conditions in the marine area where they operate. This requirement has been analysed in the COMKISS project with particular emphasis on the improvement that could result from a better application of satellite observations on a near real-time basis. The full Work Package report is provided as annex to this final report (Nerzic, 2000)

The analysis was based on Corsica Ferries 1999 summer season (May to September). The routes operated by Corsica Ferries are between Nice (France) and Bastia or Calvi (Corsica), and between Savona (Italy) and Bastia (see Figure 2.8).

Corsica Ferries provided the COMKISS project with data from marine weather forecasts prepared by M t o France and with ship observations during crossings that are summarized in figure 2.9. Satellite Observing Systems provided satellite data for the analyses.

During this period (May — Sept 1999), there were some occurrences of severeweather conditions, with winds up to Beaufort 7/8 and waves up to 4m (the local operational limit of HSC). In one occasion a severe storm was not accurately predicted, causing some trouble in Corsica Ferries operations.

Satellite Data and Weather Forecast

Satellite measurements of sea state and wind over the Corsica Ferries routes were used to assess sea conditions on selected occasions during its operating season. Unfortunately coverage of ERS-2 scatterometer (measuring wind fields) and SAR wave mode data (providing images of sea states) is poor in the Mediterranean, and no data were available in the Corsica region for summer 1999. This poor coverage follows partly from the fact that the ERS-2 SAR is often switched out of its wave and scatterometer modes over the Mediterranean. In any case, the numerous islands in the Mediterranean mean that even when the scatterometer is switched on, valid ocean returns are rarely received on all three of the scatterometer antennas. In the latter case further off-line processing is necessary to retrieve valid wind data, and although a scheme has been developed, these data were not available to COMKISS for 1999. SAR image data were not considered, because the COMKISS budget could not allow extra purchase of these data.

Thus only altimeter data have been extracted. Satellite Observing Systems has extracted wind speed and significant wave height data from ERS-2 and TOPEX, for the months of May to September, for all data within 40¡-45¡N, 6¡-12¡E (Carter, 1999). The ERS-2 data were retrieved from the fast delivery data streams, and so had not undergone any post processing by the designated processing facilities. This can mean that certain aspects of quality control were not carried out and some doubtful data may remain in the data stream. All satellite data were calibrated or corrected according to conversion formulas given in WP4000 final report (Nerzic, 2000).

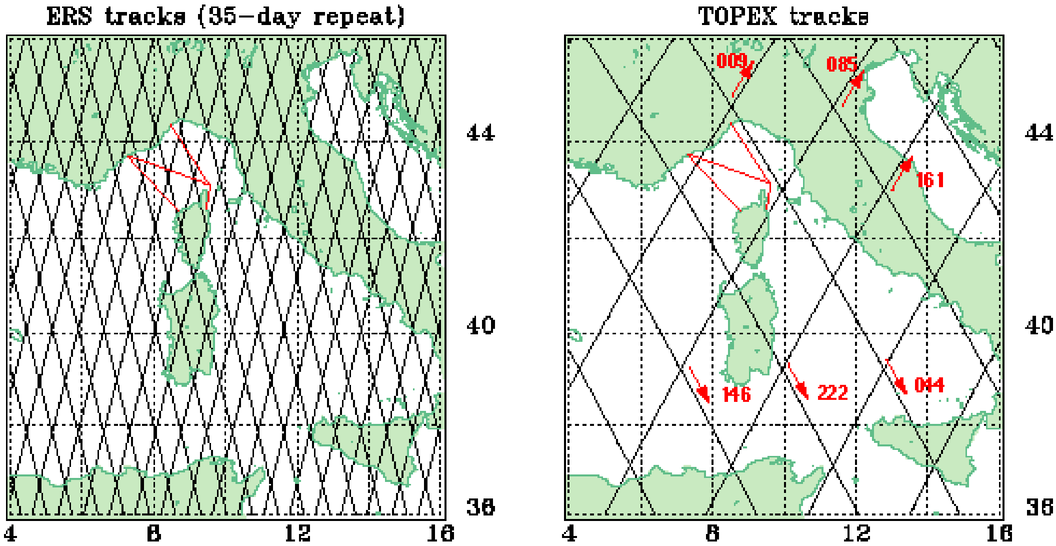


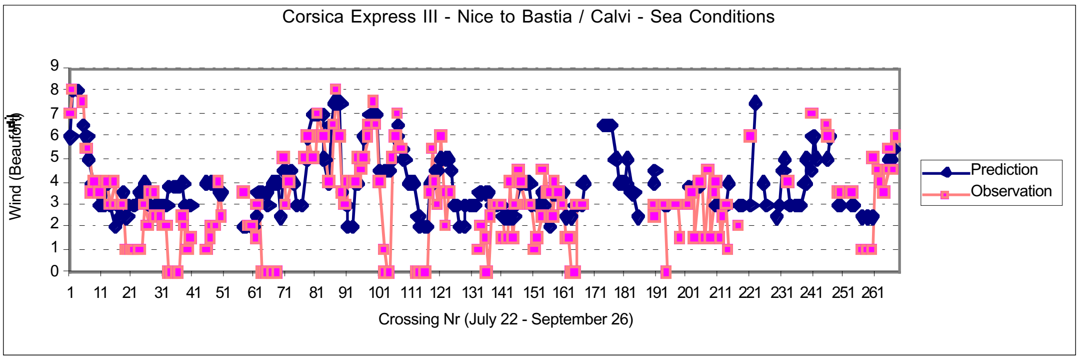
Figure 2.8 ERS-2 and TOPEX tracks (black lines) over Corsica Ferry routes (red lines): Nice to Calvi/Bastia, Savona to Bastia.

M t o France routinely provided weather forecasts to Corsica Ferries. Forecast data were derived from an analysis of meteorological conditions collected by M t o France and from the application of forecast / hindcast models. The meteorological conditions were collected in particular from the ECMWF atmospheric model and from meteorological stations along the Mediterranean coast. Also available were offshore data, such as the marine weather buoy deployed in deep water off Nice. The main models used by M t o France were a wind model for the European area (Arp ge) and a wave model for the Mediterranean Sea (VagMed). The data issued from the models were analysed further by meteorologists from the Aix-en-Provence office of M t o France and then dispatched to Corsica Ferries.

For operational purposes, and also to ensure safe sailing conditions, the company used the marine weather forecast dispatched in the morning (6H30) and in the afternoon (17H30). These very short time forecast data are the most useful data for routine operations. However when bad weather is predicted, with several days notice, the forecast information is of prime importance for planning purposes (for passages by HSC *and* conventional ships). Reports warning of severe weather conditions, occasionally issued by the meteorological office, are also essential for safety reasons; sometimes, bad weather can be predicted only a few hours before it develops in the Mediterranean Sea. In such case, a rapid dissemination of information to all ships in the affected area is essential.

In addition to weather forecast bulletins, Corsica Ferries also uses information from other sources, coastal land stations and other ships crossing in the area. Despite this, there remains a clear demand from HSC operators for more information on weather conditions on a near real-time basis, particularly when sea conditions are changing rapidly.

A summary of morning forecast data and observed weather conditions along the routes is presented in Figure 2.9. In the first analysis of weather forecasts for the Nice —Corsica area, a comparison between predicted and observed data was carried out. An initial overview suggested that predicted wind and wave conditions were generally consistent with ship observations. But a more detailed analysis indicated that during calm wind and wave conditions forecasts generally overestimated, while during severe conditions they sometimes slightly underestimated. This was verified by a regression analysis, which also showed a quite large scatter. The tendency of wave models to underestimate high waves, and overestimate low waves is known to be a common problem (e.g. Sterl et al., 1998).



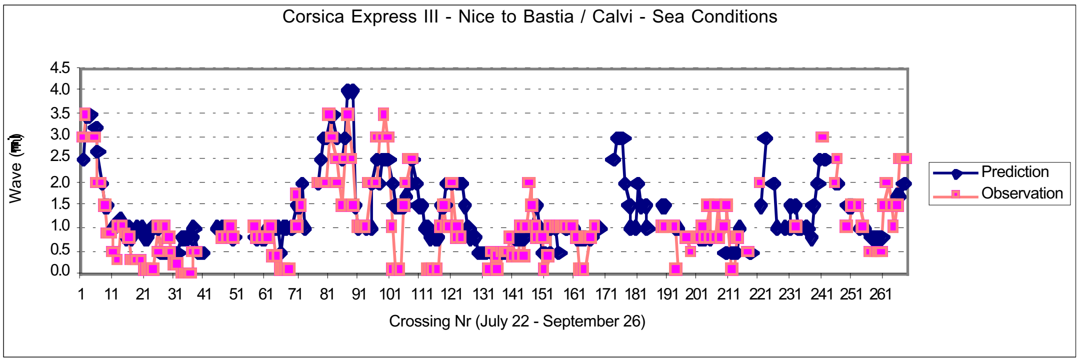


Figure 2.9 Weather forecast and observations on Nice - Corsica routes. Top —wind speed, Beaufort scale. Bottom significant wave height, Hs in m.

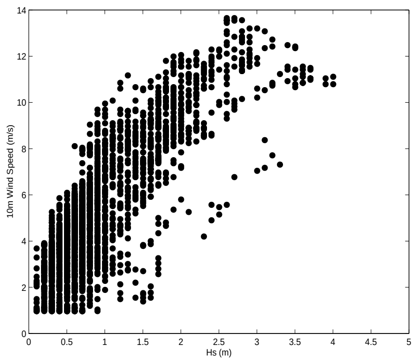


Figure 2.10 Wind — wave scatter diagram from satellite observations

In addition, a basic analysis of wind and wave conditions recorded from satellites in the Nice — Corsica area (cf. Figure 2.10.) indicated a generally good correlation between local wind and significant wave height. But the plot also showed some data that did not have the same properties as the rest of the data: see the data points with wind speeds between 4 and 8 m/s and significant wave height between 2.3 and 3.5m in the lower right of the figure.

Further analysis revealed that these data were recorded on May°21/22, when Corsica Ferries reported divergences between the weather forecast and actually observed marine conditions. The particular weather conditions during this period were investigated in greater detail and it was found that rather unusual weather conditions were experienced during this period, with strong wind gradients and rapid changes in meteorological conditions.

Potential Benefits and Recommendations

The analysis of wind and sea conditions experienced by Corsica Ferries on Nice-Corsica crossings during their 1999 operational season, in relation with weather forecast and with satellite observations, led to some useful conclusions regarding possible improvements of weather coverage for operations by High Speed Craft. It should be noted however that, considering the limited available information on sea condition forecasts, and the lack of in situ wave measurements, some conclusions should have to be confirmed with reference to data from other sources.

First, the analysis showed some limitations on the accuracy of weather forecast in this area of the Mediterranean Sea, where local conditions can influence weather and sea states, and rapid changes from mild to severe weather conditions can occur. This inadequacy is clearly connected to the limited number of observations and measurements of wind and sea conditions in the area, and to the quite low resolution of weather forecast models. These issues are particularly important when one considers the rapid and local changes of weather in the area.

However, the input of satellite observations is too limited at present to contribute to improvements in weather forecast performance. This is because satellite coverage is too sparse, with measurements (for altimeter data) limited to narrow tracks. However, if satellite coverage was widely extended, and if satellite data were transmitted to weather forecast offices in near real-time, this would certainly result in significant improvement in local weather analyses.

Also, if satellite coverage was significantly extended, and if wind and sea observations were transmitted to HSC operators in near real-time, this would give the operators complementary information to aid in decision making with regard to HSC crossings in critical situations, for instance for decisions of whether or not to cancel crossings.

Box 7 summarises the HSC requirements for near real-time data

Box 7. High Speed Craft requirements for near real-time data

More data on actual wind and sea conditions in their operational area.

More reliable weather forecasts.

A network that would dispatch all available information (land and ship observations, coastal and open sea measurements, satellite observations, weather forecast) on a near real-time basis.

2.4.2 WP4200 HSC Performance Related to Wave Conditions

Introduction

Another important aspect of the operation of High Speed Crafts, with respect to metocean conditions, is their behaviour in rough seas. To understand and predict their behaviour, we must satisfy two requirements, to have a detailed characterisation of sea states and an accurate model of ship response to sea conditions. The main objectives of the analysis of HSC performance are to improve the safety of HSC, from a refined characterisation of sea states and to control ship behaviour with respect to passenger comfort.

As pointed out in section 2.4.1, the main sources for sea state characterisation are hindcast models and satellite observations, in addition to in situ measurements which are available only at few locations.

In the COMKISS project, the HSC performance was investigated in relation to satellite data and available hindcast data, based from the lessons drawn from Corsica Ferries experience in the operation of Nice —Corsica routes. Other maritime areas where HSC are operating (English Channel / Manche, Irish Sea, Baltic) have been considered also in the investigation, with the objective of taking account of the sensitivity of HSC performance against different climatologies.

HSC Response to Sea Conditions

The main HSC response parameters that have to be considered for the study of HSC behaviour at sea can be summarized in three categories as follows:

- Accelerations in the 6 degrees of freedom (heave, pitch, roll, sway, surge, yaw), that are of main importance for passenger comfort. Because of the particular behaviour of HSC at sea, compared to conventional ships, these parameters have to be analysed very carefully.

- Ship motions in the same 6 degrees of freedom, which are particularly important for ship manoeuvrability.
- Strains in all structural parts, that are of prime importance to ensure its structural strength.

These parameters are studied and calculated by naval architects and engineers, on the basis of specified local sea conditions in the area of operation, and in relation to the specified HSC performance (operational speed, etc.) These studies then lead to the analysis of operational limits, taking account of passenger comfort and ship behaviour. In the Nice-Corsica area, the limit was set to Hs°=°4m.

For these studies, the following information was requested:

- *Metocean conditions in the area of operation*

Statistics and extreme values of the following metocean parameters over the whole area are needed: wind speed and direction; current speed and direction; tide (when relevant); directional wave spectra.

Among these parameters, the most important are those related to wave conditions, which are of prime importance with respect to accelerations, motions and strains. In general, there are few data on directional wave spectra, and wave data are usually limited to statistics of significant wave height, associated wave period and wave direction,

When available, more detailed wave characteristics such as wave spectral shape, directional spreading and information on crossed seas are also of importance for refined engineering studies.

- *Information on High Speed Craft Performance.*

In particular, information on HSC operational speed and maximum speed, and vessel heading together with relative wave direction, are required.

Specific metocean analyses of HSC maritime routes are necessary in general, and are of particular importance when sea conditions are variable along the route. This is often the case for HSC routes because of local effects near coasts. In the specific case of Nice-Corsica route, there are at least three different areas, one close to Nice which experiences land influences, another in open sea (the area known as Balagne) and a third one near Cap Corse, with specific sea conditions related to the local relief. Detailed analysis of sea conditions along Nice-Corsica route, as well as other HSC routes, would require detailed wind and wave data that were not available. Consequently, only large scale sea conditions from satellite observations were considered.

Climatology Statistics for HSC Performance Studies

Wind speed, significant wave height and period (Davies et al., 1997) can be derived from altimeter data for sea climatology of any maritime area. Other parameters (directional and spectral data) have to be acquired from other sources, either from other satellite instruments such as wind scatterometer and SAR wave mode, from wind and wave hindcast models, or from site measurements.

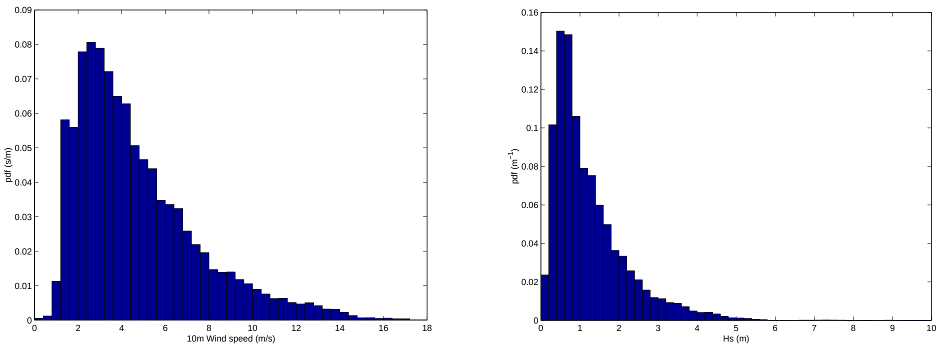


Figure 2.11 Histograms of wind speed and significant wave height from altimeter data

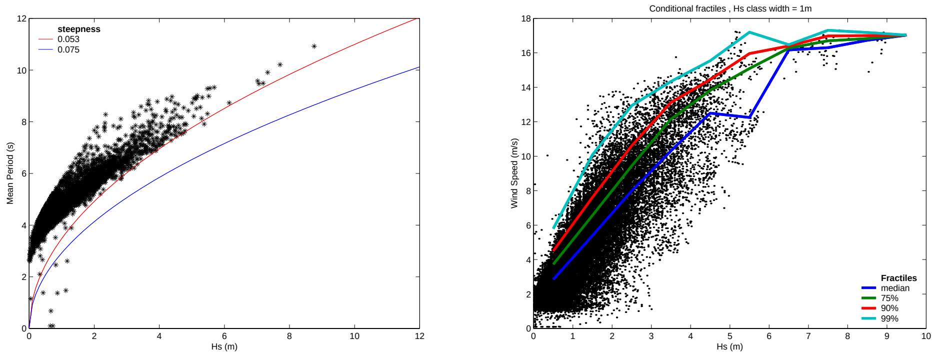


Figure 2.12 Scatter diagrams of significant wave height and wind speed / mean wave period in Nice-Corsica area, from satellite altimeter data

For the Nice-Corsica routes, only altimeter data were available. For the present study, the TOPEX and Poseidon altimeter significant wave height (Hs) wind speed (U10) data, together with an estimate of zero upcrossing wave period (Tz) have been extracted from archived data. Data, covering the period October 1992 to December 1998, have been extracted within the region 40¡-45¡N and 6¡-12¡E. The data are presented in Figures 2.11 (raw histograms of U10 and Hs) and 2.12 (scatter diagram of Hs-Tm in relation with 2 steepness curves, and diagrams of Hs-U10, with conditional fractiles).

The satellite data characterize the local climatology in terms of wind speed, significant wave height and mean wave period, with their correlations. A main advantage of satellite data is that they now cover a relatively long period (over 10 years), which is of evident interest from a statistical point of view, providing information about the interannual variability of wind and sea conditions. However, it must be considered that because satellite coverage is infrequent, peak storm conditions are often not observed and, therefore, wind and sea statistics may not adequately represent these severe conditions.

In addition, it has to be considered that statistics of altimeter data are prepared generally for large maritime areas which would normally be expected to have somewhat different climatologies. In particular, wave conditions are significantly different in open seas and in coastal areas. Also there is evidence that the altimeter may underestimate wind speed (by up to 30%) in semi-enclosed and enclosed seas (Cotton 1999a and 1999b). Therefore, satellite observations must be carefully analysed before an accurate climatology can be derived.

Hindcast data provide an alternative or a complementary source, because hindcast models can produce long time series of wind and sea parameters over large areas. However, although we were able to collect wind fields from ECMWF for COMKISS , we could not easily (and inexpensively) gain equivalent access to wave fields. This indicates that it is not easy to build a local wind and sea climatology from hindcast data for HSC performance studies.

However, there is no difficulty in deriving the wind and sea parameters, mentioned above as required for modelling HSC performance, from hindcast results. This is because hindcast models are able to produce wind speed and direction parameters as well as directional wave spectra parameters over any maritime area. In addition, tide and current parameters can also be computed from models.

But, beside the availability of hindcast data from suppliers, there are also some limitations in the use of hindcast data for HSC performance studies. The wind fields from ECMWF for the Nice-Corsica area have a grid size of 1.125¡ x 1.125¡, and a time step of 6 hours. This grid scale is too coarse to represent the spatial variations and rapid changes of wind and sea conditions that are known to occur in the area. In addition, hindcast models also have some limitations, particularly when used in semi-enclosed or in enclosed seas. This is because the physics involved in the meteorological and oceanographic phenomena are very complex. A recommendation from COMKISS is to use available observations to calibrate and validate hindcast models.

A third source of wind and sea data are surface observations, in three categories:

- observations from land stations,
- ship observations
- site measurements, on land and coastal stations or from buoys.

Land and ship observations are very useful for maritime operation management, because they can be dispatched very rapidly. Such systems are used routinely by HSC operators for decision making.

However, for the purpose of climatological statistics, the accuracy of the visual observations is not, in general, good. Therefore, the observations used for climatological studies are often limited to meteorological measurements from land stations and to wave measurements from wave buoys.

When available, local measurements are of prime importance. Even if they do represent only a local climatology, and even if the duration of site measurements is often limited to a few years, they are the most reliable information. Therefore, when they are used to calibrate or validate other sources such as satellite observations or hindcast data, they contribute to improvements in their reliability.

When climatological statistics are available over an operational area, as a minimum requirement the following statistical data are necessary:

- monthly directional distributions of wind speed (U10) over the area,
- monthly directional distributions of significant wave height (Hs) over the area,
- joint distributions of significant wave height and peak energy period (Hs-Tp),
- typical directional wave spectra, if available.

Then, the HSC performance can be analysed, on a monthly basis if necessary, in relation to operational limits on acceleration, motion or strain. In particular, for instance, this can result in estimates of stand-by duration for bad weather conditions, on a monthly basis.

Potential Benefits and Recommendations

Because HSC are highly sensitive to rough sea conditions, with respect to ship behaviour and hence passenger comfort (of prime consideration), it is of major importance to evaluate their performance in any maritime area where they may operate.

HSC are much more sensitive to sea conditions than conventional ships, which are able to operate safely in rougher seas. HSC behaviour is more sensitive to certain wave properties, such as wave length, directional spreading, crossed seas, all of which must be considered in relation to the HSC heading relative to wave direction. Therefore, for safety reasons and for operational reasons (for example for stand-by estimates), precise local climatology statistics are necessary to estimate HSC performance with accuracy.

From the analysis carried out in COMKISS project, we conclude that the use of hindcast data and satellite observations, validated with site measurements when available, would allow for the development of adequate climatological statistics for HSC performance analyses. There are some remaining limitations that could be overcome with refined hindcast models, with more satellite observations and with more site measurements.