# Marine and Offshore Telematics Systems

Adam Weintrit

Gdynia Maritime University, Faculty of Navigation
Al. Jana Pawla II 3, 81-345 Gdynia, Poland
weintrit@am.gdynia.pl

**Abstract.** Throughout the field of transportation and vessel systems control is gaining importance. This paper focuses on the current key problems engineers in this field are facing and highlights some major recent accomplishments. In the fields like marine or offshore systems, the focus of research is on the swarming behaviour of multiple vessels. New sensors and networking will also enable more efficient traffic flow control which will allow for a better use of the resource network capacity. A forecast on future trends in marine and offshore telematics systems including e-Navigation concept is given at the end of the paper.

**Keywords:** offshore technology, telematics, IT, marine control systems, transport systems, e-navigation.

## 1 Introduction

The advantage of the latest technical development in the field of automation, electronics, telecommunications, informatics, telematics, geomatics and global position fixing techniques, achievement in maritime and offshore data storing, processing, analysing, transferring and visualisation should be taken into account and applied to the maritime and offshore systems. In the paper the Author defines offshore industry entities: offshore constructions and offshore supply vessels, tries to discuss the key issue and priorities of e-Navigation concept, including hydrographic data, position fixing and communications, as well as satellite navigation systems, the use of telemetry on offshore worksite, autonomous marine control systems installed on board of unmanned surface vehicles (USVs), unmanned underwater vehicles (UUVs) and remotely operated vehicles (ROVs), describes marine and offshore telematics systems which are revolutionizing not only shipping but also the boating industry, and finally governance of offshore IT outsourcing. A forecast on future trends is given at the end of the paper.

## 2 Offshore Industry Definition

In an industry encompassing functions of drilling, exploration, production and environmental protection competitiveness will be determined less by sheer size and

J. Mikulski (Ed.): TST 2012, CCIS 329, pp. 334–348, 2012.

asset holding and more by agility, speed of response, and capacity for innovation. This can be axiomatically stated of the offshore oil & gas industry today.

### 2.1 Offshore Constructions

Offshore construction is the installation of structures and facilities in a marine environment, usually for the production and transmission of electricity, oil, gas and other resources.

Construction in the offshore environment is a difficult and dangerous activity. Construction and pre-commissioning is typically performed as much as possible on land or inshore areas. To optimize the costs and risks of installing large offshore platforms, different construction strategies have been developed.

One strategy is to fully construct the offshore facility inshore, and tow the installation to site floating on its own buoyancy. Bottom founded structure are lowered to the seabed by de-ballasting, whilst floating structures are held in position with substantial mooring systems.

The size of offshore lifts can be reduced by making the construction modular, with each module being constructed onshore and then lifted using a crane vessel into place onto the platform. A number of very large crane vessels were built in the 1970s which allow very large single modules weighing up to 14,000 tonnes to be fabricated and then lifted into place.

Specialist floating hotel vessels known as flotels are used to accommodate workers during the construction and hook-up phases. This is a high cost activity due to the limited space and access to materials.

Oil platforms are key fixed installations from which drilling and production activity is carried out. Drilling rigs are either floating vessels for deeper water or jack-up designs which are a barge with liftable legs. Both of these types of vessel are constructed in marine yards but are often involved during the construction phase to pre-drill some production wells. Other key factors in offshore construction are the weather window which defines periods of relatively light weather during which continuous construction or other offshore activity can take place. Safety is another key construction parameter, the main hazard obviously being a fall into the sea from which speedy recovery in cold waters is essential.

The main types of vessels used for pipe laying are the "Derrick Barge (DB)", the "Pipelay Barge (LB)" and the "Derrick/Lay Barge (DLB)" combination. Diving Bells in offshore construction are mainly used in water depths greater than 120 ft, less than that, the divers use a metal basket driven from an "A" frame from the deck. The basket is lowered to the water level, then the divers enter the water from it to a maximum of 120 ft. Bells can go to 1500 ft, but are normally used at 400 to 800 ft.

Offshore construction includes the design, construction, and/or repair of offshore structures, both commercial and military, including:

- subsea oil and gas developments,
- offshore platforms - fixed platforms, semi-submersibles, spars, tension leg platforms (TLPs), Floating Production Storage and Offloading (FPSOs), etc.

- Floating Oil and Gas Platforms - semi-submersibles, spars, TLPs, FPSOs, etc.

## 2.2 Offshore Supply Vessels

These are cargo vessels that regularly transport goods, supplies or equipment in support of exploration or production of offshore mineral or energy resources. Offshore supply vessels are typically operated by shipowners: either companies set up specifically to own and operate such vessels or companies combine with other vessel operations like salvage, shipping, etc.

The general mission of supporting offshore oil and gas exploration and production can be sub-divided according to specific mission requirements. Also vessels may involve in more than one kind of such specific missions. Like every other design criteria, optimizing based on the priority is done in the design process, and also meeting the safety requirements.

These specific missions include:

- seismic survey to locate oil and gas bearing areas
- towing of rigs and platforms to their location, positioning them, and laying anchoring & mooring equipments
- supplying rigs and platforms with necessary personnel, equipment, stores, provisions, etc.
- subsea operations like ROV operation, diving support, inspection, and maintenance,
- safety standby.

Offshore vessels can be divided into the following types:

- Platform Supply Vessels. These are used for transporting supplies to the rigs and oil platform and return other cargoes to shore. The supplies include fuel, fresh water, equipments, consumables, stores and provision for the operation of the oil platforms and for the personnel onboard. The design and construction of these vessels depend on the working environment - weather conditions, distance from the shore, and hence design varies by location. These ships range from 20 to 100 meters in length and accomplish a variety of tasks. The primary function for most of these vessels is transportation of goods and personnel to and from offshore oil platforms and other offshore structures. In the recent years a new generation of Platform Supply Vessel entered the market, usually equipped with Class 1 or Class 2 Dynamic Positioning System;
- Multi-purpose Supply vessels. These are similar to the Platform Supply Vessels but are fitted with additional systems for example, for subsea inspection, maintenance and repair;
- Anchor Handling vessels. These are used to towing and anchor handling and are fitted;
- Seismic vessels;
- Crew boats;
- Safety / Standby vessel;
- Combination vessels.

**Table 1.** Modern merchant ships

| | |
|---|---|
| Dry cargo | Barge · Bulk carrier · Lake freighter · Car float · Coaster · Collier · Container ship · Heavy lift ship · Hopper barge · Lighter aboard ship · Reefer ship · RORO ship · Submarine Cargo Vessel · Train ferry · Livestock carrier |
| Tankers | Chemical tanker · FPSO unit · LNG carrier · LPG carrier · Oil tanker · Tanker · Gas Carriers |
| Passenger | Cargo liner · Cruise ferry · Cruise ship · Ferry · HSC · Narrowboat · Ocean liner · RORO ship · Train ferry |
| Support | Dive support · Fireboat ·Supply ship · Tender · Towboat · Tugboat |
| Other | Pipe-laying ship · Cable layer · Crane vessel · Dredger · Drillship · Fishing vessel · Icebreaker · Merchant submarine · Narco submarine · Research vessel · Riverboat · Semi-submersible · Snagboat |

## 3 Key Issues and Priorities of e-Navigation

e-Navigation is the future, digital concept for the maritime and offshore sector. Larger and faster ships, greater congestion and reduced manning levels have all provided the impetus for this development [5]. Considering the wide range of options and benefits that could become part of e-Navigation, the primary value of e-Navigation is to join the ship's bridge team and sea traffic monitoring teams to create a unified navigation team that would achieve safer navigation through shared information. For full implementation of such a system it would need to be mandatory for SOLAS vessels and scaleable to all users.

It was suggested that before the primary benefits and value-added services could be realised, an architecture comprising three fundamental elements should first be in place. These are:

- Electronic Navigation Chart (ENC) coverage of all navigational areas (WEND - Worldwide Electronic Navigational Chart Database);
- a robust electronic position-fixing system (EPFS), with redundancy; and
- an agreed infrastructure of communications to link ship and shore.

Specifications for these fundamental elements are contained as follow.

### 3.1 Hydrographic Data (ENCs)

A full coverage of ENCs for navigational waters will require considerable effort from the world's hydrographic community. It has further been noted that the existence of proprietary updating software in many ECDIS systems has become a key cost issue when implementing ENC data. It is thought that if, through IMO, an open architecture system could be agreed, this would allow a more competitive environment in the purchase, and maintenance of ECDIS systems thus reducing the overall costs of ENC's and increasing the global rate of acceptance. From the seaman's point of view there is unsolved question of responsibility for correction of information presented by ECDIS and ENC updating.

### 3.2 Position Fixing

Electronic position-fixing systems, which could be integrated into e-Navigation, can be divided into Global Navigation Satellite Systems (GNSS), GNSS augmentations, terrestrial radio-navigation systems and non-radio positioning systems. There are two operational GNSS at present (GPS & GLONASS) and two more planned: European - Galileo and Chinese - Compass. It has long been recognized that GNSS require augmentation to achieve the required integrity for safety of life applications and the accuracy needed for specialized navigation and positioning. Augmentation systems fall into two broad categories: Ground Based (GBAS) and Satellite Based (SBAS). GBAS (IALA) maritime beacon system has been the standard GNSS augmentation system for maritime applications. SBAS is based on two operational (WAAS, EGNOS) and two planned public service (MSAS, GAGAN).

There are many high accuracy, local terrestrial radio-positioning systems provided, mostly on a commercial basis, for specialized applications. However, the only terrestrial radio-navigation system with widespread, regional coverage is Loran-C. The Far East Radio-Navigation System (FERNS) is provided under an international agreement between PRC, Russia, Korea and Japan and extends from the Bering Straits to the South China Sea. Saudi Arabia also has a system, covering its own territory and the Arabian Gulf. Non-Radio Positioning Systems is the Inertial Measuring Unit (IMU), usually integrated with GNSS to enhance it and cope with outages.

The problem of fixing position coordinates for navigational needs considered only in terms of measurement error seems to have already been solved in a global scale. Its realization with higher or lower precision is only a function of the technical solution adopted. Therefore, other, equally important, although often omitted, exploitation parameters of navigation systems become crucial. These are: availability, integrity, continuity and also reliability.

The following is a list of key elements required for e-Navigation position fixing:

- appropriate accuracy, availability, continuity, and integrity (alert limit, time to alarm, integrity risk), already included in IMO Resolution A.915(22);
- adequate redundancy;
- compatibility between systems; and
- appropriate datums (vertical and horizontal).

There is also necessity to develop a unified theory of the some navigational criteria (availability, reliability, continuity, and integrity) under consideration and to determine the relations between them, because:

- reliability and availability refers to different functional structures,
- definition of continuity is ambiguous,
- lack of mathematical connection between availability, reliability and continuity,
- vague procedures and methods of determining each of the criteria,
- measurement of the criteria is based only on statistic analysis of empirical measurement data.

These and others methodological problems should be solving as soon as possible, because all fixing systems characteristics have to be considerate in the same standardized way. The next important problems in implementation position systems to e-Navigation are:

- identification of the service provider responsibility (especially for global and wide area positioning systems) for accidents caused by non-operation status,
- to establish international cooperation between GNSS service providers related to others than positioning services (safety of live, commercial, search and rescue, etc.),
- to solve responsibility problem for core navigational system provider and augmentation signal deliverer.

Current GNSS has a common weakness in that they are all subject to accidental or intentional interference. Hence, alternative and independent position fixing capabilities need to be considered. Consideration should be given to independent non-GNSS Electronic Position Fixing System and sensors as a potential component of E-Navigation.

e-Navigation systems should enable the electronic capture of radar ranges, radar and visual bearings, etc. for position fixing.

### 3.3 Communications

The following is a list of key communication aspects required for e-Navigation, relating to both technical and content:

- autonomous acquisition and mode switching (i.e., minimal mariner involvement needed);
- common messaging formats;
- sufficiently robust (e.g., signal strength, resistance to interference);
- adequate security (e.g., encryption);
- sufficient bandwidth (data capacity);
- growth potential;
- automated report generation;
- global coverage (could be achieved with more than one technology); and
- the use of a single language (English), perhaps with other languages permitted as options.

The following communications issues are among those that will require resolution to achieve the above:

- it seems likely that a satellite broadband link will be required to achieve the above requirements, and consideration must be given to how this will be achieved; and
- the question of cost and who pays for the provision of a satellite broadband link must be resolved early in development of e-Navigation.

The standardization and unambiguous interpretation of information plays an essential role in the appropriate accomplishment of navigational information acquisition and exchange processes in the e-Navigation System. The definition of relevant standards will enable unequivocal interpretation of the information. Measures taken to unify the above mentioned standards are aimed at the development of the navigational information ontology. The starting point for the creation of this ontology is an analysis and classification of navigational information accounting for its kind and range. This will allow to sort out the structure of navigational information, thus the availability and exchange of information will be extended.

# 4 Satellite Navigation

The provision of satellite navigation services is presently under U.S. monopoly through GPS. GPS was conceived primarily to serve military user requirements and cannot as such satisfy most of civil user expectations. GPS and Glonass, if it matures, require significant adjustments to become civil usable systems. A system satisfying civil user requirements, and particularly transport services, will bear the generic name of GNSS - Global Navigation Satellite System. This situation provides a window of opportunity for Europe to play its cards through Galileo system.

## 4.1 Civil User Requirements - Diversity

Potential areas of applications are numerous, obviously for all modes of transport, but also for offshore industry, sea bed exploration, geodesy, gravimetry, timing services, hydrography, leisure, ...

**Transport Applications:**
Today's shipping would be impossible without the extensive use of radio navigation. These maritime and offshore activities could derive numerous benefits from the application of satellite navigation.

Potential benefits for shipping are: low equipment cost; one system world-wide instead of numerous different systems in use today; a high accuracy will enable the use of satellite navigation for harbour approach and in narrow waterways, where radio navigation accuracy was insufficient so far; the integration of satellite positioning with digital map displays simplifies navigation; position reporting systems, particularly for the surveillance of fishing vessels and dangerous goods, can be implemented easily.

**Geodesy, Surveying:**
Surveyors are a rather small, but important user group. The high cost of maintaining national reference networks as well as the cost of actual surveying tasks can be significantly reduced by the use of satellite positioning. Economic effects in the offshore sector can be significant, as the allocation of revenue from the recoverable deposits within an exploitation block depends on the exact definition of the boundaries of these blocks.

**Other Applications:**
There are numerous other applications of GNSS, which will become operational once the level of development has reached a mature stage. For instance applications in fish

farming, marine agriculture, where an optimum distribution of organic fish fertilizers can be achieved by linking accurate position data with in situ measurements of yields. Furthermore, the high quality precise time distribution and synchronisation system can be used for timing purposes on the ground. Finally, there is an enormous potential for satellite navigation in leisure activities for hikers, amateur pilots and sailors as the most common examples of user groups for better safety and for pleasure.

GNSS will be the first radio navigation system in history having the potential to fulfil the requirements of practically all areas in which radio positioning and navigation can be applied. Therefore, GNSS is likely to become an indispensable part of the world-wide infrastructure.

**Civil User Requirements - Characteristics**

The complexity of the present situation can be grasped having in mind the two following fundamental considerations:

- the availability of GNSS serving a public service role and/or commercial service purposes for civil use is foreseeable in the near future but is still not there. GPS give only the flavour of it.
- many categories of users and service providers are dreaming about the potential applications of GNSS as perceived through the experimental use of GPS but their detailed requirements are generally not mature.

Users will increasingly rely on GNSS as it comes to fulfils operational requirements, provided that cost-benefit relation is satisfactory. Operational requirement may comprise compliance of GNSS to specific rules according to:

- the nature of the applications: public service missions, commercial operations, leisure activities,
- the mode of operation: accessory or supplemental or self-sufficient mean of navigation, safety critical or not with respect to human life, vehicles, goods.

These operational requirements can be turned into system performance requirements expressed in terms of the following characteristics:

- accuracy: the system will provide relatively homogeneous accuracy world-wide, some applications may require better precision than could be obtained by technique called "differential". This principle involves a ground reference station (or a network of such stations, depending on the area to be covered), which determines local errors of the satellite positioning and transmits them to the user via a datalink.
- integrity: ability of the system to alert in the appropriate time frame on errors.
- availability: measurement of the amount of hours per year the system will be unusable. This relates to the number of active satellites.
- continuity of service: relates to the commitment required from the service providers to offer perennial service at stable financial conditions. This comprises the institutional issue of who controls the systems as well as the financial issue of the cost recovery mechanism.

# 5 The Use of Telemetry on Offshore Worksite

Telemetry is a communication technology used for remote sensing and control often used for hydrographical and offshore industry related purposes [3].

The use of telemetry on offshore worksite:

- DGPS shore reference station transmitting differential correction data to all DGPS users on the worksite,
- shore based monitoring station to control and log overall operational data as position off all infield installations like different vessels, information and sensor data from wave height and direction buoy, tidal information from tide gauge,
- information such as position, dredged quantities from dredger to shore and GPS correction data from shore station to dredger,
- position information of survey vessel to shore and DGPS correction data from shore station to vessel,
- position information of stone dumping barge to shore station and DGPS correction data from shore station,
- position information of shallow water survey lounge to shore and DGPS correction data from shore station,
- tidal information from the tide gauge is transmitted via the telemetry of the DGPS shore station to all installations on the work site,
- wave height and direction information transmitted to the shore station and from there available for all users on the site.

## 5.1 Radio (DGPS) Datalink

The most common type of transmitting corrections is, at the moment, radio transmission. Radio transmission is relatively cheap and provides access to a large group of users. This type of system is also called Local Area Augmentation System (LAAS). Depending on the type of users a frequency is chosen, the most common being: UHF/VHF, MF and HF.

**UHF/VHF**. These are generally short range systems used in hydrographic surveying. Transmitters are generally portable and can be set up by the user. Special attention should be given to the frequency and power level chosen, since there may be restrictions (like the need to apply for a permit) on either in a specific area / country.

A generally used frequency band for DGPS corrections is the 439 MHz band, which is free for power output levels with a maximum of 0.5 Watt. The range is up to 25 kilometres from the transmitter with these setting. The accuracies achieved with this type of system are in order of 1-2 meters. When a multi reference solution is used the accuracy can be 0.5 meters.

The disadvantage of UHF / VHF is that it is a line of sight system, meaning that obstructions between the transmitter and receiver can block the signal. Another problem with UHF / VHF is the reflection of the signal off islands, structures and buildings, thus creating shadow zones and multipath.

**MF**. When the survey area is bigger than 20 kilometres, a medium or long range system should be used. Around the world IALA beacons are used to provide range corrections to navigational users of GPS. These corrections can be received using cheap receivers from reference stations placed around most international waters used for shipping. The range of these systems is up to 150 kilometres with an accuracy of about 2-3 meters.

**HF.** These systems use HF frequencies for transmitting and can cover 100 to 600 kilometres and provide a DGPS system at 1.0 to 5 meters accuracy. In general, these services are not free of charge. The signal will be scrambled by a code, which can be obtained for free from the supplier of the signal. An advantage of these type of systems is the signal monitoring by the supplier and the relatively high accuracy achieved.

**Public Radio Broadcast.** In some countries signals are broadcasted over public radio as a so-called piggy back signal. In general FM transmissions are used and the accuracies achieved will be in the order of 3 meters.

**Eurofix.** A specific form of radio telemetry is the Eurofix system. With Eurofix, Loran-C transmitters transmit the DGPS correction signal. Loran-C is a terrestrial radio positioning system that seemed to become a victim to the wide spread use of DGPS. However, since then various reports, Volpe report (United States) and Helios study (Europe), criticized the vulnerability of GPS as a sole means of navigation. Since Loran-C uses terrestrial transmitters with high power signals in a different frequency band it is not vulnerable to the same sources as GPS. As a stand-alone system it is however less precise. To be able to be an independent backup for GPS, Loran is currently being upgraded to enhanced Loran - eLoran.

By combining Loran and GPS, a system is created that is less vulnerable and which can achieve a precision of meters even when the GPS signal is interrupted. The Americans are fully convinced that Loran-C should remain active for this reason and are modernizing their Loran-C transmitters. Some European governments however are less convinced and one of the Loran-C chains, the NELS (Northwest Europe Loran-C System) is reportedly threatened to be shutdown.

The argument often heard is that Galileo will solve the problem mentioned. This is not a valid argument however, since Galileo is vulnerable in much the same way as GPS and/or Glonass since all systems are based on the same principles and frequency bands.

**Mobile Telephone.** Corrections via mobile telephone are at the moment offered by commercial services only. The advantage of these networks is that they offer a large number of reference stations over a relatively small area. As a result a high precision is achievable without the need to erect an own base station. The main disadvantage is the high cost when performing continuous measurements. As a result these networks are commonly used for calculating base positions. However, with the introduction of UMTS and GPRS techniques costs will probably drop considerably.

**Satellite Transmission.** As we have seen with radio based telemetry systems, they can cover a couple of hundred kilometres at best. This is not enough from precise positioning in the middle of the Atlantic ocean. When DGPS signals are transmitted via a satellite network, they can cover a much larger area than when transmitted from terrestrial beacons. There are a number of commercial networks based upon satellite telemetry. An example of such a network is the Furgo Omnistar / Starfix network.

A special form of satellite DGPS as WAAS (Wide Area Augmentation System) and its European counterpart EGNOS (European Geostationary Overlay System). With EGNOS the - free - correction signals are transmitted on the same frequency as the GPS signals themselves. As a result no expensive separate DGPS receiver is needed. The GPS receiver however needs to be able to receive the so-called satellite-based augmentation system (SBAS) messages that are transmitted by geo-stationary satellites. Currently three systems are being developed, WAAS (USA), EGNOS (Europe) and MSAS (Japan). EGNOS uses 3 satellites to broadcast the correction messages, two Inmarsat satellites (IOR, AOR) and an ESA Artemis satellite. Next to the correction message, a GPS signal is transmitted as well, so the three augmentation satellites can also be used as an additional GPS satellite.

### 5.2 Hydroacoustic Telemetry

Another type of telemetry is used for underwater purposes and called hydroacoustic telemetry. This type of underwater telemetry is mostly used in the offshore industry for controlling valves and sensor measurements from subsea installations. For this type of telemetry acoustic underwater hydrophones are used to transmit and receive the signal. Also AUV's (Autonomous Underwater Vehicle) communicate with a baud rate of approximately 2400baud via a underwater acoustic system with mother vessel.

AUV's are used to carry payload like sonar and can carry out bottom profiles during autonomous operation the bottom profile data is logged inside the AUV and can be transferred via a cable when the AUV is on deck of the mother vessel. Only simple commands can be given due to the slow speed of the underwater telemetry.

## 6 Autonomous Marine Control Systems

During the last decade there has been a rapidly growing interest in the design and development of autonomous marine craft [1, 2, 4]. The craft in question being unmanned underwater vehicles (UUVs) and unmanned surface vehicles (USVs). It is considered that this area of marine control systems design will be one of the key areas for research and application both in the military/naval and industrial sectors for the foreseeable future.

The dynamic characteristics of an UUV present a control system design problem which classical linear design methodologies cannot accommodate easily. Fundamentally, UUV dynamics are nonlinear in nature and are subject to a variety of disturbances such as varying drag forces, vorticity effects and currents Therefore they offer a challenging task in the development of suitable algorithms for motion and position control in the six degrees of freedom in which such craft operate, and are required to be robust in terms of disturbance rejection, varying vehicle speeds and dynamics. It should be noted that the term ''unmanned underwater vehicle'' as used here is a generic expression to describe both an autonomous underwater vehicle

(AUV) and a remotely operated vehicle (ROV). An AUV being a marine craft which fulfils a mission task without being constantly monitored and supervised by a human operator, whilst an ROV is a marine vessel that requires instructions from a human via a tethered cable or an acoustic link.

Although ROVs play an important role in the offshore industry, their operational effectiveness is limited by the tethered cable, and the reliance and cost of some form of support platform. Whilst even though AUVs cannot be considered as being commonplace at this moment, they are thought by many to be the future technology to provide essential platforms for instruments and sensors for various kinds of subsea missions. These missions could include environment forecasting, policing exclusive economic zones and under-ice operations as well as ocean basin monitoring.

Issues surrounding the deployment of AUVs at sea are mainly threefold. The first is a non-technical matter that needs to be resolved as soon as possible and revolves around the legal responsibilities and liabilities for AUVs when working at sea. The second relates to the limited endurance capacity of existing power systems. To overcome this problem, there needs to be a major breakthrough in battery technology and/or a shift to other power sources. The third and final restricting factor is associated with the capabilities of onboard navigation, guidance and control (NGC) systems.

Paramount importance for AUV is the requirement for it to be equipped with a robust navigation subsystem that can accurately predict its current position. High accuracy can be gained by employing costly inertial systems. However, as the popularity and use of AUVs increases so will the demand for continued high navigational accuracy but at low cost. The solution to this ongoing problem lies in the use of inexpensive sensors being used in multi-sensor data fusion (MSDF) algorithms. Without doubt the development of MSDF algorithms is a priority for research. In addition, as the navigation aspects of an AUV improve so must the guidance laws become more sophisticated.

Although AUVs are seen as having great potential, such craft cannot be deployed in shallow or inland waters to undertake, for example, surveying and pollutant tracking tasks. As a result, operational costs are currently high as self contained underwater breathing apparatus (SCUBA) divers or special vessels containing a number of people have to be employed. Hence the interest in providing such services at low cost via USVs which are capable of operating in river systems, and littoral and deep water. USVs can also be usefully commissioned for search and rescue missions, police, and custom and excise operations, and a variety of deterrent, attack and covert military roles.

The dynamic characteristics of USVs will vary depending upon whether it is a mono or twin hull vessel. However, irrespective of the hull configuration, they are all exhibit highly nonlinear behaviour. Further complications arise with these vehicles when attempting to control the surge, sway and yaw modes owing to underactuation. In many cases, underactuated USVs are more easily served using nonlinear control theory. Thus underactuated marine systems and the application of nonlinear control theory in the design of their control systems are considered as a necessary field of continued research.

It may be argued the navigation of an USV is less of a problem than that of an AUV because of the access to GPS information. To a certain degree this may be true, however, they can be required to operate in areas of non-existent/degraded GPS reception. Thus the navigation of USVs is still difficult and thereby the need for intelligent dead reckoning algorithms applies equally to such vessels as well as AUVs.

The navigational aspects of an USV can be further complicated if it operates in a pack with similar vehicles. This can be further exacerbated if the pack or an individual also has to be linked with other air borne and/or subsea autonomous assets.

Hence as USVs can be engaged in multi-entity operations, research into network centric systems is essential along with that for robotic co-operative and swarming behaviour.

## 7 Marine and Offshore Telematics Onboard of Boats

Marine and offshore telematics systems are revolutionizing not only shipping but also the boating, offshore, recreational fishing and commercial fishing industries. Marine and offshore telematics involves the use of wireless voice and data communication systems which provide vessel tracking, emergency aid, system monitoring, internet access, and other features.

Systems normally consist of a user interface, satellite antenna, and a communication link with the vessel's electronic systems. This technology can be vital to the user since it provides a satellite link to the outside world when other communications may unavailable.

Several companies have entered the marine telematics market for boats. Some of them integrate Global Positioning System (GPS) technologies with electronic mapping and mobile communications to monitor and provide important boat data from port, land or sea. Installed in boats they have received wide acclaim from prominent boat builders and boat owners alike. They offer an array of services that cater to boat security, boater safety, and boating enjoyment, including an advanced emergency messaging system that can pinpoint a distressed boat's location offshore. They can also alert boat owners to potential problems when they are not using their boats, such as low battery voltage or water intrusion in the bilge. In addition, they have a proven record of assisting law enforcement agencies in tracking and recovering stolen boats, offering boat owners a new level of security and safety.

The systems provide emergency communications, detailed messages, including information on GPS position and other critical parameters, between watercraft and the dedicated maritime rescue coordination centre. This data is intended to help rescue agencies locate a vessel and respond appropriately during an emergency.

Other wireless maritime information system companies provide Vessel Monitoring System (VMS) services to commercial fishing vessels. These systems include GPS, two-way communications and e-mail. A network operations centre provides continuous support. The term Vessel Monitoring System, or VMS, refers to a wireless information system that automatically reports fishing vessel position and activity.

## 8 Governance of Offshore IT Outsourcing

The lack of effective IT governance is widely recognized as a key inhibitor to successful global IT outsourcing relationships. In this study the development and application of a governance framework to improve outsourcing relationships is presented. The approach used to developing an IT governance framework includes a meta model and a customization process to fit the framework to the target organization. The IT governance framework consists of four different elements: (1) organisational structures, (2) joint processes between in- and outsourcer, (3) responsibilities that link roles to processes and (4) a diverse set of control indicators to measure the success of the relationship. The IT governance framework is put in practice in Shell GFIT BAM, a part of Shell that concluded to have a lack of management control over at least one of their outsourcing relationships.

## 9 Conclusion

The key structural components of a safe and comprehensive e-Navigation policy for marine and offshore purposes are:

- accurate, comprehensive and regularly up-to-dated Electronic Navigational Charts (ENCs), covering the entire geographical area of a vessel's operation;
- accurate and reliable electronic positioning signals, with "fail-safe" performance (probably provided through multiple redundancy, e.g. GPS, GLONASS, Galileo, differential transmitters, Loran C and defaulting receivers or onboard inertial navigation devices);
- provision of information on vessel route, course, manoeuvring parameters and other status items (hydrographic data, ship identification data, passenger details, cargo type, security status etc) in electronic format;
- transmission of positional and navigational information: ship-to-shore, shore-to-ship (e.g. by VTS, coastguard centres, hydrographic offices) and ship-to-ship;
- accurate, clear, integrated, user friendly display of the above information onboard and ashore (e.g. using IBS or INS);
- information prioritisation and alert capability in risk situations (collision, grounding etc), both onboard and ashore; and
- reliable transmission of distress alerts and maritime safety and security information with reduction of current GMDSS requirements by utilizing newly emerged communication technologies.

There is a growing trend towards the use of remote control centres. These require continuous monitoring, with the concept of the digital field wholly dependent on guaranteed secure communications.

## References

1. Fossen, T.L.: Marine control systems: Guidance, navigation and control of ships, rigs and underwater vehicles. AS: Marine Cybernetics (2002)
2. Kiencke, U., Nielsen, L., Sutton, R., Schilling, K., Papageorgiou, M., Asama, H.: The impact of automatic control on recent developments in transportation and vehicle systems. Annual Reviews in Control 30(1), 81–89 (2006)
3. Lekkerkerk, H.-J., Theijs, M.J.: Handbook of Offshore Surveying, 2nd edn. Projects, Preparation & Processing, vol. 1. Skilltrade BV, The Netherlands (2011)
4. Roberts, G.N., Sutton, R. (eds.): Advances in unmanned marine vehicles. IEE Control Series. IEE Press (2005)
5. Weintrit, A.: Telematic Approach to e-Navigation Architecture. In: Mikulski, J. (ed.) TST 2010. CCIS, vol. 104, pp. 1–10. Springer, Heidelberg (2010)
6. Weintrit, A., Wawruch, R., Specht, C., Gucma, L., Pietrzykowski, Z.: Polish Approach to e-Navigation Concept. TransNav – the International Journal on Marine Navigation and Safety of Sea Transportation 1(3), 261–269 (2007)
7. Yoon, D., Yi, M., Jeong, J.S., Park, G.K., Son, N.S.: Safety Control of Maritime Traffic Near by Offshore in Time. TransNav – the International Journal on Marine Navigation and Safety of Sea Transportation 5(1), 65–69 (2011)