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

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

Abstract: This paper is describing the Orbcomm users segment as a wide area packet switched and global two-way data transfer network providing satellite communication, tracking, monitoring and logistics services between mobile, remote, semi fixed or fixed Subscriber Communication Units (SCU) in Mobile Satellite Communication (MSC) and 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. 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, Little LEO, Orbcomm, Users Segment, Ground Segment, Satellite Terminals, SAT and Fleet Management, Heavy Equipment, Transportation Management, S-AIS

1. Introduction

The Orbcomm system is a wide area packet switched and two-way data transfer network providing satellite communication, tracking and monitoring services between mobile, remote, semi fixed or fixed Subscriber Communication Units (SCU) and Gateways (GES) or Gateway Control Centres (GCC) accomplished via the constellation of Little LEO satellites and Network Control Centres (NCC). Namely, Orbcomm is a global mobile satellite system that offers affordable wireless data and messaging communications services via small GPS/Orbcomm tracking devices via Orbcomm Little LEO satellite constellation.

The system is capable of sending and receiving two-way alphanumeric packet messages, similar to the well-known two-way paging, SMS or E-mail. The Orbcomm network enables two-way monitoring, tracking and messaging services through the world's first commercial Little LEO satellite slow data communications system, which applications include tracking mobile assets such as ocean going ships, fishing vessels and barges, containers, vehicles, trailers, locomotives and rail cars, heavy equipment and aircraft including monitoring and controlling fixed sites. Fixed service is SCADA or 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.

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-based data communications system. The FCC granted Orbcomm 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 Orbcomm Company owns and operates a network consisting in 36 LEO satellites and four terrestrial Gateways deployed around the world. Small, low-power and commercially proven SCU can connect to private and public networks, including the Internet, via these satellites and Gateways. Through this network, Orbcomm delivers information to and from virtually anywhere in the world on a nearly real-time basis. The Orbcomm satellites have a subscriber Tx that provides a continuous 4.8 Kb/s stream of downlink packet data, which is capable of transfer even at 9.6 Kb/s.

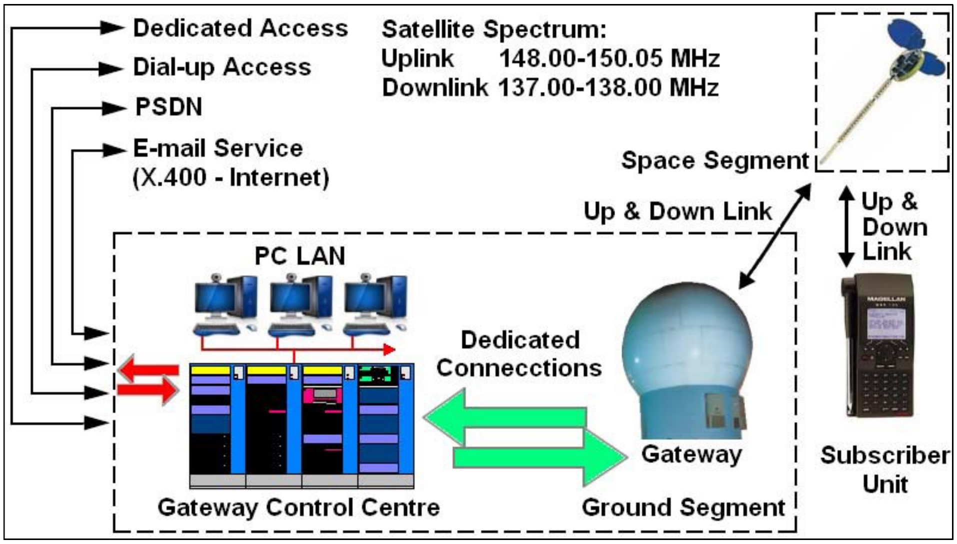

Figure 1. Orbcomm System Overview

Vital messages generated by a variety of Orbcomm applications are collected and transmitted by an appropriate mobile or fixed SCU to a satellite in the Orbcomm constellation. The satellite receives and relays these messages down to one of four US GES. 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, through terrestrial networks to a subscriber communicator or pager and to dedicated telephone line or facsimile.

The Orbcomm Space and Ground network with GES, GCC and SCU (mobile or fixed users) is presented 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 terminals then transmit the information using Orbcomm global telecommunications network. Orbcomm serves customers through Value Added Resellers (VAR) that provide expertise in specific industries. These Orbcomm VAR provide whole product solutions and customer support to end-users. The different customers from around the world currently rely on Orbcomm satellite network for a wide range of mobile, farming and fixed site data applications including:

1. Monitoring and controlling assets at remote or rural sites for oil and gas platforms, extraction and pipeline operations, meteorological centres, water stations, construction and agriculture, satellite SCADA (M2M) control, storage, custody transfer and electric power generation and distribution;

2. Messaging for truck and bus fleets anywhere, owner operators and remote workers;

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

4. Weather data reports for general aviation and especially for small aircraft.

Orbcomm communication network consists in 36 operational satellites in little LEO orbit at about 825 km above the Earth's surface. Vital messages generated by a variety of space applications are collected and transmitted by an appropriate mobile or fixed SCU to the Orbcomm satellite. The satellite receives and relays these messages down to one of several GES. The GES then relays the message via certain satellite link or dedicated terrestrial line to the NCC. The NCC routes the message to the final addressee via Internet via E-mail to a personal computer, through terrestrial networks to a mobile subscriber unit or pager and to dedicated telephone or facsimile.

The Orbcomm MSC operator has received a license to launch up to 47 satellites. The constellation consists of four planes of eight satellites each inclined at 45 degrees, two highly inclined planes of four satellites each, and one equatorial plane of seven satellites. The amount of time available each day on the Orbcomm satellite 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 5100-km (3200-mile) diameter geometric footprint of each satellite.

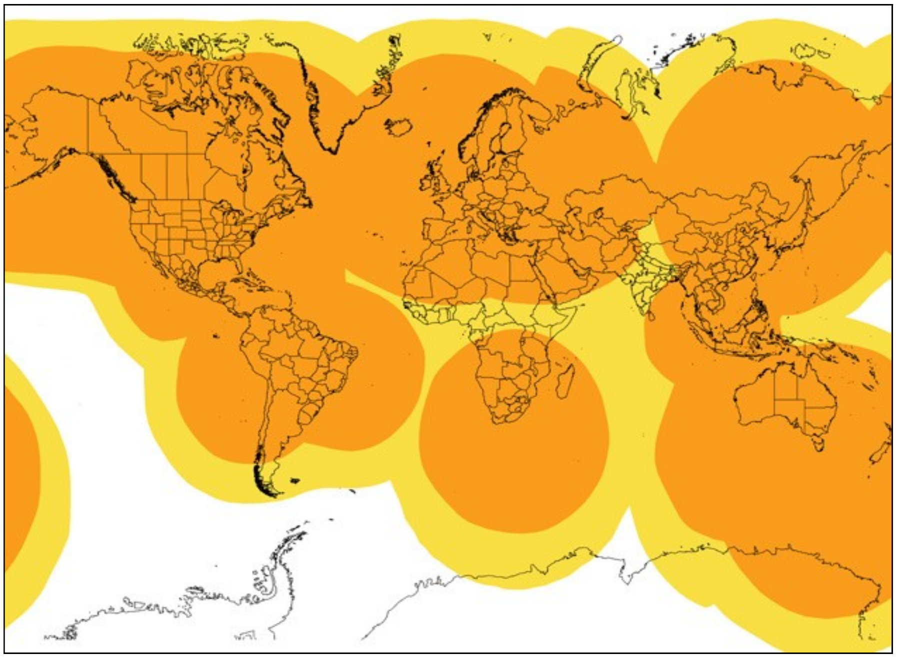

Figure 2. Orbcomm Satellites Coverage

The Orbcomm system allows users to track, monitor and manage remote assets via satellite network, which almost global coverage is shown in **Figure 2.** Through a network of LEO satellites and regional GES, 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 System Description

The Orbcomm network is a wide area, packet switched, two-way data communication system, which provide communications between Subscriber Communicator Units (SCU) terminals and Orbcomm Gateways via a constellation of Orbcomm Little LEO satellites. While the Orbcomm Gateways are connected to dial-up circuits, private dedicated lines, or the Internet.

The Orbcomm network consists of the ground, space and users segments. A Network Control Center (NCC) manages the overall system worldwide.

1. The ground segment contains the Orbcomm Gateway, which provides message processing and subscriber management.
2. The space segment currently consists in constellation of 35 LEO satellites and one Satellite Control Center (SCC).
3. The users (customer) segment consists of the SCU terminals (mobile or fixed) used by Orbcomm system subscribers to transmit information to and receive information from the LEO satellites.

The RF spectrum for communication within the ORBCOMM System operates in the Very High Frequency (VHF) portion of the frequency spectrum, between 137 and 150 MHz. The Orbcomm satellites have a subscriber transmitter that provides a continuous 4800 b/s stream of downlink packet data, while the downlink is capable of transmitting at 9600 b/s.

Each Orbcomm satellite also has multiple subscriber receivers that receive short bursts from the SCU terminals at 2400 b/s. The Orbcomm network is capable of providing low-bit-rate wireless data communications service around the world. All communications within the Orbcomm network must pass through an Orbcomm Gateway via own satellite constellation.

An Orbcomm Gateway consists of a Gateway Control Center (GCC) as the facility that houses the computer hardware and software that manages and monitors message traffic and a Gateway Earth Station (GES). The GES terminal provides the link between the LEO satellite constellation and an Orbcomm GCC terminal.

For instance, if a user (SCU) located in a remote location, out of range of a cellular telephone system, it will be possible to send an email message to another user's home computer, which is attached to the Internet via an E-mail account. In this pint, the messaging sequence, using the Orbcomm network proceeds as follows:

1. The remote user, equipped with a laptop computer and an Orbcomm SCU, composes an email message on the laptop. The user downloads the message to the SCU (mobile or fixed user).
2. The SCU terminal waits for a satellite to come into view. When it receives a satellite's downlink broadcast, it transmits the message to a satellite, which in turn receives, reformats, and relays the message to a GES.
3. The GES transmits the message over a dedicated line to the GCC terminal. The GCC terminal places the message on the public switched network for delivery to the recipient's Internet Service Provider (ISP).
4. After logging onto the Internet via the ISP, the recipient downloads the email message.

If the user at the home computer wants to reply to the remote user, the messaging sequence occurs in the reverse order: from the home computer to the Internet over a public switched network, from the ISP to the GCC, from the GCC to the GES, from the GES to a satellite, and finally from the satellite to an SCU terminal and from the SCU equipment to the fixed or mobile user display unit. The interrelationship of the Orbcomm network elements and communication infrastructure is illustrated by the diagram shown in **Figure 1.**

2.1. Multiple Access Protocols

Communication from an SCU to the satellite constellation is divided between two different types of communication channels: random access channels and reservation/messaging channels. The NCC terminal controls the number of satellite receivers assigned to these two channel types. Information exchanged on the random access channels permits either short data reports or control packets to be passed between the GCC's Gateway Message Switching System (GMSS) and the SCU terminal, or permits the ORBCOMM System to assign a messaging channel to an SCU for transferring longer message packets.

The satellite downlink channel distributes information based on the satellite/Orbcomm Gateway connection being used; the current random access uplink frequencies selected by the Orbcomm network, and other pertinent Orbcomm system information. By the way, this information is updated every few seconds. The basic multiple access process contains modifications to a standard Aloha modulation scheme.

2.2. Orbcomm Service Elements

There are four basic service elements that the Orbcomm network is capable of providing:

1. Data Reports – A Data Report is the basic service element an SC uses to transmit or receive a single packet containing 6 bytes or less of user-defined data. Thus, a Data Report is transmitted via the random access protocol and may be generated as needed or on a periodic basis. A Data Report may be sent on request and polled by the Orbcomm system or may be sent when data are available. A Data Report can require an acknowledgment of successful delivery to the Orbcomm Gateway, but such acknowledgment may be omitted to save space segment resources.

2. Messages – A Message is the basic service element an SCU terminals uses to transmit or receive a longer sequence of data. In fact, messages typically have lengths less than 100 bytes, although the Orbcomm system can handle longer Messages. To ensure reliability, Messages are transferred over the satellite reservation channels via short packets containing a checksum with acknowledged or retransmitted packages. Messages are accepted and delivered via public or private data networks. The SCU terminal Originated Messages may be generated at the request of the subscriber (random access) or at the request of the network (polled). Message data packets are transferred in a polled (reservation) with a lower case "m" refers to raw subscriber data, while with an upper case "M" refers to user data that are segmented, encapsulated, sequenced, and transmitted via satellites.

3. GlobalGram – A GlobalGram is the basic service element an SCU terminals uses to transmit or receive a single, self-contained data packet to or from a satellite that is not in view of an Orbcomm Gateway. This allows remote and oceanic areas to be served in a "store-andforward" mode. For an SC-Terminated GlobalGram, the relaying satellite stores the data packet in memory and transmits it upon request from the destination SC.
An SC-Terminated GlobalGram contains 182 bytes of user data. Therefore, for an SC-Originated GlobalGram, the satellite receives the GlobalGram from the SC acknowledges it and archives it in satellite memory until the destination ORBCOMM Gateway establishes contact with the satellite. An SC-Originated GlobalGram contains 229 bytes of user data.
4. Commands – A Command mode is the basic service element used to transmit a single packet containing 5 bytes or less of user-defined data. Commands may be signals to initiate action by devices attached to the SC. Acknowledgments may or may not be required.

2.3. Dynamic Channel Activity Assignment System

The ORBCOMM system Earth-to-satellite uplinks are designed to operate in the 148-150.05 MHz band, which is shared worldwide with terrestrial communication services. The heart of uplink interference avoidance is the Dynamic Channel Activity Assignment System (DCAAS).
Thus, the DCAAS configuration uses a scanning receiver aboard each satellite that is capable of measuring the interference power across the entire uplink band. The DCAAS configuration scans subscriber uplink bands, identifies clear channels, and assigns them for uplink use by the SCU terminals. Namely, the DCAAS configuration is designed to evaluate the channel assignments at intervals of 5 seconds or less.
The satellite processes the interference information to identify a list of preferred uplink channels. The channels are prioritized in terms of interference power expected on the next scan. Information gathered from commercial service, as well as from simulations, indicates a high success rate in predicting channels that are likely to be free of terrestrial transmissions on the next band scan.
Based on scan data and other channel-selection criteria, DCAAS changes the assignment of uplink random access channels frequently. Each subscriber message transmission occurs on an uplink frequency selected by the satellite, and the selections can vary from burst to burst. The DCAAS configuration permits the Orbcomm system to avoid harmful interference to the terrestrial mobile systems, while improving the quality of service provided to Orbcomm subscribers.
The satellite uplink receivers and downlink transmitters are designed to be frequency agile, although satellite downlinks and GES uplinks operate at fixed frequency assignments. This design feature permits the ORBCOMM System to avoid generating and receiving interference in the 148 - 150.05 MHz band, and allows flexible use of the 137 - 138 MHz band. Data collected, including data from experimental payloads that preceded the commercial satellites, indicate that even during the "busy hour" a sufficient number of interference-free channels will be available.

2.4. Position Determination Capabilities

The ORBCOMM network provides sufficient information for SCU terminals to perform Doppler positioning. Control information broadcast from satellites includes satellite Position, Velocity and Time (PVT). This control information is derived from the on-board Global Positioning System (GPS) receiver and the frequency of the downlink signal itself. The SCU terminal measures the satellite downlink frequency to determine the Doppler shift.
The Doppler shift, time, satellite position, and satellite velocity represent one data point. After enough data points are gathered, the SC can calculate the Doppler position. Thus, an Ultra High Frequency (UHF) beacon signal transmitted from the satellite can be used by SCU equipped with UHF receivers to improve the Doppler position accuracy. For now, the SCU terminals are not currently equipped with UHF receivers. Some SCU terminals are equipped with internal GPS receivers and associated GPS antennas. This improves the position determination accuracy by receiving position data signals directly from the GPS satellites.

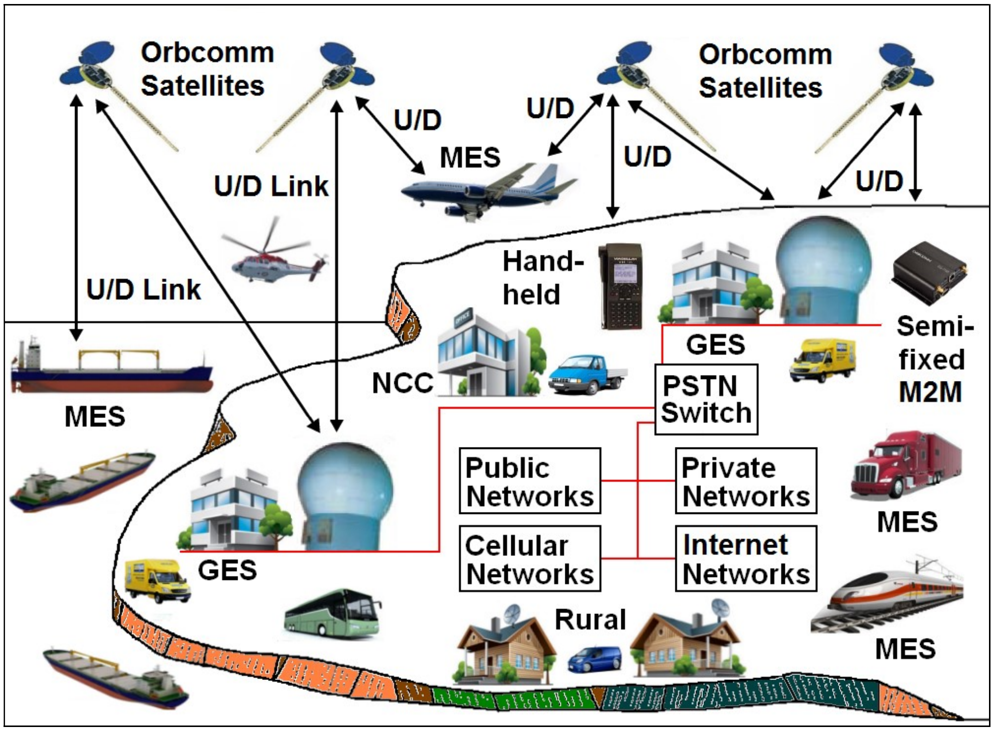

Figure 3. Architecture of Orbcomm Space, Ground and Users Segments

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The Orbcomm ground segment, 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 terminal. Gateways terminals, which include the GES, GCC and NCC terminals, 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.

In **Figure 3** is introduced architecture of Orbcomm space, ground and users segments. Thus, ground segment is connecting mobile or fixed user terminals (SCU) with TTN infrastructure via Orbcomm satellites. In fact, Orbcomm satellite constellations are bridges between user (SCU) terminals and ground segment. The ground segment is connected to the TTN infrastructure, which is composed of the GES, NCC and other terminals.

The TTN infrastructure is composed pf the Public Switched Telephone Network (PSTN), and other networks, such as Public, Private, Cellular and Internet networks. The Users segment is represented by Mobile Earth Station (MES) subscriber terminals, handheld and semi-fixed SCADA or M2M terminals. Thus, MES terminals are represented by transport systems for maritime, land (road and rail) and aeronautical applications.

When communicating between space, ground and users segment, up and down links (U/D) are used, so that the Up Link uses RF at 148 to 150 MHz band, while the Down Link uses RF at 137 to 138 MHz band. However, Up Link and Down Link from Orbcomm satellite to GES and viseversa provides a continuous 57.6 Kb/s stream using Offset Quadrature Phase Shift Keying (OQPSK) modulation.

Down Link from Orbcomm satellite to subsribers terminal provides a continuous 4.8 Kb/s stream, while Up Link from subscriber terminal provides a continuous 2.4 Kb/s stream, both streams are using Staggered Differential Phase Shift Keying (SDPSK).

3.1. 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 terminal provides 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 system licensee requires a Gateway terminal 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.

3.2. Gateway Control Centre (GCC)

The GCC terminals are located in a territory that is licensed to use the Orbcomm system and provide the following functions: locate wherever Orbcomm system is licensed; link remote SCU with terrestrial-based systems; communicate via X.400, X.25, 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.

3.3. Network Control Centre (NCC)

The NCC is responsible for managing the Orbcomm communications network elements and the USA Gateways 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 anomalies; archiving all satellite and ground telemetry data for analysis; monitoring the performance of the USAGES terminals and so on.

4. Orbcomm User Segment

The Orbcomm satellite network 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. The main component of the ground segment is an SCU terminal which is a wireless VHF modem that transmits messages from a user to the Orbcomm network for delivery to an addressed recipient, and receives messages from the Orbcomm network intended for a specific user (MES).

Manufacturers have different proprietary designs and are free to include unique features in their SCU design. However, each design must be approved by Orbcomm system operator and adhere to the OrbcommAir Interface Specification, Subscriber Communicator Specifications, and Orbcomm Serial Interface Specification (if an RS-232 port is available). Typical technical specifications of an Orbcomm MES or SCU terminal are given in **Table 1.**

Table 1. Typical SCU or MES Terminal Specifications

Transmission Power	5 Watts
Receive Dynamic Range	-116 to -80 dBm
Sensitivity Performance	bit error rate of 10^{-5} at -116 dBm input
Power consumption (at +12 VDC)	
Sleep	< 1 mA
Receive	100 mA
Transmit	2 A
Operating Temperature	-30 to +60 °C
Approximate Size (First Generation)	15 cm (6 in.) x 15 cm (6 in.) x 5 cm (2 in.)
Weight (First Generation)	0.85 kg (30 ounces)
Typical Antenna Type	1/2 wave (1 meter) whip

Different versions of SCU terminals are currently available in production quantities. The SCU or MES terminals now available include “black-box” industrial units that have RS-232C ports for data uploading and downloading. Current options on a number of SCU terminals include internal GPS receivers and/or additional digital and analog input and output ports. Other models with different features are planned, under design, or in the pre-production stage.

4.1. Magellan GSC 100 Terminal

The Magellan users 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 depicted in **Figure 4 (Left)**.

This users terminal unit offers communication and navigation using the Orbcomm network and GPS system. Integrated GPS receiver 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.

Messaging features allow worldwide messaging via Orbcomm MSC service, send and receive brief, global 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 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 user terminal is equipped with telescopic whip antenna, rechargeable NiCad battery package and universal AC converter, 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.

Figure 4. Two Generations of SCU Terminals

4.2. Stellar DS300 Terminal

The Stellar users terminal is a two-way satellite communicator for use with the Orbcomm network, which second generation of is shown in **Figure 4 (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.
The world-class design and stable performance make the Stellar DS100 reliable device for transportation, heavy equipment, marine, aeronautical and many other markets. This 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.

4.3. Quake Q4000 Terminal

The Quake unit is cost effective and fully programmable satellite and GSM data modem with 22 channel GPS global tracking capability, which is shown in **Figure 4 (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.

4.4. Orbcomm OG2-GPS Modem

This tracking modem 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 5 (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.

Figure 5. Third Generation of SCU Terminals

Figure 6. Terminals for Fleet Management

4.5. Orbcomm GT 1100 Modem

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

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

To enhance safety and security in transportation systems it will be necessary to implement SAT 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. 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:

5.1. 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 6 (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).

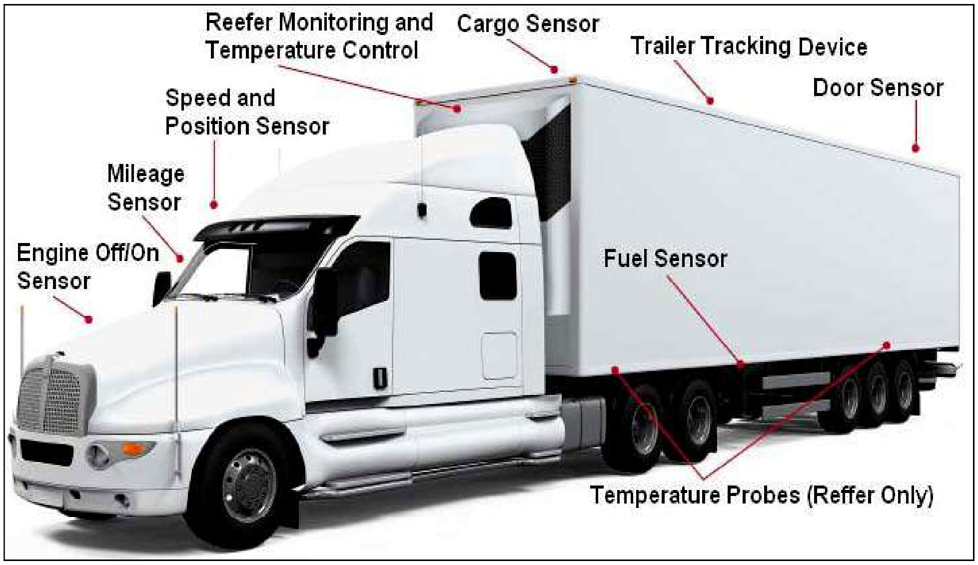

Figure 7. Tracking Sensors onboard Truck

5.2. 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 6 (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 7.** Therefore, 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

The Orbcomm Little LEO operator provides Satellite - Automatic Identification System (S-AIS) for oceangoing ships onboard broadcast system that transmitted ship identification, position and PVT critical data received from GES can be used to assist in navigation and improve maritime safety and security at sea. In the similar way, the Orbcomm 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.

Most current terrestrial-based Radio AIS (R-AIS) system is already implemented by IMO and provides only VHF limited coverage nearby shorelines and not able to provide global coverage. 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. In such a way, Orbcomm was the first commercial satellite network that started operations with S-AIS data service.

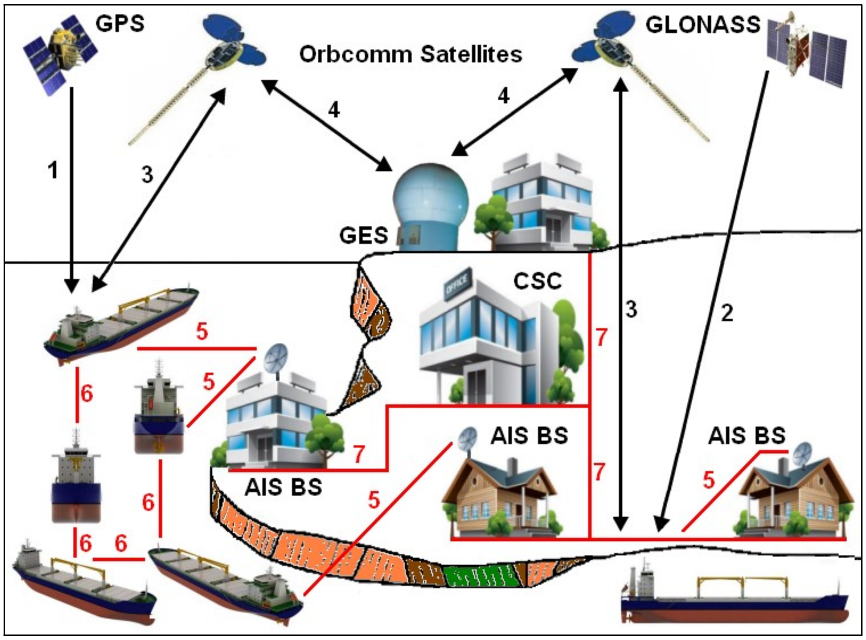

Figure 8. Orbcomm Satellite AIS (S-AIS)

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.
In **Figure 8** is shown space and ground configuration of S-AIS integrated with R-AIS proposed by author of this paper. 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 users segment provides communication, tracking, monitoring, management and PVT service to mobile and fixed in rural and remote environments for Satellite Asset Tracking and Fleet Management (SATFM), Machine-to-machine (M2M) or Supervisory Control and Data Acquisition (SCADA) command and logistics applications at sea, on the ground and in the air. These Orbcomm small devices are a very new satellite communications and tracking tools available for all professionals in transportation, business people, oil and gas, agriculture and remote environment to everyone who likes to have satellite messaging, tracking and logistics using Little LEO Orbcomm satellite systems everywhere.

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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 more than 330 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.