Galileo and EGNOS will bring vast amounts of new possibilities to many application areas in the maritime domain. The maritime uses span from Safety of Life (SoL) and Security, to highly specialised niche applications in navigation, positioning, offshore and surveying.

Common to most of the professional areas is that the user will require extensive validation of the navigation system before he can rely on the system as a primary source of navigation and positioning. Simply put, any new services using Galileo input should be proven for accuracy and integrity before it will be used, even by traditional high technology, professional sectors, let alone the mainstream.

Typically, for SoL applications there are international requirements that must be met and should influence the specifications of the system. This task has been addressed by several GNSS (Global Navigation Satellite System) development programmes.

However, there is also a continuous need to contribute to the development of these requirements so that they eventually reflect the new opportunities — or the ‘technology push’ of the new systems.

**Work in progress**

Latterly, the subject of tailoring the Galileo signals for the maritime industry has been addressed by the formation of several international working projects including MARUSE and MARGAL, both co-ordinated by Kongsberg Seatex.

The MARUSE consortium, which has been formed to further study the benefits of future use of Galileo to the maritime and inland waterways industries, is a Galileo Joint Undertaking (GJU) project. The GJU is a joint office of the European Space Agency and the European Union.

The MARUSE consortium, made up of 15 companies, focuses on technology and application development, implementation and demonstration in key maritime applications where utilisation of Galileo will be a clear benefit. Typically, these are professional, high-end applications where the benefits are improved security, safety and efficiency of a broad range of maritime operations.

The MARGAL project aims to identify a number of cases based on the forthcoming Galileo satellite constellation and the EGNOS (European Geostationary Navigation Overlay Service) differential correction signal, with the ultimate goal to provide a seamless harmonised service of increased accuracy positioning at sea and inland.

Utilising AIS and positioning experience and equipment from Kongsberg Seatex, the project is set to provide improved Vessel Traffic Service (VTS) and vessel control from the sea through to rivers. Specifically, MARGAL addresses challenges related to:
- Port and harbour approach
- General navigation
- Vessel movement monitoring
- Inland waterways monitoring
- Precise navigation and calamity abatement.

**Special applications**

Regarding special applications the validation process might be somewhat different. An example is applications that today are utilising commercial, differential GPS (global positioning systems) to achieve the necessary accuracy and integrity for their purpose.

If the new systems such as EGNOS and Galileo should be able to eventually replace the
existing system, they should go through a long-term validation process building confidence to the users, and this is what projects such as MARGAL and MARUSE intend to do through the use of technology demonstrations, such as the prototype demos that took place at the end of 2005 in Budapest and Harwich.

Navigation service performance in the maritime sector has traditionally been focused on accuracy. The other performance parameters, like integrity, continuity and availability, have rarely been addressed in quantitative terms.

However, this situation is about to change. The four element service performance model associated with aviation is gradually being adopted also by the maritime community and the standardisation bodies.

Since maritime navigation and positioning consists of a variety of applications and types of vessels this forms a very complex and challenging scenario. It is difficult and expensive to assess representative and realistic requirements for all these situations. It is, however, important to note that the four service performance parameters are correlated. The hierarchy is shown in Fig 1.

The accuracy performance influences the performance of integrity since it will be directly related to protection levels. Accuracy also influences the continuity and availability parameters since increased accuracy requirements will reduce the capability to meet this requirement at all times and under all conditions. The same argument can be applied to the other levels of the pyramid.

Professional applications

Two main drivers for the development of the Galileo signal in the maritime market can be identified as regulations (eg IMO) and performance.

An important part of the professional market will be driven by performance requirements since the ability to operate safely and efficiently will depend on the ability to accurately and safely monitor the position, velocity and heading of the vessel under all types of conditions.

Some of the most challenging operations are those of docking and where vessels have to work close to other vessels or structures. For instance, offshore operations are sometimes conducted under the most extreme weather conditions since the economical consequences of terminated operations are huge. Safety-of-life and the risk of pollution of vulnerable environments are also of great concern during vessel manoeuvres at sea or in port.

It is usually assumed that availability of satellite signals is satisfactory. This is not always true, since port and offshore operations often take place close to huge man-made structures like oil platforms and production units, cranes or hangers which can cause a ‘shadow’ on the signal, making it unavailable in certain positions. These structures may not only make a challenging environment due to blocking of the signals, but also by interference since many types of equipment actively use radio frequencies for different purposes. These factors affect availability and continuity performance. Accuracy and integrity will additionally be affected by a factor like multi-path of the satellite signals.

The requirements in the offshore sector have led to the development of high performance DGPS (Differential global positioning system) solutions based on using data from multiple reference stations to achieve sufficient performance, although these applications have yet to be adopted fully by the general shipping and port industry.

International regulations

At the core of all standardisation and regulation activities within the maritime field is the IMO (International Maritime Organization). The IMO is responsible for measures to improve the safety of international shipping and to prevent pollution from ships. The IMO Conventions and protocols have treaty status in most of the world, and the most important Conventions are accepted by countries whose combined merchant fleets represent 98% of the world total tonnage.

The most important of all maritime safety instruments is the Safety of Life at Sea (SOLAS) convention. Chapter V of SOLAS deals with the safety of navigation, including carriage requirements of navigational equipment. All such equipment must comply with the performance standards set out in the various IMO resolutions.
The two resolutions — A.953(23) and A.915(22) — form a backbone of IMO’s requirements for future Maritime Radio navigation Systems. A.953(23) gives the formal requirements and procedures for accepting new systems as ‘components of the World Wide Radio navigation System (WWRNS)’, while A.915(22) is a ‘positioning’ document related to the requirements for future developments of GNSS to be considered within the framework of A.953(23).

A.915(22) distinguishes between requirements for general navigation and positioning and lists a long range of applications with different requirement allocations. A summary of the requirements is given in Table 1.

Among the various developments taking place for enhancement of GNSS, the following systems have been recognised by IMO as potential future candidates for the World Wide Radionavigation System:

- Eurofix; a DGNSS service based on a chain of Loran C stations (the future of Loran C in Europe is currently under debate)
- WAAS/EGNOS/MSAS
- Galileo.

Since resolution A.915(22) is still a ‘positioning’ document, high risk operations have led to the development of other types of requirements and recommendations. An example is requirements related the use of Dynamic Positioning (DP), specifically used in offshore operations but in recent years adopted in some part by other sectors of the marine industry, such as cruise shipping.

The IMO has developed a set of requirements related to three classes of DP operations. The DP class requirements define the minimum number of active position reference systems that should be in operation.

For the most critical types of operations at least three active systems are required, and at least two of them are to be based on different principles.
This means that it is possible to use two GPS-based systems in combination with one other system (for example Kongsberg Seatex’s RADius, radar-based system).

There is no doubt that these requirements should be refined by adopting methodology from other applications, like aviation. Several GNSS programs have addressed the standardisation issue like SAGA (Standardisation Activities for Galileo) and GARMIS, which has resulted in a draft of Galileo standards for maritime applications.

Integrity is about how trustworthy the positions from the reference system are, assuming that the system is in good physical shape and operating within its specifications. There is always a risk that the position information is incorrect or that the system fails to provide position information because it is out of service.

A system with good integrity capability will indicate an out of tolerance situation by different indicators and by raising alarms. Then the user can choose not to use the system or even terminate the operation to avoid an unsafe situation. It is also important that the system raises the alarm if the integrity capability for some reason is not maintained.

Standalone GPS can provide a certain level of integrity by self-monitoring (RAIM) but safe operations require differential corrections or wide area augmentation systems to provide sufficient integrity. The integrity capability is generally increased with access to data from many different sources.

With access to data from multiple sources like several DGPS reference stations and Space Based Augmentation Systems like WAAS, EGNOS (DPS 116 and DPS 132) and Galileo Local Elements, it is possible to provide an unmatched level of integrity performance.

The development towards more stringent requirements, driven by IMO, and a need for improved performance in some critical maritime markets, requires initiatives to meet new challenges within safe navigation and positioning, such as those Kongsberg Seatex is involved in.

It will be necessary to establish supporting activities for bridge performance offered by these systems, and user competency levels and institutional requirements. A considerable amount of work is underway and the collaborations of MARUSE and MARGAL are working towards the utilisation of the new generation of European satellite signals.

The potential in Galileo is great, but there is still work to do before the new systems are fully trusted and therefore an integral part of life at sea.

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