3 CONCLUSIONS AND FUTURE STEPS

The Chapter 3 Structure is as follows:

Section 3.1 Summary of Results and User Recommendations

Section 3.2 Potential Solutions to Offshore User Requirements

Section 3.3 Dissemination and Exploitation

Section 3.4 Meeting COMKISS Objectives

3.1 Summary of Results and User Recommendations

3.1.1 Introduction

In section 3.1 we summarise the COMKISS recommendations for making best use of ocean remote sensing data, both through the enhancement of existing applications and through the development of new applications. As we have noted before, the types of applications fall into three categories: Near real-time data, wave climate databases, and provision of surface current information. We will discuss the recommendations separately for each of these categories, and present the possible ways of making progress in satisfying the recommendations. First, however, we make a brief presentation of the joint COMKISS / OGP (international association of Oil and Gas Producers) Met Ocean Committee workshop, held at the Total Fina Elf Offices in Paris in October 2000.

3.1.2 COMKISS/ OGP workshop

Although the commercial partners of COMKISS represented a good cross-section of offshore users of MetOcean data, the COMKISS team was especially pleased to be able to hold a workshop with members of the SAFETRANS JIP (Joint Industry Programme) of the OGP MetOcean Committee. This allowed a presentation of the COMKISS programme to a number of influential and experienced representatives of the offshore oil and gas production industry. It was to allow this workshop to take place within the COMKISS programme that a two month extension was granted to the COMKISS Work Programme. The workshop programme and minutes are provided as an annex to this final report. We summarise the (informal) conclusions here in Box 12. These conclusions represent a synthesis of opinion, gained from discussions during and following the workshop. The should not be taken to represent the formal view of the OGP MetOcean Committee, as no such formal opinion was agreed (or sought).

Box 12. Recommendations from the COMKISS / OGP workshop.

- A high priority is separate information on swell and sea.
- Good presentation to ensure that ships officers will make use of a service is essential. The data can be of the highest quality, but if they are not presented in an accessible form, then they will not be used.
- Satellite data are useful to the industry, **but** satellites by themselves do not solve any problems, and even more, the satellite data, when they come out of the space agencies, still require significant efforts before they can be used
- Oil industry buys metocean services from providers, they do not develop them in-house, and funding can only be expected for a project which addresses a consensus view on risk assessment and safety criteria. . It should be noted that space agencies should not expect funding support from the industry for the launch of additional satellites.

3.1.3 Near Real Time Data

Requirements

Boxes 7 and 10 gave the user requirements for near real-time data. Many offshore users are finding that they have a requirement for higher accuracy sea state forecasts than are provided by the present sources. Problems are encountered when unexpectedly severe conditions occur. Many forecast sources now have an impressive reliability, but the few occasions when they fail are often during severe events when the consequences are the most serious. It is perhaps surprising that it is difficult to find statistics on the level of reliability with which particularly severe conditions are predicted. Thus we have added a further recommendation (see Table 2.6) for a study (independent of the forecast providers) to investigate the accuracy of sea state forecasts, specifically with regard to their ability to forecast the location and severity of wave fields associated with storms.

There are clear requirements, from all sectors, for a higher density of measurements (in time and space) and for reliable measurements of wave direction and wave period at all wavelengths. The spatial and temporal density requirements vary with the region and the type of craft. Thus trans-ocean shipping are rarely subject to sudden and localised changes in weather and sea state, whereas high speed craft in sheltered seas experience, and are much more sensitive to, a higher level of small scale variability. In the former case six hourly updates, based on a 1 degree global grid, would be satisfactory. In the latter case, at least three hourly updates should be available, and measurements should be available at a resolution to match local variability (< 10 km in coastal regions). These improved data sources would need to be backed up by a network that would dispatch all available information (land and ship observations, coastal and open sea measurements, satellite observations) on a near real-time basis, and must be completed with wave forecasts to avoid overlapping / double services. Table 2.6 summarises the recommended further work to develop and improve near real-time applications of satellite ocean data.

Ref.	What	Who ?	How
NRT 1	Ensure nowcast is consistent with reliable observations.	Academia, Research Institutes	Provide "exact" merging methods of measurements with nowcasts
NRT 2	Provide easy access to near real-time satellite data.	Satellite data providers and resellers, Forecasting Offices	Merge satellite information transmission with that of regular forecasts.
NRT 3	Improve temporal and spatial resolution by at least one order of magnitude.	Government Agencies, and public private partnerships	Launch and operate more ocean observing satellites
NRT 4	Simplify and improve methods to make information available on-board	Government Agencies	NRT delivery of relevant information to value-added resellers that the end-users may then poll
NRT 5	High resolution information in coastal waters	Research institutes, resellers	Merging of satellite (and other) measurements with high resolution local wave models.
NRT 6	Assess ability of wave models to forecast severe sea state conditions	Academia, Research Institutes	Compare (satellite) measurements of storm conditions with forecasts.

Table 2.6 Recommendations of further work to optimise use of Near Real-time Satellite MetOcean data.

Potential benefits

When using near real-time satellite data for operational decisions, the financial benefits are difficult to quantify precisely. This is partly due to the lack of precise information on forecast accuracy of the severe conditions which results in damage or delay, and partly because of the lack of detailed information on the actual commercial cost of such damage and delay. These costs will often be spread across several cost centres of a commercial operation, including such areas as maintenance, insurance, and fuel.

However, we can make a rough estimate. Let us say that, for offshore use, a good near real-time forecast service could save up to 5 days a year on average per ship. At an estimated 20 —30,000 Euro per day, this would come to 100 —150,000 Euro per ship per year. In addition, the reduction in consequential damage could easily build up to several hundred millions of dollars. In fact it could be argued that the insurance companies and cargo owners stand to benefit most from an improved service.

For coastal use, the financial benefits are perhaps even less easy to quantify, because we can add to the above factors the rather less tangible consequences of passenger confidence. However, if we assume 500 passengers each paying 100 Euro per passage, a single cancelled crossing will cost the company 50,000 Euro in lost revenue.

It is known that commercial organisations currently pay of the order of 50 Euros per day per vessel for metocean and routing services. The current combined shipping and oil industry ocean fleet numbers roughly 40,000 vessels. So if we assume, for the purposes of a rough costs estimation, 250 operating days per annum, and a charge of 10 Euros per day for a new metocean daily service, we come to a market value of the order of 100 million Euro per year, in this sector only (not including passenger transport, the military, or the small craft sector). Market studies suggest that one can reasonably expect a 10% market penetration, so we have a final potential market sum of 10 million Euro per year (in the commercial large ship and oil and gas sectors(Stephens, 1999).

In terms of environmental clean up costs, we understand that the expenditure of Total Fina Elf, following the Erika disaster off the coast of Britanny has recently exceeded 500 million Euros. Expenditure by public bodies can be reasonably supposed to be at least equal to this. Thus, if it is assumed that improved sea-state information can reduce the number of incidents such as the Erika, the potential benefits to society run to billions of Euro.

3.1.4 Wave Climate Databases

Recommendations

Box 8 detailed the recommendations on improvements to wave climate databases. The requirements for wave climate databases are well established. For conventional design studies, scatter diagrams of directional wind and wave spectra are required, on a gridded monthly basis. Existing conventional databases provide these with varying degree of geographic and temporal resolution. For some applications (especially coastal) this resolution is not satisfactory. New methods based on Monte-Carlo simulations require a time ordered, gridded, archived hindcast database, to allow multiple calculations of voyages along a given route.

First, we consider applications of more conventional design methods to databases which provide gridded sea state climatologies which are assumed to be consistent year on year. We have seen in Chapter 2 that satellite data can be used to generate joint probability density functions of wave height and period. We have further seen that the estimation is robust, and is at least equal in definition to that which climatological atlases can provide, although a longer time series of data would be preferable. These are the reasons why this sector has already seen the development of a number of commercial satellite based wave climate atlases. However, these new atlases based on satellite derived data have not completely replaced atlases based on data from other sources. It was therefore important to establish where the satellite derived atlases could not match the performance of others. It seemed that the main problems were to do with accessibility (or flexibility). Often database designs were too rigid to allow new procedures to be applied.

Directional and spectral information are also of vital importance. Although SAR data have been available for nearly 10 years, there is still an apparent lack of confidence in the wave parameters derived from this instrument.

Now we consider the applications where time ordered data are desired, for instance the fail-safe calculations of Bureau Veritas, or the Monte Carlo design methods.

We saw in the fail-safe studies for Bureau Veritas that data were required to provide information on the evolution of the consecutive sea states, so that information with time regularity was very important. Databases containing archived output from hindcast models can provide this information, on their own satellite data cannot. This provided the incentive for the research activities based at the University of L nd, which developed a very important and useful basis for understanding the (stochastic) nature of statistics necessary for calculating fail-safe conditions, particularly when neatly arranged time ordered data are not available.

We were also confronted with the need to provide improved reconstruction of the sea-state that prevailed during classification and certification trials. We suggest such applications must involve the combined use of satellite archives and wind/wave models.

We also noted that alternative ways of dealing with some of these problems were available. For instance it would be possible, and in some instances desirable, to generate a satellite based equivalent of the time ordered hindcast archives through some intelligent combination with hindcast models. However, we argued that safety assessments should be approached in a stochastic manner. This is not yet current practice everywhere, but models were developed which were built upon such an understanding, and allowed the more direct use of satellite data.

Ref.	What	Who ?	How
WC 1	Provide time-histories, and/or alternative techniques to Monte-Carlo simulations	Academia, Research Institutes	Characterize the sea state temporal and spatial process, and give methods to estimate the corresponding parameters
WC 2	Provide detailed spectral and directional information on sea states	Academia, Research Institutes	Improve processing algorithms (note that altimeter periods are of great use).
		Government Agencies	More accessible, and better coverage of, satellite derived directional wave products
WC 3	Simplify access to satellite data, have formats suitable for industry applications	Government Agencies	Better organisation of archive databases
		Satellite data providers and resellers	Improve extraction and compilation methods, go one or several steps beyond climatological atlases.

Table 2.7 Recommendations of further work to develop the use of climate databases holding satellite MetOcean data.

Table 2.7 summarises the recommendations for development of climate database applications.

Potential benefits

Satellites are able to provide a vast amount of environmental data containing oceanographic parameters, which is useful to vessel operators. They can provide measured data at a much higher spatial and temporal resolution than was previously possible. These data are of reliable quality in all areas of the ocean, and are not biased towards any particular type of conditions.

High quality satellite wind and wave spectral data can enable the development of more precise design techniques, perhaps allowing overseas transports which were previously not feasible, but certainly allowing better estimates of safety margins.

It is again difficult to put a price on these developments. Conventional wave climate databases do not command a high price, perhaps a few thousands of Euro. More, the volume of such sales is not large. However, databases which allow the development of more accurate design techniques, or improved estimates of safety may be able to command a higher price. This may be particularly so in the light of recent incidents (Erika, Ievoli Sun - http://www.ifremer.fr/com/ievolisun/), which as we have seen can cost the public purse and private companies billions of Euro. Shipping safety is coming under the spotlight again, and it seems that new legislation is under consideration.

3.1.5 Surface Currents

Recommendations

- Box 11 summarised the conclusions and recommendations of the surface currents study. It was found that there was certainly scope for satellite data to provide a near real-time service which would represent a significant improvement to that presently available. However, some of the necessary processing techniques are not yet well enough developed for such a service to be created at the present time. Thus, some further background development is required.

Ref.	What	Who ?	How
SC 1	Market Study	Sponsored Consultancy project	Define commercial system, including: preliminary market study, cost benefit assessment, outline system specification delivery mechanisms
SC 2	Application Development	Joint programme, with industry and academia	Develop, trial and cost an operational near real-time surface current data service.

Table 2.8 Recommendations of further work to develop the use of satellite MetOcean data in provision of surface current information

Potential Benefits

If a commercially viable system of interest to offshore users is to be realized, it is necessary to demonstrate that worthwhile cost savings can be realised. In addition, there may be an opportunity to develop a more complete intelligent advice system, ship or office based.

Savings would be realised through reduced journey time (or reduced ship speed), resulting in a saving of fuel, or, with improved accurate knowledge of expected voyage duration, more efficient use of expensive port facilities. Fuel is a major component in the costs of ocean transport, and potential savings are significant. For example if improved surface current information allowed a moderate 0.5 knot improvement on an average 10 knot speed over a 2000 NM voyage, the journey time would be reduced by10 hours. Assuming an average fuel consumption of 30 tonnes per day, consumption would be reduced by 12.5 tonnes. For slower or larger vessels the savings could be even more significant. Port facilities are highly priced, and so any unused quayside time is an expensive and unnecessary cost.

3.2 Potential Solutions to Offshore User Requirements

3.2.1 Introduction

It was never the purpose of COMKISS to suggest that satellite data could, or should, completely supersede other metocean data sources. The aim was rather to identify how best use could be made of these new data sources which are now available, and to indicate what new developments would have the best impact on offshore activities. Thus within this section we explore the ways in which the expressed desires and recommendations of offshore operators can be met best.

The foregoing pages of this report have revealed the large potential that exists for the better use of satellite data. However, it can be argued that the various modes of metocean data provision and application have not changed sufficiently to enable commercial users to take best advantage of these new data sources. Until now, use of satellite data has largely been limited to assimilation into existing (or modified) wave forecast models, or to the development of climatological databases for use in design techniques which have not markedly changed. We suggest that a more innovative approach should be encouraged, which may suggest the adoption of new design and forecast methods.

We will first discuss the general techniques that are available, before moving on to consider in more detail how each recommendation might be met. Broadly speaking there are four ways of making more use of satellite data:

- Improved processing of existing data sets, to present them in a form which is more accessible to the non-expert user, or to generate secondary parameters which are of interest.
- Merging of satellite data with other data or model output.
- The launch of new satellite systems, targeted specifically at operational use.
- The development of new statistical techniques for use in design methods, which will enable the more direct use of satellite data.

We discuss each of these in more detail below.

Improved Data Processing

Satellite data sets currently provided by the centres appointed as distributors by the space agencies (AVISO, CERSAT) are rarely in a form accessible to the non-specialist user. This is because the data centres seem to concentrate in providing the data in a form suitable for academic studies. Thus the role being taken up by value added companies (often SME s) is to interpret and process the data into a form more suitable to industry users. The wave climate databases of OCEANOR, ARGOSS, Meteomer, and Satellite Observing Systems represent such an activity. However, we suggest that there is scope for more activities in this area. One suggestion from users has been that it should be possible to query databases on line, and request information in a specific desired format.

An example of value added services is provided by Jenifer Clark s Gulfstream . Here a number of different types of satellite data have been processed into higher level data sets by academic organisations, and are then freely available on web sites. However, a further level of interpretation and merging is required before a product of use to the non-expert user is generated (sea surface current maps).

Thus the extra processing can be quite sophisticated (the generation of maps of geostrophic sea surface current variability from altimeter range data), or almost trivial (the bringing together of a few different sources of freely available information). However, they each perform a service in making the data accessible to the inexpert offshore user.

Data sets currently not well used are image data of all kinds (SAR, ocean colour, SST). These data sets require intensive processing, often with subjective human intervention. This is because the image contains information from a mix of influences which can interact in complex ways (see for example Topliss et al., 1994). To date it has proved difficult to develop generic processing schemes to enable the extraction of selected geophysical (e.g. sea state) parameters. An extra barrier to the routine exploitation of long time series of image data is the high cost of individual scenes.

New Merging Techniques

For short term sea state forecasting, the major part of the offshore industry continues to rely on existing suppliers of data. These include, or are based on products supplied by, the national meteorological agencies. These large agencies often seem to be unwilling to be innovative with regard to the inclusion of new data sets into their forecast or database systems. Often the only use they make of satellite data is in the validation of existing models or through assimilation into modified forecast models. As satellite data now represent by far the largest single source of measured ocean data, this situation does not seem to the COMKISS partners to represent the best use of satellite data.

In particular the COMKISS end-users have expressed that sea state model nowcasts should be consistent with reliable measured data. Their officers wish to know the very best estimate of local conditions and cannot understand why once a model has assimilated some measured data it can continue to be inaccurate at the point of assimilation. In particular they lose faith in forecasts once the nowcasts have been seen to be wrong (even only once). In contrast, they are able to place extra faith in information that includes reliable direct measurements. Thus one of the major recommendations of COMKISS is that new techniques for combining satellite measured data with wave nowcasts and forecasts should be developed. The principle is that reliable measured data should be used to generate the nowcast wave field at regular synoptic periods. This renewed nowcast is then used as the starting point for each new forecast. The development of this technique, currently applied in a number of geophysical disciplines (including seismology), lies at the heart of the COMKIAS proposal, outlined later in this chapter (Section 3.3.1)

The COMKIAS proposal is aimed at offshore use. However, models and satellite data can also be usefully merged to provide climate and real-time information close to the coast. We have explained that satellite altimeters by themselves cannot provide information close to the coast. SAR image data could in principle provide information close to the coast, but as we have noted, processing schemes have not yet been developed which can successfully, and automatically, extract the information on waves that may in principle be available. At present the best way forward is provided by the combination of satellite data and wave models. In a UK study, JERICHO, Cotton et al., (1999) demonstrate how shallow water wave models can use satellite measurements as boundary conditions to derive wave climate information close to the coast. However, they found that the wave models had to be set up anew at each new coastal location, where local in-situ data were required to allow suitable adjustments to model parameters. Once the models were setup, historical satellite measurements could be used to generate a longer term climatology. In a similar vein, a European study, EUROWAVES (Cavaleri et al., 1999), proposes a technique to provide wave climate information based this time on a generic application of the SWAN wave model (Ris et al., 1999), the boundary conditions being provided by the larger grid ECMWF wave model, verified against satellite and other measured data sources.

New Satellite Systems

Up to now, satellite missions providing oceanographic data have been driven by the requirement to satisfy academically defined scientific goals, or the need to prove and develop new technology. Although the data sets they have produced have been shown to have a wide range of applications, with one exception, the missions have not been designed to have a long term operational remit. This exception is the US NOAA TIROS (advanced Television InfraRed Observation Satellites) series, which carry the AVHRR (Advanced Very High Resolution Radiometer) instrument to map sea surface temperature, in operation since 1978, (Vasquez et al., 1995). More recently there has been a move to provide operational provision of ocean winds, through satellite-borne radar scatterometers. However, one could not yet regard this provision as operational. Also, because until now it has been relatively expensive to build and launch a satellite, there has been a tendency to build in a high level of redundancy and place a lot of instrumentation on a single platform. This increases the costs of satellite missions, so that ENVISAT will cost an estimated 3 billion Euro. There is now a move to cheaper, smaller satellites (Zheng, 1999). Such satellites, so called micro-satellites, may weigh 100kg rather than many 1000s kg, they require much less power and may be built and launched for millions, instead of billions, of Euro. We suggest that this type of satellite, with their much lower cost, will provide the most likely option for operational provision of EO data over the ocean.

New Statistical Techniques

As a result of the studies carried out at the University of L nd for WP3000, we propose this fourth option. Existing design method techniques have been developed to work with the form of data that has been most widely available until now. That is gridded climatological databases, or archived wave hindcasts. Satellite data provide the most prolific source of measured data, and it is suggested that that new techniques should be developed to make use of these data. Thus the techniques proposed by Baxenavi et al., (2000a) and (2000b) recognise the essentially stochastic nature of sea state forces, and make use of satellite data to provide random samples of sea state. It is clear that further development is required. In particular the techniques should be expanded to make use of directional and wavelength information (e.g. from Synthetic Aperture Radar). However, we believe that these studies provide a valuable step towards the development of new design method techniques.

3.2.2 Near Real Time Data

There are 6 main recommendations (Table 2.6) for Near Real Time Applications

NRT 1 Remove Nowcast Discrepancies

The need here is to develop new merging techniques to combined a higher volume of measured data with output from wave models (see above discussion). Here the measured data will be used to define the current state, rather than as a means to adjust a model defined state. Some new research is required here, and so we have suggested that academic and research institutes are involved in some developmental studies and trial applications. The development of these new techniques forms part of the COMKIAS proposal, which will be presented briefly in Section 3.3.1

NRT 2 Provision of Satellite Information with Regular Forecasts

One problem for users of forecasts is that they cannot know the reliability of individual forecasts. One way of dealing with this problem is to provide actual measured information along with the nowcast from which the forecast is obtained, then the user can himself judge the accuracy of the model prediction. This tends to increase faith of the user in the service provider. The Satellite Observing System s Sea State Alarm service provides an example of such a service.

NRT 3 Improve Temporal and Spatial Information.

It seems clear that the only way to provide better *data* coverage is through an increase in the number of satellites providing data. The radar altimeter is the least expensive (and the most accurate) instrument which measures waves from space. However, it makes a measurement in a narrow beam (5-10 km wide) directly under the satellite.

It is relatively simple to calculate the coverage that a series of such satellites can provide. A satellite on a near polar orbit at heights of 600-800 km will complete about 14 orbits a day, taking roughly 100 minutes (1.67 hours) to complete each orbit. Thus adjacent tracks are separated by about 25¡ at the equator. Each orbit contains an ascending and a descending pass, on opposite sides of the earth, thus satellites in a single orbital plane will provide 12 hourly coverage of any given region. If a measurement is to be available within 200 km of any location at 6 hourly intervals (a specification suggested by offshore users), the maximum track separation must be 400km (or roughly 4¡ at the equator). Thus there should be 6 satellites within each orbital plane. If 6 hourly coverage is desired, this requires a further 6 operational satellites launched into a second plane, offset from the first by close to 90¡. Thus a total of 12 operational satellites would be required to provide the requested service. The GANDER proposal (see section 3.3.1) has shown how such a service could be provided, through the use of relatively inexpensive microsatellites.

In 2001 two new satellites with wave measuring radar will be launched, ENVISAT, and JASON. Both will have near real-time data capability. However, even with two satellites, sampling will be sparse. According to the above calculations the best coverage we can hope for is tracks 12.5¡ apart (1375 km), with 12 hourly coverage. Nonetheless this will double the availability of near real-time data. It is planned that COMKIAS and Sea State Alarm will carry out trials to test the added benefit.

Swath measuring instruments potentially provide better coverage. For instance the US Quickscat radar scatterometer provides measurements over a 1800 km swath width and generates 90% global coverage every day. However, at present there are no swath-type satellite instruments that are able to provide wave measurements. The French SWIMSAT proposal, being developed by CETP (Hauser, 2000) proposes such an instrument (again see section 3.3.1).

NRT 4 Simplify and improve methods to make information available on board

An important recommendation is that all satellite missions which generate potentially useful metocean data should have a near real-time data provision facility, allowing a delay of 3 hours or less between the time of measurement and the dissemination of the data to users. These data should be (electronically) available to meteorological agencies and to value added companies who can then ensure easy access to end-users

NRT 5 High Resolution Coastal Information

We have already shown that 12 or more satellites carrying radar altimeters would be required to supply the suggested offshore coverage (measurements within 200 km every six hours). The coastal requirements are even more restricting (~10 km every three hours), implying a requirement of 60 satellites in each of four planes — 240, all told. Thus it is not realistic toexpect that satellite altimeter data can meet the coastal data requirements. The present state of the art scatterometers (e.g. Quikscat) provide wind fields with a daily coverage at 25 km resolution, and so we could not get wind fields at the necessary resolution from even these instruments. Finally there are SAR image data. These data have been seen to provide highly detailed information of wind wave variability near the coast (see e.g. Alpers et al, 1998). However, even if the already noted processing and cost problems can be overcome, coverage is again limited. The ERS-2 SAR has a swath width of 100 km (giving a latitudinal coverage of 2800 km per day, so one such satellite would take approximately 15 days to provide complete global coverage.

Therefore in the short term the best option is likely to involve the use of high resolution regional models, merged with remotely sensed data where they are available.

The ability of HF wave radar to measure ocean waves has been demonstrated by a number of researchers (see. e.g Wyatt 1999). Other developments have demonstrated how a modified ship s X-band radar can measure local wave fields (Reichert et al., 1999). A combination of these measurements with local wave models (validated by in situ data) should be able to provide a more reliable service in coastal waters.

NRT 6 Investigate Accuracy of Forecasts in Critical Conditions

When planning the development of a new forecast system, it is important to know how much one can hope to improve on existing sources, so as to be able to assess the potential value of an improved system. Thus it is necessary to have a good understanding of how well the existing forecasts perform in critical situations, those conditions under which most losses occur offshore. Most forecasts assessments that are publicly available seem to provide overall statistics, which indicate good performance in general terms, but they do not provide a focussed assessment of severe conditions, when one may expect that it is most difficult to provide accurate forecasts. We thus recommend an independent study to assess the performance of wave model forecasts during storm events.

3.2.3 Wave Climate Databases

There are 5 main recommendations (Table 2.7) for Wave Climate applications

WC 1 Provide Time Histories, or alternatives to Monte Carlo Simulations

Because of the incomplete sampling of global wave fields, gridded time histories can only be provided when measurements and model hindcasts are combined. At present satellite data are used to validate the hindcast data locally, and are not included as an intrinsic part of such databases (see e.g Cox et al, 2000). It is suggested that better use could be made of the satellite data. The new data merging techniques we have suggested in response to recommendation NRT 1, could be used in the generation of a new series of hindcasts to provide an alternative hindcast archive — one which contained an exact representation of reliable measured data.

We have already addressed the need for industry to consider new techniques for design methods, which are better suited to the measured data that are available. Baxenavi et al., (2000a and 2000b) provide a starting point for such developments, but more work is required.

Both these aspects would require a combination of academic / research institutes, with direction provided by a co-operating end-user.

WC 2 Better Provision of Spectral and Directional Information

Directional and spectral information are of a high priority for offshore users. However, although such parameters are available from SAR wave mode products, and these parameters are included in climate databases and wave model assimilation schemes, SAR wave data have yet to gain the widespread acceptance that altimeter data now have.

We suggest that a problem lies within the processing and distribution of wave mode data by the ESA appointed distribution agency. For a new data set to become accepted by a group of users the data must first be easily accessible. Even a moderately low cost on new data sets can make them unattractive, when the potential benefits are uncertain. It could be argued, with strong justification, that altimeter data would not have gained such wide acceptance if thousands of Euro had been charged for the use of the global Geosat and TOPEX altimeter data sets. In addition there is an apparent confusion about the best processing scheme to apply to SAR wave mode data, perhaps stemming from the need to apply a wave model based first guess in the interpretation of wave spectra.

For ERS SAR wave mode data to be better and more widely used, we suggest that they should be re-issued, with processing based on a well regarded algorithm, at a price set only to cover distribution costs. The schemes for distribution of ENVISAT wave mode data are currently being established. We would again suggest that anything above a simple distribution cost price will limit the potential user community to expert academic groups.

WC 3 Simplify Access to Satellite Data / Improve Extraction and Compilation Methods

It is well known to all users of satellite data that in the majority of cases it is easier and quicker to retrieve data from US databases than European databases. With this ease of access to US databases, any extra charges or difficulties placed in the way of accessing data from other sources simply result in these other data not being used. We believe therefore that the agencies responsible for data distribution must maker greater attempts to make the data sets more accessible and should be adequately funded to do this. Otherwise European researchers and value added industries are placed at a disadvantage with regard to their competitors/colleagues in the US.

If some of the initial data processing and cost burden is lifted from the value added industries, then they will be better placed to invest in the development of more sophisticated data extraction and compilation tools for use by their customers.

3.2.4 Surface Current Applications

There are 2 main recommendations (Table 2.8) for Surface Current applications. They could be brought together under a single Applications Development programme.

SC 1 Market Study

It seems likely that there is scope for better use of satellite data with regard to provision of surface current data. However, the size of a potential market for such products is not well defined. There is also a need to establish end user requirements and to determine service specifications and delivery mechanisms. A short-term market study would define the value of the potential market and establish the commercial viability of a new satellite based surface current prediction system. In addition the survey would help to determine whether a system should be limited to a data service, or included as part of a more comprehensive ship advice system.

SC 2 Application Development

There are scientific and technical problems to be overcome. We have seen that present techniques need further development and improved validation. There is also a need to investigate ways to blend information from various data sources.

Such a study would require a partnership between research institutes, value added companies and a commercial end-user (either a shipping company or a routing company). A first stage would develop and refine the processing techniques used to generate the near real-time current data sets, and would be followed by a full scale operational trial including transmission of data to an offshore operation. Finally, after a review of the trial various options of a fully operational service would be investigated.

3.3 Dissemination and Exploitation

Exploitation of the COMKISS results has already commenced, through the highly successful COMKISS/OGP workshop. It is intended and hoped that this connection between the OGP and researchers with expertise in the use of satellite data will continue, at least in an informal way. Further routes of exploitation are planned through proposals for joint research or applications development programmes, for funding under various mechanisms. In addition we highlight some proposals for new satellite missions, which could provide improved operational coverage.

Other exploitation will take place through the distribution of copies of the COMKISS final report and other material, and through presentations at appropriate forums, such as workshops and industry discussion meetings.

3.3.1 Proposals /Applications

COMKIAS (Conveying Metocean Knowledge into an Advisory System)

COMKIAS is an innovative proposal to develop and test a pre-market advanced marine on-board advisory system. The COMKIAS system will combine on-board load measurements with on-board and remote sea state data (including near real-time satellite data) and high quality forecasts, to generate advisory information for vessel operation and planning. A two stage, three year, programme is proposed. An initial development stage includes a market study and the development of key components of the prototype advice system, including the development of new techniques to merge satellite data and models. The second, implementation stage will assemble a prototype COMKIAS system and carry out trials on selected end-user offshore operations. Thus the COMKIAS programme will address a number of the key recommendations from COMKISS (NRT1, NRT2, and NRT4). The COMKIAS proposal was initiated by one of the COMKISS end-users, Dockwise, and builds on some experience within the Joint Industry Project SAFETRANS. The COMKIAS partnership now includes SEMA, Ecole de Mines, IFREMER, Dockwise, University of L nd, OPTIMER, and Satellite Observing Systems. The team was advised that the COMKIAS proposal did not fit well into the key activities being addressed by Framework V, so the intention is to seek EUREKA status and look for industry sponsorship.

SEAROUTES

SEAROUTES is a Framework V proposal, now accepted, in the Growth programme. SEAROUTES is led by the Technical University of Berlin and was initiated quite independently of the COMKISS work, but embraces a number of the recommendations that have come from COMKISS (NRT 2, NRT 4 and NRT 6). The SEAROUTES proposal aims to develop an advanced decision support system for ship routing based on full-scale ship-specific responses, and improved sea and weather forecasts including synoptic, high resolution near real-time satellite data. The project is particularly directed at high speed craft for which new response models will be developed. One of the key aspects is the use of near real-time satellite data, although they will be used in a relatively conventional way —assimilated into the ECMWF wave model. However, the accuracy of these forecasts under critical conditions will be examined.

SEAROUTES has 10 partners (including Satellite Observing Systems), with a mix off industrial and academic partners. It will commence in January 2001, and run for three years.

GANDER

The GANDER programme proposes the launch of a constellation of microsatellites, each carrying a wave measuring radar altimeter. Detailed technical studies have shown that a micro-satellite platform could carry such a radar on a 100kg platform providing 50W of power (Jolly et al, 2000). A constellation of 5 such GANDER satellites could be built and launched for approximately 40 Million Euro. It has been shown that, to ensure a continuous service, some redundancy is necessary and failure must be allowed for. Thus a constellation of 16 would be required to provide the ideal coverage recommended by the COMKISS offshore users, requiring 12 operational satellites (see section 3.2.2 recommendation NRT 3). Such a system would cost commensurately more although there would be some savings through the benefits of bulk production. Altimeter data rates are low, so the ground segment of the operation would be relatively simple to establish, and could be based largely on existing infrastructure. It is intended that the GANDER system will be a complete end-to-end ship advice system, providing forecasts and nowcasts to the bridge from the GANDER central office. It would incorporate wave models through the new merging techniques recommended by COMKISS. Thus GANDER addresses all the NRT recommendations under NRT (1-5), except NRT 6 (coastal information). Although a detailed market study (Stephens, 2000) has demonstrated that a GANDER system could be economically self supporting, substantial initial start up funding is required, some years before revenue starts to flow. Thus it would be difficult to gain adequate investment purely from the private sector, and some initial support from public funds will be necessary.

SWIMSAT(Hauser, 2000)

SWIMSAT is a proposal, under preparation at the French Laboratory CETP (Centre d tudes des Environnements Terrestre et Plan taires, for a satellite mission carrying a real aperture wave measuring radar, for submission as one of the European Space Agency s Earth Explorer Opportunity Missions. The radar will make directional wave measurements along a ~200km swath, providing directional spectra at 15¡ resolution in wavelengths from 50-500m. SWIMSAT thus addresses recommendation WC 2, and if it operates a near real-time data delivery system, could also address recommendations NRT 1, 2, 3 and 5.

AltiKa (Vincent et al., 2000)

AltiKa is a project within the French space agency (CNES) to build a Ka band satellite altimeter, possibly to be launched as a partner to JASON-2. Moving to Ka band (a higher frequency than Ku band) allows a lower power altimeter, with a smaller antenna, and so allows the possibility of a dual frequency altimeter on a microsatellite platform. However, the higher frequency also renders the radar signal more vulnerable to attenuation by atmospheric liquid water. Note that, in contrast to the purely wind/wave measuring basic GANDER design, AltiKa will be a range measuring and wave measuring altimeter. In consequence it is also a higher cost satellite.

GAMBLE

GAMBLE is a proposal for Thematic Network under Framework V. The proposal, currently under review, is led by CNES and Satellite Observing Systems. The intention is to build a co-operative network of all major altimeter experts in Europe to ensure that complementarity of proposed altimeter missions is exploited to the full. Satellite altimeter missions approved and under consideration are ENVISAT, JASON (Escudier et al. 2000), GANDER, Altika (Vincent et al, 2000), and SWIMSAT (Hauser, 2000). Under the GAMBLE proposal a number of themed workshops will take in expert opinion to advise on the specification of new missions, and on the joint processing of data from different missions.

Surface Currents

Satellite Observing Systems intends to generate a proposal for an applications development project, in partnership with a major ship routing company and an end-user company. The proposal will take into account the COMKISS recommendations, but is presently in the early stages of development.

3.3.2 Workshops, Space Agencies, and Other Opportunities

COMKISS OGP workshop

The joint COMKISS /OGP workshop has already been discussed, and further details are provided in an annex to this report. It is intended that the workshop will open a dialogue between the COMKISS partners and the OGP Metocean committee. The Final COMKISS report will be distributed to members of this committee.

European Space Agency

We were grateful for ESA s participation in the COMKISS /OGP workshop in the person of Jerome Benveniste, from ESA/ESRIN. The COMKISS final report will be provided to key people within ESRIN, who are responsible for the exploitation of EO data, with an invitation for feedback and discussion. Satellite Observing Systems hopes to present COMKISS results at the first post launch ENVISAT symposium.

CNES (Centre National d Etudes Spatiales), and AVISO

The COMKISS final report will be provided to key people within CNES and the distribution agency AVISO, again with an invitation for feedback and discussion. Satellite Observing Systems is a member of the JASON Science Working Team, and aims to present COMKISS results at the post launch JASON SWT in October 2001.

Other Opportunities

All COMKISS partners will aim to present COMKISS results at appropriate industrial and scientific meetings in the coming year. A full distribution list is being drawn up and will be available to the EC scientific officer

3.3.3 COMKISS Material for Dissemination

COMKISS material available for dissemination in early 2001 will include:

- The full final COMKISS report plus annexes.
- All COMKISS scientific papers and technical reports:

Baxenavi A., K. Podg rski, and I. Rychlik, Distributions of Responses experienced by a vessel, 23 pp, September 2000.

Baxenavi A., G. Lindgren, I. Rychlik, and L. Tual, A statistical analysis of satellite data of wave parameters in the Mediterranean and Northern Atlantic Ocean , 31 pp, September 2000.

Cotton P. D., 2000, Final Report for WP5300, Surface Currents from Satellite Measurements, Technical report for COMKISS , Godalming, UK, June 2000.

Leenaars C., S. Louazal, and P. Brugghe, 2000, Comparison of wave databases and design methods for major shipping routes, COMKISS WP5100 Scientific Report, 77 pp, July 2000.

Nerzic N., and M. J. C. Prevosto, 2000, *COMKISS Project — WP4000 High Speed Passenger Craft°— Final Report*, Optimepublished Technical report for COMKISS , Brest, France., 45 pp, October 2000.

- The COMKISS web site: http://www.maths.lth.se/matstat/staff/georg/comkiss
- The COMKISS Demonstration Modules at http://www.ifremer.fr/metocean/shipping/shipping.htm
- The COMKISS Executive Summary report
- A CD containing all the above. Documents in pdf format, other information as HTML.

3.4 Meeting Project Objectives

In the COMKISS proposal and Technical Annex, the principal project objective was defined as:

To demonstrate to major segments of the European marine transport industry the benefits of integrating satellite derived information on sea state with the more conventional methods used by them at present.

We believe that, with this final report and the dissemination of the material listed above, this primary aim has been amply fulfilled. In the later stages of COMKISS, the joint OGP / COMKISS workshop provided an ideal opportunity to demonstrate applications of satellite data to an informed and powerful group of users. In the end, what was perhaps anticipated as a one-way demonstration of applications has very definitely developed into a two way process. Whilst the industrial partners within COMKISS have been fully involved in the testing of some trial applications, and have accepted the value of satellite data in a range of applications, they have provided important feedback to the scientific partners of their needs from wind and wave data sources. Thus, the scientific partners of COMKISS have learned some valuable lessons on the methods and needs of end-users, and many of the recommendations coming at the end of the COMKISS project are directed at data providers, rather than data users. We can thus add a rider to the primary objective:

To communicate to value adders, research institutes and space agencies the operational requirements of offshore end-users for sea state data.

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