Architecture of Orbcomm Satellite System for Global Mobile Satellite Communications (MSC) Networks

Dimov Stojce Ilcev
University of Johannesburg (UJ), Johannesburg, South Africa.

Abstract: This paper is introducing the Orbcomm Little Low Earth Orbit (LEO) or Non-Geostationary Earth Orbit (Non-GEO) for Global Mobile Satellite Communications (MSC) Networks and Equipment as a wide area packet switched and global two-way data transfer satellite network. This network provides satellite communication, tracking, monitoring and logistics services between mobile, remote, semi fixed or fixed Subscriber Communication Units (SCU) for MSC via Gateway Earth Stations (GES) or Gateway Control Centres (GCC) accomplished via LEO satellites and Network Control Centres (NCC). Orbcomm Global, L.P., from Dulles, Virginia, USA equally owned by Teleglobe and the Orbital Sciences Corporation, provides global services via the world's first LEO satellite data and messaging communications system. Thus, the US Federal Communications Commission (FCC) granted Orbcomm system a commercial license in October 1994 and the Commercial service began in 1998. Orbital Sciences was the prime contractor for the design project of Orbcomm satellites. The Company owns and operates a network consisting in 36 Little LEO satellites and several GES deployed around the world, connecting small, low-power and commercially proven SCU terminals to private and public networks, including the Internet. Orbcomm delivers information to and from virtually anywhere in the world on a nearly real-time basis to the Terrestrial Telecommunication Network (TTN). The Orbcomm space segment has subscriber transmitters (Tx) that provide a continuous 4.8 Kb/s to 9.6 Kb/s stream of downlink packet data to the receivers (Rx), and vice versa.

Key Words: MSC, SCU, GES, GCC, NCC, TTN, Space/Ground/User Segments, SATFM, S-AIS, SCADA

1. Introduction

The Orbcomm system is a wide area packet switched and two-way data transfer network providing MSC, tracking and monitoring services between mobile, remote, semi fixed or fixed SCU devices and GES or GCC terminals accomplished via the constellation of Little LEO satellites and NCC terminals. Namely, Orbcomm is a global mobile satellite system that offers affordable wireless data and messaging communications services using a small integrated GPS/Orbcomm tracking devices via Orbcomm Little LEO satellite constellation.

The Orbcomm satellite system and network with special onboard mobiles equipment is capable of sending and receiving two-way alphanumeric packet messages, similar to the well-known two-way paging, SMS or E-mail messages. This satellite network enables two-way monitoring, tracking and messaging and information services through the world's first commercial Little LEO satellite slow data communications system, which applications include tracking mobile assets such as oceangoing ships, fishing vessels and barges, containers, land vehicles, trailers, locomotives and rail cars, heavy equipment and aircraft including monitoring and controlling fixed sites. Fixed Orbcomm service is Supervisory Control and Data Acquisition (SCADA) or Mashine-2-Machine (M2M) of electric utility metres, water levels, oil and gas storage tanks, wells, pipelines and environmental projects and a two-way messaging service for consumers, commercial and government entities.

The Company owns and operates a network consisting in 36 LEO satellites and 4 terrestrial GES terminals deployed around the world. Small, low-power and commercially proven SCU can connect to private and public networks, including the Internet, via its satellites and Gateways. Through this network, Orbcomm delivers information to and from virtually anywhere in the world on a nearly real-time basis, which Tx subscribers provide a continuous 4.8 even to 9.6 Kb/s stream of downlink packet data. Vital messages generated by a variety of applications are collected and transmitted by an appropriate mobile or fixed SCU to a satellite in the Orbcomm constellation. The LEO satellite receives and relays these messages down to one of four US GES terminal. The GES then relays the message via satellite link or dedicated terrestrial line to the NCC. The NCC routes the message to the final addressee, through the Internet via E-mail to a personal computer (PC), through terrestrial networks to a subscriber communicator or pager and to dedicated telephone line or facsimile.

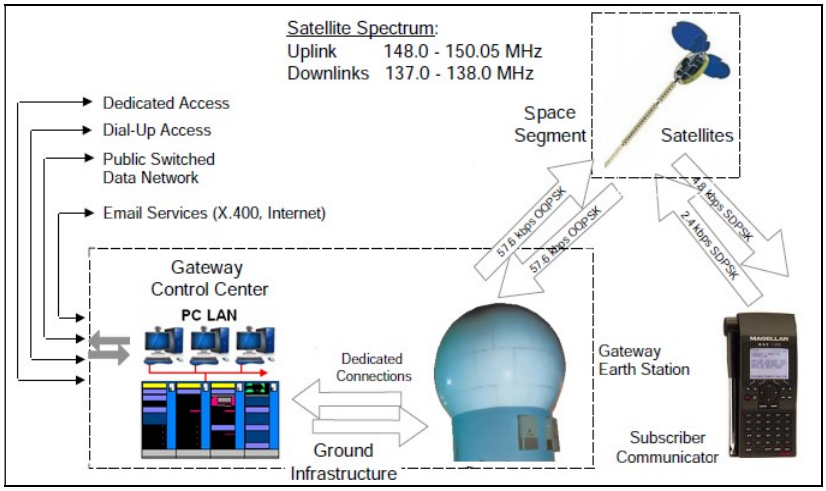

Figure 1. Orbcomm System Overview

The Orbcomm Space and Ground network with GES, GCC and SCU is illustrated in **Figure 1**. Messages originating outside the USA are routed through international GCC in the same way to its final destination. In reverse mode, messages and data sent to a remote SCU can be initiated from any computer using common E-mail systems, Internet and X.400. The GCC or NCC then transmits the information using Orbcomm's global telecommunications network. Orbcomm serves customers through Value Added Resellers (VAR) operators that provide expertise in specific industries. These Orbcomm VAR provide whole product solutions and customer support to end-users. Customers from around the world currently rely on Orbcomm for a wide range of mobile and fixed site data applications including:

1) Monitoring and controlling assets at remote or rural sites for oil/gas extraction, pipeline operations, storage, custody transfer and electric power generation and distribution;

2) Messaging for truck fleets, owner operators and remote workers;

3) Tracking and managing construction equipment, locomotives, rail cars, trucks, trailers, containers, vessels, aircraft and locating and recovering stolen vehicles and cargo and

4) Weather data for general aviation.

The Orbcomm system allows users to track, monitor and manage remote assets. Through a network of LEO satellites and regional GES terminals, users can communicate with their mobile or fixed assets anywhere in the world. This system is operational, robust and provides service to customers worldwide today. Orbcomm is in a position to offer low-cost and high-quality service to each customer. Therefore, Orbcomm committed staff are dedicated to fulfilling the specific needs of all potential users. The main service of the Orbcomm network and onboard mobiles devices are optimized to provide near real-time, remote vessel and container tracking, monitoring and control for commercial fishing boats, merchant marine oceangoing and inland vessel fleets as well as ocean buoys stationed or traveling global sea, ocean and inland waters. Through its versatile suite of programmable satellite and dual-mode devices, the Orbcomm network enables commercial fleets of any size to maintain vital data communications links with home ports, no matter where they are on the world's oceans. Vessel tracking systems also improve maritime security and fuel efficiency while cost-efficiently ensuring regulatory compliance.

In addition, the Orbcomm network enhances maritime safety, vessel security at sea and in ports, Search and Rescue (SAR) service and guide rescue operations in distress alert. It further improves crew safety with panic buttons linked to shore systems to identify maritime emergencies and guide rescue operations. It also participates in the formation of the system for transmitting in the real-time weather (WX), navigation (NX) and safety alerts to crews at sea, tracks vessel locations to comply with Long Range Identification and Tracking (LRIT) network and Ship Security Alert Service (SSAS) regulations and recommendations. It provides service of the Simplify Vessel Monitoring System (VMS) deployment and accelerates time to market and reduce integration service costs with a pre-certified VMS kit.

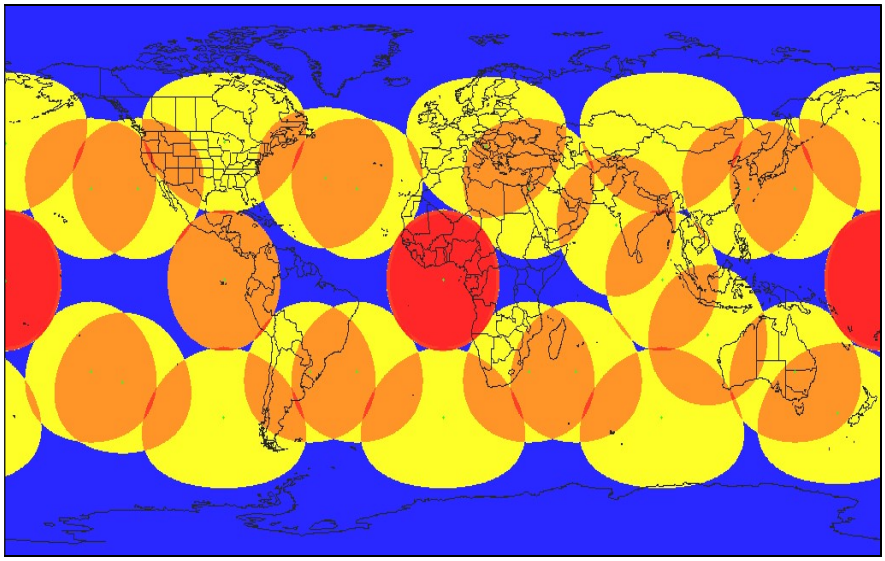

Figure 2. Orbcomm Satellites Coverage and Footprints

Finally, the Orbcomm network reduces total cost of ownership with cost-effective hardware and software, network services and professional support. It ensures compliance with existing fisheries regulations, sends required forms, logs, and files from a vessel to port authorities, reduces vessel fuel costs and monitor engine performance, optimizes fuel consumption and reduce costs by monitoring vessel fuel sensors in near real-time.

It collects vessel engine performance data and ensures fleets are always operating at their best, seamlessly integrates vessel tracking onboard devices into existing fuel monitoring solutions, monitors vessel performance and reduce paperwork, ensures all vessels are working at peak efficiency at all times through continuous monitoring of vessel performance data. This satellite network reduces paperwork with direct connections to onboard IT systems, telemetry reports, and information gathered on oceangoing vessels, transmit catch reports, fishing forms, e-mails and more with shore systems in near real-time.

The Orbcomm system for VMS infrastructure includes everything shipping and fishery companies need to simplify the development and deployment of VMS network solutions, and learn how the satellite tracking onboard ships devices are integral in developing a centralized VMS solution for a government fisheries regulator.

In general, the Orbcomm satellite network allows fixed, maritime, land (roads and rails) and aeronautical users to provide tracking, monitoring and manage remote assets via satellite network, which almost global coverage and footprints are shown in **Figure 2.** Through a network of LEO satellites and regional GES terminals, various users can communicate with their mobile or fixed assets anywhere in the world. Orbcomm is in a position to offer low-cost and high-quality service, which staff is dedicated to fulfilling the specific needs of all potential users.

2. Orbcomm Space Segment

Orbcomm communication network consists in 36 first generation operational satellites in Little LEO orbit at about 825 km above the Earth's surface. Orbcomm is also developing second new generation (OG2) satellites, which will also provide new service known as Satellite - Automatic Identification System (S-AIS). By the way, the main function of Orbcomm's satellite network is to complete the link between the SCU terminals and the switching capability at the NCC stations in the US, or a licensee's GCC terminals in other countries. Orbcomm is a family of LEO MSC satellites, operated by the US satellite communications company Orbcomm. As of July 2014, 51 such satellites have orbited Earth, with 50 still continuing to do their service. The Orbcomm LEO satellites are "orbiting packet routers" ideally suited to "grab" small data packets from mobile or fixed sensors and relay them through a tracking Earth station and then to a GCC terminals.

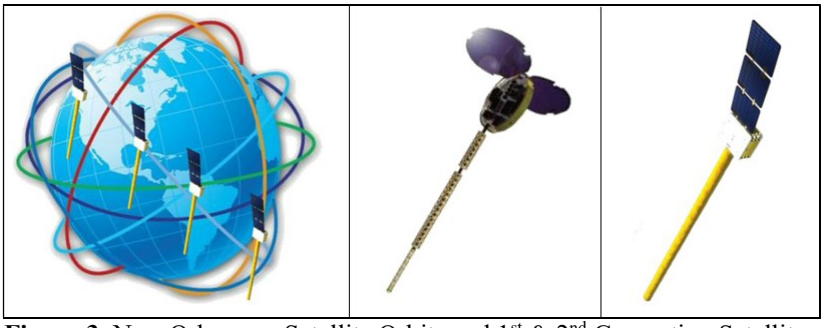

Figure 3. New Orbcomm Satellite Orbits and 1st & 2nd Generation Satellites

The modern Orbcomm-CDS (Concept or Capability Demonstration Satellites) MSC network are spacecraft launched to test equipment and communication techniques used by other satellites. The first three CDS satellites, Orbcomm-X, CDS-1 and CDS-2, were launched before any operational satellites, in order to validate the systems to be used in the operational constellation. Orbcomm-X, also known as Datacomm-X, was launched in 1991, which carried communications and GPS experiments. Then, CDS-3 was launched in 2008, along with the 5 Quick Launch satellites. It contained experiments for relaying signals from the US Coast Guard AIS infrastructure through the satellite constellation. The new generation of the Orbcomm's OGx satellites for the Internet of Things (IoT) service will be commercially available with nearly global coverage starting on 18 June 2024, so Orbcomm will be rolling out additional features and functionalities for the OGx network in the near future, opening ongoing growth opportunities for IoT solution providers. In **Figure 3 (Left)** is shown the new Orbcomm satellite constellation, while in **Figure 3 (Middle & Right)** are illustrated the 1st and 2nd Orbcomm satellites, respectively.

The Orbcomm satellites constantly move, so large obstructions do not prohibit available coverage is in remote rural areas. In comparison, the GSM (cellular) coverage depends on tower location, usually centered on major highways and cities and cannot reach remote areas. Moreover, the GEO satellite system requires large space constructions, costly and power-intensive hardware. Except slow data transfer, large data files (such as graphics) or emergency response latencies are, however, not appropriate applications for Orbcomm.

As mentioned, the last Orbcomm constellation consisted in 36 satellites in orbit:

1) Planes A, B and C is inclined at 45° to the equator and each contains eight satellites in a circular orbit at an altitude of approximately 815 km.

2) Plane D is also at 45° containing seven birds in a circular orbit at an altitude of 815 km.

3) Plane F is inclined at 70° and contains two birds in a near-PEO at an altitude of 740 km.

4) Plane G is inclined at 108° and contains two satellites in a near-polar elliptical orbit at an altitude varying between 785 km and 875 km. Plane E is in circular equatorial orbit.

The Orbcomm network depends on the number of satellites and Gateways in operation and the user's location. As the satellites move with the Earth, so does the approximately 5.100 km diameter geometric footprint of each satellite. This system provides redundancy at the system level, due to the number of satellites in the constellation. Thus, in the event of a lost satellite, Orbcomm will optimize the remaining constellation to minimize the time gaps in satellite coverage. Consequently, the Orbcomm constellation is tolerant of degradations in the performance of individual satellites.

To date, 36 Orbcomm satellites have been launched, using Pegasus XL and Taurus launch vehicles, which are based on the Orbital Microstar satellite bus. Undeployed, the Orbcomm satellite resembles a circular disk and the spacecraft weighs circa 43 kg, measuring approximately 1 m in diameter and 16 cm in depth. Circular panels hinge from each side after launch to expose solar cells. These panels articulate on the 1-axis to track the Sun and provide 160 W. The satellite's electrical power system is designed to deliver circa 100 W on an orbit-average basis, near its expected End of Life (EOL) in a worst-case orbit. The satellite solar panels and antennas fold up into the disk or "payload shelf") with the remainder of the payload during launch and deployment. Once fully deployed, the spacecraft length measures about 3.6 m from end to end with 2.3 m span across the solar panels disks. The spacecraft long boom is a 2.6 m VHF/UHF gateway antenna.

As already stated, in **Figure 3 (Right)** is shows the main parts of a fully deployed satellite. Each spacecraft carries 17 data processors and seven antennas, designed to handle 50,000 messages per hour. Its satellite transponder receives by 2400 b/s at 148 to 149,9 MHz and transmits by 4800 b/s at 137 to 138 MHz and 400.05 to 400.15 MHz. The system uses X.400 (CCITT 1988) addressing and message size is typically 6 to 250 bytes (no maximum). The most important orbital parameters of the Orbcomm constellation are presented in **Table 1**.

Table 1. Orbital Parameters of Orbcomm Spacecraft

Background	Prime contractors: Orbital Science Corporation
Owner/Operator: Orbcomm Global LP, USA	Type of satellite: Microstar (Little LEO Project)
Present status: Operational	Stabilization: Magnetic with gravity gradient assist
Altitude: 775/739 km	Design lifetime: 4 years
Type of orbit: LEO	Mass in orbit: 43 kg
Inclination angle: 45º/70º	Dimensions stowed: 1.83 x 12.50 m circular
Number of orbital planes: 4/2	Electric/ SSPA power: 135 W (EOL)/ 10 W
Number of satellites/planes: 8/2	**Communications Payload**
Number of satellites: 32/4 Little LEO	Frequency bands:
Coverage: Worldwide	Service/Feeder uplink 148.0-150.05
Additional information: system offers data and asset tracking messaging with 14 GES all over the world	Service/Feeder downlink 137.0-138.0 MHz
Spacecraft	Multiple access: FDMA/TDMA
Name of satellite: Orbcomm	Number of transponders: 6 Uplink Rx; 2 Downlink Tx; Ka-band operation
Launch date: Started in November 1998	Channel capacity: 15 Gb/s total data rate
Launch vehicle: Pegasus XL & Taurus	Channel polarization: Circular
Typical users: Global Mobile Messaging Service	EIRP: Varies over coverage area
Cost/Lease information: Approximately 900M $	G/T: Varies over coverage area
	Saturation flux density: High

The Orbcomm communication subsystem is the principal payload flown on the satellite, consisting in five major parts:

a). Subscriber Communications Section as the main payload part consists in one subscriber Tx, seven identical receivers and the associated receives and transmits filters and antennas. Six of the receivers are used as subscriber receivers and the seventh is used as the Data Center as a Service (DCAAS) Rx. The subscriber Tx is designed to transmit an operational output power of up to circa 40 W, although the output is less during normal operations. The power of each Tx can vary over a 5 dB range, in 1 dB steps, to compensate for aging and other lifetime degradations. The Symmetric Differential Phase-Shift Keying (SDPSK) modulation is used on the subscriber downlink at a data rate of 4800 b/s. (It is capable of transmitting at 9600 b/s.). The satellite uplink modulation is SDPSK; with a data rate of 2400 b/s. Raised cosine filtering is used to limit spectral occupancy.

b). The Orbcomm Gateway Communication Section (GES) contains both the Gateway satellite Tx and Rx. Separate RHCP antennas are used for transmits and receives functions. In fact, the Orbcomm Gateway Tx is designed to transmit 5 W of RF power. The 57.6 Kb/s downlink signal to the GES is transmitted using an OQPSK modulation in a Time Division Multiple Access (TDMA) modulation format. The Gateway Rx is designed to demodulate a 57.6 Kb/s TDMA signal with an OQPSK modulation. The received packets are routed to the onboard satellite network computer.

c). The Satellite Network Computer receives the unlinked data packets from the subscriber and the Orbcomm Gateway receivers and distributes them to the appropriate Tx. The computer also identifies clear uplink channels via the DCAAS Rx and algorithm and interfaces with the Global Position System (GPS) receiver to extract information pertinent to the communications system. Several microprocessors in a distributed computer system aboard the satellite perform the satellite network computer functions.

d). The UHF TX is a specially constructed 1 W Tx to emit a highly stable signal at 400.1 MHz. The Tx is coupled to a UHF antenna designed to have a peak gain of circa 2 dB.

e). The Satellite Subscriber Antenna Subsystem consists in a deployable boom containing three separate circularly polarized quadrifilar antenna elements.

The Attitude Control System (ACS) is designed to maintain both nadir and solar pointing. The satellite must maintain nadir pointing to keep the antenna subsystem oriented toward the Earth. Solar pointing maximizes the amount of power collected by the solar cells. This satellite employs a three-axis magnetic control system that operates with a combination of sensors, which also obtains its position through its onboard GPS receiver.
Satellite planes A/B/C are designed to maintain a separation of 45° (± 5°) between satellites in the same orbital plane. Planes D/E provide 51.4° spacing between satellites, while highly inclined satellite planes (F/G) are spaced for 180° apart (± 5°). Thus, the springs used to release the satellites from the launch vehicle give them their initial separation velocity. A pressurized gas system will be used to perform braking maneuvers when the required relative in-orbit satellite spacing is achieved. An Orbital Sciences Corporation formation-keeping technique will maintain the specified satellite intra-plane spacing. One of the benefits is that, unlike GEO satellites, it does not affect the satellite's life expectancy in fuel usage.

3. Orbcomm Ground Segment

The Orbcomm ground segment terminals and antenna systems, which has most of the intelligence of the Orbcomm system, comprises Gateway Earth Stations (GES), Control centres and both mobile and fixed SCU user terminals. Otherwise, the space segment of satellite constellations and orbits are controlled by one SCC stations.
The Orbcomm Gateway terminals, which include the GES, GCC and the NCC, are located at Orbcomm headquarters in Dulles. Within the USA, there are four GES located in Arizona, Georgia, New York State and Washington State. The NCC also serves as North America's GCC and manages the overall system worldwide. Orbcomm Gateways are connected to dial-up circuits, private dedicated lines, or the Internet. The SCU hand-held devices for personal messaging are fixed and mobile units for remote monitoring and tracking applications.
1. Gateway Earth Station (GES) – Orbcomm is committed to continuing the deployment of additional regional GES to provide near-real-time service for all major areas of the world, as well as developing and launching a new generation of satellites that will enhance and expand the current system's capabilities. All Orbcomm's GES terminals link the ground segment with the space segment and will be in multiple locations worldwide. The GES provide the following functions: acquire and track satellites based on orbital information from the GCC; link ground and space segments from multiple worldwide locations; transmit and receive transmissions from the satellites; transmit and receive transmissions from the GCC or NCC; monitor status of local GES hardware and software; and monitor the satellite system level performance "connected" to the GCC or NCC. The GES terminal is redundant and has two steerable high-gain VHF antennas that track the satellites as they cross the sky. It transmits to a satellite at a frequency centered at 149.61 MHz at 56.7 Kb/s with a nominal power of 200 W. It receives 3 W transmissions from the satellite at 137 to 138 MHz range. These up and downlink channels have a 50 KHz bandwidth. The mission of the GES is to provide an RF communications link between the ground and the satellite constellation. It consists in medium gain tracking antennas, RF and modem equipment and communications hardware and software for sending and receiving data packets. An Orbcomm licensee requires a Gateway to connect to Orbcomm satellites in view of its service area. Namely, the Gateway consists in a GCC and one or more GES sites, as well as the network components that provide interfacility communications.
2. Gateway Control Centre (GCC) – The Orbcomm GCC terminals are located in a territory or state that is licensed to use the Orbcomm system and provide the following functions: locate wherever Orbcomm is licensed; link remote SCU terminals with the terrestrial-based systems; communicate via X.400 message transfer protocol, communicate via X.25 standard protocol suite for packet-switched data communication in Wide Area Networks (WAN), leased line, dial-up modem, public and private data networks and E-mail networks including the Internet; efficiently integrate the Orbcomm infrastructure with new or existing customer Management Information Systems (MIS) solutions, etc.

Figure 4. Two Generations of SCU Terminals

3. Network Control Centre (NCC) – The NCC is responsible for managing the Orbcomm communications network elements and the US Gateway terminals through telemetry monitoring, commanding and mission system analysis. It provides network management of Orbcomm's satellite constellation and is staffed 24 hours a day by Orbcomm-certified controllers and has the following main functions: monitoring real-time and back-orbit telemetry from the Orbcomm satellites; sending real-time and stored commands to the satellites; providing the tools and information to assist engineering with resolution of satellite structure and ground system anomalies; archiving all satellite and ground satellite telemetry data for analysis; monitoring the performance of the usages terminals and so on. The NCC manages the entire Orbcomm satellite constellation and its processes and analyzes all satellite telemetry. The NCC is responsible for managing the Orbcomm system worldwide. Through OrbNet, the NCC monitors message traffic for the entire Orbcomm system and manages all message traffic that passes through the US Gateway. The NCC is staffed 24 hours a day, 365 days a year and is located in Dulles, Virginia. A backup NCC system was established in 2000, which permits the recovery of critical NCC functions in the event of an NCC site failure.

4. Satellite Control Centre (SCC) – The SCC serves in a territory that is licensed to use the Orbcomm system and provides control of the Orbcomm satellite constellation.

5. Satellite Communication Unit (SCU) – The SCU equipment are both mobile and fixed terminals used for connection to the Orbcomm satellite network through Gateway stations. The SCU terminal is a wireless Very High Frequency (VHF) modem that transmits messages from a user to the Orbcomm system for delivery to an addressed recipient and receives messages from the Orbcomm system intended for a specific user. Manufacturers have different proprietary designs and each model must be approved by Orbcomm and adhere to the Orbcomm Air Interface Specification, Subscriber Communicator Specifications and Orbcomm Serial Interface Specification (if an RS-232 port is available). Different versions of SCU terminals are currently available, which include "black-box" industrial units that have RS-232C ports for data uploading and downloading. Current options on a number of SCU include internal GPS receivers and/or additional digital and analog input and output ports.

4. Orbcomm User Segment

The Orbcomm system is designed to enable short communications between different often unmanned remote fixed or mobile modems, positions and customer information hubs. The Orbcomm hardware and software components comprise a global, packet-switched two-way data communication service optimized for short messages and small file transfers.

1. Magellan GSC 100 Terminal – This terminal is the world's first handheld satellite terminal that allows sending and receiving text and E-mail messages to and from anywhere in the coverage area, which first generation of SCU terminal is illustrated in **Figure 4 (Left)**. This terminal offers communication and navigation using the Orbcomm network and GPS system.

Integrated GPS Rx capabilities allow one to identify position, plot and track course, store waypoints and send this information to anyone, anywhere in the world. Unlike traditional landlines, cellular/paging systems, the GSC 100 and Orbcomm network operate from isolated parts of the world, where TTN systems do not reach.

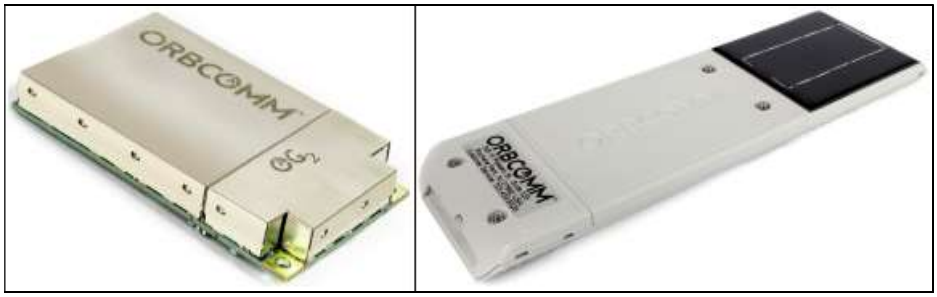

Figure 4. Third Generation of SCU Terminals

Messaging features allow worldwide messaging via Orbcomm MSC service, send and receive E-mail messages called GlobalGrams to any E-mail address via Internet, easy-to-use menu-driven interface, storing up to 100 messages and 150 E-mail addresses, sending and receiving messages at pre-selected time intervals and automatic wake-up. The GPS network features provide navigation and pointing location worldwide, displays position, speed, distance, time-to-go, continuously points to the destination and keeps on a true course, displays the trip's progress with a track plotter, stores up to 200 user-defined waypoints, relays present location by inserting GPS position into GlobalGram message. This unit is equipped with telescopic whip antenna, rechargeable NiCad battery package and universal Alternating Current (AC), software update, data and power extension cables and instruction manuals. Optionally, it is possible to supply external GPS antennas, fixed Site VHF Antennas, Combined GPS/VHF Magnetic Mount Antennas and Combined GPS/VHF Roof or Trunk Top-Mount Antennas.

2. Stellar DS300 Terminal – This device is a two-way satellite communicator for use with the Orbcomm network, which second generation of is shown in **Figure 3 (Middle)**. The DS300 terminal is a complete hardware solution for companies using a wide variety of applications to track, monitor and communicate with fixed and mobile assets around the globe. It features a satellite modem, user-programmable application processor, integrated GPS receiver, adequate software configurable I/O options, and battery charger packaged in a rugged, automotive-grade enclosure. However, the world-class design, and stable performance make the DS100 reliable device for transportation, heavy equipment, marine, aeronautical and many other markets. This satellite modem is configurable with 8 input or output digital channels, 4 input analog channels and 8 GPS receiving channels. However, its user programmable application processor can facilitate Value-added service providers or customers for different applications.

3. Quake Q4000 Terminal – This unit is cost effective and fully programmable satellite and GSM data modem with 22 channel GPS global tracking capability, which is shown in **Figure 3 (Right).** It has almost the same technical characteristics as serving as already stated Q4000i and it can be used for SCADA (M2) and business-to-business Internet links with land, marine or aviation based assets and equipment anywhere in the world.

4. Orbcomm OG2-GPS Modem – This tracking unit delivers connectivity over the LEO Orbcomm VHF satellite network for marine, heavy equipment, transportation, agricultural and other markets, which third generation is depicted in **Figure 4 (Left).** Mechanical features of this unit are 40mm×70mmx 0.5mm, which Mini PCI Express has 52-pin edge connector and 0.8 mm pitch. Its electrical usage at input voltage is 2.8 VDC to 15 VDC and input current in transmit mode is 1.6 A, GPS on is 35 mA and receive mode uses 70 mA.

5. Orbcomm GT 1100 Modem – This unit powered by solar rechargeable battery enables full control of mobile assets and containers, which is shown in **Figure 4 (Right)**.

5. Orbcomm Satellite Asset Tracking (SAT) and Fleet Management (SATFM)

To enhance safety and security in maritime, land (roads an rails) transportation systems it will be necessary to implement SAT systems for all mobile solutions, especially for ships and aircraft. Inmarsat, Iridium, Globalstar and Orbcomm operators offer global two-way data transfer devices in size as personal CD players.

Figure 5. Terminals for Fleet Management

Thus, with their reduced consumption of main, solar or battery power supply these units are an effective way of remotely collecting PVT data from ships, containers, vehicles, locos with wagons and aircraft to the Tracking Control Station (TCS). The author of this book has developed projects for all mobile SAT applications including for living beings. In this stage will be introduced only two Orbcomm SAT and Fleet Management terminals:

1. Orbcomm Heavy Equipment Management PT-7000 Terminal – This unit integrates cellular and optional satellite tracker in case that monitoring units are outside of Orbcomm satellite coverage, which is illustrated in **Figure 5 (Left).** This SAT terminal provides a comprehensive monitoring and control for heavy equipment and vehicles used in the construction, mining, rail and utility industries. As part of a comprehensive telematics solution that includes sensors, connectivity and applications, the PT 7000 available as a cellular or dual-mode satellite-cellular version is giving customers complete visibility and control of their heavy equipment fleet and allows them to manage their operations more effectively by enabling access to real-time data and analytics. Thus, it receives asset status updates and engine alerts, configures reporting intervals, request asset position and more. A satellite connectivity option is available for critical applications to ensure alarm delivery and response. It also receives real-time alarms when specific conditions are detected or thresholds are exceeded and an asset has been turned on, an engine reading has exceeded a threshold, an asset entered or exited a geofence, low oil pressure is detected and more. It provides accurate status and position information along with key operational metrics so all users can proactively manage their fleet anywhere in the world. By leveraging valuable equipment utilization and maintenance reports, customers know where their equipment is, if it's productive or needs maintenance, if oil pressure is within limits and how it's being used in order to better allocate resources and improve operational efficiency. In addition, equipment alerts including unauthorized movement or out-of-spec sensor readings such as loss of oil pressure or high coolant temperature can be quickly communicated to a mobile device to ensure a timely response. Necessary time to provide alert delivery is 30 seconds and poll response time is 2-3 minutes. This terminal provides reporting interval position, motion start/stop, condition-based fault codes, engine/idle hours, fuel consumption, battery voltage, antenna connect/disconnect and pre-defined event triggers. It interfaces 4 digital inputs, 2 digital outputs, 2 pull-up, 2 pull-down, 4 analog inputs, 4 1(/2) CAN/J1939 bus ports, 2(/1) Serial ports, LED and BLE (Bluetooth Low Energy).

2. Global Transportation Management RT-6000 Terminal – This terminal can be used as an integrated GPS and dual-mode cellular and satellite tracking and management with many interfaces for monitoring sensors, which is depicted in **Figure 5 (Right).** In fact, this is ruggedized RT 6000+ provides visibility, control and decision rules to dispatch and operations centers, maintenance organizations and operational managers of transportation companies worldwide. Using a unique direct interface to any refrigerated asset it provides comprehensive temperature and fuel management, maintenance, logistical and management applications services to revolutionize refrigerated transportation operations, which solution of tracking sensors installed onboard truck are shown in **Figure 6.** Customers can make immediate, important decisions about their reefer or any vehicle business, allowing for smarter investments in transportation system operations and immediate savings as well as improved end-to-end operations. However, with two-way interfaces, this solution delivers the most effective refrigeration and fleet management tools in the industry for maximum compliance, efficiency and Return on Investment (ROI).

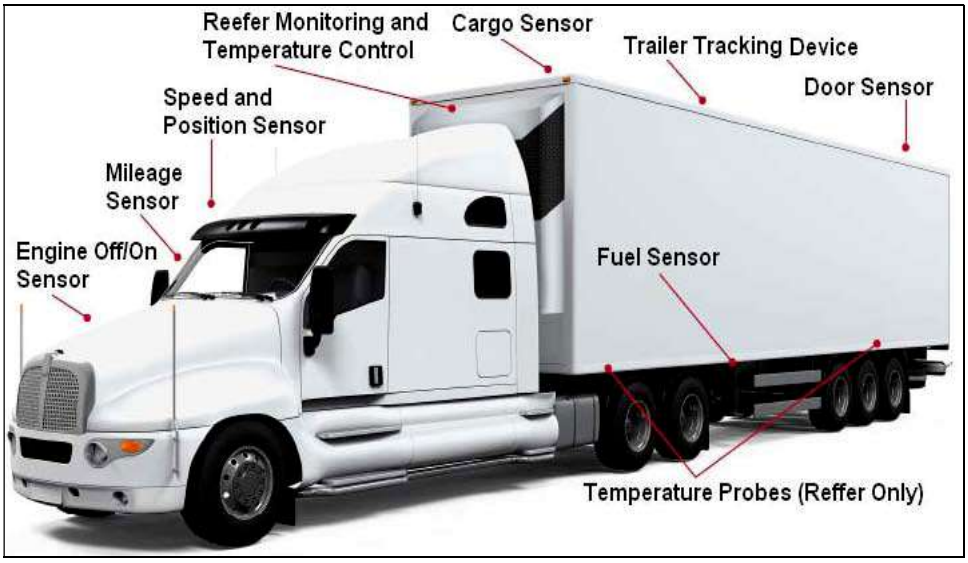

Figure 6. Tracking Sensors onboard Truck

Using a unique direct interface to any refrigerated asset it provides comprehensive temperature and fuel management, maintenance, logistical and management applications services to revolutionize refrigerated transportation operations, which solution of tracking sensors installed onboard truck for Satellite Asset Tracking and Fleet Management (SATFM) are illustrated in **Figure 6.** Customers can make immediate, important decisions about their reefer or any vehicle business, allowing for smarter investments in transportation system operations and immediate savings as well as improved end-to-end operations. However, with two-way interfaces, this solution delivers the most effective refrigeration and fleet management tools in the industry for maximum compliance, efficiency and Return on Investment (ROI).

6. Orbcomm Satellite AIS (S-AIS) Service

All oceangoing ships of more than 300 tons and all passenger vessels, irrespective of size, are mandated by the International Convention for the Safety of Life at Sea (SOLAS) to carry a transponder that broadcasts their position, course and speed as a collision avoidance system. This tracking system, called AIS, sends information to other nearby vessels so it can be displayed and utilized in conjunction with radar. The terrestrial radio AIS data is transmitted through VHF radio waves, so its horizontal range has generally been limited to approximately 50 nautical miles or less.
On the other hand, the Orbcomm LEO operator provides global Satellite - Automatic Identification System (S-AIS) for oceangoing ships onboard broadcast system that transmitted ship identification, position and other critical data received from GES terminals can be used to assist in navigation and improve maritime safety and security at sea. In the similar way, S-AIS system can be implemented for aeronautical applications that aircraft position and other critical data can be used to assist in flight and improve aeronautical safety.
The Orbcomm system overcomes many of these issues thanks to a fully Satellite AIS (S-AIS) data service, which is able to monitor maritime 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 started with development S-AIS. Namely, an AIS receiver using satellite will be able to extend the VHF range of R-AIS systems considerably and make it easier to monitor ship and fishing ocean navigation areas. Thus, Orbcomm was the first commercial satellite network that started operations with S-AIS data service. In 2008, Orbcomm launched the first LEO satellites specially equipped with the capability to collect AIS data and has plans to include these capabilities on all future satellites for ongoing support of global safety and security initiatives. Orbcomm's next launches started in 2011.

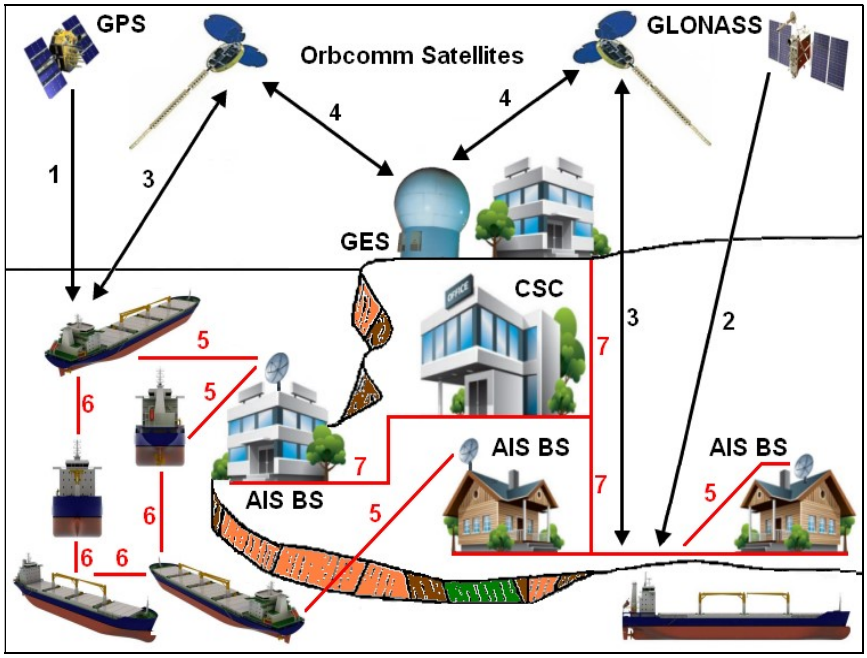

Figure 7. Orbcomm Satellite AIS (S-AIS) Network

In **Figure 7** is shown space and ground configuration of S-AIS integrated with R-AIS proposed by author of this book. In fact, all ships are receiving GNSS PVT signals from the US GPS (1) or Russian GLONASS (2), then ships out of R-AIS coverage are sending via service link (3) PVT data to AIS satellite, which this data transmits via feeder link to the GES (Gateway) terminal (4). On the other hand, all ships sailing inside of R-AIS coverage are sending GNSS PVT data to R-AIS Base Station (BS) via radio link (5), while all these ships have AIS data communication via inter-ship links (6). Received AIS data GES and AIS BS are forwarding via terrestrial links (7) to the SCS terminal for processing. In such a way, AIS data with positions of all ships in certain sailing region can be displayed on radar like screen and used for collision avoidance.

7. Conclusion

The Orbcomm satellite system enables users to communicate, track, monitor, control and operate mobile and remote assets for SATFM, SCADA or M2M, command and logistics applications at sea, on land (road and rail) and in the air. These small devices are very new communication tools available for all transportation professionals, business people, oil/gas and remote environments and anyone who likes to have satellite messaging, tracking and logistics using Little LEO Orbcomm satellite systems everywhere.

The different nomenclature of LEO satellite network is commonly known as Non-GEO satellites. Compared to large LEO systems, the smaller size of the Little LEO system allows for easy data processing with silent storage and forwarding functions. The Orbcomm Little LEO satellite system enables low-speed data transmission for MSC systems and fixed machines almost worldwide, for SATFM, SCADA or M2M, and especially for roads and rails transport. Through a network of LEO satellites and regional GES terminals, users can communicate with their mobile or fixed assets anywhere in the world.

This system is operational, robust and today serves customers worldwide. Orbcomm is in a position to offer low cost and high quality service to every customer. Orbcomm's dedicated staff is dedicated to meeting the specific needs of all potential users, such as SATFM and logistics of trailers and containers, locomotives, wagons, heavy equipment, fishing vessels and barges; and to provide SCADA or M2M monitoring and control of fixed locations such as electricity meters, water levels, oil and gas storage tanks, wells, pipelines and environmental projects and two-way messaging service for consumers, commercial and government entities.

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BIOGRAPHY OF AUTHOR

Prof. Dimov Stojce Ilcev is a senior research professor at University of Johannesburg (UJ). He has three BSc degrees in Radio Engineering, Nautical Science and Maritime Electronics and Communications. He got MSc and PhD in Mobile Satellite Communications and Navigation as well. Prof. Ilcev also holds the certificates for Radio operator 1st class (Morse), for GMDSS 1st class Radio Electronic Operator and Maintainer and for Master Mariner without Limitations. He is the author of 9 books and about 300 papers in mobile Radio and Satellite CNS, DVB-RCS, Satellite Asset Tracking (SAT), Stratospheric Platform Systems (SPS) for maritime, land (road and railways), and aeronautical applications.