TRANSNAV
http://www.transnav.eu
the International Journal
on Marine Navigation
and Safety of Sea Transportation
Volume 16
Number 3
September 2022

DOI: 10.12716/1001.16.03.09

Architecture of Positioning and Tracking Solutions for Maritime Applications

D.S. Ilcev
University of Johannesburg (UJ), Johannesburg, South Africa

ABSTRACT: This paper discusses the current and new satellite transponders for global tracking and detecting of oceangoing ships, assets, crew, passengers and any moving objects at sea for enhanced vessels traffic control and management. These transponders are able to monitor all maritime assets and to improve safety, security of movements and collision avoidance, especially during very bad weather conditions and visibility. By deployment of the Global Navigation Satellite System (GNSS) in integration with Inmarsat, Iridium and other satellite systems in one unit with antenna, it is possible to provide reliable positioning and tracking solutions for civilian maritime, other mobiles and personnel at different Radio Frequency (RF) bands. The existing and forthcoming space and ground segment for positioning and tracking solutions as a modern Satellite Asset Tracking (SAT) onboard ships, and other relating systems are discussed and benefits of these new technologies and solution for improved positioning and tracking are explored.

1 INTRODUCTION

After the Soviet Union launched the first in the world artificial satellite, Sputnik 1, satellite systems became the delivery mode of choice for communication positioning information with developments of first Global Navigation Satellite Systems (GNSS). The US military system Transit started with development from 1960 and the Soviet Union military system Cicada was established in 1974. After early experimentation with the doomed Transit and Cicada systems, remember having to wait hours for the next satellite to appear overhead, new GNSS of GPS and GLONASS were created at the end of 20th Century to offer highly accurate global satellite positioning system in longitude and latitude, almost anytime and anywhere in the world.

The Transit system was switched off in 1996 to 2000 after more than 30 years of reliable service. By then, the US Department of Defence was fully converted to the new GPS network. The GPS service could not have the market to itself, the ex-Soviet Union (Russia) developed a similar system called GLONASS in 1988 and ceased the previous Cicada system. The Transit or Cicada systems, provided intermittent two-dimensional (latitude and longitude) position fixes every 90 minutes on average and were the best suited to marine navigation, The GPS or GLONASS GNSS-1 satellite networks provide continuous position and speed in all three dimensions (latitude, longitude, and altitude), equally effective for navigation and tracking at sea, on land and in the air, which space, users and ground segments are shown in Figure 1.

In the meantime, China started development own GNSS-2 navigation system known as Compass (BeiDou), which is regionally operational. The BeiDou GNSS network consists of two separate satellite constellations that have been operating since 2000 and a full-scale global system is currently under construction. However, the second GNSS-2 satellite network still in development stage is the European Galileo.

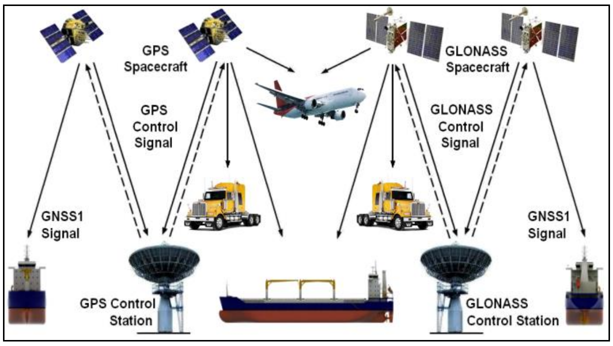

Figure 1. Military GNSS-1 Network – Source: Ilcev

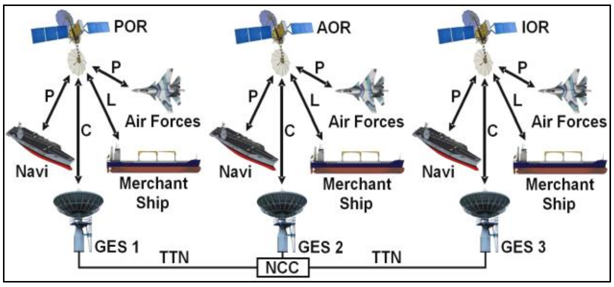

Figure 2. Marisat Space and Ground Segments – Source: Ilcev

The US GPS and Russian GLONASS as GNSS-1 satellite positioning networks, all-weather spacecraft, full jam resistant and continuous operation navigation system, utilize precise range measurements of Position, Velocity and Time (PVT), call sign of ship and ID data anywhere in the world. This GNSS system provides military and commercial maritime, land and aeronautical users via Medium Earth Orbits (MEO) satellites with highly accurate worldwide three-dimensional, common-grid, position and location data, velocity and precise timing to accuracies that have not previously been easily attainable. The GNSS service is based on the concept of triangulation from known points similar to the technique of "resection" used with a map and compass, except that it is done with radio signals transmitted by satellites. The GNSS receiver must determine when a signal is sent and the time it is received. Nothing except onboard ships and other mobiles GNSS receivers is needed to use the system free of charge, which does not transmit any signals and therefore they are not electronically detectable [01, 02, 03].

Most communications between ships or other mobiles and traffic controllers are still conducted via VHF, UHF and HF analog and digital voice or radiotelephone RF-bands, known as Mobile Radio Communications (MRC) system. However, in some busy portions of the world this system is reaching its limit, the RF-bands are congested and additional frequencies are not available. These disadvantages limit the growth in the traffic to those ships or mobiles that can be safely handled. Thus, to improve the communication and traffic control facilities of all maritije and mobile users almost 40 years ago was implemented civilian Mobile Satellite Communication (MSC) system, which takes less time, reduced interference and can handle more information than MRC system alone.

Before that, the World's first military maritime MSC system "Marisat" was unveiled in 1976 by the US Comsat General with only three satellites and networks in the Atlantic, Pacific and Indian oceans. In Figure 2 is shown Military Satellite Communication Network for navy, ground and air forces using L/C/Ka-band, which can provide MSC service via current Geostationary Earth Orbits (GEO), MEO or Low Earth Orbits (LEO) satellite constellations. Thus, modern military satellite communications can additionally use UHF, S, X and Ku-band between Mobile Earth Stations (MES) and Military Control Centre. The MSC systems are not designed only to provide more cost effective, reliable, redundant and fastest communication links between ships and traffic controllers, but also to integrate GNSS data for implementing new service for enhanced tracking, navigation, surveillance and tracking solutions. The convergence of MSC and Internet transmission technique has opened many opportunities to provide positioning and tracking data to the ground infrastructure and for implementation new Communication, Navigation and Surveillance (CNS). With the need for increased bandwidth capability, the numbers of new GEO and Non-GEO satellites is increasing dramatically. The size of the Earth requires multiple or some hybrid satellites to be placed in orbit constellation to cover areas of interest and adequate communications coverage [3, 4, 5].

2 GLOBAL S ATELLITE ASSET TRACKING (SAT) SYSTEMS

The GNSS network is represented by fundamental solutions for PVT, identification and other data of the US GPS and Russian GLONASS military satellite systems, which suffer from particular weaknesses that render them unsuitable for use in modern transportation state affairs as sole solutions for positioning, tracking and detecting of of ships and other mobile assets. A major goal of the near-universal use of GNSS systems is their integration with maritime and other MSC systems, which very small GNSS/Satellite units will be able to improve positioning, detecting and tracking facilities of ships, crew, passengers and other mobile, such as ground vehicles and aircraft.

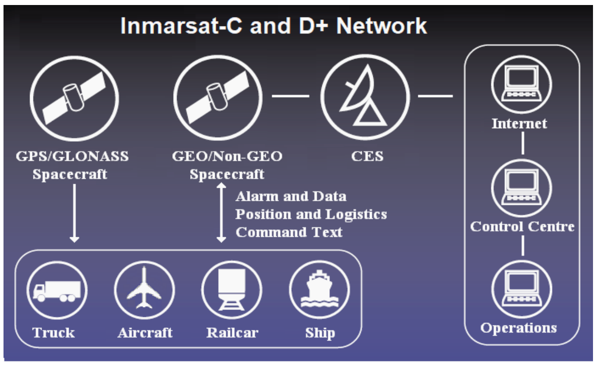

Figure 3. Configuration of SAT System – Source: Inmarsat

As a result of these significant efforts, new positioning, detecting and tracking technologies have been projected and developed to utilize modern space (radio and satellite) Communication, Navigation and Surveillance (CNS) solutions and services for enhanced traffic control, monitoring, and management of civilian and military mobile personal and assets. Received tracking data by GPS/GLONASS Receiver (Rx) onboard oceangoing ships and other offshore objects can be sent via Inmarsat GEO or Iridium Non-GEO spacecraft, Ground Earth Stations (GES) terminals and Internet to the Control Centres and Operations Control. In fact, all ships and crew require far more sophisticated service from modern satellite tracking systems than standalone GPS or GLONAS positioning systems in disress and Search and Rescue (SAR).

In fact, it is proposed Satellite Asset Tracking (SAT) system as integrated configuration in one Satellite Tracking Unit (STU) containing very small GPS or GLONASS receivers integrated with miniature GEO and Non-GEO satellite transceivers with both adequate antennas in one radome. The configuration of SAT infrastructure for civilian applications is illustrated in Figure 3, which integration is deploying the GNSS subsystem of US GPS and Russian GLONASS to provide free of charge PTV and other data to oceangoing ships an d all mobiles in seaport area. This PTV and other data can receive ships and vehicles, such as trucks and railcars and ships via onboard GPS/GLONASS Rx integrated with satellite transceiver [4, 5, 6].

The SAT satellite transponder will provide solutions for the global identification and tracking of all type of vessels and crew, such as cargo ships and containers, and including land vehicles and aircraft. As shown in Figure 4, the SAT onboard equipment receives GNSS signals from GPS or GLONASS spacecraft (1) and sends PTV tracking messages of position (2) via GEO satellite to GES (3) of Satellite Application Service Providers, Terrestrial Telecommunication Network (TTN) and Internet, to the receiver and processor of Tracking Control Stations (TCS) infrastructure (4). Thus, the positioning, communication tracking lines are highlighted in black, while all opposite lines highlighted in red are indicating SAT receiving process, namely, the receiver of onboard ships and other mobiles SAT terminals are receiving PVT and other data from TCS useful for collision avoidance and showing it on receiver display.

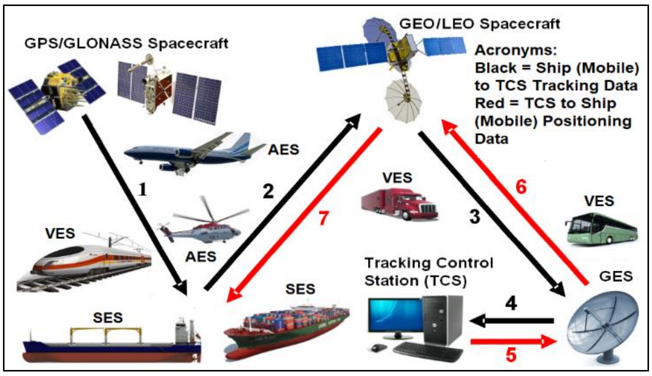

Figure 4. Configuration of SAT Network – Source: Ilcev

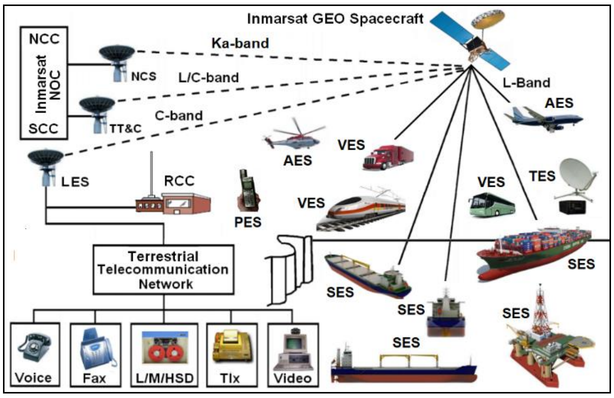

Figure 5. Inmarsat Maritime and other Mobile Satellite Network – Source: Ilcev

As already stated, then the Satellite Transceiver (Rx/Tx) is providing frequently transmissions of PTV and other data via GEO or Non-GEO spacecraft through GES or Gateway terminals and Internet to the Control and Operations Centres. Because of many incidents in past time, without successful search, detecting and tracing of oceangoing ships disappeared in some disasters caused by collision or grounding, were proposed new positioning and tracking and detecting solutions via SAT onboard devices and ground facilities. Thus, if SAT transponder was fixed onboard Air France or Malaysian aircraft crashed in 2009 and 2014, respectively, SAR forces should find the wreck in 1-2 days and in area of maximum 100 to 200 miles.

At present only the following mobile satellite operators are providing global or near-global satellite constellations for civilian and military SAT service: (1) Inmarsat GEO near-global satellite network provides coverage up to 800 North and South; (2) O3b MEO satellite network provides near-global global coverage up to 500 North and South; (3) Iridium Big LEO satellite network provides only real complete global coverage, because of intersatellite links; (4) Globalstar Big LEO satellite network with limited coverage that is depending on distributed number of Gateways; and (5) Orbcomm Little LEO global satellite network with limited coverage depending on distributed number of Gateways.

The problem of current satellite fixed and mobile operators is that they are providing service via GEO satellite constellations and in this case are not able to cover both polar areas, such as Inmarsat, Eutelsat and Intelsat. To realize a real global coverage will be necessary to implement Hybrid Satellite Orbits (HSO) combined between Inmarsat, O3b, Globalstar and Orbcomm High Elliptical Orbit (HEO), such as Russian Molniya satellite constellations [1, 4, 5, 6, 7].

3 INMARSAT MSC NETWORK AND EQUIPMENT

Inmarsat was established as not-for-profit company in 1979 as the International Maritime Satellite Organization (Inmarsat) set up at the behest of the International Maritime Organization (IMO) and United Nations (UN), with its headquarter office in London. Initially was developed for the purpose of establishing a maritime satellite communications network for commerical, cprporate and safety applications. It began trading in 1982 via GEO satellite constellation for oceangoing ships and searigs providing coverage up to 800 North and 800 South. Afterwards Inmarsat started with development service for land (road and rail), personal (handheld), transportable and aeronautical applications. The current Inmarsat-4 is providing service at the following RF bands: 1.6/1.5 GHz of L-band (Service Link) and at 6.4/3.6 GHz of C-band (Feeder Link) .

In 2016, the fourth generation of Inmarsat-4 satellite constellation is upgraded with fifth generation of Inmarsat-5 satellite constellation, which maritime and other MSC networks operate via L, C and Ka-band, which maritime and other mobile satellite network is shown in Figure 5. The current Inmarsat network provides comercial mobile service via Land Earth Stations (LES) and Inmarsat satellites for Ship Earth Stations (SES), Vehicle Earth Stations (VES), Aeronautical Earth Station (AES), Transportable Earth Station (TES), Personal Earth Station (PES) terminals.

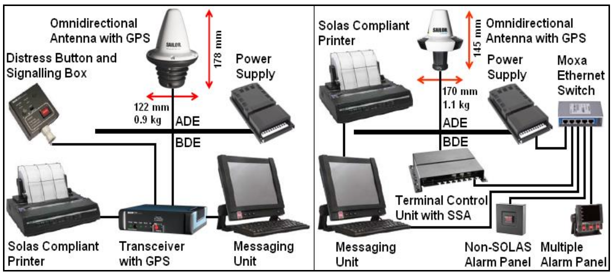

Figure 6. Maritime Sailor Inmarsat-C and mini-C Terminals – Source: Inmarsat

The emergency and distress service is provided via special Rescue Coordination Centres (RCC). Entire Inmarsat network is managed by Network Control Centre (NCC) in London, Network Coordination Stations (NCS), Network Operations Centre (NOC), and Telemetry, Tracking and Command (TT&C).

The sixth generation of Inmarsat network known as Global Express GX) developed by Boeing for about $1.2 billion will include a new plans for the Orchestra satellite network roadmap, which currently includes seven satellites over the next three years to provide additional L and K-band capacity for Fleet GX users. Five of those satellites will operate in GEO orbit, with two being placed in Highly Elliptical Orbits (HEO) to provide polar coverage on the network for the first time. In addition, Orchestra will bring together existing GEO satellites with new LEO and terrestrial 5G into an integrated solution for about $3 billion.

The Inmarsat I-4 and I-5 satellite constellations are providing Global Ship Tracking (GST) service for maritime applications onboard seagoing or inland vessels are providing IsatData Pro, IsatM2M, Inmarsat-C, mini-C, FleetPhone and old Standard-D devices. The ground segment comprises a network of LES terminals managed by LES operators. However, the major part of the ground segment and network for maritime applications are SES terminals as mobile subscribers. Each LES operator provides a transmission link between satellite network and TTN, capable of handling many types of calls to and from MES terminals simultaneously over the Inmarsat networks [03, 04, 05, 08].

3.1 *Inmarsat-C and mini-C Terminals*

The Inmarsat-C and mini-C standards are a two-way packet data small satellite terminals dedicated for installation onboard ships or other mobiles for transmission of two-way data and telex messages at an information rate of 600 b/sec on L-band. These messages are transmitted only in ship-to-shore direction via LES terminals, TTN and Internet to PC terminals with special software to bi processed and memorised, which PVT data can be used for tracking of ships and any other mobiles.

Inmarsat standard-C is developed in 1988 for commercial and distress application for merchant fleets. The typical SES-C has a small and compact omnidirectional antenna in radome as an Above Deck Equipment (ADE), which can be easily mounted on all type of ships, yachts, fishing boats, offshore rigs and other mobiles. The main components of Standard-C terminal shown in Figure 6 (Left) contains ADE and Below Deck Equipment (BDE) with peripherals. The ADE can be a single Inmarsat-C or combined Inmarsat-C with GPS omnidirectional antenna. The BDE component can be an Inmarsat/C transceiver only or combined with a built-in GPS receiver installed in the radio station or on the navigating bridge interfaced to messaging unit, printer and distress button with signalling box. Some SES-C has built-in message preparation and display facilities and others have a standard RS-232 port so that users can connect their PC or other data equipment. This standard provides data, E-mail, position reporting and polling, Fax, Tlx, X.25, inters-hip communication, Supervisory Control and Data Acquisition (SCADA) or Machine-to Machine (M2M), etc.

The Inmarsat mini-C terminal was introduced in 2002 as smallest and very compact ships Inmarsat satellite communication transceiver integrated with 2-channel GPS Rx in one single device, with a total with of 1.1 kg and a size of 15 cm, which is depicted in Figure 6 (Right). The mini-C unit provides the same service as Inmarsat-C, and both can be deployed as ships solutions for Global Maritime distress and Safety System (GMDSS), Long Range Identification and Tracking (LRIT), and Vessel Monitoring System (VMS). The power requirements of both terminals can be met from a ship’s mains or via battery sources via power supply unit with rechargeable facilities, (03, 04, 09].

Figure 7. Maritime Inmarsat-D+ Generations – Source: Orbcomm

3.2 *Inmarsat-D/D+ and Inmarsat-IDP Terminals*

Inmarsat-D introduced in 1997 offers global one-way (simplex) and Inmarsat-D+ two-way (duplex) data communications utilizing equipment no bigger than a personal CD player, which 1st and 2nd generations respectively are shown in Figure 7.

These units are integration of a Standard D+ transceiver with the US GPS or Russian GLONASS receivers and both antennas. It is ideally suited for ships and mobile tracking, short data messaging, SCADA (M2M), broadcast of information, financial data, stock exchange, and many other data. These terminals can store and display at least 40 messages of up to 128 characters each, and will also be able to transmit PVT data derived from integrated GPS or GLONASS receivers. All messages sent to SES will be numbered to enable the subscriber to identify any lost messages. Repeated messages will be sent with the same message number to allow repeated call indication. The Inamrsat D+ standard equipment is capable to transmit from ships subscribers to base stations: a) Acknowledgement Burst, b) Short Burst Data (SBD) and c) Long Burst Data (LBD).

Due to the development of the new Inmarsat IsatData Pro and IsatM2M standards, as of 31 December 2015, new Inmarsat-D + activations have been suspended. Alternatively, Inmarsat offers a new generation of similar telematics known as IsatData Pro and IsatM2M satellite terminals, which are fully programmable and environmentally sealed, use the global two-way Inmarsat Isat satellite service integrated with GPS or GLONASS data for remotely managing fixed and mobile assets. These equipment, whether used for oceangoing ships, fishing vessels, buoys, containers, vehicle tracking, SCADA (M2M) or oil and gas equipment, these standards facilitates improved asset tracking and fleet management in lower operating costs and regulatory compliance.

1. IsatData Pro – This standard is a global two-way packet data service for M2M that enables companies to track and monitor their fixed or mobile assets, giving them increased visibility of business operations, enhanced efficiency, and greater safety and security for their assets, cargo and drivers, while lowering operational costs. It sends 6,400 bytes and receives 10,000 bytes, with a latency of 15 to 60 seconds depending on the size of the message.
2. IsatM2M – This standard is global, store-and-forward low data rate messaging (SBD) to and from remote assets for tracking, monitoring and control operations. It supports critical applications such as ships and other mobile tracking and monitoring system at speed rate of 10.5 or 25.5 bytes in the transmit direction and 100 bytes in the receive direction, with a latency typically between 30 to 60 seconds. The Inmarsat IDP-690 terminal shown in Figure 8 (Left) is part of the IDP 600 series of terminals for vessel tracking device, while in Figure 8 (Right) is the IDP-800 dedicated to monitor trailers, containers, and vessels.

Figure 8. Maritime Inmarsat-IDP new Generations – Source: Orbcomm

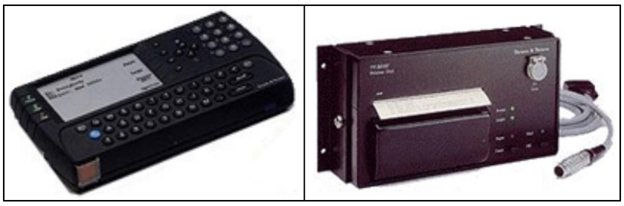

Figure 9. Thrane&Thrane Message Terminal & Capsat Printer – Source: Cobham

Thus, Inmarsat-IDP terminals with their serial interface and published communication protocol enable easy integration with an external controller, mobile display terminal or PC (Laptop) terminal. If there is not enough space for a laptop or PC, both Inmarsat-IDP terminals can be interfaced to small message terminal shown in Figure 9 (Left) with a key board and a very small printer shown in Figure 9 (Right) [5, 10, 11, 12, 13].

4 IRIDIUM MSC NETWORK AND EQUIPMENT

The concept for the Iridium MSC system was proposed by Motorola engineers in late 1989 and after a phase of research, the Iridium LLC satellite system was founded in 1991, with an investment of about $7 billion. Maintaining its leadership, Iridium LLC became operational MSC system on 1st November 1998. After a period of bankruptcy, the Iridium service was relaunched on March 28, 2001. The Iridium Big LEO satellites are situated in a near-polar orbit at an altitude of 780 km. They circle the Earth once every 100 minutes travelling at a rate of about 26,856 km/h. Each satellite is cross-linked via intersatellite links to four other satellites, with two satellites in the same orbital plane and two in the adjacent plane.

The Iridium satellite constellation consists in 66 operational satellites and 14 spares once orbiting in the satellite constellation of six polar planes. The Iridium system provides true global coverage and roaming globally over 48 spot overlapping beams, and the diameter of each spot is about 600 km. Iridium as a true global operator provides voice and data service including SAT for ships and all mobile applications via uplink/downlink at 1621.35-1626.5 MHz, feeder links at 29.129.3 GHz of Ka-band (uplink) and at: 19.4-19.6 GHz of K-band (downlink) and cross-link or intersatellite link at 23.1823.38 GHz of Ka-band.

The current Iridium network shown in Figure 10 provides maritime and other mobile service via Ground Earth Stations (GES) and Iridium LEO satellites connecting SES, VES, AES, PES as handhelds and semi-fixed terminals with Public Switched Telephone Network (PSTN) ground network. The PSTN switch system is connected to a Public Network, a Private Network, a Cellular Network, and a terrestrial Wireline Network.

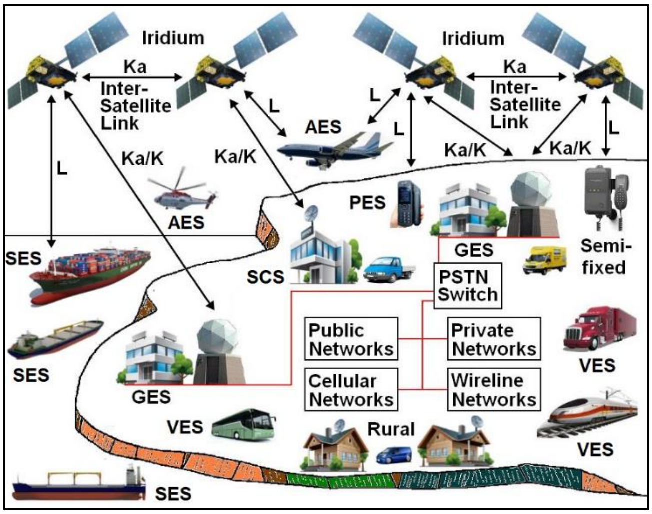

Figure 10. Iridium MSC Network – Source: Ilcev

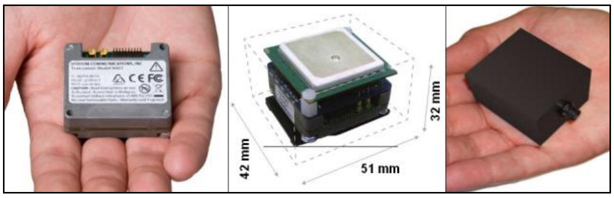

Figure 11. Iridium Miniature SAT Terminals – Source: Iridium

The Entire Iridium network is managed by the System Control Segment (SCS), which consists of three main components: four Telemetry Tracking and Control sites, the Operational Support Network, and the Satellite Network Operation Centre. The SCS ground network is what commands and controls the satellites for the Iridium system. It provides global operational support and control services for the satellite constellation. It also delivers satellite tracking data to the Gateways [1, 5, 14].

4.1 *Iridium MSC and Fleet Management Terminals*

The Online Tracking Platform (OTP) system is a Web based integrated Iridium, Inmarsat and Global System for Mobile Communications (GSM) or cellular system tracking solution, which is compatible with modern Web browsers and works on a multilingual platform and displays and manages them in a single unified interface. With OTP, asset locations and movements, including position, speed, altitude and heading are tracked in real-time worldwide via GPS updates. This system may be integrated GSM and satellite tracking in one solution which via Web provides superior GPS tracking and mapping, no special hardware or software is required, seamless software and firmware updates, reliably tracks personnel, equipment, ships or vehicles, anywhere in the world. On the other hand, some trackers may use adequate software and not OTP system.

1. Quake 9602 Mini Tracker – The 9602 is a short-burst data transceiver designed for use as a basic unit for many tracking devices using the Iridium Network, illustrated in Figure 11 (Left). This very tiny, 41x45x13 mm and 27.22 grams, two-way transceiver is perfect for use in a variety of applications for fast-growing mobile devices, including remote tracking of aircraft and real estate and M2M tracking solutions. This Iridium unit does not have a GPS Rx, but can be connected to the built-in GPS via input/output ports. In addition, appropriate sensors can be connected to the inputs of this device, such as mileage, fuel consumption, temperature, doors, cargo etc.
2. Iridium SL Mini Tracker – Iridium very small and lightweight SBD modem with integrated GPS Rx is the smallest self contained Iridium tracker in the world, which 32 bit Advanced RISC Machine (ARM) processor supported by a fully user customizable LUA scripting language, where RISC is Reduced Instruction Set Computing. Its internal dimensions 1.77 x 1.77 x 1.34 inches (45 x 45 x 34mm), including the battery, which modem and antenna are illustrated in Fig. 11 (Middle). It can transmit the location from anywhere in the world and is built on the latest satellite, antenna and electronics technology tfor tracking and monitoring all mobiles in real time, the actual size of which is shown in Figure 11 (Right).
3. Quake Q4000 Tracker – The Iridium Q4000i tracker manufactured by the American company Quake is small enough to fit in your hand. It is a two-way rugged transponder that can combines dual-mode operability over Iridium satellite and GSM terrestrial networks with GPS into a versatile, all-in-one mobile asset tracking solution, illustrated in Figure 12 (Left). Quake is also supplying the same Q4000 modem that can be optionally used for service over Inmarsat, Globalstar and Orbcomm integrated with 50 channels of GPS Rx and with optional GSM cellular service.

Figure 12. Iridium Mobile SAT Terminals with Antenna – Source: Quake

Figure 13. Iridium Personal Satellite Trackers – Source: Iridium

Technically, this is am SBD transceiver designed for use as a base unit for many mobile trackers using the Iridium network, such as oceangoing ships and container tracking, as well as for tracking land vehicles and aircraft. In addition, this equipment without integrated GPS can be implemented for monitoring of many machines, pipelines, devices, instruments, power stations and so on over the SCADA (M2M) network. This unit provides the following interfaces: 3 serial RS-232C, J1939 can bus, input/output 2 analog inputs, 8 digital GPIO and digital outputs (relay). Its dimensions are size: 3.91″x 2.52″x .63″ (99.3mm x 64mm x 15.9mm) and weight is 375lbs (170 grams). In Figure 12 (Middle) is shown bolt, magneting or adhesive mount Hirschmann low profile Iridium antenna (63x63x18mm) for Iridium/GPS/3G/GSM WLAN and other mobile applications, which can be used for Q4000i and other satellite trackers onboard all mobiles.

4. Quake Q-Pro Multipurpose Tracker – This unit is small (119.2x119.4x57.6 mm and 390.6 grams) and rugged, environmentally-sealed multi-satellite GPS integrated with Iridium, Globalstar, Orbcomm and GSM modem with many options, shown in Figure 12 (Right). For SAT applications this unit has an integrated GPS receiver with 50 channels and can also be connected to Hirschmann low profile Iridium antenna, shown in Figure 12 (Middle) [5, 14, 15].

4.2 *Personal Satellite Trackers*

The following Iridium personal satellite trackers are ideal units for tracking of passengers and crew after grounding or in emergency situation with absence of any luck in distress communications:

1. E-Track Epsilon Personal Tracker – This personal tracker is a waterproof satellite messaging and personal tracking device, which provides autonomous and global real-time coverage, shown in Figure 13 (Left). Developed around 9602 Iridium modem, it benefits from the latest developments in satellite technology of GPS and is IP67. The unit provides two-way texts messaging, predefined and free-text "HELP" key to send a distress message with accurate GPS position of the incident.
2. GeoPro Personal Messenger – This personal tracker is a solution for remote workforce security, location awareness and a two-way solution for exchanging personal messages,, shown in Figure 13 (Middle). When work takes staff off the grid they often have no reliable means of maintaining communication. It is an affordable and rugged device supporting global two-way text messaging and can be used in one hand with a non-slip network of factors using a joystick to navigate through on-screen menus and the keyboard.
3. NANO Personal Tracker – This unit has an ultra-low power consumption of less than 35μA during sleep, shown in Figure 13 (Right). This pocketsize and self-contained personal satellite tracker provides 256-bit transmit and receive encryption, precise GPS positioning, real-time reporting and truly global coverage via the following features: (1) Power/Enter turns the device ON/OFF and selects highlighted item on the menu; (2) The Up/Down/Right Arrow navigates the cursor; (3) The Check-In Soft Key is accessing Check-In feature; (4) The Way Point Soft Key is used for Way Point functions; (5) The USB Port is serving to charge the battery and connects the PC; (6) The Emergency key may send an emergency alert, distress and notification to the search and rescue (SAR) forces; (7) The Guard button protects the emergency button from accidentall activation; (8) The LED unit displays tracking and emergency statuses; 9. The Antenna post shows the GPS antenna; and (10) The Antenna post shows the Iridium antenna [3, 5, 14].

5 GLOBALSTAR MSC DATA NETWORK AND EQUIPMENT

The American company Loral Space & Communications, together with Qualcomm Incorporation, developed the concept of the Globalstar system at a similar time as Iridium. Globalstar received a license to operate from the USA Federal Communications Commission (FCC) in November 1996. In May 1998, the first launch of four Globalstar satellites took place, and therefore its space segment consists of 48 Big LEO spacecraft.

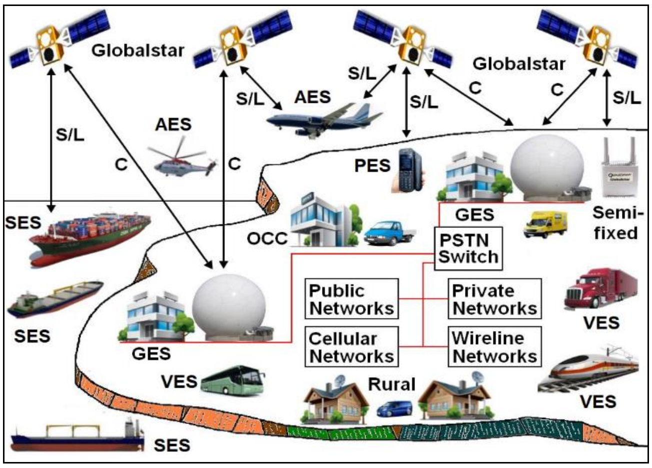

Figure 14. Globalstar MSC Network – Source: Globalstar

In fact, Globalstar does not have an inter-satellite connection and thus needs a large number of GES terminals around the world, the spacee, ground and user network of which is shown in Figure 14. The current Globalstar network controled by the Operations Control Centre (OCC) provides maritime and other mobile service via GES and LEO satellites connecting SES, VES, AES, PES as handhelds and semi-fixed terminals with PSTN and other ground networks

The Globalstar satellite operator is providing service for users via satellite at 1.610-1.621 GHz (uplink) and at 2.483-2.500 GHz (downlink) and from satellite to GES at 5.091-7.055 GHz (feeder link). Globalstar equipment such as Axonn mobile satellite tracker devices are designated for asset tracking of ships and other mobiles such as land vehicles, trains, containers, and trailers, but with simply modification of GPS Rx can be used for aircraft tracking as well. Here will be introduced 2 simplex and 1 duplex

Globalstar mobile satellite trackers manufactured by Axonn company:

1. Simplex AxTracker – This unit provides a battery-operated, self-contained SAT transmitting PVT data only (simplex) device, delivered complete and ready-to-go with no need for an external antenna or power source, which is shown in Figure 15 (Left). It measures 9.25x6.25x1and is ideal to operate in hazardous environments, such as ships container, because can work independently of power source and any inspection. The units can be pre-programmed according to the requirements and to send GPS location and other information at predefined intervals.
2. Simplex Axonn SMARTONE Tracker – This GPS Rx/satellite Tx mobile traking device is designed for the intelligent tracking and management of powered and non-powered movable assets, and is a practical solution to improve operating efficiency and security, which is illustrated in Figure 15 (Middle). The design of this unit allows it to be easily installed and field managed without the need for harnesses, antennas and external power. The advantages of independent power supply, this unit can work and send position data even if ships is emergency grounded or a missing ships container without any power sources. The SMARTONE device is powered by 4 AA 1.5 V lithium batteries providing 3+ years of battery life and removes the need to purchase expensive proprietary batteries for replacement.

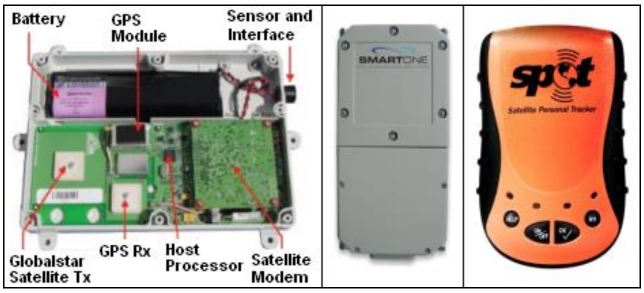

Figure 15. Globalstar Simplex and Duplex Satellite Trackers – Source: Globalstar

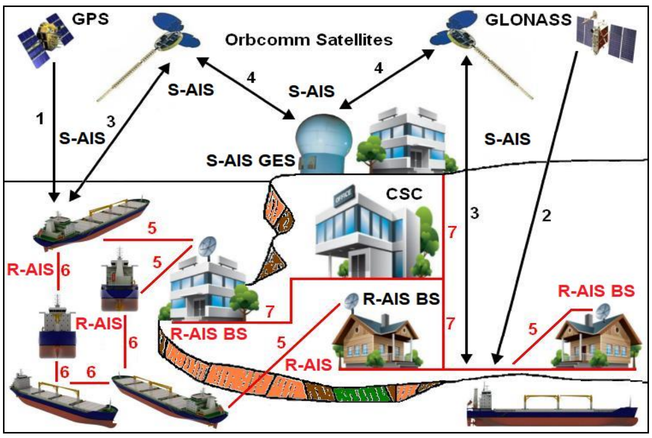

Figure 16. Orbcomm Satellite AIS (S-AIS) – Source: Orbcomm

3. Duplex Spot Satellite Personal Tracker (Spot 1) – The Spot Personal Tracker or Spot 1 was introduced to the market by Axonn in early 2008, shown in Figure 15 (Right). Using Spot Tracker, people in emergency and their families ones have peace of mind knowing help is always within reach. It is using the GPS Rx to acquire its coordinates, and then sending its location with a link to Google maps and a pre-programmed message via a satellite network. This unit does more than just call for help and checking emergency progress, non-emergency assistance are also available, just by pressing a button. Spot features four key functions that enable users to send messages to friends or family, based upon varying levels of need [5, 15, 16, 17].

6 ORBCOMM MSC EQUIPMENT AND DATA NETWORK

The Orbcomm MSC system is a wide area packet switched and two-way data transfer network that provides GPS/Orbcomm Satellite tracking, determination and monitoring services via similar SAT devices shown in Figure 12. This system may also provide Satellite Automoatic Identification System (S-AIS) integrated with Radio AIS (R-AIS) for tracking, monitoring and determination of maritime and other mobile assets via 36 Orbcomm Little LEO satellites, whichn space, ground and user network is shown in Figure 16.

Except S-AIS service, Orcomm also provides SAT for oceangoing ships onboard broadcast system that transmitted ship identification, PVT and other critical data received from GES can be used to assist in navigation and improve maritime safety and security at sea. Most current terrestrial-based Radio AIS (R-AIS) system is already implemented by IMO and provides only VHF limited coverage nearby shorelines via Base Stations (BS) and not able to provide global coverage. The Orbcomm system overcomes many of these issues thanks to a fully S-AIS and SAT data service, which is able to monitor vessels well beyond coastal regions and horizon in a cost-effective and timely fashion and send this data via GES to the Coastal Surveillance Centre (CSC) or Tracking Control Station (TCS). To spread R-AIS coverage globally some institutions and companies olso started with development S-AIS [5, 18, 19, 20].

7 CONCLUSION

Mobile SAT networks and solutions for maritime and all mobile applications that can be used for both civilian and military applications are described. SAT mobile networks can operate anywhere in the world, providing services across the horizon to ships, vehicles, planes and people on the move. Tracking messages are transmitted via the above-mentioned commercial satellites in near real time and space, whose mobile locations are displayed on computers with maps of the Geographic Information System (GIS). Thus, SAT networks and transponders operate through various existing GEO or non-GEO satellite constellations, and some of them are designed to automatically switch from one satellite system to another, depending on the situation on earth. In fact, some of the SAT terminals are designed to operate over 2 or 3 satellite operators, such as Inmarsat, Iridium, Globalstar and Orbcomm. Otherwise, all messages are encrypted from end to end, including the addresses of the sender and recipient for information security purposes. The future of mobile SAT and communication, navigation and surveillance (CNS) in general will be a combination of GEO, LEO and other orbits, such as MEO and HEO or Molny orbit in so-called hybrid satellite orbits (HSO), which can provide reliable service globally level even across the North Pole.

REFERENCES

[1] Ilcev D. S., Satellite Asset Tracking (SAT), CNS Systems Durban, South Africa, 2015.
[2] Prasad R. and Ruggieri M., Applied Satellite Navigation Using GPS, GALILEO, and Augmentation Systems, Artech House, Boston, US, 2005.
[3] Ilcev D. S., Global Aeronautical Communications, Navigation and Surveillance (CNS) - Theory and Applications, AIAA, Reston, Virginia, 2013.
[4] Inmarsat Web Sites: Available from: <www.inmarsat.com>.
[5] Ilcev D. S., Global Mobile Satellite Communications for Maritime, Land and Aeronautical Applications - Theory and Applications, Springer, Boston, 2017.
[6] Del Re E. and Ruggieri M. Satellite Communications and Navigation Systems,Springer, New York, 2008. 765 p.
[7] Seedhouse E. Military Satellites, Current Status and Future Prospects, SpaceRef, 2012.
[8] Nejat A., Digital Satellite Communications Systems and Technologies – Military and Civil Applications, Kluwer Academic Publishers (Springer), Dordrecht, Holland, 1992. 597 p.
[9] Diggelen V. F., A-GPS, Assisted GPS, GNSS and SBAS, Artech House, Boston, 2009.
[10] Orbcomm Web Sites: Available from: <www.orbcomm.com>.
[11] Kaplan D. E., Understanding GPS Principles and Applications, Artech House, London, 1996.
[12] Grewal M.S., at al, Global Positioning Systems, Inertial Navigation, and Integration, Wiley, London, 2008.
[13] Cobham Web Sites: Available from: <www.cobham.com>.
[14] Iridium Web Sites: Available from: <www.iridium.com>.
[15] Quake Web Sites: <www.quakeglobal.com>.
[16] Globalstar Web Sites: Available from: <www.globalstar.com>.
[17] CNS Systems, Maritime Radio and Satellite Communication Systems, Durban, South Africa, 2019.
[18] Ilcev D. S., Global Ship Tracking and Automatic Identification System, CNS Systems, Durban, South Africa, 2011,
[19] Orbcomm, Global Visibility Beyond Coastal Regions, AIS - Orbcomm Satellite System, Rochelle Park, 2015,
[20] Weintrit, A., & Neumann, T. Information, communication and environment: Marine navigation and safety of sea transportation. (pp. 1-284) doi:10.1201/b18514, 2015