

# USER REQUIREMENTS FOR SAR DATA IN THE COASTAL AND MARINE ENVIRONMENT

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## ABSTRACT

Several efforts have already been undertaken to analyse user requirements for Earth observation (EO) data in the marine and coastal environment. However, little has been done to identify the specific requirements for Synthetic Aperture Radar (SAR) data. A fundamental component of the current EU 5<sup>th</sup> Framework project Marine SAR Analysis and Interpretation System (MARS AIS), deals specifically with user requirements explicit to SAR data and SAR application capabilities. The project aims to identify and involve potential end users of SAR data and to generate end user feedback, which in turn will be fed into the development of an operational MARS AIS prototype focussing on sea state, winds, slicks and surface currents near fronts and internal waves.

The collation of end user feedback was achieved using a range of interview techniques, end user workshops, and a Context of Use (CoU) survey. The latter included a questionnaire survey in 2002 to assess SAR data needs, capability and capacity constraints, benefits of SAR data use and perceived obstacles to SAR data use.

Analysis of the 96 CoU survey questionnaires returned shows potential for greater exploitation of SAR data and SAR derived products within the coastal and marine environment. End users showed a preference for processed products and more frequent temporal coverage. Cost emerged as a primary obstacle to the use of SAR data within the coastal and marine community.

## 1. INTRODUCTION

Earth observation (EO) data provides a valuable contribution to the monitoring and management of the marine and coastal environment. Over the last decade Synthetic Aperture Radar (SAR) data has increasingly been employed for a number of applications of specific relevance to the coastal and marine environment e.g. detection and monitoring of oil slicks, sea state, high resolution wind field, shallow water bathymetry, ship detection and fisheries management [1, 2, 3]. In order to exploit the maximum potential of SAR data in the marine and coastal environment it is essential to understand the needs and requirements of coastal and marine end users and to incorporate this into the development of SAR products [4].

Having reviewed the available literature, it has become clear that a number of efforts have been undertaken to analyse user requirements for Earth observation (EO) data in general [5, 6]. However, little has been done to identify the specific requirements for SAR data in the marine and coastal environment. Thus, a key objective of the EU 5<sup>th</sup> Framework Project MARS AIS, is to ensure that user driven SAR derived products are developed and effectively exploited [7, 8, 9, 10].

End user involvement is pivotal in the development and refinement of the MARS AIS prototype. By incorporating end user opinion in the research, their information needs are recognised and a tangible transfer of requirements into applied technology can be achieved. MARS AIS looks to determine state of the art analysis and interpretation capabilities for SAR image data and to allow for a more user-friendly exploitation of the large volume of existing SAR and other remote sensing data in Europe in the context of the coastal and marine environment. End user feedback was attained using a series of interview techniques. However, this paper focuses specifically on one aspect, namely the Context of Use (CoU) survey.

## 2. METHODOLOGY

As one of the components of MARS AIS, a multi-faceted end user requirements work package was designed to assess end user requirements. A number of mechanisms were utilised: literature review; consultation with MARS AIS User Group (MUG)<sup>1</sup> and MARS AIS Advisory Group (MAG)<sup>2</sup>; end user workshops (Germany [Hamburg, 2001], Ireland [Cork, 2002]), Greece [Athens – EuroGOOS, 2002], Norway

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<sup>1</sup> The MARS AIS Users Group (MUG) refers to potential end users who provided input to the end user requirement work package, contact with these key end users was maintained throughout the duration of the project.

<sup>2</sup> The MARS AIS Advisory Group (MAG) is composed of a group of SAR experts who act as external consultants throughout the lifespan of the MARS AIS project providing feedback and recommendations where appropriate.

[Svalbard – Workshop on Coastal and Marine Applications of SAR, 2003]); Context of Use (CoU) survey; product and project reviews; dissemination and promotion of project information. The aforementioned mechanisms enabled the project team to collate significant information on current and potential end users of SAR data within the coastal and marine environment.

This paper focuses on one feature of the end user requirements study, namely the CoU survey. The CoU survey involved the analysis of the data obtained from respondents to a questionnaire. The CoU questionnaire survey was undertaken between April and November 2002 to identify the requirements of current and potential end users of SAR data within the coastal and marine environment. The style and format of the MARS AIS questionnaire was developed in close consultation with the project partners. Previous studies involving end user questionnaires, e.g. EuroGOOS Data Requirements Survey [5] and MAG recommendations were taken into consideration and influenced the final development of the questionnaire.

The CoU survey focused on eight potential applications of SAR data use (pollution incidents, current features, waves, wind, ice, natural films, internal waves and shallow water bathymetry) and the nature of use associated with these applications (examining the following eight variables: geographic coverage; SAR product type; delivery medium; latency of delivery [time from the request for data to the delivery of data]; spatial resolution; temporal resolution; forecast period and synergy). In addition, respondents were asked to provide their opinion on limiting factors in their use of SAR data. The choices focused on cost, capability and capacity.

The Coastal and Marine Resources Centre (CMRC) built up a database of contacts relating to potential end users of SAR data. The Potential User Database (PUD) was generated to house the contact details of individuals and organisations considered to be potential end users of SAR data. The value of this resource is pertinent to MARS AIS but also to end user research currently underway in initiatives such as Global Monitoring for Environment and Security (GMES) [11].

Using the PUD the MARS AIS questionnaire was distributed to almost 500 remote sensing/SAR experts, coastal managers and individuals in other marine application domains (such as harbour authorities and offshore operators). In order to obtain feedback individuals were contacted by phone, by e-mail and in person (via workshop and conference attendance). All returned questionnaires were examined for

completeness and quality. Ambiguities were clarified by direct communication with the respondent.

### 3. RESULTS

Questionnaire respondents were grouped into the following sectors of activity: transport, energy production, environmental protection/preservation, mineral extraction, defence, engineering, services, basic and strategic research and other. For the purpose of analysis, respondents were also categorised into the three broad user categories of commercial, academic and government sectors. A variety of methods were used to obtain feedback (which reduced bias in the selection of respondents), resulting in a wide geographical distribution of respondents.

Individuals from the aforementioned sectors of activity returned completed questionnaires from 19 countries. A total of 96 completed questionnaires formed the basis of the CoU survey results, 65 were from the MARS AIS partner countries (Ireland, Norway, Germany, Greece, France, UK) seven were from other European countries and 24 were from outside Europe. This rate of response is considered good [12] and forms an adequate sample base for the purpose of the research. The number of responses varied according to the sector of activity.

The highest number of respondents came from within the environmental protection and preservation sector, followed by those in the basic and strategic research, service and engineering sectors. The defence, transport, mineral extraction and energy production sectors all featured in the response to a lesser extent. The number of respondents who do not use SAR data at the moment exceeded the number of SAR data users by a ratio of 3:1.

Respondents indicated a strong preference for the use of SAR imagery in the examination of current features, shallow water bathymetry and pollution incidents. Lower levels of interest were demonstrated for the use of SAR data in relation to features such as internal waves, wind and waves.

In a choice between cost, capability and capacity, cost was cited as the most significant limiting factor in the use of SAR imagery in the marine and coastal end user community. The issue of cost was found to relate to both the price of the data and the associated pricing scheme. The former is significant due to the actual expenditure involved and the latter is a complex system that can appear perplexing even to experienced SAR users [13].

Capability (training and skills) and capacity (infrastructure) also influence the use of SAR data [13,

14] in the coastal and marine environment. The CoU survey showed that the effects of capability and capacity on the use of SAR data among end users are intrinsically linked.

The results of the CoU survey highlighted a number of issues relating to the following variables: SAR product type; geographic coverage; delivery medium; synergy; and temporal resolution within the coastal and marine end user community.

The responses indicated a clear requirement for processed imagery, as opposed to raw data and statistics. In addition, the demand is highest for SAR data acquired closer to the coast rather than in the open ocean.

At present, SAR data users largely employ disc as a delivery medium, with a strong demand for networked data also apparent. SAR data users frequently use optical data and infrared data in synergy with SAR data. Examples of such synergy are demonstrated in the MARS AIS project e.g. use of AVHRR and SAR to examine current fronts. Respondents also expressed a strong desire for synergy with hyperspectral data should the opportunity be made available in the future.

There is a demand from the coastal and marine end user community for more frequent temporal coverage, particularly in the case of pollution incidents where the immediate post incident period is critical in the monitoring and containment of the spill.

#### **4. DISCUSSION**

The level of response to the questionnaire varied between sectors. Despite efforts to obtain a balanced view from a wide audience of end users, the feedback was predominantly from the environmental protection, research and engineering sectors. Where prudent, gaps identified within the response were followed up by conducting informal interviews. This additional material and other elements of ongoing work will be included in the final user requirements document.

The low level of response from the defence, marine transport, mineral extraction and energy production sectors could also suggest that some effort should be directed towards increasing awareness of the potential of SAR data for these marine and coastal activities in particular.

The comparatively low response for the use of SAR data for studying wind and waves is surprising and potentially misleading as we know that SAR derived ocean wave spectra are assimilated into the WAM model at several weather centres (i.e. European Centre

for Medium-Range Weather Forecasts [ECMWF]). Trends in demand are also likely to be influenced by the availability of sophisticated products. For example, relatively sophisticated SAR data products currently exist for oil spill detection and shallow water bathymetry [15, 16, 17, 18]. A gap exists in the availability of mature end user orientated SAR products for other application areas such as for ocean surface current applications.

In relation to product availability it is important to note that SAR algorithms relevant to the monitoring of marine parameters are currently at different levels of maturity. As a result, certain applications are at a more advanced stage than others. Thus, further basic research is needed to improve SAR data analysis as described in the expert papers presented in this document.

The level of expertise of an end user will greatly influence their capability to access and utilise SAR imagery. Users need to consider the cost of improving capacity and capability (investment in hardware and employing or training individuals to interpret SAR data) against the increased cost of purchasing processed data.

SAR data providers, including the European Space Agency (ESA), should take steps towards the simplification of pricing schemes to ensure maximum uptake of SAR products by potential end users, in particular by first time and non-expert end users. Initiatives such as Open Distributed Information and Services for Earth Observation (ODISEO) are a positive step in this regard. Similarly, ESA's implementation of the category 1 and 2 pricing schemes is to be welcomed and certainly supports a wider use of SAR data. Data cost effectiveness, accessibility and distribution have also been identified as key issues to be addressed by the GMES initiative [19].

The survey results indicate that many organisations lack the capacity and capability to access and interpret SAR imagery for themselves. This coincides with a gap in the marketplace for interpretive, value adding services; particularly in relation to less mature and emerging application areas, such as those related to wind fields and sea state. Value adders are a crucial link between raw data providers, who distribute SAR data, and the end users who need valuable information relevant to their activities. The challenge is to provide well developed products and/or services to suit end user needs at an attractive cost.

Support should be provided for SMEs willing to maximise new opportunities to exploit SAR data in the marine and coastal environment. As an example, some end users are not interested in SAR data itself, but rather in the information that can be derived via thematic maps

to aid decision making. SAR data products should be developed with the level of expertise of the end user in mind. Tools should be adapted for use by non-specialists.

The promotion of SAR data products for the marine and coastal environment should be focused on concrete examples where efficiency, availability and affordability can be demonstrated. This is a key factor for consideration by the MARS AIS consortium and other EU FP5 research projects of a similar nature.

Careful attention should be paid to the strong trends that emerged in the results for particular variables in the development of future SAR products and technologies (e.g. demand from the coastal and marine end user community for more frequent temporal coverage, particularly in the case of pollution incidents).

Solving current environmental problems often requires more than one algorithm or model. The potential of combining multiple tools to produce more generic products should be examined. In some instances, SAR products of this category may be more marketable than single application products. Combining slick detection and wind retrieval algorithms for improved wind estimates is one example.

The CoU questionnaire survey was designed to reduce or eliminate sources of potential bias or ambiguity and to be as representative of the user community as possible. Despite this, certain limitations were identified during the analysis of the data, in particular, the low number of responses to the questionnaire from certain sectors (e.g. marine transport and mineral extraction as already mentioned). Rather than being a failing of the sampling regime this may simply be due to the different levels of maturity and advancement of SAR use within certain sectors.

## 5. CONCLUSION

The conclusions on end user requirements derived from the CoU survey will be used as guidelines by the MARS AIS consortium in the future development of generic coastal and marine applications for SAR, both within and beyond the scope of the MARS AIS project. Although MARS AIS is a three year funded FP5 project, due to end in December 2003, the post project options for utilisation of the tools and products are outlined under the Technical Implementation Plan (TIP) to be delivered before the end of the project.

The findings of the CoU survey, with the overall results of the end user work package, will be useful to scientists involved in developing tools and algorithms for SAR data (including the MARS AIS project consortium),

policy makers and stakeholders concerned with the distribution of SAR data, value adding commercial entities, and coastal and marine area managers interested in learning more about applications of SAR in their working environment.

The results of this survey should not be considered in isolation. It is important to bear in mind that the future of coastal area management involves the use of EO based technologies in integrated management systems, where EO products will be integrated into intelligent systems capable of assimilating different types of data to produce what is requested by resource managers.

The above recommendations are of relevance to the GMES Services Element programme which focuses upon the delivery of policy-relevant services to end users, primarily (but not exclusively), from EO services. The results of the CoU survey were disseminated to appropriate audiences in ESA and the EU.

In summary, this survey shows that there is potential for the further development of SAR data, targeted towards the desires of end users in the marine and coastal environment. This potential can be realised through continued basic and applied research into the application of SAR data for use in coastal and marine environmental monitoring.

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