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Space Positioning and Tracking Solutions for Military Applications

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Abstract:

This paper is discussing the current and new satellite transponders for global tracking and detecting of military assets and personnel at sea, on the ground and in the air for enhanced traffic control and management. These transponders are able to monitor all military mobile vehicles, to improve safety of movements and collision avoidance, especially for navy and air forces assets. By using 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 or military mobiles and personnel. The existing and forthcoming space and ground segment for positioning and tracking solutions as a modern Satellite Asset Tracking (SAT) onboard mobiles and other relating systems are discussed and benefits of these new technologies and solution for improved positioning and tracking are explored.

Keywords:

GNSS, GPS, GLONASS, MEO, SCS, SNS, SSS

1. Introduction

After Soviet Union launched the first in the world artificial satellite, Sputnik 1, satellite systems became the delivery mode of choice for positioning information with developments of first Navigation Satellite Systems (NSS). The US military system Transit started with development from 1960 till last launch in 1988 and the Soviet Union military system Cicada was established in 1974. After early experimentation with the doomed NSS Transit and Cicada systems, remember having to wait hours for the next satellite to appear overhead, new GNSS of GPS and GLONASS were created

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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. However, 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. While both, Transit or Cicada systems, provided intermittent two-dimensional (latitude and longitude when altitude is known) 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, equally effective for navigation and tracking at sea, on land and in the air. The configuration of military GPS and GLONASS GNSS-1 space, users and ground segments are shown in Fig. 1. In the meantime, China started development of its own GNSS-2 navigation system known as Compass (BeiDou), which is operational. The BeiDou 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.

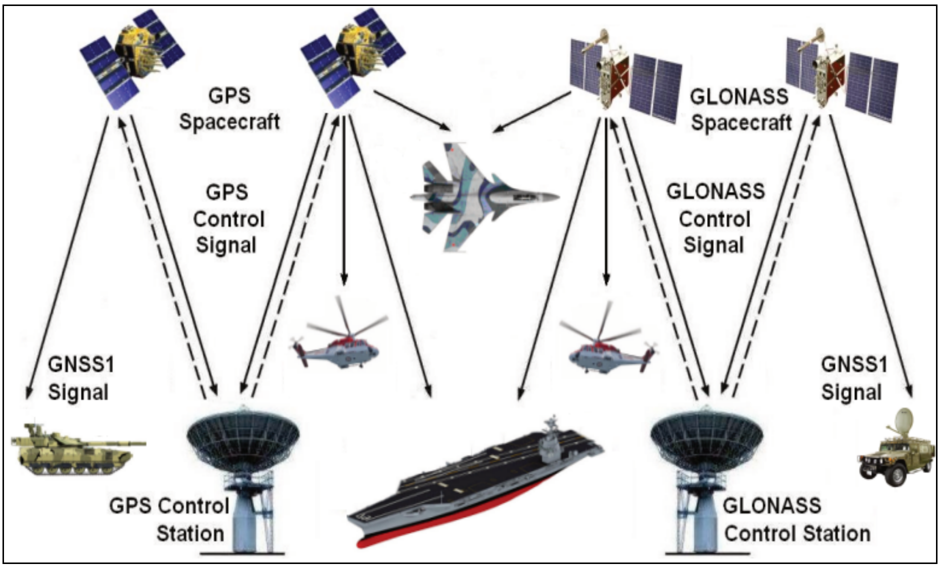

Fig. 1 Military GNSS-1 Network [1]

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), altitude 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 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 [1-3].

On the other hand, most communications between mobiles and traffic controllers are still conducted via VHF, UHF and HF analogue 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 mobiles that can be safely handled. Thus, to improve the communication and traffic control facilities of all mobiles, civilian Mobile Satellite Communications (MSC) system was implemented almost 40 years ago, which takes less time, reduces 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 Fig. 2, Military Satellite Communication Network for navy, ground and air forces is shown using L/C/Ka-band, which can provide MSC service via current Geostationary Earth Orbits (GEO), MEO or Low Earth Orbits (LEO) satellite constellations. 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 designed not only to provide more cost effective, reliable, redundant and fastest communication links between mobiles and traffic controllers, but also to integrate GNSS data for implementing new service for enhanced navigation, surveillance and tracking solutions.

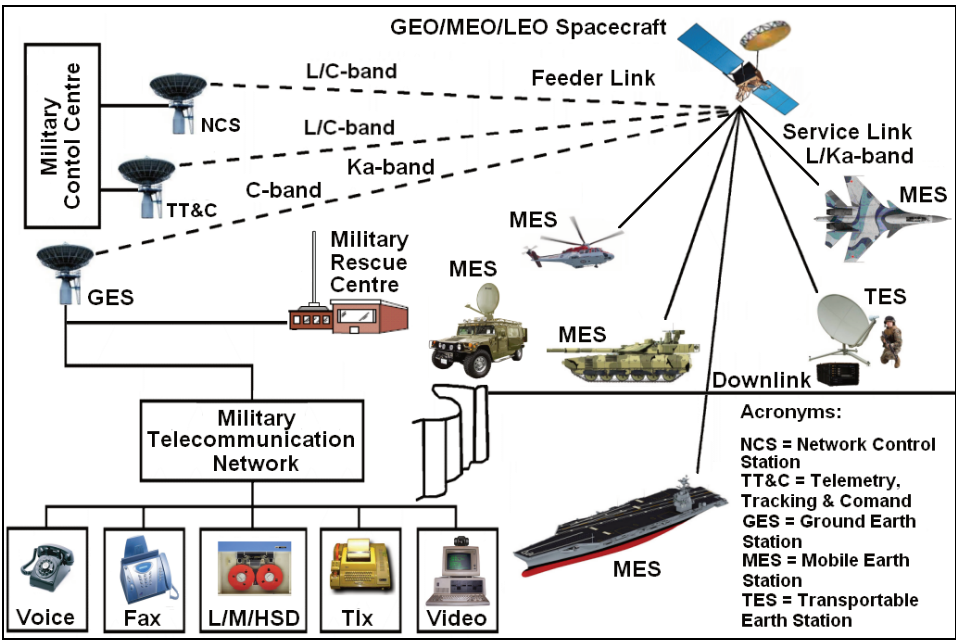

Fig. 2 Military Satellite Communication Network [4]

The convergence of MSC and Internet technique has opened many opportunities to provide positioning and tracking data to the ground infrastructure. 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 satellites to be placed in orbit constellation to cover areas of interest and adequate communications coverage [4, 5].

2. Global Satellite Asset Tracking (SAT) Systems

The GNSS network is represented by fundamental solutions for PVT of the US GPS and Russian GLONASS military 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 military and civilian mobile assets. A major goal of the near-universal use of GNSS systems is their integration with satellite communication systems; subsequently, very small GNSS/Satellite Communication units will be able to improve positioning, detecting and tracking facilities of military personal and mobile assets, such as ships, ground vehicles and aircraft.

As a result of these significant efforts, new positioning and tracking technologies have been projected and developed to utilize modern satellite Communication, Navigation and Surveillance (CNS) solutions and services for enhanced traffic monitoring, control and management of civilian and military mobile personnel and assets. Tracking data of military personnel or mobile assets received by GPS/GLONASS Receiver (Rx) can be sent via GEO or Non-GEO spacecraft, Ground Earth Stations (GES) terminals and the Internet to the Control Centres and Operations Control. In fact, all military mobiles and personnel require far more sophistication from modern satellite tracking systems than standalone GPS or GLONAS positioning systems. Thus, Satellite Asset Tracking (SAT) system is proposed 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 Fig. 3, whose integration is deploying the GNSS subsystem of US GPS and Russian GLONASS to provide free of charge PTV (Personal Transport Vehicle) and other data to different military or civilian assets. This PTV data can be received by land vehicles (trucks), aircrafts, railcars and ships via onboard GPS/GLONASS Rx integrated with satellite transceiver [4-6].

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

The SAT satellite transponder will provide solutions for the global identification and tracking of all types of military mobiles and personnel, such as Navy ships and containers, all types of Ground Forces vehicles and aircraft of Air Forces. As depicted in Fig. 4, the SAT onboard equipment receives GNSS signals from GPS/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 the Internet, to the receiver and processor of Tracking Control Stations (TCS) infrastructure (4). Thus, the positioning, communication tracking lines are highlighted in black, while **a**ll opposite lines highlighted in red are indicating SAT receiving process, namely, the receiver of onboard mobiles SAT terminals are receiving PVT data from TCS useful for collision avoidance and showing it on receiver display.

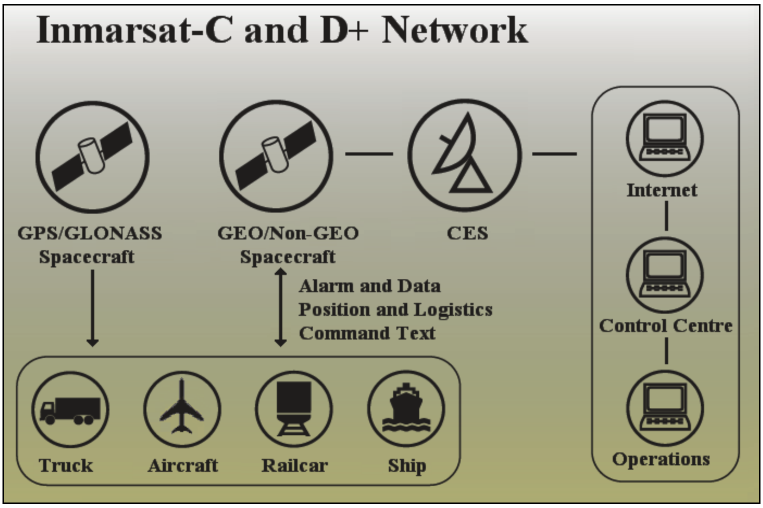

Fig. 3 Configuration of SAT System [4]

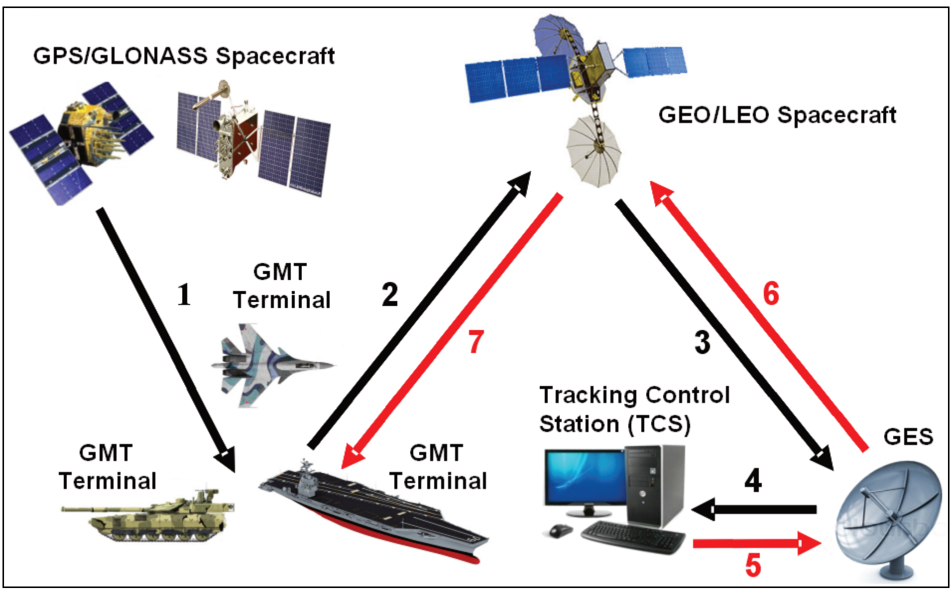

Fig. 4 Configuration of Military SAT Network [1]

At present, only the following five satellite operators are providing global or near-global satellite constellations for civilian and military SAT service:

- Inmarsat GEO satellite network provides coverage up to 80° North and South,
- O3b MEO satellite network provides full global coverage,
- Iridium Big LEO satellite network provides only real complete global coverage, because of intersatellite links,
- Globalstar Big LEO satellite network provides limited coverage that is depending on distributed number of Gateways, and
- Orbcomm Little LEO global satellite network provides 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 GEO and LEO, MEO or High Elliptical Orbit (HEO) and other satellite constellations or to use existing LEO constellations of O3b, Iridium, Globalstar and Orbcomm networks [1, 4, 5, 7].

3. Inmarsat SAT Data Network and Equipment

Inmarsat was established as no-profit firm in 1979 as the International Maritime Satellite Organization (Inmarsat), initially for the development of maritime mobile satellite communications. It began trading in 1982 via GEO satellite constellation, whose space segment with three ocean coverages of Inmarsat-4 (IO-4) satellite constellation is shown in Fig. 5. Afterwards Inmarsat started with development service for land (road and rail), personal (handheld), transportable and aeronautical applications. Inmarsat 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).

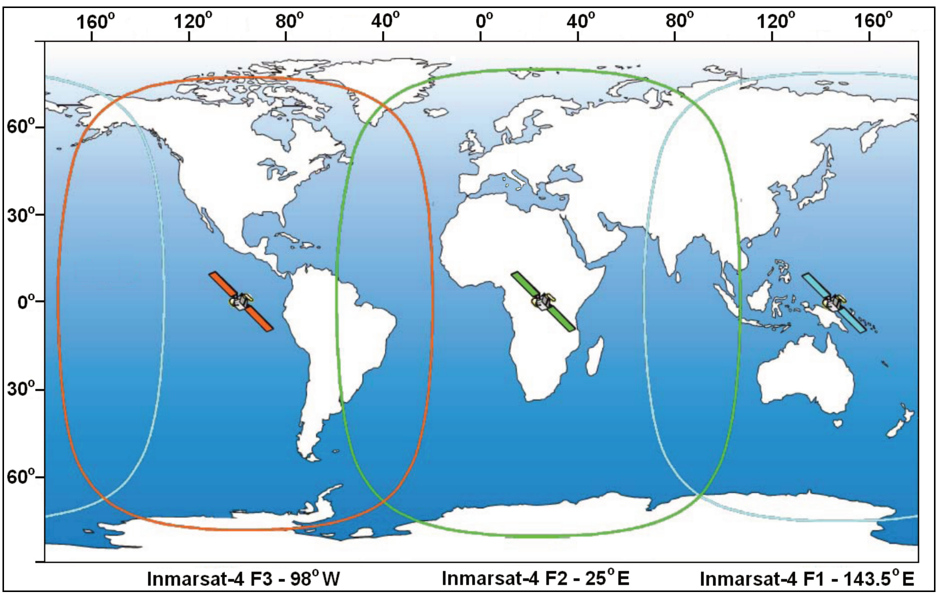

Fig. 5 Inmarsat-4 Satellite Coverage [4]

The Inmarsat I-4 satellite constellation is providing three ocean region coverages such as: I-4 F3 at position 98° W, I-4 F2 at position 25° E and I-4 F1 at position 143.5°E. The current fourth generation of Inmarsat-4 satellite constellation is upgraded with fifth generation of Inmarsat-5 satellite constellation. The Inmarsat has contracted Boeing, the US aerospace manufacturing company, to build a new constellation of Inmarsat-5 (I-5) satellites as a part of a new 1.2 billion US$ worldwide wireless broadband network called Inmarsat-5 Global Xpress (GX), which includes launch costs. The Boeing already built three Inmarsat-5 (I-5), F1, F2 and F3 satellites based on its 702HP spacecraft platform.

The Inmarsat-5 GX system may be used for government and defence applications for Navy, Ground and Air Forces, whose scenario is depicted in Fig. 6. This network can also serve for civilian and military positioning and tracking of all kinds of military assets and personnel. The Inmarsat I-4 and I-5 satellite constellations are covering the following SAT applications and units for civilian and military applications:

- shipborne service onboard seagoing or inland vessels are providing IsatData Pro, IsatM2M, Inmarsat-C, mini-C, FleetPhone and old Standard-D devices,
- vehicleborne service onboard all kinds of land vehicles are providing IsatM2M, IsatData Pro, Broadband Global Area Network (BGAN), IsatPhone, LandPhone and old Standard-D devices,
- airborne service onboard of aircraft and helicopters are providing Aero-C and some of IsatData Pro or SAT devices.

The Inmarsat satellite network is serving with the deployment of onboard equipment and solutions, such as Ship Earth Stations (SES), Vehicle Earth Stations (VES), Transportable Earth Stations (TES), Personal Earth Stations (PES) and Aircraft Earth Stations (AES).

In general, SAT system can be implemented for service onboard ships as Global Ship Tracking (GST), onboard land vehicles as Global Vehicle Tracking (GVT) for road and rail transport, Global Aircraft Tracking (GAT), TES and PES.

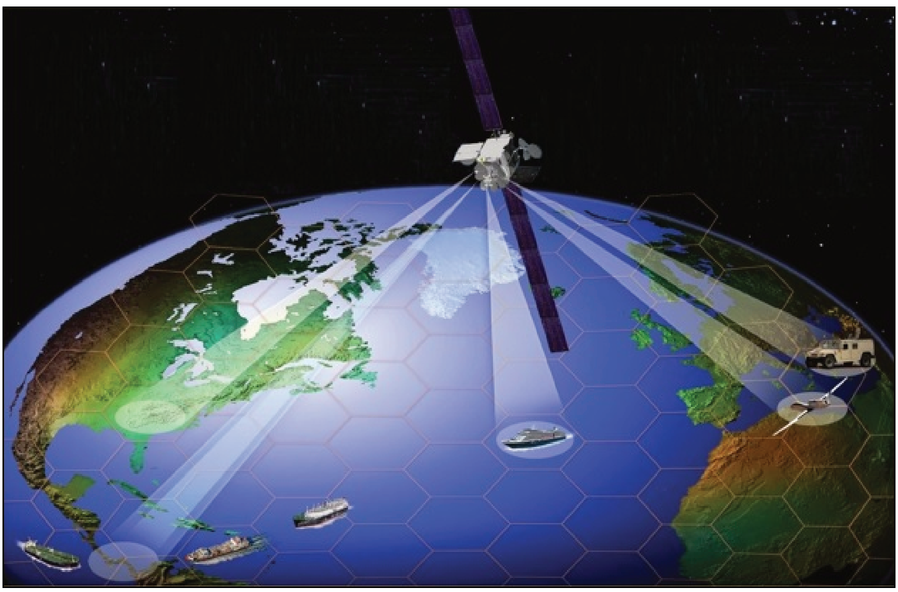

Fig. 6 Inmarsat I-5 Solutions for Military Applications [4]

The ground segment comprises a network of GES terminals or Land Earth Stations (LES), which are managed by LES operators, Network Coordination Stations (NCS) and Network Operations Centre (NOC). However, the major part of the ground segment and network are mobile subscribers or MES as service users. 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 [4, 5, 8].

3.1. Inmarsat-C and Mini-C Terminals

The Inmarsat-C and mini-C standards are a two-way packet data smallest satellite terminals dedicated for installation onboard of all mobile, semi-fixed and transportable assets for transmission of two-way data and telex messages at an information rate of 600 b/s on L-band, while facsimile and E-mail messages are transmitted only in ship-to-shore direction via LES terminals. From LES terminals two-way or duplex transmission are going via TTN and the Internet to PC terminals with special software to be processed and memorised, which PVT data can be used for tracking of ships and any other mobiles.

The Inmarsat-C is second standard developed in 1988 by Inmarsat dedicated at first for commercial and distress maritime application on merchant and even military fleets. The typical SES-C has a small and compact omnidirectional antenna in radome as an Above Deck Equipment (ADE), which because of its lightweight and simplicity, can be easily mounted on all type of ships, yachts, fishing boats, offshore platforms and other mobiles. The main components of Standard-C terminal shown in Fig. 7 (left) contain ADE Below Deck Equipment (BDE) with peripherals. The ADE can be a single Inmarsat-C or combined Inmarsat-C/GPS omnidirectional antenna. The BDE component can be an Inmarsat/C transceiver only or combined with a built-in GPS receiver and installed onboard ships 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.

The Inmarsat mini-C terminal was introduced in 2002 as smallest and very compact Inmarsat satellite communication transceiver integrated with 2-channel GPS Rx in one single device, with a total weight of 1.1 kg and a size of 15 cm, which is depicted in Fig. 7 (right). This mobile unit 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-C and mini-C satellite terminals can be deployed as solutions for many applications to onboard vessels for Global Maritime distress and Safety System (GMDSS), Long Range Identification and Tracking (LRIT), Vessel Monitoring System (VMS), SCADA or M2M and so on. The power requirements of both terminals can be met from a ship’s mains or in emergency by rechargeable battery sources via ships power supply unit [3, 4, 9].

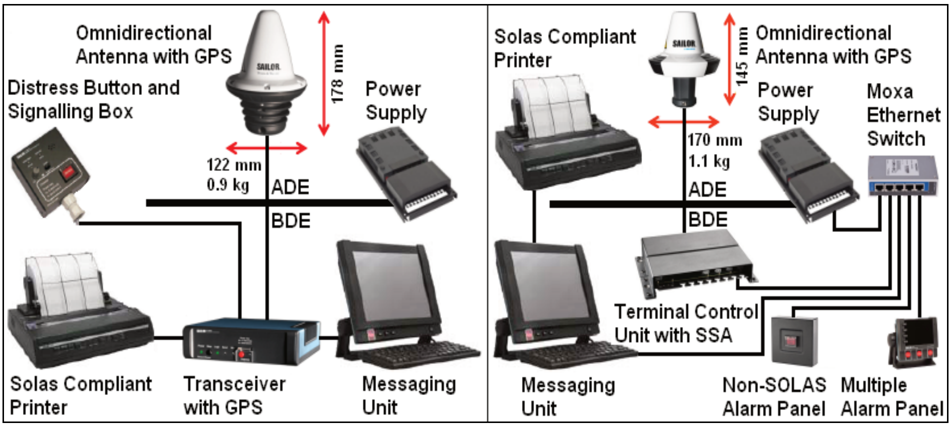

Fig. 7 Maritime Sailor Inmarsat-C and mini-C Terminals [4]

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, whose 1st, 2nd and 3rd generations respectively are shown in Fig. 8. These units are integration of Standard D+ transceiver with the US GPS or Russian GLONASS receivers and both antennas. It is ideally suited for all mobile tracking, tracing, short data messaging and SCADA (M2M) applications. In addition, it may be used in the point-to-multipoint broadcast of information, typically for financial data, such as exchange rates and stock exchange prices, credit-card listings, distress and disaster alerts. Subscribers can receive tone, numeric and alphanumeric messages, as well as clear data.

Fig. 8 Maritime Inmarsat-D+ 1st (left), 2nd (middle) and 3rd (right) Generations [10]

These terminals can store and display at least 40 messages of up to 128 characters each, and will be also able to transmit PVT data derived from integral GPS/GLONASS. The service provides the capability to send a message to a group of MES users, which will require a group member Pager Identity (PID) in addition to the individual PID. The MES terminals will not generate an acknowledgement to a group call, however all messages must be controlled via the end-to-end application. All messages sent to an MES 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 D+ solution is capable to transmit from the mobile subscriber to the base: a) Acknowledgement Burst, b) Short Burst Data (SBD) and c) Long Burst Data (LBD).

Due to the development of new Inmarsat IsatData Pro and IsatM2M standards, as of 31 December 2015, new mobile activations of Inmarsat-D+ are no longer accepted and the service will no longer be provided as of 31 December 2016. As an alternative, Inmarsat is offering new generation of similar telematics service known as IsatData Pro and IsatM2M satellite terminals.

As stated above, successors of Inmarsat-D+ are recently developed solutions by Inmarsat known as IsatData Pro (IDP) and IsatM2M. Both standards, 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 in near global coverage. These equipment, whether used for oceangoing ships, fishing vessels, containers, buoys, vehicle tracking, trailers, mining assets, SCADA Machine-to-Machine (M2M) or oil and gas equipment, these standards facilitates improved asset visibility, management, increased productivity, lower operating costs and regulatory compliance [5, 10, 11].

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 s to 60 s depending on message size

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 transport vehicle security, industrial equipment monitoring and marine tracking, giving companies visibility and control of fixed or mobile assets. Speeds of 10.5 bytes or 25.5 bytes in the send direction and 100 bytes in the receive direction, with a latency of typically from 30 s to 60 s.

Purchasing SkyWave manufacturer of Inmarsat tracking satellite terminals and their menu of products, Orbcomm satellite operator reproduced under its brand two standards that provides maritime tracking solutions. First Inmarsat IDP-690 terminal is part of IDP 600 series of terminals for vessel tracking device engineered for maritime and low elevation-angle applications, which is depicted in Fig. 9 (left). Second terminal shown in Fig. 9 (right) is IDP-800 dedicated to monitor trailers, containers, vessels and more with fully programmable satellite tracking enabled by GPS or GLONASS PVT data. The Inmarsat-IDP terminals with its serial interface and published communication protocol allow an easy integration with an external controller, mobile display terminal or PC (Laptop) terminal. If there is not enough space, both Inmarsat-IDP terminals can be interfaced to message terminal shown in Fig. 10 (left). Fig. 10 (right) shows a printer [5, 10, 12, 13].

4. Iridium SAT Data Network and Equipment

The concept for the Iridium MSC system was proposed in late 1989 by Motorola engineers and after the research phase, Iridium LLC system was founded in 1991, with an investment of about 7 billion US $. Maintaining its lead, Iridium LLC became operational MSC system on 1st November 1998. After a period of bankruptcy, the Iridium service was relaunched on 28th March 2001.

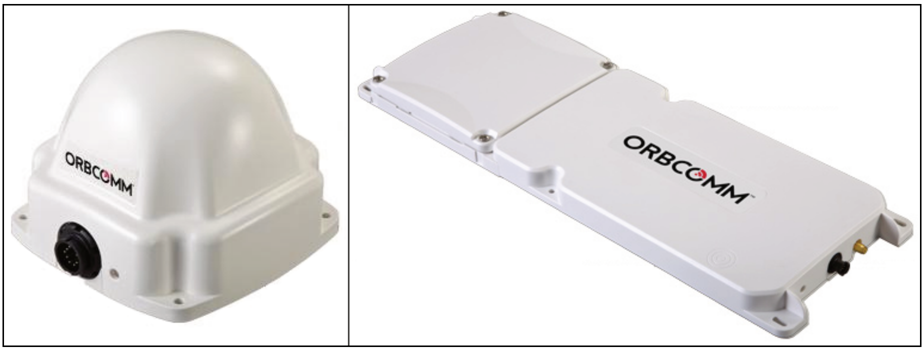

Fig. 9 Maritime Inmarsat-IDP new Generations [10]

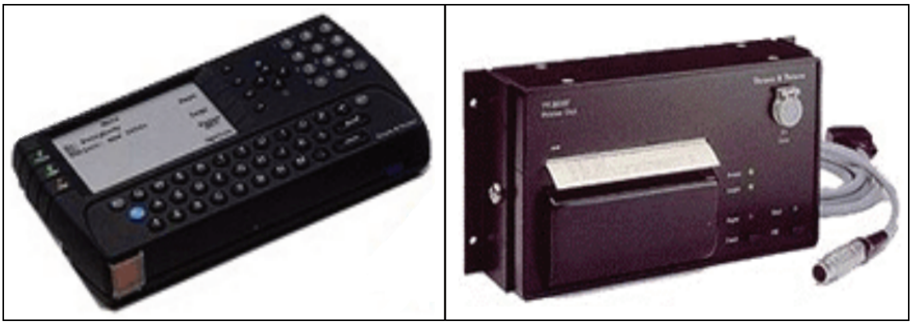

Fig. 10 Thrane&Thrane Message Terminal and Capsat Printer [13]

The Iridium Big LEO satellites are situated in a near-polar orbit at an altitude of 780 km. They circle the Earth once in every 100 minutes travelling at a rate of about 26 856 km/h. Each satellite is cross-linked to four other satellites, with two satellites in the same orbital plane and two in an adjacent plane. The Iridium constellation consists in 66 operational satellites and 14 spares orbiting in a constellation of six polar planes. The Iridium system provides a real global coverage and roaming the whole Earth's surface via 48 spot satellite overlapping beams and the diameter of each spot is about 600 km, shown in Fig. 11. Iridium as a real global operator provides voice and data service including SAT for all mobile applications via uplink/downlink at 1 621.35-1 626.5 MHz, feeder links at 29.1-29.3 GHz of Ka-band (uplink) and at: 19.4-19.6 GHz of K-band (downlink) and cross-link or intersatellite link at 23.18-23.38 GHz of Ka-band.

4.1. Iridium SAT and Fleet Management Terminals

The Online Tracking Platform (OTP) system is a web-based integrated Iridium, Inmarsat and GSM 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 via web and it provides superior GPS tracking and mapping, while no special hardware or software is required, seamless software and firmware updates. It reliably tracks personnel, equipment 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 basic unit for many trackers using the Iridium Network, illustrated in Fig. 12 (left). This very tiny, (41 × 45 × 13) mm and 27.22 g, two-way transceiver is perfect for use in different applications for the rapidly growing mobile, including aircraft and fixed remote asset tracking and M2M monitoring solutions. This Iridium unit has not GPS Rx, but can be connected to onboard GPS via built-in GPS input/output ports. In addition, the adequate sensors can be connected to this device inputs, such as mileage, consumption of fuel, temperatures, door, cargo etc.

2. Iridium SL Mini Tracker – The Iridium very small and lightweight SBD modem with integrated GPS Rx is the smallest self-contained Iridium tracker in the world, which a 32 bit Advanced RISC Machine (ARM) processor supported by a fully user-customisable LUA scripting language, where RISC is Reduced Instruction Set Computing. Its internal dimensions are (1.77 × 1.77 × 1.34) inches (45 × 45 × 34) mm, including battery, whose modem and antenna are illustrated in Fig. 12 (middle). It can transmit location from anywhere in the world and it is built on the latest satellite, antenna and electronics technology to track and monitor all mobiles in real time, whose real size is depicted in Fig. 12 (right).

3. Quake Q4000 Tracker – Though the Iridium Q4000i is small enough to fit in hand produced by the US Company Quake. It is a two-way rugged transponder that can combines dual-mode operability over Iridium and GSM terrestrial networks with GPS into a versatile, all-in-one mobile asset tracking solution, which is shown in Fig 13 (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.

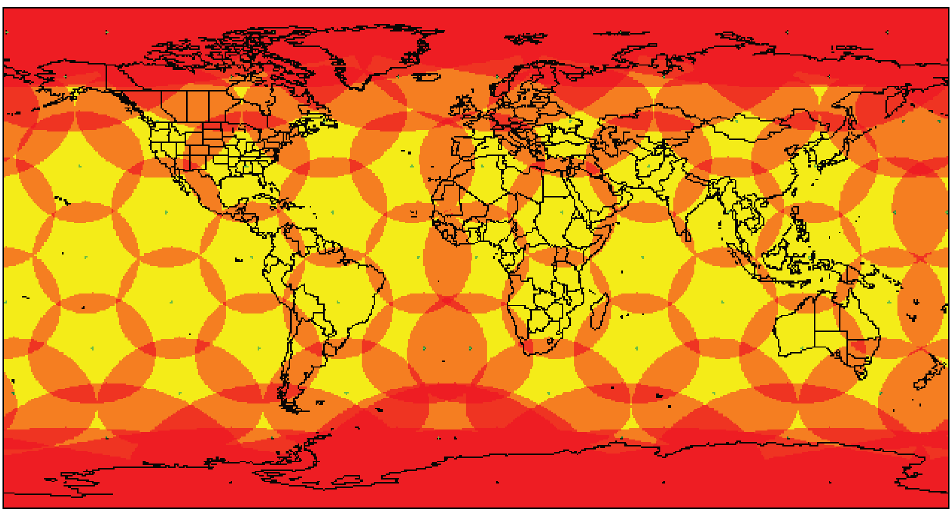

Fig. 11 Iridium First and Second Generation Coverage Map [14]

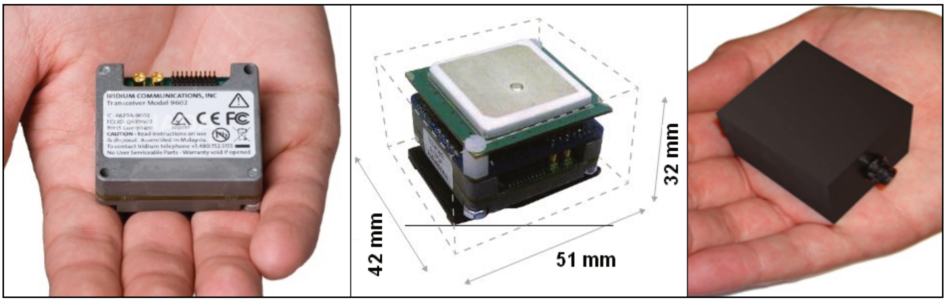

Fig. 12 Iridium Miniature SAT Terminals [14]

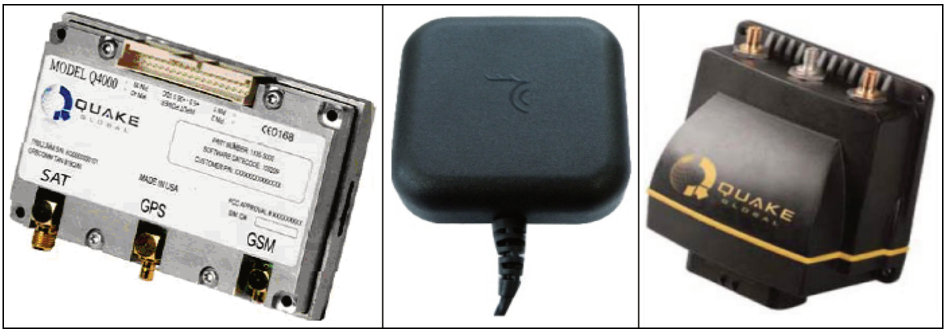

Fig. 13 Iridium Mobile SAT Terminals with Antenna [14]

Technically this is an SBD transceiver designed for use as basic unit for many mobile trackers using the Iridium network, such as oceangoing ships and container tracking, as well as for land vehicles and aircraft tracking. In addition, this tracker without integrated GPS can be implemented for monitoring of many machines, pipelines, devices, instruments, power stations and so on via 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 (3.91 × 2.52 × 0.63)", i.e. (99.3 × 64.0 × 15.9) mm, and weight is 0.375 lbs (170 g). Fig. 13 (middle) shows a bolt, magneting or adhesive mount Hirschmann low profile Iridium antenna (63 × 63 × 18) mm 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 a small (119.2 × 119.4 × 57.6 mm and 390.6 g) and rugged, environmentally-sealed multi-satellite GPS integrated with Iridium, Globalstar, Orbcomm and GSM modem with many options, shown in Fig. 13 (right). For SAT applications this unit has integrated GPS with 50 channels and can be also connected to Hirschmann low profile Iridium antenna, shown in Fig. 12 (middle).

4.2. Personal Satellite Trackers

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

1. E-Track Epsilon Personal Tracker – This personal tracker is waterproof satellite messaging and personal tracking device, providing real-time autonomous and global coverage, presented in Fig. 14 (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 incident.

2. GeoPro Personal Messenger – This personal tracker is a remote workforce safety, location awareness and two-way personal messaging solution, illustrated in Fig. 14 (middle). When work takes staff off the grid, they often have no reliable means of maintaining communication. It is the affordable and rugged device supporting global two-way text messaging and can be used in one hand with non-slip form factor network by a joystick to navigate on-display menus and keyboard [3-5, 14].

Fig. 14 Iridium Personal Satellite Trackers [14]

3. NANO Personal Tracker – This unit has ultra-low power consumption less than 35 μA during sleep, shown in Fig. 14 (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 device ON/OFF and selects highlighted item on the menu; 2. Arrow Up/Down/Right is navigating the cursor; 3. Check-In Soft Key is accessing Check-In feature; 4. Way Point Soft Key is used for Way Point features; 5. USB Port is serving to charge the battery and connects PC; 6. Emergency key can send an emergency alert, distress and notification to search and rescue forces; 7. Guard button protects emergency button from being accidentally activated; 8. LED displays tracking and emergency statuses; 9. Antenna post is showing GPS antenna; and 10. Antenna post is showing Iridium antenna.

5. Globalstar SAT Data Network and Equipment

Loral Space & Communications, with Qualcomm Incorporation developed the concept of Globalstar system at a similar time to Iridium. Globalstar gained an operating license from the USA FCC in November 1996. Then, the first launch of four Globalstar satellites occurred in May 1998 and therefore its space segment is consisting in 48 Big LEO spacecraft. Globalstar has not intersatellite links and therefore needs a number of GES terminals worldwide, whose coverage is shown in Fig. 15. Globalstar 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).

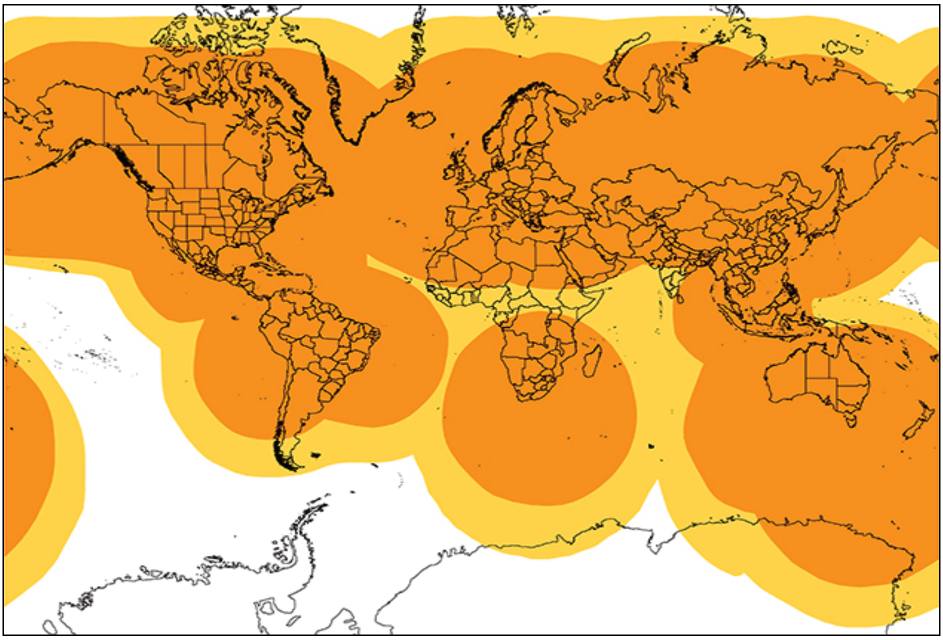

Fig. 15 Globalstar Simplex and Spot Data Coverage Map [15]

The Globalstar equipment such as Axonn mobile satellite trackers are designated for asset tracking of road vehicles, trains, containers, trailers and ships, but with a simple modification of GPS Rx it can be used for aircraft tracking as well. On the other hand, Guardian SAT producer has solutions just for aircraft tracking. It will be introduced here 2 simplex and 1 duplex Globalstar mobile satellite trackers of Axonn producer:

1. Simplex AxTracker – This unit provides a battery-operated, self-contained SAT transmitting PVT data only (simples) device, delivered complete and ready-to-go with no need for an external antenna or power source, which is illustrated in Fig. 16 (left). It is (9.25 × 6.25 × 1)” in size and ideal for hazardous operating environments. Moreover, it is ideal for aircraft installation and tracking because it can work independently of power source and any inspection. This unit can be pre-programmed in the way to send PVT, ID and other data in pre-defined intervals of each 5, 10 or “n” minutes.

2. Simplex Axonn SMARTONE Tracker – This GPS Rx/satellite Tx unit is designed for the intelligent tracking and management of powered and non-powered fixed and movable assets, and it is a practical solution to improve operating efficiency and security, which is illustrated in Fig. 16 (middle). The design of this unit allows it to be easily installed and field managed without the need for harnesses, antennas and external power. Because of the advantages of independent power supply, this unit can work and send position data even if aircraft is emergency grounded without any power sources. The SMARTONE is powered by 4 AA 1.5 V lithium batteries providing 3+

years of battery life and eliminates the need to purchase expensive proprietary batteries for replacement.

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 Fig. 16 (right). With the Spot Tracker, people in emergency and their families have peace of mind knowing help is always within reach. It is the only device of its kind, 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 commercial satellite network. This unit does more than just call for help and since not only checking emergency progress, but also non-emergency assistance are also available, both simply at the push of a button. Spot features four key functions that enable users to send messages to friends, family or emergency responders, based upon varying levels of need.

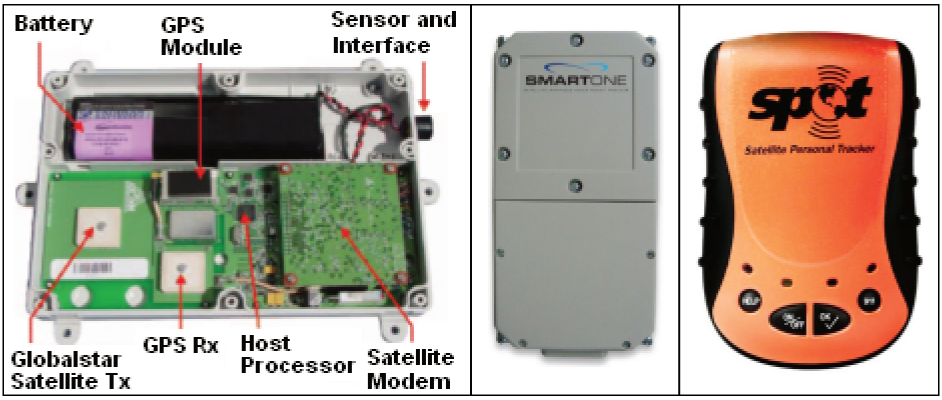

Fig. 16 Globalstar Simplex and Duplex Satellite Trackers [15]

6. Orbcomm SAT Equipment and Data Network

The Orbcomm SAT system is a wide area packet switched and two-way data transfer network providing GPS/Orbcomm Satellite tracking, determination and monitoring services via similar SAT devices of above stated networks to previous stated SAT for fixed and mobile assets via 36 Orbcomm Little LEO satellites [1, 3, 5, 14, 15].

7. Conclusion

This article describes SAT networks and solutions for all mobiles applications, which can serve for both civilian and military applications. The SAT networks can operate anywhere in the world giving over-the-horizon service to ships, vehicles, aircraft and personnel on the move. The PVT and other data messages transmitted via selected satellites can be received in the real-time and space by the GES and Internet and they are displayed on the users´ computers via special GIS maps

Thus, the SAT networks and transponders operate over variety of existing GEO or Non-GEO satellite constellations and some of them are designed for transition automatically from one satellite system to another, as the situation on the ground requires. In fact, some of SAT terminals are designed to work via 2 or 3 satellite operators, such as Inmarsat, Iridium, Globalstar and Orbcomm. Otherwise, all messages are encrypted end-to-end, including sender and recipient addresses for information security purposes. The future of mobile SAT and Communication, Navigation and Surveillance (CNS) in general will be combination of GEO, LEO and other orbits, like MEO and HEO or Molnya orbit in so called Hybrid Satellite Orbits (HSO), which can provide a reliable service globally even over North Pole.

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