Chapter 2
Non-GEO GMSC Systems

Non-GEO GMSC infrastructures are space solutions for Global Mobile Personal Satellite Communications (GMPSC), such as LEO, MEO, and current regional systems.

2.1 Big LEO GMSC Systems

The handheld and semi-fixed satellite phones are very new communications tools available for business people, professionals in transportation, and fixed environments including who wants to have satellite telephone access via Big LEO GMSC systems at sea, on land, and in the air. Compared to the little LEO, big LEO systems are expected to be bigger and to have more power and bandwidth for different services to their subscribers. Their bigger size of these satellites enables more complex data processing in the transponders than the simple store-and-forward feature of the little LEO systems. These systems provide a wide variety of services, such as voice, data and Fax, SMS and paging, SAR, environmental monitoring, Position, Velocity and Time (PVT) data, and determination, see Fig. 2.1.

Several decades ago the USA and European GMSC providers began to develop new Mobile Satellite Service (MSS) multipurpose applications, ground access technology, and voice transmission protocols in order to enhance the commercial and military communications industry in the new millennium. In September 1991, Inmarsat announced its strategy for the future development of Project-21. The culmination of this project was the introduction of a handheld phone prototype before the entire world under the service name Inmarsat-P. In order to implement this service, new Space Segment architecture would be required.

At that time, Inmarsat evaluated a number of possibilities for the Inmarsat-P Space Segment including enhanced GEO, new LEO, and MEO satellite configurations. In any event, these investigations subsequently led to the identification of a MEO satellite constellation as the optimum solution and the eventual establishment

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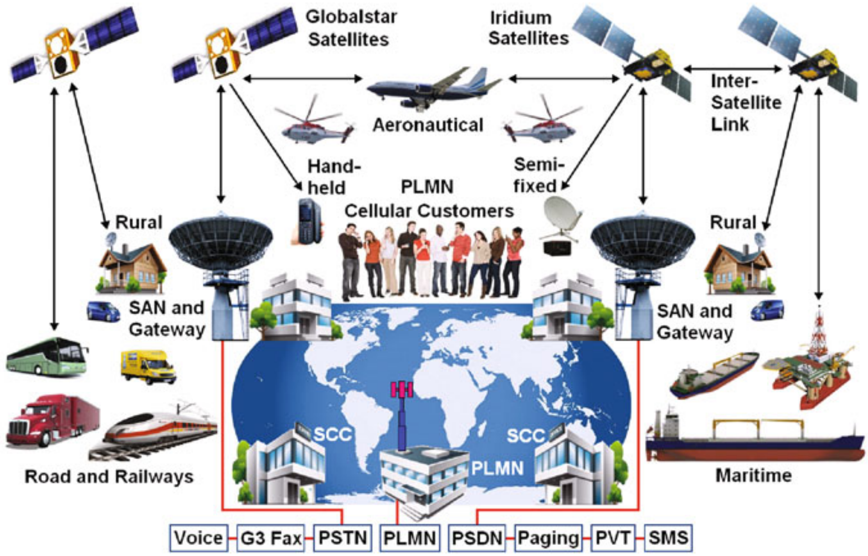

Fig. 2.1 Big LEO system concepts. Courtesy of manual: by Ilcev

of ICO company in order to finance the development of the new MSS. The first GMPSC system, ICO Global Communications, formerly known as the project Inmarsat-P Affiliate company, was established in January 1995 as a commercial spin-off of the Inmarsat organization, but still without success.

In addition, other GMSC providers Globalstar, Iridium, Ellipso, Odyssey, Aries, and AMSC proposed to exploit the Big LEO satellite constellation. However, on January 31, 1995 only Globalstar, Iridium, and Odyssey were awarded licenses by the FCC to operate in the USA. The American organization TRW also proposed to exploit the MEO satellite solution using a configuration of satellites named Odyssey. The Odyssey constellation was to consist in 12 satellites, equally divided into three orbital planes, inclined at 55° to the equator. The satellites were to be placed 10,600 km above the Earth. The FCC awarded TRW a license to establish its MEO satellite system in 1995, with the caveat that building of the first two spacecraft should commence by November 1997. Odyssey was predicted to start service in 1999, at an estimated cost of 3.2 billion US$. Unable to find another major investor willing to support the project, Odyssey was abandoned in December 1997.

The investment of 1.2 billion US$ in ICO by Teledesic was announced in November 1999, but after many problems the system was also abandoned. In the meantime, Iridium and Globalstar experienced bankruptcy protection in the USA after number of difficulties with establishment of Space Segments and problems with penetration on the market. Finally, both systems got sufficient funding and to implement the next stage of system development for the upgrade of its terrestrial network and personal satellite communications.

2.1.1 Globalstar Big LEO GMSC System

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 US FCC in November 1996. Then, the first launch of four Globalstar satellites occurred in May 1998 by Delta rocket from Cape Canaveral and completed the deployment of 48 satellites plus four spares, using Delta and Soyuz-Ikar rockets.

The system uses Code Division Multiple Access (CDMA) and FDMA methods with an efficient power control technique, multiple beam active-phased array antennas for multiple access, frequency reuse, variable rate voice encoding, multiple path diversity, and soft handoff beams to provide high-quality satellite service to users anywhere in the world, even when affected by propagation interference and environmental conditions. Globalstar CDMA is a modified version of the IS-95, which was originally developed by Qualcomm.

Globalstar is a LEO satellite-based digital telecommunications system that offers wireless telephone and other telecommunications services worldwide, starting from the end of the last century. The communications system is designed to provide worldwide digitally crisp voice, data, and facsimile services to portable, mobile, and fixed user terminals. To the user, operation of a Globalstar phone is similar to that of a cellular phone but with one main advantage: While a cellular phone works only with its compatible system in its coverage areas, the Globalstar system will offer worldwide coverage and interoperability with current and future public-switched telephone and land mobile networks.

The Globalstar system consists in three major segments such as: the space, ground and user segments including a Terrestrial Telecommunication Network (TTN), as shown in Fig. 2.2. The Globalstar satellites are receiving signals from mobiles at S-band forward link and sending signals to mobiles at L-band return link. Link between satellites and Ground Earth Stations (GES) is at C-band, and system is controlled by Operations Control Centre (OCC).

2.1.1.1 Space Segment

The Globalstar system has a constellation of 48 satellites in eight planes with six satellites per plane inclined at 52° to the equator at an altitude of 1414 km LEO and four in-orbit spares parked at a lower altitude. The low orbits permit low-power user phones, similar to cellular. The constellation is a 48/8/1 Walker Delta pattern with 52° inclination, designed to provide global Earth coverage between 70°N and S latitudes, see Fig. 2.3.

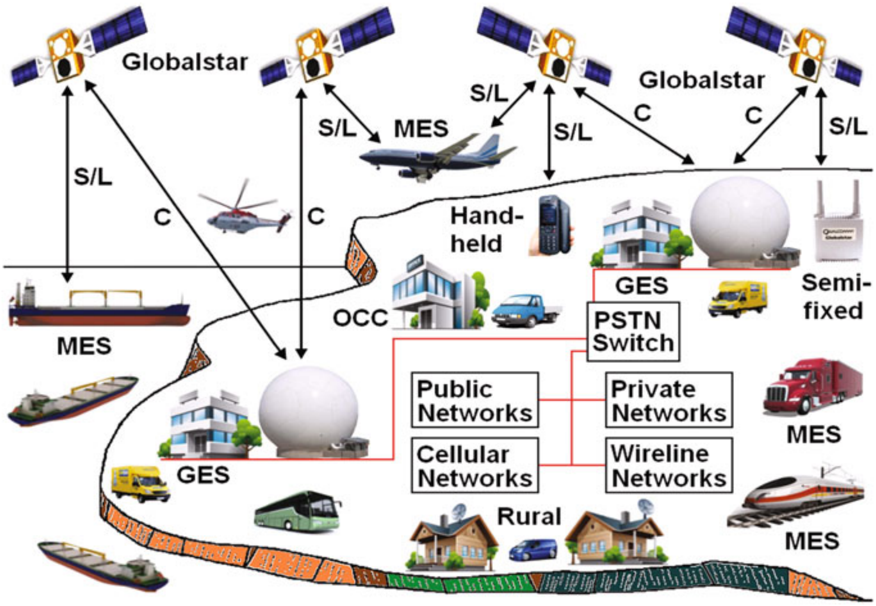

Fig. 2.2 Globalstar GMSC network. Courtesy of manual: by Ilcev

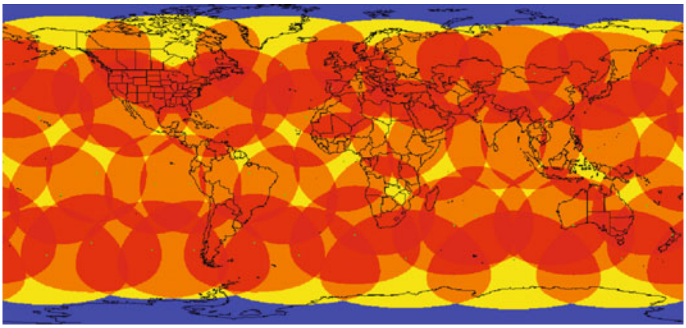

Fig. 2.3 Globalstar satellites coverage. Courtesy of manual: by Lloyd

The contours shown indicate that a user terminal (UT) within the area can communicate with the satellite at an elevation angle above 10°N and S. Constraining the UT to operate with satellites that have higher elevation angles with reference to the UT will reduce the overlapping coverage but would provide an advantage in that it would reduce the power demands placed on the UT to close the link. This would result in longer battery life for the UT. Thus, the satellite orbits are optimized to provide highest link availability in the area between two poles. Service is feasible in higher latitudes with decreased link availability.

The satellite payload is a "bent-pipe" transponder, which includes two antenna arrays with two sets of 16 spot beams on the Earth's surface for service uplink (user-to-satellite) and reverse downlink; one horn antenna for feeder uplink (GES-to-satellite) and reverse downlink; Tx and Rx antennas and circuitry for TT&C. Globalstar satellites function as a relay between the user segment and the ground segment; therefore, they merely transmit the signals received from user terminals to the gateways and vice versa. Gateways are similar to Base Stations in cellular systems; however, the primary difference compared to terrestrial cellular is that the user signals are relayed through satellites to the gateways.

There are two problem areas in the coverage: The first is over the equator where the beam is narrow, and there has been some study using additional satellites to cover the equatorial area. The second area that is not covered well is the polar area, and some study on supplementing coverage with Molniya orbit satellites has been performed.

The Globalstar provides coverage from any point on the Earth's surface to any other point worldwide with multiple overlapping satellite beams for simplex data and voice/duplex data, exclusive of both Polar Regions. The simplex data coverage map is shown in Fig. 2.4 with current 14 GES terminals indicated as ground satellite antenna units. This service is for Satellite Asset Tracking (SAT) and SAT and Fleet Management (SATFM) of all mobile assets including aircraft, known as Global Aircraft Tracking (GAT). Globalstar is also providing fixed data service for fixed assets known as satellite SCADA of M2M. These units are designed to transmit just a single packet message 3-times (the original transmission plus 2-repeats) per day in the frequency appropriate for the given regions in the coverage area.

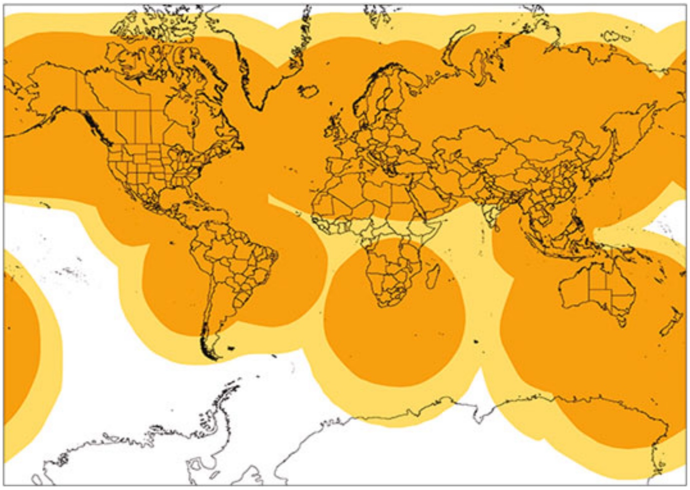

Fig. 2.4 Globalstar spot and simplex data coverage map. Courtesy of manual: by Globalstar

The coverage area may vary based on terminal location, terrain features, signal strength, and other factors affecting satellite communications. The Globalstar Simplex data service is provided via unit containing GPS Rx and satellite Tx only. Thus, to provide complete coverage for simplex data similar to the Inmarsat coverage map, Globalstar has to provide additional 4 GES for Pacific 2 GES for Atlantic and 3 GES cites for Indian Ocean Region.

The voice and duplex data coverage map is shown in Fig. 2.5 with current 22 GES terminals indicated as ground satellite antenna units. This service is available for satellite personal, mobile and fixed voice (Tel), and duplex data transmission and data service for SATFM of all mobiles assets including aircraft. In fact, map indicates coverage for voice and dial-up data calls only. Direct Internet calls (Dialing #777 send) can be made from all regions except China and the following Central American countries: Belize, Panama, Guatemala, Honduras, Nicaragua, El Salvador, Costa Rica, and the surrounding coastal waters of these countries.

However, actual coverage may vary because of gateway deployment, local licensing, and other factors. Globalstar service is a satellite radio technology subject to transmission limitations caused by type of terrain, service area limits, customer equipment use, and other variable conditions including the functionality and orbital locations of the satellites themselves. The Globalstar coverage area will be extended in 2012 by three new GES terminals situated in Central America, Nigeria, and Singapore. To provide complete voice and duplex data coverage similar to the Inmarsat coverage map, Globalstar has to provide additional 6 GES for Pacific 3 GES for Atlantic and 5 GES cites for Indian Ocean Region.

The Globalstar satellite transponder is transparent, thus, unlike the Iridium system, without cross- or intersatellite links and onboard traffic processing, all traffic switching service happens on the ground and traffic routing is through the existing fixed Public Switched Telephone Network (PSTN) with associated

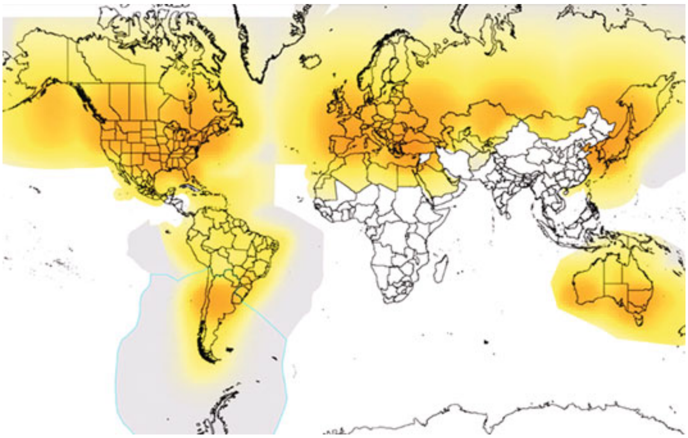

Fig. 2.5 Globalstar coverage map for duplex voice, duplex, and SatFi. Courtesy of manual: by Globalstar

networks. A satellite-phased array antenna produces 16 elliptical spot beams that enable continuous multiple satellite global coverage, path diversity, and position locations. Conversely, lowering the angle to the satellite will increase the overlapping coverage. Thus, small changes can dramatically increase the coverage area, which is particularly apparent in the Polar Regions. If operated at low elevation angles, polar areas that otherwise could not be covered can receive service.

In both polar areas, overlapping coverage would be increased and power demands may be increased because the look angle to the satellite is limited. High-gain directional antennas become practical for fixed and even portable installations. The payback is that Globalstar could now serve areas that otherwise might be unserviceable. Thus, same considerations for polar areas apply to equatorial areas, where the overlapping coverage is less than 100%.

The Globalstar communication satellite is a simple, low-cost satellite designed to minimize both satellite costs and launch costs.

The first-generation satellite, spacecraft orbital planes, and second generation of Globalstar satellite are illustrated in Fig. 2.6 (Left), (Middle), and (Right), respectively. Globalstar launched six new generation satellites in October of 2010, an additional six in July of 2011 followed by another six satellites in December 2011. Launch of the second-generation constellation was completed in February 6, 2013, with the launch of the final six satellites using a Soyuz 2-1a launch vehicle. These satellites have previously been providing improved coverage for Globalstar customers outside of North America and the surrounding territory. The orbital parameters and technical characteristics of first generation of Globalstar spacecraft are presented in Table 2.1.

2.1.1.2 Ground and User Segments

The Globalstar ground segment consists network of gateways, the Satellite Control Centre (SCC), OCC, and the Globalstar Business Office (GBO) that are interconnected via a Globalstar Data Network (GDN).

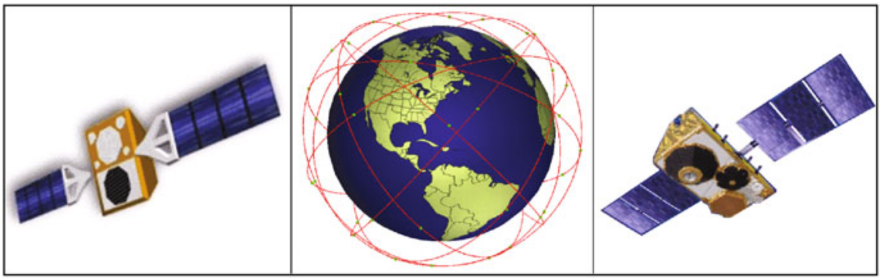

Fig. 2.6 Globalstar satellites and space constellation. Courtesy of manual: by Globalstar

Table 2.1 Orbital parameters of Globalstar spacecraft

Background Owner/operator: Globalstar, USA Present status: operational Altitude: 1414 km Orbital period: 114 min Type of orbit: LEO Inclination angle: 52° of orbital planes Number of orbital planes: eight Number of satellites/planes: six Number of satellites: 48 Big LEO Coverage: global between 70°N and S Additional information: The Globalstar Space Segment has 12 spare satellites; each satellite is fitted with bent-pipe transponder; the system requires GES to be about 65 *Spacecraft* Name of satellite: Globalstar Launch date: different Launch vehicle: Delta 2 and Soyuz Typical users: all mobile applications Cost/Lease information: construction and launch estimated at 3.26 billion US$600 million US$	Prime contractors: space system/loral Other contractors: Alenia Spazio Type of satellite: Big LEO Stabilization: three axes Design lifetime: 7.5 years Launch weight: 450 kg Mass in orbit: 125 kg Batteries: 64 A/h Electric power: 1100 W (EOL) SSPA power: 100–400 hundred per satellite at less than 1 W will be built into phase array antenna *Communications payload* Frequency bands: User uplink: 1.610–1.621 GHz User downlink: 2.483–2.500 GHz and Feeder link: 5.091–7.055 GHz Multiple access: CDMA Number of transponders: 16 spot beams resulting in 2400 circuits Channel polarization: LHCP EIRP: 26.8—36.3 dBW G/T:—11.5 dB/K

Functions of the gateways as a GES are to provide the interface between the satellites and the PSTN/PLMN, to provide TT&C and control link between the SCC and the satellites and to allocate satellite resources on a call-by-call basis. The Globalstar system has many gateways distributed all around the world, which receive and transmit feeder link signals from and to the satellites and provide interconnection to the PSTN. Gateways are designed for unmanned operation; each consists in up to four 5.50 m antennas and electronics equipment installed in a building or shelter. The gateway connects the Globalstar Space Segment to terrestrial switching equipment, receives telephone calls from the terrestrial switching equipment, and generates CDMA carriers to transmit through the satellite. The satellite then retransmits the signal to UT. This UT equipment may be either handheld, fixed, or mobile and located anywhere within the satellite antenna footprint. In the return direction, the UT transmits to the satellite(s), and the satellite (s) retransmit the signal to the gateway. The gateway connects the call to terrestrial switching equipment, which can then connect to any subscriber using the standard telephone system. Connections can also be made to terrestrial cellular subscribers or to other Globalstar UT stations.

The Globalstar system also includes two OCC to manage and control system planning and execution. Each is completely capable of operating the network and managing the satellite constellation. There are two to circumvent the possibility of earthquake, power grid failure, or other disaster. One is located in San Jose, California, and one is located near Sacramento. Each includes OCC, SCC, and

GBO. The OCC manages the satellites, controls the orbits, and provides T&C for the satellite constellation. In order to accomplish this function on a worldwide basis, the OCC communicates with T&C units collocated at selected gateways. The T&C units share the RF links with the gateway communications equipment to relay commands and to receive telemetry. The SCC manages all satellite telemetry, track, command, and control functions and launches operations. To support the GBO, the Globalstar Accounting and Billing System (GABS) is collocated with the OCC and the SCC. The GABS is responsible for all financial activities associated with Globalstar.

The user segment includes three different kinds of UT equipment, such as handheld unit, mobile-mounted unit, and fixed units. User terminals with omnitype antennas are designed to support data rates up to 9.6 kb/s. A variable rate vocoder is used that varies its rate each frame cording to voice activity. This automatically reduces transmitter power for lower vocoder rates, which means, on average, less interference to other users and higher system capacity. Satellite diversity is utilized in the system; if a call is transmitted through multiple satellites, the user terminal and the gateway receive at least two and usually more signals and coherently combine them, which brings diversity gain, reduces the required link margin on each individual link and increases the capacity. Diversity overcomes the adverse effects of propagation such as blocking, shadowing, and fading. With the constellation, double satellite coverage is available nearly 100% of the time; therefore, UT devices can provide diversity as required. Both forward and reverse link power control are used to adjust the gateway and UT powers to the minimum required to maintain high performance. The power is increased only as needed, which means less interference to other users and increased capacity.

The UT Globalstar units in a particular location on the Earth are illuminated by a 16-beam satellite antenna as it passes overhead for 10–15 min out of each orbit. A smooth transfer process between beams within one satellite and between many satellites provides unbroken communications for users. Coverage is maximized in the temperate areas with at least two satellites in view, providing path diversity over most of the area. There is some small sacrifice in multiple satellite coverage at the equator and at latitudes above 60°.

2.1.1.3 Handheld and Fixed Satellite Terminals

The Globalstar handheld terminals look like a standard cellular telephone. They can be used as equipment for alert after emergency grounding of aircraft. Thus, there are multiple mode handsets that operate with the local cellular system or Globalstar, such as:

1. Tri-mode UT offers a global roaming solution for USA-based AMPS/IS-95 (Advanced Mobile Phone System) North American analog system for cellular users; or the IS-95 CDMA digital coverage; or the Globalstar service, the

Fig. 2.7 First generation of Globalstar handhelds. Courtesy of manual: by Globalstar

presented tri-mode satellite phone for AMPS/CDMA/Globalstar services shown in Fig. 2.7 (Qualcomm GSP-1600).

2. Dual-mode UT offers global service for Global System for Mobile Communications (GSM) cellular class 4 phone for Globalstar/GSM users, as shown in the Ericsson and Telit dual-mode GSM/Globalstar phones in Fig. 2.7 (Ericsson R-290 and Telit SAT550).
3. Globalstar mode only is one of the smallest and lightest SatPhone with dimensions 16.92 cm (H) × 7.33 cm (W) × 5.79 cm (D), shown in Fig. 2.7 (Qualcomm GSP-1700).

The Globalstar in general offers two types of fixed satellite terminals:

(a) Payphone terminals are single-line Globalstar fixed units used to connect a payphone service into the PSTN for rural and remote areas used in the USA out of terrestrial landline or cellular coverage, as depicted in Fig. 2.8 (Left). This unit can be also installed on mobiles, namely onboard aircraft as flush mount and fuselage antenna for passenger service. Access to the Globalstar network is via an antenna mounted outside the booth with a clear view of the sky or via mobile satellite antenna. This antenna can be connected to the CDMA radio unit.

(b) Fixed single-line device offers communication service in remote office environments, in which indoor telephone kit and outdoor antenna are illustrated in Fig. 2.8 (Right). The antenna can be mounted in a convenient position on the roof, wall, or mast with a clear view of the sky and connected to the subscriber's equipment. The system is compatible with all RJ11 type subscriber equipment such as wall, desk, and cordless phones and value-added devices

Fig. 2.8 Globalstar payphone and fixed terminals. Courtesy of manual: by Ilcev and Qualcomm

like Fax/answering machines. The Globalstar also offers standard trunk interface for compatibility to local switching systems, such as PABX. This terminal can be used for satellite link between ACT or aircraft owner and cockpit. The fixed UT equipment has a performance equivalent to the MES except that the antenna gain and transmitter power may be even higher. In fact, fixed terminals do not require path diversity to combat fading and blockage and must support seamless beam-to-beam and satellite-to-satellite handoff.

Since there is no handoff between the local cellular system and Globalstar network, and if the user crosses a service boundary between the local cellular system and Globalstar, the call could be dropped and must be placed again. The indicators tell the operator that the mode has changed. The system will not clash in a boundary area, thus all users/MES can select the preferred mode. If cellular is preferred and coverage is not available, the UT will drop the call. The call can be placed in Globalstar mode, and the call will continue until the phone is in an idle state. The Globalstar system in general offers voice, duplex data speeds from 9.6 to 200 kb/s, Circuit Switched Data (CSD) similar to dial-up Internet services, Packet Switched Data (PSD), Internet, SCADA, and integration with GPS for satellite navigation.

2.1.1.4 First Generation of Mobile Satellite Terminals

Globalstar MSS offers three types of GMSC terminals similar to the Inmarsat system: for maritime, land, and aeronautical applications. In fact, here will be presented few solutions of first-generation Mobile Satellite Terminals for all three mobile applications.

The Medium Data Rate Satellite System (MDSS) developed by Qualcomm for use aboard mobiles offers up to 128 kb/s, high-quality digital voice, and data connections. Globalstar allows interactive access to and from mobile platforms equipped with MDSS transceiver. Using the Globalstar satellite system, the MDSS supports any mobile application including high-speed access to Internet, e-mail, or private networks.

Other mobile solutions include real-time video and audio monitoring of passengers cabins and bridges or cockpits; alerts maritime or aviation authorities of emergency situations and crisis situation; remote control of onboard cameras; transmission of real-time mobile data to the ground stations; automatic real-time monitoring of sailing or flight data.

1. **ICS550 Maritime MES Terminals**—The maritime solutions via Big LEO Globalstar satellite network are very important for maritime private subscribers. In Fig. 2.9 (Left) is shown the ICS550 maritime radiotelephone with antenna as a product of the ICS and Telit companies. This equipment is designed for sea-going vessels of all sizes to operate anywhere within the Globalstar satellite coverage area, with the possibility to switch if required to GSM cellular telephone networks when close to the coast. Otherwise, the Telital SAT550 hand terminal may be removed as a part of MES for use ashore.
2. **GCK-1410/GSP1600 Vehicle MES Terminal**—The land vehicular terminal of MSS Qualcomm's Globalstar GCK-1410 hands-free car kit equipment, with wired handset telephone and external antenna, is shown in Fig. 2.9 (Right). This car dual-mode kit will complement existing fixed and cellular telephone networks by switching from terrestrial cellular telephony to satellite telephony as required.
3. **ARNAV RCOM-100 SatPhone**—This is a single-line, multiport Globalstar transceiver for installation onboard aircraft and helicopters, in which block diagram is shown in Fig. 2.10. The RCOM-100 is a Globalstar satellite telephone and tracking solution for aviation. It is housed in an ARINC 600 2MCU compact enclosure. The RCOM-100 is designed to provide voice and data

Fig. 2.9 Globalstar maritime and land vehicle terminals. Courtesy of manuals: by Globalstar

communication in an avionics application. The voice connection is established through a standard tip/ring interface. The RCOM-100 can be connected to any standard telephone handset that complies with EIA/TIA-464B and TIA/EIA/IS-470-B. The data connection is through the RCOM-100 data port, which supports two types of data modes: asynchronous and packet data. However, asynchronous data provide the capability of establishing a connection between a device connected to the data port, and any Hayes compatible modem connected to the PSTN. For packet data, the device connected to the data port must be able to support a PPP session over TCP/IP. Therefore, this is the typical standard used by computers for dial-up services. The installation to the RCOM-100 consists locating and mounting the transmit/receive antenna, locating and mounting the GPS antenna, installation of the mounting tray for the ARINC 600 2MCU box, and wiring the 37 pin circular connector for power, tip/ring, and the data connection port. However, for systems used only for data communications the tip/ring interface is not required, and for systems using just voice communication only, the data port connection is not required.

The first generation of ARNAV RCOM-100 phone system shown in Fig. 2.11 (Left) offers the following features:

1. A standard telephone interface for installation flexibility;
2. Installation is facilitated through simple tip-and-ring connection to the ARNAV DialPad Annunciator and interfaces to an audio panel, headset, privacy handset, Multi-Function or PC Display; and
3. The DialPad and annunciator alert the passengers and crewmembers to incoming calls or SatPhone In-use status.

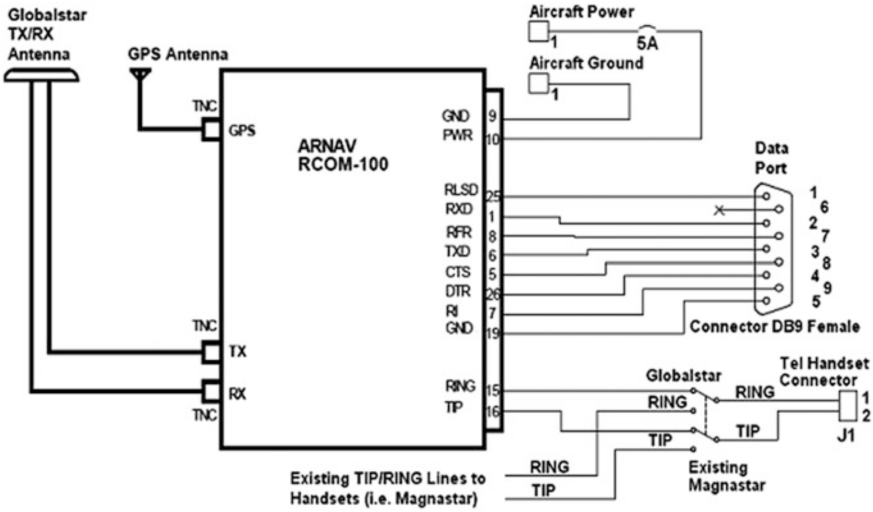

Fig. 2.10 Block diagram of ARNAV RCOM-100 SatPhone. Courtesy of manual: by ARNAV

Fig. 2.11 Globalstar aeronautical satellite voice and data terminals. Courtesy of manuals: by ARNAV, NAT & Geneva

This unit provides service in cockpit for pilots and cabin for crew and passenger via Globalstar spacecraft and high-quality air-to-ground, ground-to-air and air-to-air voice communications, often with better voice quality than cellular networks. The unit makes mobile-originated calls and receives incoming calls from anywhere via simple dial access. As a Globalstar, airtime provider will compile one statement for all local and roaming call service. Globalstar makes the airborne office a reality. Bridging the last thousand-mile air gap, its true packet data network offers direct Internet connection and e-mail access at 3× or higher data rates than typical with satellite communication networks.

The ARNAV Communications, ARCOMM, offers specialized Flight Data Services through their VHF network or through Globalstar connection. ARCOMM is the official FAA Flight information service data link provider of aviation weather to the cockpit. Weather products include NEXRAD, METAR, TAF, AIRMET, SIGMET, CATMET, NOTAM, Winds Alof, Significant Weather Turbulence, Icing, Convection Forecast, and miscellaneous Significant Weather graphical and text reports.

The ARCOMM weather is available worldwide for the American continents, Caribbean, North Atlantic, Europe, Asia, and South Pacific. Flight Tracking Services with automatic position reporting to multi-terminal PC Flight Dispatch Software permit secure asset management and recording of flight events. At this point, the text and graphic messages are easily exchanged between a PC Dispatch terminal and a cockpit Multi-Function Display.

Fleet-wide flight tracking can be shared through low-cost Internet TCP/IP connection or by secure encryption via frame relay through ARCOMM. Optionally, Engine Trend Monitor health status records can be transmitted to appropriate engine and fleet maintenance authorities automatically. The RCOM-100 has full duplex transmit and receive capability, data packet 9.6 kb/s, with frequency for forward link at 2484.39–2499.15 MHz and for reverse link at 1610.73–1625.49 MHz. The system can provide Qualcomm CDMA modulation and encryption. Its low-profile dual-band active antenna provides excellent Globalstar operation.

4. **NAT STX100 SatPhone Transceiver**—Northern Airborne Technology is a company affectionately known as NAT, and is a Canadian division of Chelton. In 2003, they introduced a Satcom system, called STX100, shown in Fig. 2.11 (Middle). This is a Globalstar-based system supporting both voice and data. The STX100 includes a remote mount transceiver, cockpit-mounted dialer, and Cobham Comant aircraft antenna. However, there are optional handsets available to meet the cabin installation requirements. The optional LMC01 Latitude Mobile Controller module is available to provide Mobile Dispatch, tracking, data delivery, position, and status reports. This Dzus-rail unit allows flight crew access to satellite connection through the aircraft audio system, using a two-wire interface.

The features include hook, hold, last number redial, flash, and volume controls. This unit is a fully certified airborne communication system as a compact, lightweight, aircraft grade equipment, providing easy installation and integration. In addition, flight crews can access the connection system through the aircraft audio panel using Northern Airborne's PTA12 Dialer/Headset interface unit. This permits full headset operation, while a handset may be used in parallel to provide independent access from the cabin. Data may be accessed directly from the STX100, supporting both asynchronous and packet data formats for all your remote communication needs. The soft tactile touch-tone keypad of the PTA12 provides a standard DTMF (Dual Tone Multiple Frequency) encoder dialing capability, while other features include precision controlled tones, reverse polarity protection, RF filtering, LED backlighting, and solid state switching. This device uses nit, determines the uplink frequency band (reverse link) of 1610.5–1621.35 MHz and downlink band (forward link) of 2483.5–2500.0 MHz, provides data interfaces of RS232 (19,200 b/s, 8-N-1), gives RF power output of 2 watts maximum (+33 dBm), its operating mode is full duplex, its RF Input/Output Impedance is 50 Ω and has remote interface of POTS (2-wire).

5. **Geneva P-145 PK SatPhone Transceiver**—This Geneva Aviation satellite transceiver is a flexible aircraft-mounted cradle unit with the Qualcomm GSP-1600 satellite phone, shown in Fig. 2.11 (Right).

This unit can be installed on small aircraft including helicopters for communication and Safety facilities in the footprint of Globalstar phone and duplex data coverage. A lack of communication leaves a pilot of small aircraft at risk, especially when flying in a remote area. This unit is compact and lightweight, provides a reliable telephone connection and no-delay voice transmission, mounts conveniently near pilot and is built-in modem for data/fax connections. P145-PK Installation Kit includes antenna assembly, junction box, aircraft-mounted cradle unit with battery charger, and Qualcomm GSP-1600 satellite single phone shown in Fig. 2.11 (Right). The satellite phone unit easily slides into cradle, yet secure while in flight cradle charges the satellite phone battery, modularized components provide easy ergonomic installation and easily connects and adapts the phone to the existing aircraft audio system. The antenna unit is small and lightweight with 3″ in diameter and 3″ height suitable for jet speeds. The Qualcomm GSP-1600 satellite phone can be used independently inside of cockpit and outside of aircraft for emergency purposes. The dimensions of phone are 177 mm H × 57 mm W and 48 mm D. Satellite mode batteries can be used up to 3.5 h of talk time and up to 9 h of standby time. CDMA mode battery time is up to 4.5 h of talk time and 72 h of standby time. The display of phone has four lines of 12 characters and one line of icons. The satellite phone integrates polymer lithium battery, which is used when phone is out of cradle. This unit is using the same frequency band as previous models determined for the Globalstar satellite links.

2.1.1.5 New Generations of Mobile Satellite Terminals

The new generations of Globalstar GMSC solutions are advanced handheld and portable satellite phone available today for maritime, land, and aeronautical market. They integrate Globalstar MES terminals with cellular solutions and provide WiFi/SatFi connections.

1. **Maritime Satellite Solution GSP-1700-MR Bundle**—The shipborne GSP-1700 is the most advanced handheld portable satellite phone available today for maritime and offshore industries. This unit is mostly suitable for installations onboard small and fishing vessels, which are able to become a complete satellite phone system with clear voice and fasted data speeds. However, particularly designed for use at sea, this unit with the pole mount helix antenna and various cable length options is even ideal for all vessel sizes inside of Globalstar network coverage, in which unit with antenna is depicted in Fig. 2.12 (Left).
2. **Car/Vessel GIK-1700 Transceiver Kit**—The GIK-1700 provides convenient, in-vehicle and in-vessel operation of the Globalstar GSP-1700 mobile satellite

Fig. 2.12 Globalstar maritime, vehicular/vessel, and portable satellite terminals in the bag. Courtesy of manuals: by Globalstar

phone by connecting it to an easily magnetic mountable external antenna, in which configuration is illustrated in Fig. 2.12 (Middle). This transceiver offers flexibility and hands-free usability for voice calls when traveling and working in areas where cellular coverage is unavailable.

3. **Portable Docking Kit GPDK-1700**—The GPDK-1700 is providing the same service that the Globalstar Mobile Kit GIK-1700 does, in which phone and bag are depicted in Fig. 2.12 (Right). It provides in-vehicle and in-vessel operation of the Globalstar GSP-1700 mobile satellite phone with the added advantages of being able to take the entire kit with users when they exit their vehicle or vessel.
4. **Multipurpose 9600 Data Satellite Hotspot**—The Globalstar 9600 unit is de facto satellite mini router that is providing hotspot for individuals to use a convenient app and seamlessly pair their existing GSP-1700 satellite phone with a smartphone, tablet, or laptop to send and receive e-mail and text messages over the Globalstar network, in which sample is illustrated in Fig. 2.13 (Left). For maximum performance, it is necessary to keep the Globalstar 9600 and Globalstar satellite phone a minimum of three feet apart from each other when making a satellite connection, in which configuration is shown in Fig. 2.13 (Right). Except GSP-1700, the 9600 router can connect GSP-1600 (this connection requires GSP-1600 Data Kit and GDK-G9600-ADPT cable) and GSP-2900 (this connection requires GSP-2900 Data Kit and GDK-G9600-ADPT cable).

With the Globalstar 9600 and mentioned Globalstar satellite phones, customers are able to use their existing WiFi-enabled devices to send e-mail and post to social media over the Globalstar network. Whether on land or at sea, customers will be able to maintain reliable connectivity when beyond cellular network. The Globalstar 9600 router is compatible with cell phones, such as Android, Apple iOS, Windows, and Mac. Thus, today's smartphones provide more options for staying in touch with friends and family than ever before. Unfortunately, they are dependent on the cellular network.

Now, customers can take smartphone beyond cellular with the Globalstar satellite hotspot, outdoors with a clear view of the sky, and horizon without obstructions, buildings, and large trees. Then, they have to place the phone on its

Fig. 2.13 Globalstar 9600 data satellite mini router. Courtesy of manuals: by Globalstar

side and fully extend the antenna, pointing toward the sky and turn on by pressing and holding. After 30 s, on phone screen appear two icons which means that unit is registered with the Globalstar satellite network. At the end, customers have to plug in the phone turning the power switch to on, and Globalstar 9600 is now ready to send and receive e-mail and data. This unit is ideal for industries such as: energy, oil and gas, emergency and commercial management, ferries and recreational marine, transportation, construction.

5. **Mobile Satellite Phone GSP-1700**—This phone provides true interoperability for the public and private sectors to communicate within and across agencies, jurisdictions via voice and data in real-time, in which two samples are depicted in Fig. 2.14 (Left). This phone can be used in combination with Globalstar 9600 Data Satellite Hotspot and SatFi configuration including as portable phone in a bag. It also provides convenient, in-vehicle and in-vessel operation by connection to an easily mountable external antenna.
6. **Aviation GSP-1700 Satellite Phone and Data Package**—New Globalstar aviation voice and data solutions allow customers in small aircraft to stay connected directly from the cockpit. Thus, this package is ideal for the "pilot on the go" who wants and needs the convenience of portable satellite communications. Small and lightweight, the GSP-1700 allows you to go from cockpit to car, beach, hangar, or wherever your final destination without being tethered to your aircraft. As illustrated in Fig. 2.14 (Right), this package includes SP-1700 satellite phone, Globalstar 9600TM portable data hotspot with SatFi, Supplemental Type Certificate (STC) flat aviation antenna, and SPOT TRACE Global Tacking Device (GTD) connected via phone or tablet.

This package uses Globalstar proven and reliable satellite technology to help pilots and their passengers in small aircraft to stay connected and what matters on the ground while they are soaring in the clouds. The new STC antenna connects directly to the STC phone cradle or the SatFi wireless hotspot, providing in flight

Fig. 2.14 New generations of Globalstar satellite phones and aeronautical terminals. Courtesy of manuals: by Globalstar

voice and data communications that is completely independent of cellular and radio coverage. Thus, pilots and passengers can make and receive not-interrupted voice calls, send and receive e-mail, transfer data files, post to social media, track the aircraft's position, use specialty apps and even check the latest weather reports with speeds that are up to four times faster than competition offer, provide solution of Lockheed Martin Flight Service (LMFS) Flight Plan and Deviation Monitoring for Visual Flight Rules (VFR).

7. **Maritime SatFi Satellite Phone and Data Package**—With universal Globalstar SatFi service, customers can use their existing WiFi-enabled devices to make and receive calls, send e-mail, and SMS text messages over the newest Globalstar satellite network. Whether at sea or on land or in the air, up to eight Globalstar SatFi users will be able to maintain reliable connectivity when beyond cellular with one SatFi device providing reliable voice quality and the fastest data speeds.

The Globalstar SatFi modem is a VoIP mode to Satellite Bridge allowing users to send and receive satellite calls through smartphone. User will be able to carry just a single phone and use that smartphone on both cellular and Globalstar satellite networks.

The SatFi modem is designed for all mobile applications; however, an example of a typical user at sea would be small ships and small boats. With a SatFi onboard, the owners of boat or ships captains do not have to carry both a smartphone and satellite phone, namely all they need to do is simply to register their smartphone on SatFi network. In such a way, the seafarers and passengers are now free to move about the vessel while maintaining both cellular (if it is available) and satellite connectivity all on one phone. Additionally, with a smartphone there is no need to achieve proper antenna alignment or have a clear view of the sky to send or receive satellite calls. If SatFi system is properly mounted, the captain and passengers can send or receive satellite calls anywhere on the vessel with smartphone. While normal mobile satellite phones are single user devices only one satellite call can be made at a time, SatFi allows for multiple simultaneous user connections with up to eight users may connect to a single SatFi sharing its satellite connection. Once users are registered and connected to the SatFi, they are immediately able to make outbound calls. Additional users, passengers, and guests will be able to register their smartphones on SatFi and make calls or data connections. All calls and data connections are made through the SatFi App, which needs to be downloaded on customer's Android or iOS device in order to connect to the Globalstar network.

In Fig. 2.15 (Left) is illustrated new generations of Globalstar SatFi maritime terminal, which contains the following components: Globalstar SatFi Unit, Globalstar SatFi Power Supplies (20-240VAC/12VDC), Globalstar marine helix antenna (GAT-17MR) and WiFi antenna connected to the existing WiFi-enabled devices. Users have easily to connect their WiFi-enabled device to the SatFi device with the custom SatFi and SatFi Voice Apps, which is available for Android, Apple iOS, Mac, and Windows. Using smartphones, SatFi device can make voice calls,

Fig. 2.15 New generations of Globalstar SatFi maritime and vehicular satellite terminals. Courtesy of manuals: by Globalstar

send e-mails and SMS, post information to social media, and transfer incoming calls and send text messages between connected users. In addition, it can provide SOS alert capability with GPS location data sent to emergency responders.

6. **Vehicular SatFi Satellite Phone and Data Package**—The Globalstar SatFi terminal is the same as for maritime applications and however is designed for vehicle-based application as well, in which configuration is depicted in Fig. 2.15 (Right). Vehicle-based examples may include cars, trucks, buses, Recreation Vehicles (RV), All Terrain Vehicles (ATV), locos, and transportable boats. In addition, this device can be used for fixed location solutions, which may include remote and rural areas where there is no cellular coverage, and satellite communication is desired or needed. The SatFi vehicular terminal can use special antenna for land mobiles known as Magnetic Patch Antenna (GAT-17MP).
7. **Aviation SatFi Satellite Phone and Data Package**—The Globalstar SatFi dual voltage aviation voice and data package is reliable new satellite technology for pilots who want to provide affordable voice and data services in cockpit including their passengers. Same as maritime and vehicular solutions, the aviation SatFi solution allows up to eight smart devices to connect to the Globalstar satellite network through WiFi, so pilots and passengers can be productive and run their business even in the air. As shown in Fig. 2.16 (Left), aviation SatFi terminal contains STC antenna for Part 23 Non-Pressurized Aircraft connects

Fig. 2.16 New generations of Globalstar SatFi aeronautical and building terminals. Courtesy of manuals: by Globalstar

directly to our STC phone cradle or our SatFi wireless hotspot including SPOT TRACE GTD unit connected via smartphone or tablet. Using this equipment, pilots and passengers can make and receive clear voice calls, send and receive e-mail messages, transfer data files, post to social media, track aircraft's position, use specialty apps, and even check the latest weather reports with speeds that are up to four times faster than existing competition. In fact, it gives to aircraft in flight reliable voice and data communications that is completely independent of cellular and radio coverage.

8. **Building SatFi Satellite Phone and Data Package**—The SatFi terminal for building or fixed applications contains fixed roof or mast-mounted helix antenna (GAT-17HX) and the same above-stated SatFi modem, in which configuration is shown in Fig. 2.16 (Right). The SatFi modem is connected to smartphones or tablets via WiFi antenna.

2.1.1.6 Universal Simplex Satellite Tracking Terminals

The Globalstar satellite network has enhanced simplex coverage ideal for collecting and reporting data and is renowned for its simplicity of use. This solution is perfect for use as ships, containers, land vehicle (road and rail), and aircraft tracking solutions including for fleet operators to monitor where fleet of mobiles are at all times. The device comes in both portable and fixed versions, requiring little to no installation and can be used by operators worldwide. These tracking devices will allow to be notified upon stationary or movements events including to generate reports based on fleet activity through a Web-based mapping interface via Internet.

As discussed earlier, some Globalstar equipment needs to be integrated with GPS receivers (Rx) to get PVT data and to process this data for tracking and determination facilities of all mobile applications. Thus, these units have to work properly without errors under different weather conditions, high-speed movements, and without disturbances that give obstacles and interference. The Globalstar tracking device and GPS antenna has to be installed onboard ship compass deck, atop vehicle roof, or on the aircraft fuselage into covertly beneath fiberglass or plastic enclosures.

The Globalstar equipment such as Axonn mobile satellite trackers is designated for asset tracking of road vehicles, trains, containers, trailers, and ships, but with simply modification of GPS Rx can be used for aircraft tracking as well. On the other had, Guardian producer has solutions just for aircraft tracking. Here will be introduced three solutions of Globalstar mobile satellite trackers Axonn:

1. **Simplex AxTracker**—This unit provides a battery-operated, self-contained telemetry device, delivered complete and ready-to-go with no need for an external antenna or power source, illustrated in Fig. 2.17 (Left). It is $9.25 \times 6.25 \times 1''$ in size and ideal for hazardous operating environments and is ideal for aircraft installation and tracking because it can work independently of power source and any inspection. The units can be preprogrammed to

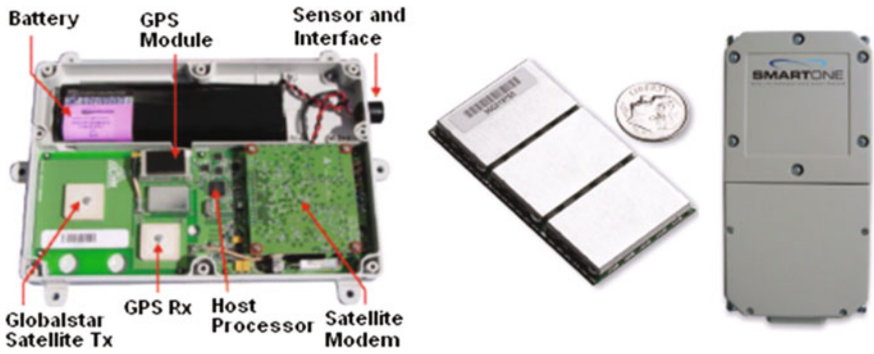

Fig. 2.17 Globalstar satellite GPS receivers and simplex data transmitters. Courtesy of manuals: by Globalstar

requirements and to send GPS location and other information on predefined intervals. Messages are transmitted over the Globalstar Simplex service through a message routing infrastructure and then sent to host application or can be integrated with a hosted mapping application. Optionally, the AxTracker units can be configured to send a GPS location once or several times a day or when mobiles move, enter/exit Geo-fencing zones or integrating the units to capture and report other information such as speed, position, engine run-time. Unit is using battery up to seven years of life what depends of usage time.

2. **Simplex Axonn STX2 Tracker**—At a mere three square inches, this unit is the world's smallest 3 Sq inches satellite transmitter available for use by product developers, which is shown in Fig. 2.17 (Middle). As part of Axonn products, it operates over the Globalstar Simplex data network to enable data collection from remote sites globally using low current and long battery life. As the lowest cost method for collecting data over satellite network, airman should consider the STX2 as an integral, low-power component for the development of aircraft asset tracking, monitoring, and management systems.
3. **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 is a practical solution to improve operating efficiency and security, which is illustrated in Fig. 2.17 (Right). The design of this unit allows it to be easily installed and field managed without the need for harnesses, antennas, and external power. The advantages of independent power supply is that 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 removes the need to purchase expensive proprietary batteries for replacement.

However, it utilizes motion sensors, comparative GPS positioning, and custom configured sensors to gather and transmit asset status information. Each unit is custom configured to track its asset's specific needs and provide intermediate and emergency alerts by e-mail and/or text/cellular.

2.1.1.7 Aircraft Simplex Satellite Tracking Terminals

Guardian Mobility is the provider of global tracking, voice and data communications, and management solutions to the aviation marketplace. Guardian has developed a full range of units and services targeted at assisting aircraft operators to increase Safety and efficiency, reduce costs, and improve reporting. Guardian introduced the first portable GPS tracking device in 2002, delivering location and status information and has since developed solutions to facilitate two-way text messaging and automatic data communications between the aircraft and the ground. Guardian's products are approved for government-mandated AFF and are used by fleet operators worldwide for Flight Data Monitoring (FDM) and Engine Trend Monitoring (ETM) to support Flight Operations Quality Assurance (FOQA) and Maintenance Operations Quality Assurance (MOQA) as part of a Safety Management System (SMS). This company is providing the following Globalstar Simplex solutions:

1. **Simplex Skytrax 3X Tracker**—This unit is the world's first commercially available aircraft GPS tracking device integrated with both a satellite transmitter and GPS receiver in one unit including both internal antennas for AFF facilities, presented in Fig. 2.18a. Itwell increases efficiency, provides situational awareness and promotes Safety by reliably monitoring aircraft movement in near-real time. This and other similar units of Inmarsat and Iridium systems are the best solution for GAT of aircraft in flight, grounded or in Distress situation. Long time ago, the author of this book proposed ICAO solution to implement such kind of equipment as obligation onboard every aircraft, similar what provided IMO for ships, but as usual they never send a reply.

   The Guardian Skytrax is able to provide the following features:

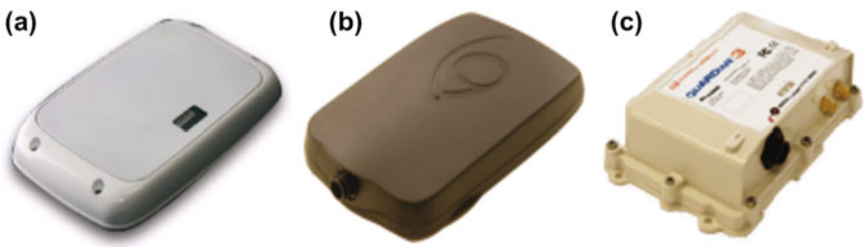

Fig. 2.18 Guardian Mobility GPS receiver and simplex data transmitter. Courtesy of booklets: by Guardian Mobility

– GPS data, speed, and heading are features provided by this unit without external sensors. In addition to accurate longitude and latitude data, speed, heading, and altitude information is also transmitted to provide you with optimum location data.
– Automated Flight Following (AFF) is compliant of this tracker that enables the US and Canadian contractors to firefighting agencies to send 2 min data transmissions directly to central servers such as the National Fire Safety Centre in Boise, Idaho.
– Wheels Up/Down and Skids Up/Down Information can be provided, namely Skytrax 3 automatically detects and transmits the critical transition points at which an aircraft begins its taxi run and/or initiates takeoff and landing.
– Store-and-forward **save** transmission costs by bundling multiple stored GPS positions into one transmission (e.g., send three GPS points every 10 min). Points can be viewed using Maptracs to give you accurate “cookie-crumb” trails.
– Transmit on movement is configuring your Skytrax 3 to collect and transmit data only when the aircraft is moving and, therefore, reduces transmission costs.
– Accurate Flight Path Tracking can be obtained because Skytrax 3 can intelligently collect only those GPS locations that best define the aircraft track. Thus, this feature can reduce transmission costs or provide enhanced resolution.
– Web-based mapping is providing position and attitude data from single aircraft, and fleets can be plotted automatically to the Web-based mapping available or Guardian Maptracs, which requires no installation and enables to view maps from anywhere via a Web browser.

2. **Simplex Skytrax SL Tracker**—This terminal is a new portable and lightweight aircraft tracking device integrated with both a satellite transmitter and GPS receiver, illustrated in Fig. 2.18b. It is quickly and easily mounted inside aircraft, but because the antenna is inside the unit itself, therefore it must be mounted with a clear view of the sky. It can be moved between aircraft within a fleet to maximize an investment in situational awareness and Safety. All technical and application features are the same as previous unit.
3. **Simplex Guardian 3 Tracker**—This device is a versatile aircraft tracking product that comes as either a portable or permanently installed device that runs on the Globalstar or Iridium satellite network, illustrated in Fig. 2.18c. It has similar features listed for Skytrax 3 and comes with various antenna configurations and is ideal for AFF compliance or fleet operators who require aircraft location and status information. There are two types of Guardian 3 units, first is with minibase enclosure providing features antenna connectors with patch or external mounted antennas, and the second is with internal antenna available either the Globalstar or Iridium (duplex) satellite network. Physical size of unit is 160 (W) × 44.5 (H) × 114.3 (D) mm, and weight is 300 g (0.65 lb). Operating temperature is −30 to +60 °C, and storage temperature is −40 to +80 °C. It provides 12 channel tracking sensitivity −156 dBm. Power input is 9–28 VDC and power consumption is <1 W average and 3 watts peak.

Frequency range is 1611.25–1618.75 MHz, internal GPS antenna gain is 2.0 db @ 90º, polarization is RHCP, Axial ratio @ 90º at 3 Db maximum. This unit is reliable, compact, easy to use, and inexpensive. It is perfect for government contractors who require AFF and for fleet operators who want to know where their aircraft is at all times. The Guardian 3 end-to-end solution will allow to be notified upon takeoff and landing events, and generate reports based on fleet activity through a Web-based mapping interface. Set up e-mail alerts and access, so friends and family can follow aircraft or receive alerts upon predefined events via a smartphone or WiFi-enabled device so that tracker can be followed from anywhere.

2.1.1.8 Duplex Satellite Tracking Terminals

Qualcomm is the provider of voice and data global tracking and communications systems for mobile and aviation applications. In this kind of satellite, equipment will be introduced in the International Communications Group (ICG) and NovCom products.

1. **GSP-1720 Satellite Data and Voice Module (SDVM)**—This Qualcomm unit provides full, two-way data and voice capability, allowing for the development of new and creative applications from basic AT Modems to fully featured fixed telephone services from remote and mobile locations.

It can provide direct connect Internet, dial-up Internet or remote terminated data sessions, and asynchronous computer-to-computer connectivity via satellite for Supervisory Control and Data Acquisition (SCADA) applications.

Thus, these options provide communication lines with land and marine-based equipment, while complementing mobile and stationary field solutions. Whether mobile or stationary, the GSP-1720 helps you monitor, control, or track any assets remotely through the Globalstar satellite network, affordably, reliably, and with very low-power requirements. This unit is modular for ease of Original Equipment Manufacturer (OEM) integration and compatible with all Windows applications. The automatic system of the unit selects and automatically seeks out the Globalstar network providing the superior CDMA digital satellite quality voice and data services at 9.6 kb/s full duplex service, also available up to 38 kb/s with compression. The unit utilizes standard and enhanced "Hayes Modem" AT commands, asynchronous voice and data communications, static IP availability, dial-up networking, SMS solutions and can be integrated into a cellular or GSM data solution. It also provides all SCADA applications such as for telemetry, remote and environmental monitoring, aviation, process control, and remote diagnostics. The SDVM OEM board and low-profile patch antenna are illustrated in Fig. 2.19a, while power supply unit and multimode data/power cable kit are shown in Fig. 2.19b. On the other hand, for remote installations, can be used multiple antenna forms in either passive or active versions. In addition, these units can be

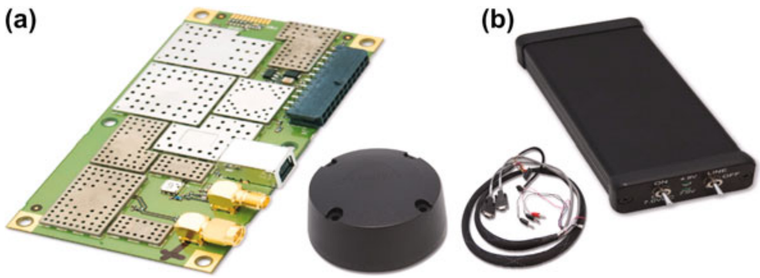

Fig. 2.19 Globalstar duplex satellite tracking terminals. Courtesy of booklets: by Qualcomm

easily modified for use for communication between aircraft and ATC controllers, for Safety and security or can be implemented for SCADA control for aviation installations. The unit can be interfaced via 22-pin Molex connector with pin-outs for data port, auxiliary port (control/NEMA), audio and power USB-B connector for data and diagnostics connectivity. The module antenna connector can be jointed to the passive TX SMA female and RX SMA female, while the active connector provides TX SMA male and RX SMA female ports.

2. **GPS-1600 Voice and Data Globalstar**—Globalstar GSP-1600 Tri-Mode Qualcomm phone serves as a wireless modem sending data from or receiving data to a computer such as an PC, laptop, or palm handhelds, illustrated in Fig. 2.20. Thus, once the unit is connected, it can use familiar software applications such as Eudora, Netscape Navigator, or Microsoft Internet Explorer for anything you would normally do through your network provider or ISP. For example, the unit could browse the Internet, access e-mail, transmit information, connect with host applications, transfer files using FTP at over-the-air data rates of up to 9.6 kb/s for Globalstar service or up to 14.4 kb/s for cellular service, with no additional modem or dedicated telephone circuits required.

The Qualcomm tri-mode phone can be connected to PC via nine-pin serial connector and data cable to any optional accessories. The PC organizer can use Globalstar network for packet data and once for asynchronous data. The packet-switched network (packet data) can be used when PC sends data to the Qualcomm phone either to a satellite and gateway (GES) in the Globalstar system or to a digital cellular network. The packet data are routed to and from the network service provider through the Globalstar system, and a router in the GES connects to the Internet, as shown in Fig. 2.20. PC also sends asynchronous data via phone, satellite, and GES, which routes all call to the destination modem via PSTN.

3. **Globalstar HardCase EDK-1410**—To adapt satellite phones for portable use in interior or extreme environments, Globalstar and NavCom Digital have developed a customized portable kit for easy transportation and installations, presented in Fig. 2.21 (Left). It was designed for use in interior environments such as buildings, land vehicles, offshore vessels, and aircraft and for exterior

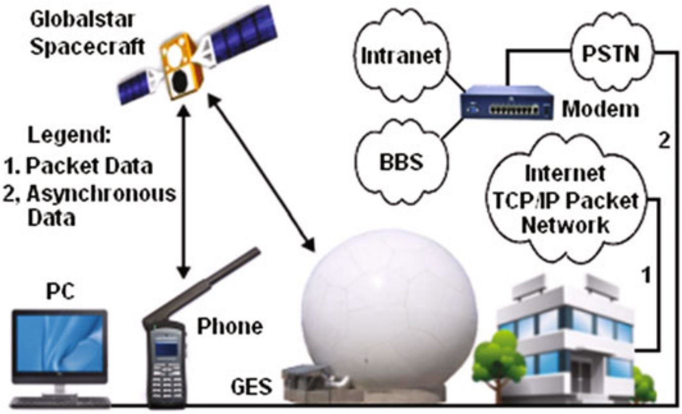

Fig. 2.20 Globalstar duplex satellite voice and data terminals. Courtesy of manual: by Ilcev

use in emergency situation. The Globalstar HardCase makes it easy to use a PC or PDA to access the voice service, Internet, e-mail, and fax. The HardCase is based on the rugged Pelican Products case, which is waterproof, dustproof, and crushproof for maximum protection when transporting in any environment. It features an automatic pressure relief valve and a lifetime warranty. This unit combines the Globalstar Mobile Kit (GCK-1410) with special adapters and cables to provide for an easy installation with the greatest versatility. It allows convenient mounting of the Qualcomm GSP-1600 in a cradle connected to the Globalstar Electronic Module (GEM) or "black box."

3. **ICG AeroCom 3000**—It is a Cabin Telecommunications Unit (CTU) multiple system in a six-MCU form factor designed for the large to intermediate corporate aircraft and offers a solution for even the most demanding application shown in Fig. 2.21 (Right). This PABX system is compatible with many transceivers and services of all types and can integrate the following: Globalstar,

Fig. 2.21 Globalstar HardCase and AeroCom terminals. Courtesy of booklets: by Qualcomm and ICG

Iridium, Magnastar ARTU, CEPT-E1, HF radio and Inmarsat Aero H (+), I and HSD terminals. Because of the vast number of interfaces that the terminal offers, it is also able to support emerging communications systems without the requirement to add special interface boxes or wholesale systems change-out. It can provide from 12 to 36 station (telephone) ports and offers many executive calling features such as multiparty conferencing, call queuing with call back, voice prompts, credit card calling. It supports many types of devices from conventional 2-Wire telephones to 4-Wire devices as well as secure voice handsets. It can be customized for virtually any application or requirement. This unit provides three-party conferencing (12-party optional), short code dialing, intercom calling, transfer and call back, class of service restrictions per extension or group, PA system and HF radio interface with VOX actuated PTT, standard dialing conventions in North America and Europe, Direct Inward Station Access (DISA) with VOX prompt, voice prompts (instructions and messages), digital echo suppression, and Fax CNG tone recognition with auto transfer. The system architecture of the unit is fanless socket 478 Pentium compatible processor with telecommunications circuits (12 Ea.) 2-Wire "Tip and Ring" subscriber (extension circuits) expandable to 36 circuits, (1 Ea) CEPT-E1 ARINC 746, (6 Ea) 2-Wire bearer (CO) channels, and (16 Ea.) I/O channels for discreet multipurpose signals. Optional circuits are (8 Ea) 4-Wire analog voice with discreet hook, ring or PTT, and (8 Ea) Euro ISDN terminal or network connections. The additional equipment can be handsets (cordless, flight deck, and retractor reel), external ringers, call annunciators, credit card readers, and complete turn-key cabin voice and data solutions.

2.1.1.9 Duplex Spot Satellite Trackers

The Spot Satellite Tracker is a device using the GPS network to acquire its coordinates, sending its location with a link to the Google maps, and then sending a preprogrammed message via a Globalstar commercial satellite network. There are two types: personal tracker and emergency messenger, which do more than just call for help, they are tracking your progress, checking in with loved ones, and non-emergency assistance is also available.

The Satellite Emergency Notification Device (SEND) is a portable emergency notification and locating device, which uses commercial satellite systems rather than the Cospas-Sarsat satellite system.

An example of one such device is Spot, which uses an internal GPS chip to gather location information via satellite to a commercial monitoring agency whose role is to pass the information to an appropriate responding agency. The responding agencies over the world would be military Search and Rescue, Coast Guard, local police, voluntary SAR or International Emergency Response Coordination Centre (IERCC), which receives alert and Distress calls and provides an accurate and up-to-date database of response agencies to contact and can quickly determine which is appropriate to the situation/location. One such commercial IERCC is GEOS (in Greek means world), used by both SPOT and DeLorme SEND units. The GEOS IERCC was officially founded in November 2007, as part of the Alliance Travel Safety Group Ltd with the culmination of various 24 × 7 monitoring centers that individually focused on travel Safety, security services, and monitoring for clients.

1. **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. 2.22a. With the Spot Tracker, people in emergency and their families ones 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 preprogrammed message via a commercial satellite network. This unit does more than just call for help and checking emergency progress, non-emergency assistance is also available, simply all 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:

– Alert 9-1-1 mode is serving to dispatch emergency responders to the exact location, when SPOT sends one message every 5 min until power is depleted or 911 is cancelled.
– Ask for Help is a request for help from friends and family in exact emergency location, when SPOT sends one message every 5 min for 1 h or until help is cancelled.
– Check-In lets contacts know where emergency is and that survivals are okay, when SPOT sends three identical messages to the SPOT service for redundancy. The first of those three messages is delivered.
– Track progress sends and saves emergency location and allows contacts to track salvage progress using Google maps, when SPOT sends one message every 10 min for 24 h or until SPOT is powered off.

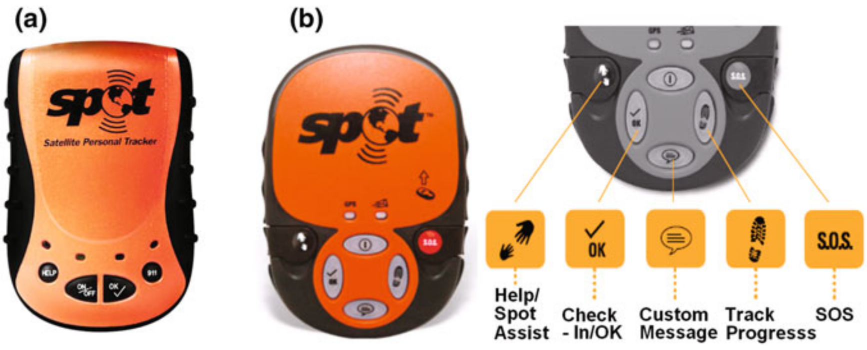

Fig. 2.22 Globalstar duplex spot satellite trackers. Courtesy of manual: by Globalstar

2. **Spot Satellite Emergency Messenger (Spot 2)**—The Spot Satellite Messenger or Spot 2 is a Satellite Emergency Notification Device or SEND was introduced in October 2009 as an improvement over the Spot 1 unit, shown in Fig. 2.22 (b Left). It is designed to be carried into remote locations where the user may require emergency assistance.

In Fig. 2.22 (b Right) are introduced the following five working modes of Spot 2 unit:

- HELP/SPOT ASSIST requests help every 5 min for 1 h from friends/family of distressed person at any emergency GPS location or asks for help from assistance groups.
- CHECK-IN/OK transmits a message to let predefined contact(s) where Distress is and that persons are okay. Attempts to send 3 messages to help ensure successful transmission.
- CUSTOM MESSAGE creates custom non-urgent preprogrammed message and sends it to friends and family with GPS location.
- RACK PROGRESS acquires GPS location of distressed person every 10 min for 24 h and sends each location one time, allowing all helping contacts to track progress of person in Distress using Google maps. Thus, previous two track points sent with current track point helping ensure consistent recording of movements.
- SOS sends the emergency assistance location of Distress person to the local GEOS IERCC every 5 min until batteries die or until the Distress is cancelled.

The Spot units work around the world virtually anywhere inside of footprints of Globalstar satellites, shown in Fig. 2.23. The GPS satellites provide signals, in which Spot messenger onboard of GPS chip determines its exact coordinates and sends location/message to the Spot Globalstar satellite system. The satellite transponder relays Spot message on radio frequency of 1610–1620 MHz L-band to

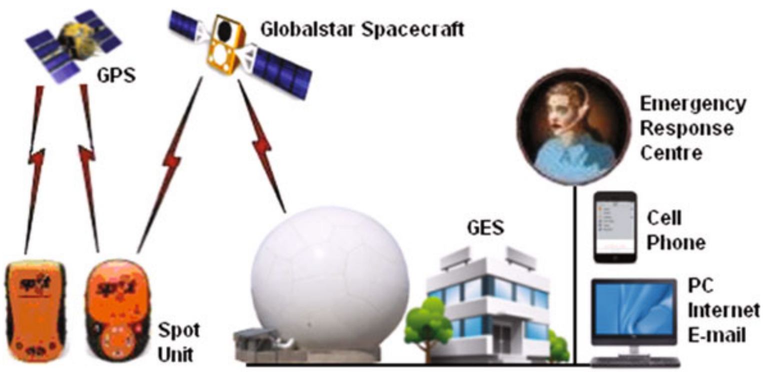

Fig. 2.23 Spot personal tracker and emergency messenger. Courtesy of manual: by Ilcev

specific satellite antennas of gateways (GES) around the world. Satellite antennas and gateways supporting equipment route message and location of the person in Distress to the appropriate network, such as Internet (e-mail), cell phone (SMS), and emergency response centre. Thus, the Distress message is delivered according to instructions of distressed person via text message, e-mail, or emergency notification via the response centre.

Therefore, both Spot devices are powerful tools for personal use onboard aircraft and every passenger can have them as a pocket or on hand-like wristwatch.

2.1.2 *Iridium Big LEO GMSC System*

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 seven billion US$. Maintaining its lead, Iridium LLC became operational MSC system on 1 November 1998. After a period of bankruptcy, the Iridium service was relaunched on March 28, 2001. This system was backed by 19 strategic investors from around the world and 17 investor partners also participated in the operation and maintenance of three ground station GES or gateways that link the Iridium satellites for duplex voice and data service to terrestrial wireless and landline public telephone networks. Thus, GES operators around the world also served as regional distributors of Iridium products and added value services in their designated commercial territories.

The Iridium system is a satellite-based network designed to provide truly global personal and mobile service of voice, facsimile, paging, and data solutions, which also include the GPS capability already developed.

With complete coverage of the Earth, including Polar Regions, the Iridium MSS delivers essential access to and from remote or rural areas, where no other form of communication is available. The company office is situated in Leesburg, Virginia, where the Satellite Network Operations Centre is located and gateway facilities in Tempe, Arizona and Oahu, Hawaii. Through its own gateway in Hawaii, the US Department of Defence relies on Iridium for global communications capabilities. Iridium is a member of GSM-MoU Association with arguments to provide complementary and value-added global roaming to augment cellular offerings. The Iridium system comprises three principal components: the satellite network, the ground network, and the Iridium subscriber products including phones and pagers, as illustrated in Fig. 2.24.

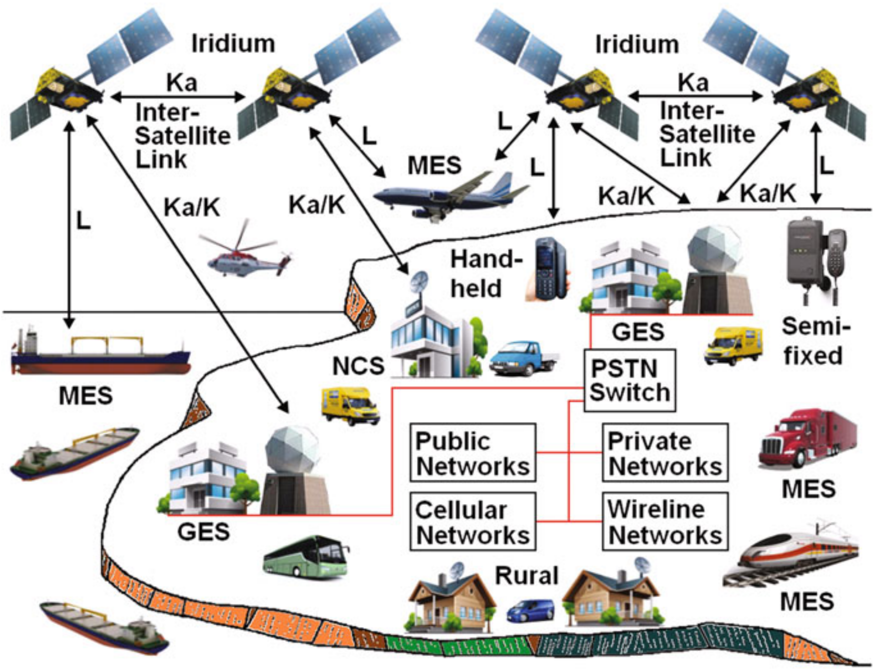

Fig. 2.24 Iridium GMSC network. Courtesy of manual: by Ilcev

2.1.2.1 Satellite Network

The first generation of Iridium Big LEO satellites is situated in a near-polar orbit at an altitude of 780 km. They circle the Earth once every 100 min traveling at a rate of about 26,856 km/h. Each Iridium satellite is cross-linked (inter-satellite link) to four other satellites, two satellites in the same orbital plane and two in an adjacent plane. In such a way, the Iridium constellation consists in 66 operational satellites and 14 spares orbiting in a constellation of six polar planes. Each plane has 11 mission satellites performing as nodes in the telephony network. The 14 additional satellites orbit as spares is ready to replace any unserviceable satellite. This constellation ensures that every region on the globe is covered by at least one satellite at all times.

The Iridium satellites provide real coverage and roaming over the entire globe with 48 spot overlapping beams, and the diameter of each spot of about 600 km is shown in Fig. 2.25 (Left). The 66 satellites enable 3168 cells, of which only 2150 need to be active to cover the whole surface of the Earth. At this point, each cell covers about 15 million km^2 and each satellite simultaneously serves an average of 80 and a maximum of 240 cells.

The global throughput varies between nominally 171 and 500 thousand simultaneous calls. As the spacecraft moves with great speed, the user encounters

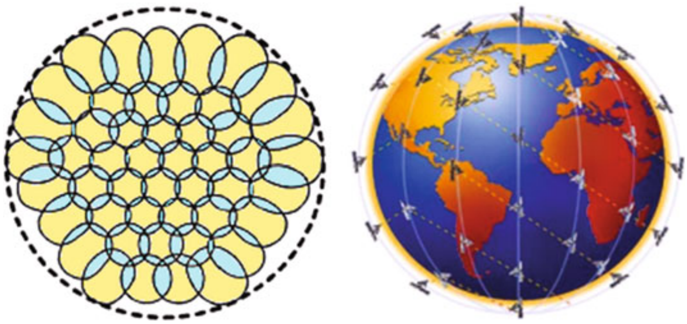

Fig. 2.25 Iridium spot coverage and satellite constellation. Courtesy of manual: by Iridium

adjacent beams about once a minute. The Iridium constellation of 66 satellites is illustrated in Fig. 2.25 (Right).

Each satellite is fitted with three antennas for communication with other spacecraft, gateways, and mobile terminals. Each antenna communicating with ground terminals will use 16 spot beams, making a cellular type honeycomb of 48 cells from each satellite. Thus, this allows considerable reuse of the same frequencies within different non-adjacent beams, something which is essential if frequency and system congestion is to be avoided. The outer beams will be turned off as satellites approach the poles, thus avoiding overlapping coverage and conserving power. The allocated frequency is divided into 12 subbands, and each subband is reused four times on a single satellite. Since at high northern or southern latitudes, some outer beams are not used, and 2150 spot beams are actually active to cover the globe, so the frequency reuse factor is 2150/12 = 180. The system is designed for each spot beam to support 80 channels; hence, the channel capacity worldwide is $2150 \times 80 = 172{,}000$ channels. Uplink and downlink frequencies are identically allocated in the range around 1.6 GHz. At this point, using 50 kb/s TDMA bursts in uplink and downlink, 4.8 kb/s voice or 2.4 kb/s data full duplex communication service is available.

The Iridium system uses only one-way links at a time, which is known as time-duplexing and the user can rapidly switch modes between receive and transmit. The use of one set of frequencies for up and downlinks simplifies the user's hardware. Like the cellular systems, such as GSM system, the user will be handed off between beams in the same satellite and when required from one satellite to the next. However, each Iridium satellite will have communication links to the bird immediately ahead and behind on the same plane and up to four links with satellites on adjacent planes for cross- or intersatellite handoff. Ka-band intersatellite links with four cross-links on each satellite: front, back and two in adjacent orbits, provide reliable, high-speed communication between neighboring satellites and connect a subscriber to a GES via various possible paths. This flexibility improves call delivery efficiency and system reliability.

The new project for Iridium NEXT constellation (second generation) will also consist of 66 operational cross-linked, Big LEO satellites intersecting over the north and south poles. The company expects to begin launching the new satellite constellation. Iridium's fixed price contract with Thales Alenia space provides for the construction of the originally planned 72 operational satellites and in-orbit spares, plus an additional nine ground spares, which provide greater risk mitigation with respect to the new satellite constellation.

Otherwise, as a result of the expanded scope of the project, the total cost of Iridium NEXT generation, including all costs associated with development, manufacture, and launch of the constellation, is now anticipated to be approximately 2.9 billion US $ in total. The orbital parameters of the Iridium satellites are presented in Table 2.2.

Iridium has entered into an Authorization to Proceed (ATP), which allows Thales Alenia space to commence on the development of satellites prior to completion of the financing, with the plan to commence the launch of the first satellites during the first quarter of 2015. The Iridium First generation spacecraft is shown in

Table 2.2 Orbital Parameters of Iridium spacecraft

Background Owner/Operator: Iridium LLC Present status: operational Orbital period: 100 min and 28 s Altitude: 780 km Type of orbit: LEO Inclination angle: 86.4° of orbital planes Number of orbital planes: six Number of satellites/planes: 11 Number of satellites: 66 Big LEO Number of spot beams: 48, each of 600 km diameter Coverage: global coverage including both Poles Additional information: Satellites have intersatellite links, onboard processing, link margin is 16 dB *Spacecraft* Name of satellite: Iridium Launch date: started in November 1998 Launch vehicle: proton, delta, and long march LMC were used Typical users: satellite-based mobile voice, paging, and data services Cost/lease information: about five billion US$ Prime contractors: Motorola Other contractors: locked martin (bus), Raytheon (main mission antenna), COM DEV (feeder and cross-link antennas) Type of satellite/stabilization: LM 700/3 axes	Design lifetime: eight years per satellite Mass in orbit: 550 kg Launch weight: 670 kg Dimensions deployed: 4.3 m high, 7.3 m solar array tip to tip Electric power: 1200 W (EOL) SSPA power: phased array main mission antenna (48 beams per satellite) Telemetry beacons: downlinks 19.4–19.6 and uplinks 29.1–29.3 GHz *Communications payload* Frequency bands: User uplink/downlink: 1621.35–1626.5 MHz Feeder links: Uplink: 29.129.3 GHz (Ka-band) Downlink: 19.4–19.6 GHz (K-band) Cross-link: 23.1823.38 GHz (Ka-band) Modulation: QPSK Multiple access: FDMA/TDMA Number of transponders: one processing Channel bit rate (uplink): 2.4–4.8 kb/s (downlink): 50 kb/s Channel capacity: 236/1100 channels Channel bandwidth: waveform F/TDMA; service link 10.5 MHz, feeder Link 107 MHz Channel polarization: service link circular EIRP—G/T: 8.5 dBW/ −23 dB/K

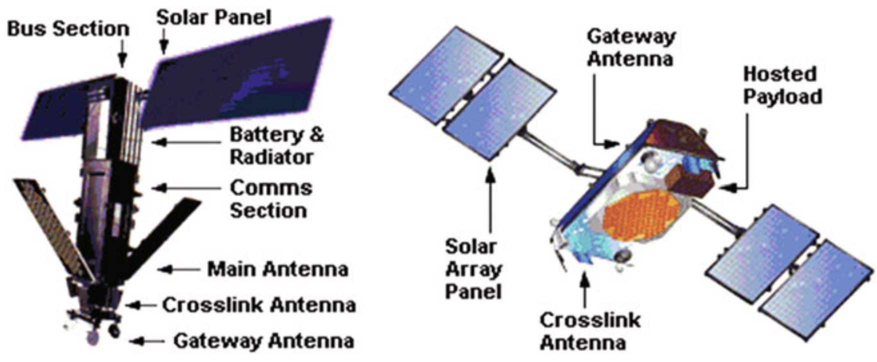

Fig. 2.26 Iridium first and second generation of spacecraft. Courtesy of manuals: by Iridium

Fig. 2.26 (Left), and the Second-generation spacecraft is shown in Fig. 2.26 (Right), both with main components.

Each Iridium NEXT satellites can provide an opportunity to fly a 50 kg secondary sensor payload using 50 W average powers. The mass of new spacecraft is 800 kg, and it employs Proteus Bus, two deployable solar arrays with batteries lifetime of 10 years (design) and 15 years (planned). The NEXT spacecraft payload employs an L-band phased array antenna for generation of the 48 beam, 4700-km-diameter cellular pattern on the Earth's surface for connection with subscribers/users. The Ka-band links are also provided for communication with ground-based gateways and for cross-links with adjacent spacecraft in orbit. Thus, the cross-linked 66 Iridium satellite constellation forms a complete global network allowing communications from a ground or any mobile user in any location on Earth to virtually anywhere else on Earth, in which coverage map is shown in Fig. 2.27.

2.1.2.2 Ground and User Networks

The ground network is comprised of the System Control Segment (SCS) as well as two telephony gateways (GES) and is used to connect to the terrestrial telephone lines. The SCS is the central management component for the Iridium system. It provides global operational support and control services for the satellite constellation, delivers satellite tracking data to the gateways, and performs the termination control function of messaging services. The SCS system consists in three main integrated components: four TT&C sites, the Operational Support Network (OSN) and the Satellite Network Operation Centre or Network Control Station (NCS). The primary linkage between the SCS, the satellites, and the gateways is via K-band feeder links and cross-links throughout the satellites.

Gateways are the land stations that enable connection to and from the PSTN via high-gain K-band parabolic antennas, to track Iridium satellites for services and

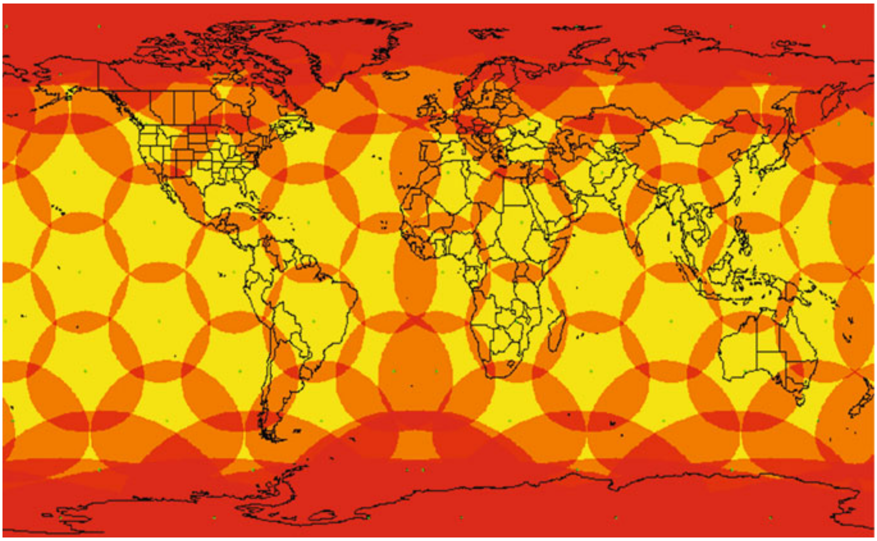

Fig. 2.27 Iridium coverage map. Courtesy of manual: by Lloyd

network operations. They support the interconnection of subscribers via the Iridium network to the terrestrial PSTN and provide network management functions of the entire infrastructure. Each GES is connected with up to four satellites and with other satellites has connections via intersatellite (cross) links. There are currently two commercial Iridium gateways or GES cites located in Arizona, USA, and Fucino in Italy. The US government owns and operates an Iridium gateway located in Hawaii, USA. Each gateway generates and controls all user information pertaining to its registered users, such as user identity, geolocation, and billing items.

The gateway also provides connectivity from the Iridium system to the terrestrial-based telecommunication networks such as the PSTN, Defence Switched Network (DSN), Internet. Although there are two gateways, a user is registered to a single gateway.

The Iridium satellites communicate with each other using Ka-band intersatellite links. Each satellite uses four cross-links, two to the fore and aft satellites in the same orbital plan and two to the satellites in orbital plane to either side. These intersatellite links allow calls to be switched and routed across the satellites in the constellation before being transferred to a gateway. Like other satellite networks if a gateway is damaged, the Iridium network can route the call to another gateway. With 66 satellites in the Iridium constellation, which offer complete planetary coverage, a call can come from a phone near the North Pole, then it could be switched from satellite to satellite before being sent down to a gateway where it can be switched to the public phone system. The gateways include the System Control Segment and telephony gateways, which are used to connect to the public phone network. As an Iridium satellite orbits the Earth, they can lose line of site as it leaves the area of the gateway. The routing tables change and frames are forwarded to the next satellite coming in view of the gateway. The Iridium constellation has intelligence built in the network where an outbound Iridium satellite call from Iridium satellite phone goes to one of the satellites, then the call is either sent directly down to the receiving satellite phone. If the receiving satellite phone is not in the spots beam of the satellite receiving the call, then the call is switched from satellite to satellite till it reaches the satellite in area of the receiving phone where it is then sent down to the call destination. Iridium network uses more satellites than any other satellite service provider. With 66 satellites in polar orbits, this gives the constellation coverage to every part of the planet. Thus, each satellite provides 1100 voice channels with high QoS, in which call-processing architecture is based on the GSM digital cellular standard, although the GES needs unique management due to satellite constellation. The relatively short distance of Iridium satellites reduces the delay and enhances the quality of the telephone conversation between MES and ground subscribers.

Therefore, the user network configuration consists in three different kinds of Maximum Transmission Unit (MTU), such as handheld, mobile-mounted, and fixed units. Thus, user terminals with omnidirectional antennas support data and facsimile at 2.4 kb/s as well as numeric and alphanumeric paging. With the Iridium system, all communications services voice and paging are delivered regardless of the user location or the availability of PSTN.

2.1.2.3 Handheld and Fixed Satellite Terminals

As stated earlier, the design of the Iridium satellite network allows voice and data to be routed virtually anywhere in the world. They are relayed from one satellite to another until they reach the satellite above the Subscriber Unit or UT (handset), and the signal is relayed back to the Earth. The Iridium handheld telephones and pocketsize pagers receive short messages and connect MES applications for ships, vehicles, and airplanes.

Hence, a variety of subscriber units is available to communicate with the Iridium network, including dual-mode handsets; numeric and alphanumeric pocket pagers; portable, fixed, and payphone terminals; and specialized maritime, land, and aeronautical equipment.

1. **Handheld Terminals**—An Iridium Portable Telephone is quite similar to a conventional handheld cellular unit because dimensions, weight, battery lifetime and so on are similar to cellular phones. Thus, it can operate in dual-mode: cellular or Iridium mode, so the Iridium terminal is also a cellular terminal and could be used where cellular networks are available.

(a) Dual-mode handheld terminals provide a global roaming for cellular and Iridium users or mono-mode for Iridium users only, as shown in Fig. 2.28a on the left and right, respectively. These two SS-66K models are products of the Japanese producer Kyocera and the unit on the left-hand side is dual-mode

Fig. 2.28 Iridium handheld and portable phones and pagers. Courtesy of manuals: by Kyocera and Motorola

integrated adapter placed inside a standard cellular handset terminal along with all of its memories and functions, in such a way that it is possible to roam both cellular GSM and Iridium networks. In Fig. 2.28c is shown the Motorola mono-mode satellite series 9500 handheld telephones, for Iridium users only.

(b) An Iridium Pager system offers the first true global satellite roaming capability in small, belt-worn, personal message receivers. In Fig. 2.28 is shown the Kyocera model SP-66 K Iridium pager **(B-top picture)** and Motorola 9501 Iridium pager **(B-lower picture)**.

2. **Fixed Terminals**—Iridium provides two types of fixed satellite terminals:

(a) Payphone-fixed terminals are single-line Iridium fixed sets used to interface a payphone service into the PSTN for rural and remote areas out of cellular coverage. The portable or semi-fixed, redeployable and freestanding payphone booths are designed to provide public access to the Iridium service in rural and remote areas. These units have their own satellite antenna and transceiver equipment and are able to operate on standard or solar power, reducing costs for the development of other expensive communication services.

(b) Fixed or portable single-line equipment offers communications services in remote/rural offices and can be a transportable unit in briefcase/car with external antennas, shown in the Motorola 9570 Portable Dock in Fig. 2.28d. This device is designed for integrated operation with the Motorola 9500 handheld portable telephone sets, to provide charging for it and two additional batteries when connected to an AC/DC power source. An external antenna can be connected by special cable from temporary or fixed locations mounted on mast, roof, or building walls. The terminal has a speakerphone for voice conferencing and a lightweight cord (passive) handset for private communications and enables data/Fax port access to 2.4 kb/s asynchronous data service via SIM card as usual for cellular service.

2.1.2.4 Handheld, Mobile, and Transportable Satellite Terminals

The following handset and Mobile Satellite Terminals (MST) can be used for any mobile applications, and they can employ external antennas as well, shown in Fig. 2.28d.

1. **Iridium 9520 Mobile Telephone**—This Iridium mobile terminal is satellite transceiver with wired handheld suitable for all mobile applications, illustrated in Fig. 2.29a. It works via SIM card for both Iridium and GSM cellular networks.
2. **Iridium 9555 Handheld and Mobile Telephone**—This is one of the smallest and most powerful handheld and mobile terminals, shown in Fig. 2.29b. This unit can be used combined with docking station onboard any mobiles including ships and aircraft.
3. **Iridium 9505 Handheld and Mobile Telephone**—The 9505 Portable Satellite Phone now smaller, lighter, and more resistant to water, dust, and shock than the previous offering, this satellite phone addition is ideal for industrial or rugged

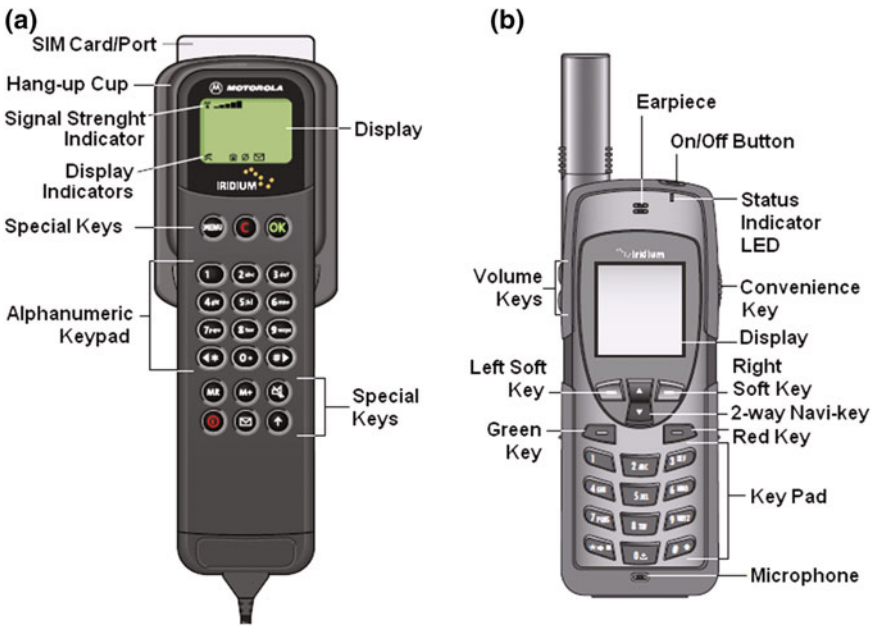

Fig. 2.29 Iridium handheld and mobile satellite phones. Courtesy of manuals: by Iridium

Fig. 2.30 Last models of iridium handheld and mobile phones. Courtesy of manuals: by Iridium

conditions, yet appealing to the traveling professional. Although the functions and features of the 9505A handset are the same as the 9505, there are some modification to the 9505A to equipment and accessories, shown in Fig. 2.30a.

It has been introduced by Iridium to address obsolescence of some 9505 phones. The specifications of this phone are: Dimensions are 158 (L) × 62 (W) × 59 (D) mm, weight is under 375 g, standby time is 30 h, talk time is 3.2 h, and operating range is −10 to +55 °C. Thus, features of this phone are as follows: 4 × 16 character display, international access key sequence (+ key), mailbox for numeric and text messages (160 characters), selectable ring tone (10 choices), and missed call indicator 100-entry in internal address book. The RST978 also provides a docking unit for the 9505A handheld telephone. The unit provides charging and docking of the handset, while the hands-free functionality enables the user to have a professional in-mobile installation, with the added benefits of having away from mobile communications with the handheld unit. This phone can be used combined with docking station or special kit onboard ships and aircraft.

4. **Iridium Extreme 9575 Handheld and Mobile Telephone**—This latest Iridium terminal is more than a satellite phone, because it will provide customers one solution in hand for voice, data, GPS, SOS, online tracking, and SMS, in which components are illustrated in Fig. 2.30b. This is the only phone with integrated tracking, GPS location-based solutions, and one-touch SOS button. A certified Satellite Emergency Notification Device (SEND), Iridium Extreme will notify help in an emergency, then notify when help is on the way. Therefore, GPS

mode enables view/send GPS satellite position as SMS to another device or to StratosTrax tracking portal using Short Burst Data (SBD). Enhanced security provides program to SOS button and uses the protective cover to avoid accidentally sending an SOS; there is also the keypad lock and PIN lock for additional security. Combined with this satellite handheld phone, Iridium Access Point allows to create a WiFi hotspot and to connect the Internet. This phone can be used as 9575 To Go Kit-Yellow in emergency situation of ships and aircraft.

5. **Transportable RapidSAT 9555 Terminal**—The complete kit is integrated into a high-quality custom case, which includes speaker, microphone magnetic antenna with 5 m cables, privacy handset, and the compact 9555 dock unit, which is illustrated in Fig. 2.31a. There is also an optional battery pack that can be inserted into the RapidSAT 9555 that will provide extended talk-standby time for portable use. This unit is ideal for short-term use or applications where many people may need to access satellite communication for rapid deployment in emergency. The flexibility of this unit enables the unit to be easily transported between various road vehicles, ships, boats, machinery, helicopters, or aircraft and simply connects to the vehicle's DC power source for in-vehicle use or alternatively the optional battery backup for away from vehicle use.
6. **Transportable RapidSAT LBT Terminal**—This unit provides global access to satellite communications as a portable system that can be used across several mobiles or away from mobile, such as ships and aircraft in Distress and emergency situations, which is shown in Fig. 2.31b. The portable bag has an intelligent handset for supporting hands-free or private voice calls along with accessing SMS functionality. The unit is very compact and can easily be installed onboard any type of ships or aircraft with subject to local approvals as primary or emergency communications. Thus, supporting all Iridium Voice, Data, and Fax services makes it the ideal solution with ability to provide a fully

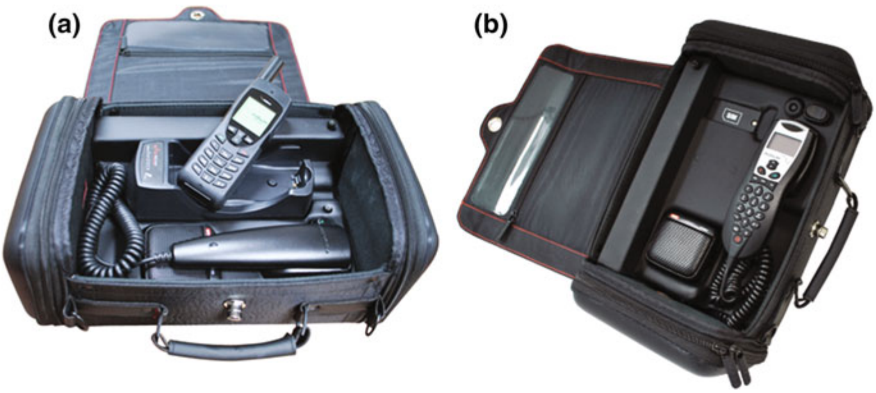

Fig. 2.31 Transportable satellite terminals. Courtesy of prospect: by Beam

integrated voice service through the mobile communications system. It can simply connect to the aircraft's DC power source or alternatively the optional battery back up for away from mobiles.

2.1.2.5 Maritime, Land, and Aeronautical Mobile Satellite Terminals

The Iridium satellite operator offers the following GMSC terminals similar to Inmarsat and Globalstar systems:

1. **Maritime Sailor SC4000 SES Terminals**—Iridium is providing for Ship Earth Stations (SES) installations of Sailor Above Deck Equipment (ADE) or antenna and Bellow Deck Equipment (BDE) or transceiver equipment. In Fig. 2.32 (Left) is shown the maritime Sailor Iridium single-channel-fixed terminal SC4000 designed by S.P Radio A/S from Denmark (today Cobham company). This unit provides one-channel voice and data at a rate 2.4 kb/s of O-QPSK modulation, can be mounted onboard ships, with one external helical omnidirectional antenna and interfaced to Tel handset, Tel/PBX, data RS232, and position information NMEA183. The same model has the possibility of multichannel service, providing four channels at a rate of 2.4 kb/s of O-QPSK modulation with four separate helical omnidirectional type antenna and the same interface solutions. The former Japanese company Kyocera offers an Iridium model IM-S100 Maritime Phone with the possibility to use it onboard different types of oceangoing ships. This is a single-channel transceiver unit with external helical omnidirectional antenna, a capacity of two handsets connection, and with possibility to use and charge a single-channel Iridium handheld Kyocera SS-66 K model.
2. **Land Vehicle Motorola 9520 VES Terminals**—The land Vehicle Earth Station (VES) terminal of Motorola's Iridium model 9520 is a permanently installed mobile telephone, as shown in Fig. 2.32 (Right). It is designed for in-vehicle operation with hands-free functionality and antenna mount options: magnetic, permanent, and fixed mast. Its transceiver meets Military Standard

Fig. 2.32 Iridium maritime and land mobile GMSC equipment. Courtesy of manuals: by Cobham and Motorola

810 (MILSPEC 810). Italian company Telit offers a similar model for car mounting the SAT550, and Japanese Kyocera offers the HF-S100.

3. **Multipurpose Pilot Broadband Station**—With the launch of multisolutions Pilot Broadband Station, Iridium provides essentially expanding the reach of its predecessor OpenPort satellite service for maritime, land, aviation, and terrestrial users. This station allows mobile and fixed users everywhere on the globe in off-the-grid locations to access Internet and voice calling at all times. Thus, the Iridium Pilot Broadband Station can be installed in either a fixed location or mounted on a vehicle, and provides pole-to-pole coverage, broadband data speeds, and independent voice lines for simultaneous voice and data communications. In addition, this station can be used for disaster recovery, remote education, business continuity, and exploration in integration with KVH TrackPhone.

In Fig. 2.33 is depicted Pilot Broadband Station for mobile and fixed application that is containing the following components: (1) Mains power cord of 2 m is providing 100–220 V AC power supply to power module; (2) Power module is transforming main power to 24 V DC; however, direct DC power supply is also supported for vehicle or other DC power locations; (3) Cable for connection power module with indoor unit or for ships installation is known as BDE; (4) Indoor Unit (IDU) or BDE is the appliance to which are connected PC, laptop, and telephones, which is capable of handling three POTS/RJ11 corded or cordless telephone handsets and one Ethernet data connection for router; (5) SIM card validates the system at start-up, allows connection to the Iridium network, and provisions the appropriate phone and data lines; (6) cable of up to 30 m is available to connect antenna or Outdoor Unit (ODU) to the IDU, which has a waterproof connection for the ODU; (7) ground cable is included to provide grounding for IDU at the installation location; (8) radome antenna or ODU with mast is useful for mounting

Fig. 2.33 Iridium Pilot Broadband Station for mobile and fixed applications. Courtesy of manuals: by Ilcev

onboard ships; and (9) optional radome antenna with short mast for installation on the roof is providing fixed communications. The same low-profile antenna without mast and with four magnets is usable for magneting mounting onboard units with metal surface, such as vehicles, toolboxes, metal roofs, and carports. However, the same antenna without mast can be used for installations on aircraft fuselage.

Pilot Broadband Station voice or data call is received by the closest mobile or fixed device located on the globe. The traffic is routed through the meshed satellite network and lands at the Alaska GES and is then routed over terrestrial networks to the gateway in Arizona. At the gateway, traffic is converted back to Internet Protocol (IP) and voice, depending on call type and delivered to the IP cloud or PSTN.

4. **Multipurpose Iridium GO Handheld Satellite Terminal**—The Iridium Go is Iridium's newest and most exciting satellite connectivity device to date that is providing backbone via WiFi users to connect their own smartphone, iPad or Android via satellite for voice and fast data communication anywhere in the world, which is illustrated in Fig. 2.34 (Left). The main components of Iridium GO depicted in Fig. 2.34 (Middle) and (Left) are as follows: (1) Swivel Antenna; (2) Device Screen; (3) Power button; (4) LED Status Indicator; (5) SOS Button; (6) USB Power/Data Socket; (7) Navigation Buttons; (8) Accessory Connector; (9) Battery Cover/Box; (10) Pressure Vent; (11) External Antennal; (12) Lanyard Connector; and (13) loudspeaker.

With the Iridium GO, mobile and fixed users get a new platform for apps of all kinds, which are optimized for the Iridium network. Thus, with apps downloaded and ready, users can use own smartphones, tablet or laptop devices for a wide range of functions, including: initiate a voice call, send an e-mail and a text message, update social media, check GPS, make a satellite-backed WiFi data call, initiate an emergency SOS Distress message, and check battery life of the unit. In particular, Iridium GO transforms users' smartphone into a global satellite phone, which enables reliable voice and data capabilities for smartphone or up to five mobile devices. The Iridium GO has integrated GPS for tracking over the entire planet, which enables for the unit allowing users to see, in real time and space, position on a dedicated individual WebPages where family or friends can track their location.

Fig. 2.34 Multipurpose iridium GO handheld satellite terminal. Courtesy of manuals: by Iridium

In any case, Iridium GO enables satellite connectivity for mobile devices where terrestrial networks cannot. Simply flip up the integrated antenna and the battery-powered unit connects quickly and automatically to the Iridium LEO satellite constellation to create an anywhere WiFi hotspot within an approximately 100 ft (30 m) radius. The Iridium GO external antenna adapter (9560 External RF Cable) is necessary to connect an external antenna to Iridium GO device. This may be advantageous in situations where it is impossible to locate the Iridium GO with a 360° view of the horizon while simultaneously within 100 ft of WiFi-enabled smart phone or tablet. In fact, if different sites of users are surrounded by tall trees, buildings, hills, mountains, or the superstructure of a ship, the view of the internal Iridium GO antenna could be obstructed. Here will be introduced some typical mobile applications where an external antenna is needed:

In Fig. 2.35 (Left) is shown Iridium GO antenna for maritime and fixed applications. The mast helix antenna in radome can be installed onboard ship usually on compass deck above the navigation bridge or atop roof of the buildings. If customers have a problem using their Iridium GO unit below decks onboard ships or inside a building, equipment suppliers can install a special ruggedized mast antenna above deck or on the building roof and therefore to improve reception of Iridium signals. Namely, outfitter satellite offers 10, 20, and 30 m antenna cables to connect antenna with Iridium Go via dedicated cable adaptor.

In Fig. 2.35 (Middle) is depicted Iridium GO vehicle bolt or mag mount (magnetic) kit with a 1.5 and 5 m antenna cables, which can be installed on the roof of cars and other commercial vehicles including railway locos. This flat patch antenna is designed for all type of land vehicle applications allowing many users to put the Iridium GO on the dashboard of their vehicle. If this does not produce adequate results, placing an antenna on the roof of the vehicle should improve performance.

In Fig. 2.35 (Right) is illustrated Iridium GO with avionic antenna useful for onboard small aircraft and helicopters. This aviation unit offers to pilots and passengers a way to stay connected in flight and on the ground, in a compact, well-built device, small enough users to carry in flight bag and placed on any glare shield or dash for reliable, always-on cockpit communications. All above-stated possibilities and services for fixed, maritime, and land mobile applications are the same.

Fig. 2.35 Multipurpose iridium GO handheld satellite terminal. Courtesy of manuals: by Iridium

2.1.2.6 Aeronautical Satellite Communication Terminals

In this section will be introduced several solutions for aeronautical satellite broadcasting and communication systems.

1. **Integrated ICG Sora ig + Airborne Terminal**—This solution provides communication and Safety service for aircraft via three-channel system integrated with peripherals and IGA SwiftBroadband antenna, in which scenario is illustrated in Fig. 2.36.

The ICG Sora ig + Airborne Terminal is specially packed with features that are important to conducting pilots with reliable communications and business on the fly. The ICG NxtLink ICS 220A is a three-transceiver Iridium device which combines two channels of global voice and a dedicated cockpit data link channel via a third SBD channel to support ACARS, FAN messaging. and Controller Pilot Data Link Communications (CPDLC). The ICG Sora ig + satellite terminal is designed specifically to provide an aircraft flight crew with reliable communications facilities for both Aeronautical Operational Control (AOC) and ATS messaging. It is a three-transceiver device which combines dual channels of global voice and 2.4 kb/s data service with a third SBD channel in a single 2MCU (Microcontroller Unit) and Line Replaceable Unit (LRU).

In addition, the aeronautical voice and data transceiver is available for cabin crew and passenger services, credit card clearing, and providing communications in case of medical emergencies. This aircraft terminal permits different connections of conventional telephony devices through either standard 2-wire "Tip and Ring" electronic circuits or 4-wire audio connections and Digital European Cordless Communication (DECT) units. In such a way, telecommunication features include intercom onboard calling, call transfer, conferencing and follow-on dialing.

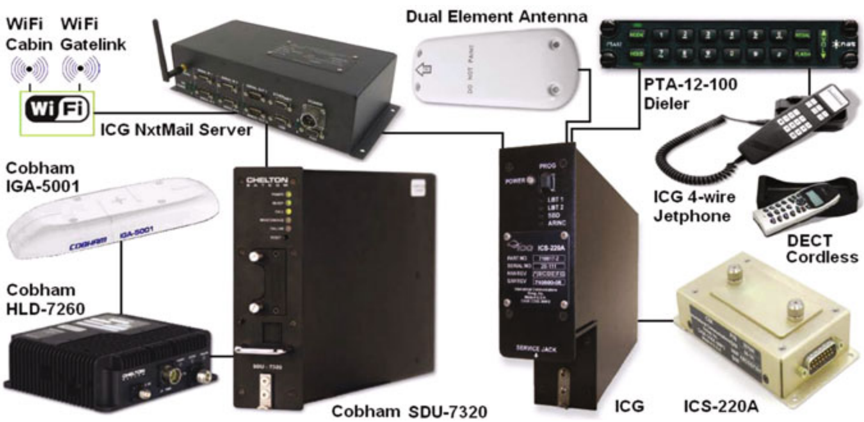

Fig. 2.36 Integrated satellite terminal. Courtesy of manual: by ICG

This cockpit terminal connects to standard aircraft systems via 4-Wire audio for flight deck voice and AR INC 429 circuits for Multipurpose Control Display Unit (MCDU) dialing or data link messaging exchanges. The integrated devices have external SIM card readers making them a true LRU, and various types of handsets including cordless can be connected for cabin use. Therefore, the ICG NxtMail Server provides a local Wireless Access Point (WAP) permitting interface of WiFi or WiMAX to capable devices such as a smartphone and personal computers to access conventional Internet Protocol (IP) services.

The Cobham SDU-7320 is 2-MCU integrated satellite data unit providing a full-featured SwiftBroadband channel with data speeds at 332 kb/s. The Cobham HLD-7260 is a highly compact unit that combines a High Power Amplifier (HPA) and Diplexer/Low Noise Amplifier (DLNA), delivering SwiftBroadband where other systems cannot. The Cobham IGA-5001 is smallest intermediate gain antenna on the market today that delivers full SwiftBroadband capabilities. It is considered to be one of the optimum antenna solutions for Inmarsat's SwiftBroadband Class 7 service offering. The ICG Sora Lg Terminal is similar as previous, which instead The ICG NxtLink ICS 220A is using ICG ICS-120A unit and instead of Cobham SDU-7320 is using Cobham SDU-7310 unit.

2. **SkyConnect Transceiver**—The integrated SkyConnect satellite telephones and tracking systems are becoming very mission-critical equipment for helicopter operations that require communications with disparate and ever-changing entities. Designed for the crews with a busy workload in helicopter cockpits, this device easily accommodates virtually any operational scenario, including fixed-wing missions. The SkyConnect transceiver, L-band antenna, Mission Management Unit (MMU) Cockpit Dialer, Tactical Dialer, and Flush-Mount Cradle are shown in Fig. 2.37.

The MMU-II equipment is a computer-controlled dialer and is very flexible operation. It communicates with the transceiver over an RS-232 port and can be programmed in the aircraft with new message sets, or software. It has a four-step dimming feature to the display. The MMU makes it a breeze to send standard

Fig. 2.37 SkyConnect transceiver and peripherals. Courtesy of manual: by SkyConnect

company-specific messages, such as number of passengers, current fuel load, patient status, Estimated Time of Arrival (ETA). There are two Tactical Dialers, a six-position and an 11-position. The 11-position dialer has a backlit faceplate and the dimming feature to the panel lights, and the annunciators can be separate or together.

3. **EMS SkyConnect Forté Phone System**—This unit is similar to previous and designed specifically for aircraft operators who want a phone that works when and where they need it, and at a cost they can afford. Each Forté satellite line can support any combination of four wireless, corded or MMU-II telephones. In contrast to other elaborate systems, Forté with antenna and few peripherals delivers the basic service aviators need to remain productive and in touch no matter where their fleet flies. Using the Iridium network, it delivers cell phone convenience anytime, anywhere, shown in Fig. 2.38 (Left).

It includes a built-in intercom feature to accommodate multiple telephones. It makes it easy for the flight crew to talk to passengers and vice versa, and is supporting phone equipment in the cockpit. It allows telephone selection on audio panel, so anyone on the flight deck can hear and be heard with the best fidelity. This device is a standard size DZUS-mounted peripheral interface with a dimmable two-line display, full telephone keypad, and sophisticated set of unique features that make it cockpit-friendly. Forté Cordless Handset convenient for larger cabins or just for those who do not want to wrangle with a cord, these handsets are designed for jet cabins with typical noise levels. Despite its compact size, the large color display and backlit keypads on this handset make it very easy to use. Up to four telephone handsets can be installed throughout the cabin and on the flight deck.

Forté Corded Handset is designated for crew and passenger cabins with higher noise levels, and this tethered handset is very effective at making your words loud and clear. It also boosts the earpiece volume so that your conversation is comfortable and easy.

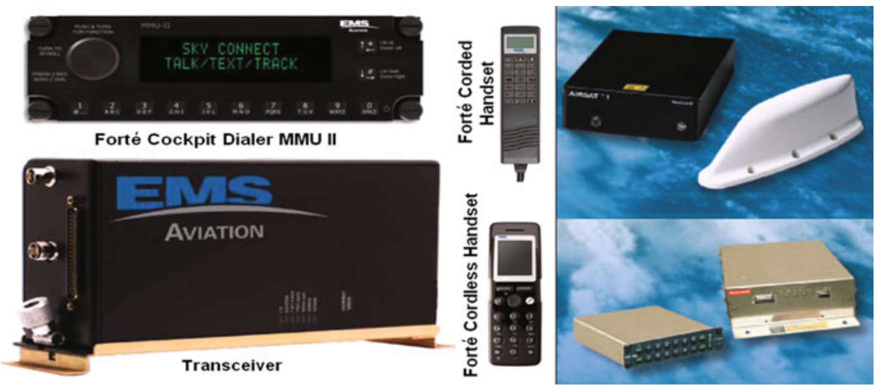

Fig. 2.38 Integrated transceivers and peripherals. Courtesy of manuals: by EMS and Honeywell

4. **Honeywell AIRSAT 1 Terminal**—This aircraft single-channel terminal was developed by Honeywell for use aboard private aircraft and offers voice and data communications for airborne applications, shown in Fig. 2.38 (Right). The system is composed of an ITU 100 Iridium Transceiver Unit and Blade Antenna ANT-100 for external or fuselage mount (Fig. 2.38) and Telephone Dialer Unit TDU-100 and Aircraft Integration Unit AIU-100 (Fig. 2.38). This terminal is including handset phones for pilot in cockpit, similar to phones shown in Fig. 2.38 (Left). This terminal provides the following requisites: The system function does not interfere with the other systems onboard; if the system should be subject to any type of failure, this will not affect the normal function of other equipment onboard, or create any danger for the remaining flight, and the installation of all devices, including the antenna, is designed so that they will not have any effect or compromise the aircraft structure or dynamics, especially in the case of emergency landings.
5. **Beam TranSAT RST620 Aero**—The Beam-fixed aero satellite telephone allows it to be fully integrated within an aircrafts communication system. The full hands-free operation enables simple and convenient communications through the headset of the aircraft as well as allowing for a privacy mode using the handset and supports all Iridium voice, data, fax, Internet, and e-mail services. The use of satellite communications to support voice, data, and tracking communications is rapidly increasing and the ability to have one service that guarantees you access anywhere on earth is what is most important.

The RST620 is equipped with an RS232 serial data port to access Iridium data services, shown in Fig. 2.39a. The terminal also supports SMS and the following Iridium data services, CSD, and SBD. Latest echo cancellation technology is deployed on TranSAT to enhance hands-free voice quality. Support features such as horn alert, radio mute, data connectivity allow the use of a compact intelligent user handset in privacy mode. The LeoTRAK tracking terminal in conjunction with this unit makes it possible to track both assets and personnel at all times. This terminal can be used for position reporting, periodic, remotely polled, movement, and activation of alarm. In particular, the same unit can provide voice and data telephone service for a wide variety of marine and land applications.

Fig. 2.39 Aircraft satellite terminals. Courtesy of prospect: by Beam

6. **Beam TranSAT RST620**—This transceiver is a duplex fixed satellite telephone with echo cancellation dedicated for maritime, land, and aeronautical solutions, which is depicted in Fig. 2.39b. The system has all the convenience and Safety of a fixed or mobile installation as well as intelligent features such as external ringer alert and compact user handset for SMS. The unit is very compact and can easily be installed onto any type of aircraft with certification for local approvals as primary or emergency communications.
7. **Beam RemoteSAT RST100**—This Beam terminal provides the functionality of using standard cordless and corded telephones equipment over the Iridium satellite network, shown in Fig. 2.39c. It is PBX Integration ideal to be installed in an aircraft or helicopter that may require away from vehicle communications through the use of a cordless handset or whereby multiple handsets for passengers need to be able to access calling. There is also a fully integrated hands-free accessory available that will provide hands-free calling as well as a compact handset for sending and receiving SMS that can be located close by the driver via SIM card. The unit combines robust design with the intelligent technology to support RJ11/POTS, voice, and data services over the Iridium network using echo cancellation and stereo integration. It also supports access to the complete range of data services provided by Iridium including SBD, CSD, Direct Internet and SMS. This unit enables a Beam TrackALERT, RST030, alert tracking interface to be connected directly to the terminal, and there is also a purpose built backup reliable battery available that can provide up to 24 h standby time for mission-critical applications. The RST973 Hands-free accessory for the RST100 is providing the benefit of having a fully integrated hands-free installation inside the aircraft.
8. **AirCell 3100/3500**—The most used terminal of Iridium satellite solutions is the AirCell ST 3100 or 3500, which supports airborne telephone, fax, and narrowband data worldwide including local cellular connections, shown in Fig. 2.40 (Left). Moreover, this unit also provides access to weather bulletin, news, financial data, ATC information and messaging, and inflight medical emergency help via AirCell's service partners. Along with its global coverage, it improves communications between the cabin and cockpit with an audio intercom feature. Easy to install, this unit is available with a wide range of antenna and handset options including a corded or cordless handset with a full-color display, illustrated in Fig. 2.40 (Right). However, the flush or bulkhead-mount cordless handsets free users for convenient mobility throughout the cabin. In Iridium mode, onboard phone accesses the Iridium Network via AirCell ST 3100 or 3500 satellite units at 1616–1625.5 MHz range consuming transmission power at level of just 7°W. The AST 3500 phone operates in both cellular and satellite modes. It accesses the AirCell Nationwide Cellular Network, which operates in the 824–894 MHz frequency range with maximum power level of transmissions is 75 mW. These phones provide many features, including a digital display, last number redial, and lockable network modes. AirCell mode provides additional phone features, including 99 memory locations, two

Fig. 2.40 Aircraft satellite and cellular terminal. Courtesy of prospect: by AirCell

"one-touch" dialing keys, three call timers, a signal strength indicator, and emergency dialing capability.

The AirCell terminal provides the ability to have a fully integrated voice service through the aircrafts communications system. Line level outputs enable this feature to be easily adapted. This system can also be used in conjunction with the Beam LeoTRAK tracking and monitoring terminals.

2.1.2.7 Aeronautical Docking and Tracking Satellite Terminals

In this section will be introduced only two types of docking satellite terminals available for aeronautical and other mobile applications:

1. **Beam SatDOCK 9555SD/G**—The docking unit for the latest 9555 Iridium telephone set provides a high-quality semi-permanent installation, using echo canceling and full duplex technologies to provide superior voice quality and professional hands-free or privacy installation for ships, vehicles, aircraft, or helicopters, subject to local or regional authorities individual approval. Other features include phone charging, inbuilt Bluetooth, USB data connector, inbuilt ringer and allow antenna and power to be permanently connected to the dock ready for use. The Iridium 9555 handset is easily inserted and removed by the press of a button on the top of the dock making it very easy to use away from the dock when required. However, this unit also supports tracking and alert functionality via the dedicated inbuilt GPS engine or PotsDOCK device. Tracking messages can be pre-configured to support periodic reporting, manual position report update via button press, remote polling, or the sending of an emergency alert message all via SMS, e-mail, or SBD.

The SatDOCK 9555SD/G unit is depicted in Fig. 2.41 (Left), which alerts and tracking module can be configured to support periodic poling or emergency alert reporting. The tracking messages can be sent from the SatDOCK via periodic position reporting, preset during software configuration of the dock; upon an alert being activated via the alert button on the cradle or connected alert button (external alert loop); and a current location position can be sent at any time by pressing the track button on the front of the SatDOCK. Alert and alarm messages can be activated on the SatDOCK using the two button press on the front of the cradle, or alternatively an additional alert button or other trigger can be connected to the unit. Once configured, the alert system is always on and will generate an alert message to the preset destination once triggered. Alerts can be triggered to continually send, until the alert is cleared either remotely, or locally on this unit. Accessories for this unit can be intelligent handsets, man down kit and mag mount GPS/Iridium antenna.

2. **Beam PotsDOCK 9555**—This unit is a docking station designed to support RJ11/POTS, Bluetooth, and inbuilt GPS transforming the beam satellite 9555 handset into an intelligent device for all mobile applications, in which unit is shown in Fig. 2.41 (Right). This device can be used in a variety of voice and data connectivity. An intelligent RJ11/POTS interface enables standard corded, cordless, or DECT handsets to be used or alternatively interfaced with a PBX presenting standard ring, busy, and dial tones like a standard phone network. It also has an inbuilt Bluetooth for voice connectivity along with an intelligent tracking and alert reporting system utilizing the inbuilt GPS Rx engine of the PotsDOCK. However, the PotsDOCK also supports the use of an optional compact Beam privacy handset that can be located next to the PotsDOCK for added convenience if required. The alert and tracking module and their configuration is the same as previous terminal.

The aircraft tracking satellite equipment enables GPS data to be transmitted from anywhere on Earth including location, direction, speed, elevation in a very simple message format for plotting on an integrated Geolocation Information System (GIS). These devices can be controlled by handsets or PDA interface, and are providing the following services:

Fig. 2.41 Aircraft docking satellite terminals. Courtesy of manuals: by Beam

(a) Automated Flight Following (AFF) using tracking terminals provides a requirement for many government aviation fleets with periodic position reporting for tracking of entire fleet at any and all times. The AFF mode is in compliant with most of the government-mandated programs for contractors.
(b) Text services are important that send and receive text messages to and from the cockpit. Thus, predefined templates speed messages with low workload while free-form messages handle unusual circumstances.
(c) Voice service is providing real-time phone conversations with crews, regardless of their location with our global satellite network (G7 and G7-FDM require optional handset).
(d) Out-of-the-gate/Off-the-ground/On-the-ground/In-the-gate (OOOI) mode send messages automatically to Back Office solutions, increase the accuracy of records, and save money.
(e) Flight Data Monitoring (FDM) provides post-flight analysis and real-time alert of Flight and Maintenance Operational Quality Assurance (FOQA/MOQA) reports.

Here will be introduced the following airborne satellite tracking devices:

1. **Flightcell DZM 2/3**—The Guardian Mobility DZM2 and DZM3 are the only solutions that provide GPS position reporting, data and voice communications simultaneously in a compact and lightweight hub, shown in Fig. 2.42 (a Above). In Fig. 2.42 (a Below) is shown outdoor antenna, phone handset and FlightcellPro handset. FlightcellPro provides the leap forward in communications integration by simultaneously connecting one or more complementary communications into aviation headset. In the cabins can be also used Auxiliary Audio Devices (AD), Intercom/Interphone System (IIS), DECT cordless phones, and cell phones. Therefore, a second transceiver connection provides for integration of a cell phone modem providing voice, data, and tracking

Fig. 2.42 Family of Guardian tracking devices. Courtesy of manuals: by Guardian Mobility

services (where available) at a lower cost than satellite (CDMA, GSM, 3rd Generation, WCDMA, HSDPA). The hardware is designed for permanent installation in any aircraft with an intercom system, but also comes in a portable version. While the DZM3 only requires an external antenna to operate, the DZM2 must be coupled with both the Iridium 9555 satellite phone and an external antenna. The DZM transmits operational information and custom data through canned messages, while acting as a built-in and portable satellite communication solution all in one with integrated voice and data communications. Connected devices can be used at all mobile positions, providing crew and passengers with global point-to-point communications. The DZM also has the ability to send SMS, SBD, and data from other equipment such as fax. This terminal is compliant with US Army Field Forces (AFF) regulations.

2. **Guardian 7**—This terminal is a robust, full-featured modular system perfect for fleet operators who are looking to reduce their data costs by receiving timely data or who want to communicate back and forth with the pilot via two-way text messaging, shown in Fig. 2.42 (b Above). In Fig. 2.42 (b Below) is shown outdoor antenna and PDA handset. It provides AFF, text, voice, OOOI (Out/Of/On/In), and FDM modes onboard aircraft. The building blocks of the Guardian 7 system are the GPS/Iridium hardware, the user services interface, and partner applications. It uses onboard sensors to gather information such as door open, door closed, wheels up, wheels down, engine start, engine shutdown. This information is automatically transmitted to the ground, reducing the cost of data entry, increasing operational efficiency and the accuracy of records. The Guardian 7 end-to-end solution comes complete with a Web-based mapping interface that can be accessed from virtually anywhere including your PDA or smartphone.
3. **Guardian 5**—This 9206 Iridium configurable and manual position modem provides real-time AFF and two-way text messaging, see Fig. 2.42 (c Above). As a stand-alone system, it can be moved from aircraft to aircraft with no need for a Supplemental Type Certificate (STC). Regular position reports are sent automatically, at a user-defined rate. MARK and ALERT reports can be sent by pressing the dedicated buttons. Text messages, either preformatted or free form, are sent in real time. In such a way, regular AFF reports provide position, altitude, speed, track, and time and pilot can select the report time intervals. An authorized user on the ground can view the position reports for the current flight or select a past flight to view an historical track on an interactive map. The MARK button allows the pilot to instantly mark a waypoint and send the position in a special report to the ground. The ALERT button allows the pilot to send an immediate position report with an alert status to the ground rescue facilities. Periodic aircraft position reports are sent at a faster, user-selectable rate until the ALERT is cancelled. The ground or the pilot can enter free-form text messages of up to 150 characters and send them immediately. Alternatively, the pilot can select any one of 99 canned messages.

4. **Guardian 3**—This 9602 configurable tracking reporting interval modem is using duplex Iridium network, similar to that using in simplex Globalstar network, shown in Fig. 2.42 (c Below). This unit is a versatile aircraft tracking product available as either a portable or permanently installed device that runs on the Iridium network. This product offers various antenna configurations and is ideal for AFF compliance or fleet operators who require aircraft location and status information.
5. **IridiTRAK RST430**—This Beam terminal is a small unit using the latest technology in providing global alert, tracking, and monitoring services. With its inbuilt 16-channel GPS engine, Iridium SBD modem and dual-mode antenna is possible to track all mobile assets vertically anywhere in the world including aircraft, in which unit with antenna is shown in Fig. 2.43a. The sending of position and status messages for any asset, mobile, or personnel can be simply and easily reported. The intelligent IridiTRAK allows the unit to be configured so that position reports can be sent upon configured periodic interval. It is designed to support a stand-alone alert/alarm management system or it can be used in conjunction with a tracking application, and can track any asset or personnel on a regular basis while having the peace of mind of an alert mode operating in the background at all times. It interface can handle multiple alarm activation points that can be physical buttons or digital inputs. When an alarm is raised, this will automatically generate the delivery of an alert notification to the predetermined destination. The delivery destination can be to any IP addresses or to any e-mail address as specified. Alert messages can be sent via Short Burst Data (SBD), which interface directly to LeoTRAK-online continuous alerting until reset Passcode protected. The SBD packet-based data allow small data packets to be transmitted and received in a very timely manner to or from the device and SBD is charged per byte.
6. **SBD Modem RST425**—This Beam data modem is a robust data terminal specifically designed to incorporate the Iridium 9601 SBD module with an inbuilt 9-32 V DC power supply as well as RS232 data connectivity into an enclosure ready for use in a wide variety of mobile applications including aircraft, illustrated in Fig. 2.43b. The terminal provides serial interface and dual mag mount antenna.

Fig. 2.43 Onboard tracking satellite terminals. Courtesy of prospect: by Beam

7. **LeoTRAK RST480**—The Beam LeoTRAK provides the latest technology to support global alert, monitoring, and tracking applications over the Iridium satellite network as well as GSM network worldwide for least cost communications, shown in Fig. 2.43c. It has an inbuilt Iridium 9601 SBD module, Quad mode GSM module and a Super Sense GPS engine providing pinpoint accuracy for tracking and alert applications globally. It has the option of utilizing satellite or GSM message delivery or voice calls on the GSM module when used with the approved accessories and an optional Beam RST045 control panel. This unit can send tracking and alert messages on demand and/or stored on the local SD card for future retrieval. The system also supports the option of inbuilt battery backup or the use of a compact control panel for simple messaging applications. An advanced LeoTRAK Management System (LMS) enables the unit to be highly configurable to support a wide variety of applications monitoring and controlling internal and external events. While the LeoTRAK devices can be configured to originate messages to other third party applications, this device connects seamlessly to the Beam LeoTRAK-Online global fleet management system: www.leotrakonline.com.
8. **Spider S3**—This unit is useful for aircraft Safety system combined with Aviator Web site. It is the ideal portable aircraft emergency location streamlined-designed for light aircraft and can be moved between aircrafts, shown in Fig. 2.44 (Left). Built around the Iridium 9602 SBD transceiver, the S3 unit is only 150 g powered via the aircraft's auxiliary power socket and has an internal antenna. The internal access keypad allows pilots to send up for four preprogrammed text or e-mail messages to nominated recipients throughout the Iridium network. The system automatically turns on and watches over every flight. It takes just the press of one button to cancel Spiderwatch and pilots can manually activate SOS alerts in the event of an accident. It will also automatically transmit text and e-mail messages to friends and family when pilot take off and land. The Aviator Web site includes an automatically populating logbook, flight following and a social networking site as well, where pilot can "follow" other pilots, share flights with others, and join or create groups of like-minded pilots to share information and love of flying online.

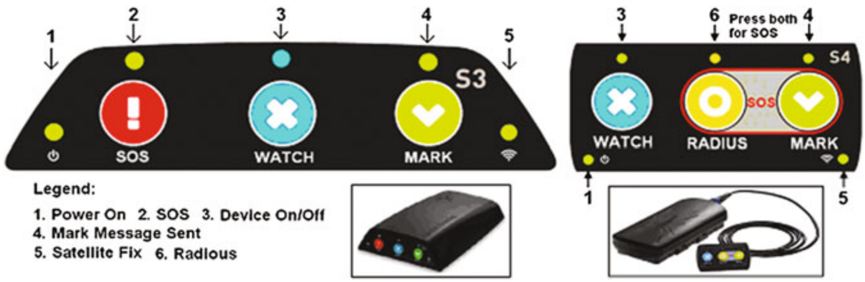

Fig. 2.44 Portable tracking satellite terminals. Courtesy of manual: by Spidertracks

9. **Spider S4**—This tracking device of aircraft is similar to previous, it has a modern robust design and an external three-button keypad, shown in Fig. 2.44 (Right). Its additional functionality makes it ideal for commercial operators. In case of emergency it will be necessary to press radius and mark together, and Distress messages are sent immediately via text and e-mail to two tiers of support people. If the alert is not resolved within 15 min, it is escalated to the second tier. Position reporting increases to 30 s, and because the SOS message contains last reported position of aircraft in Distress, the rescue services can provide assistance.

2.1.2.8 Personal Satellite Trackers

1. **E-Track Epsilon Personal Tracker**—This tracker is waterproof satellite messaging and personal tracking device, providing real-time autonomous and global coverage, which is illustrated in Fig. 2.45 (Left). Projected around 9602 Iridium duplex satellite modem, it benefits from the latest developments in satellite technology and GPS and is recognized as IP67 technology. Thus, this personal handheld terminal provides two-way text messaging, predefined and free-text "HELP" key to send a Distress message, automatic transmission of the GPS accurate position according to a programmed frequency, position and message reception in less than 15 s (almost in real time), visual and audible alert, movement activated tracking, programmable for activation at predefined times or dates for prolonged usage, and remotely programmable and highly flexible. It is using flexible power options (rechargeable or AA batteries) and has low weight of 350 g.

Fig. 2.45 Iridium personal satellite trackers. Courtesy of manuals: by Iridium

This unit is designed for ergonomic and autonomous use even in the harshest of conditions (IP 67) controlled by "Power ON/OFF," "HELP," "SEND," and "STANDBY" buttons including two programmable function keys to access "SHORTCUT." It has inclinometer, high sensitivity vibrations detection, built-in shock sensor and GPS, and Iridium built-in antennas with integrated connections for external antennas.

2. **GeoPro Personal Messenger**—This personal unit is a remote workforce Safety, location awareness and two-way personal messaging solution, presented in Fig. 2.45 (Middle). When work takes staff off the grid, they often have no reliable means of maintaining communication. Not only does this limit productivity, it also threatens their health or Safety in the event of an alert and emergency. It is the affordable and rugged device supporting global two-way text messaging. Thus, the unit is easy to be used in one hand with non-slip form factor network by a joystick to navigate on-display menus and keyboard.
3. **NANO Personal Tracker**—This unit is designed with ultra-low power consumption less than 35 μA during sleep, illustrated in Fig. 2.45 (Right). With an internal 1.95 A-Hr rechargeable Li-Ion battery, this unit is able to send a position report every hour for up to two months (about 1200 reports). It is equipped with on-screen keyboards supporting transmission of free-text, canned messages, and a combination of free-text and canned messages. It can periodically wake up from sleep to send its position report to a command centre. A guarded 911 button is used for immediate emergency/alert notifications. The data are packaged in either standard or 256-bit Advanced Encryption Standard (AES) encrypted format. The pocketsize and self-contained personal two-way satellite tracker has ultra-low power consumption, AES 256-bit encryptions both transmit and receive, very precise GPS positioning, real-time reporting, and truly global coverage via the following features:

(a) Power/Enter is providing to turns device ON/OFF when hold down for two seconds or is used to select highlighted item on the menu; (b) Arrow Up/Down/Right is serving to navigate the cursor, in which arrow on left side is used to navigate the cursor or it is used to go back to the previous menu; (c) Check-In Soft Key is used to access the Check-In feature. (d) Way Point Soft Key is used to access the Way Point features; (e) USB port is serving to charge the battery, update firmware, or setup operating parameters using a computer; (f) the emergency key can be used to send an emergency alert, Distress, and notification to SAR and rescue forces; (g) guard button protects emergency button from being accidentally activated; (h) LED displays tracking and emergency statuses; (i) antenna post is showing GPS antenna; and (j) antenna post is showing Iridium antenna.

The weighs of unit is 170 g, and the volume is $4.0 \times 2.2 \times 0.8''$, with an internal rechargeable battery using AC adapter ad computer USB port or solar charger.

2.1.2.9 Satellite Asset Trackers and Fleet Management

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 provides superior GPS tracking and mapping, no special hardware or software is required, seamless software and firmware updates, 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. **Iridium 9602 Mini Transceiver**—This SBD transceiver is designed to be integrated into wireless data devices with other host system hardware and software including GPS Rx as a complete product and specific applications. The Iridium 9602 is ideal for satellite SCADA (M2M) solutions, including tracking of ships, land vehicles, aircraft, and equipment monitoring. It is used as a basic unit for production of satellite trackers using the Iridium network, which is illustrated in Fig. 2.46 (Left). A unique feature of the Iridium 9602 is its built-in GPS input/output ports, which will permit system integrators to interface with an external GPS receiver, using a single dual-mode L-Band antenna for GPS and Iridium SBD, saving the cost of an antenna in their applications. Thus, this very tiny, 41 × 45 × 13 mm and 30 g, two-way tracker is perfect for use for the rapidly growing mobile tracking and fleet management. The 9602s very compact form factor and lower power consumption will offer great flexibility to solution developers as they design the module into their products. In fact, this transceiver is a single-board core transceiver provided as a "black box" with all device interfaces provided by a single multipin interface connector and antenna connectors. The product only provides the core transceiver and all other end user field application functions such as GPS, microprocessor-based logic control, digital and analog inputs and input/output, power supply and antenna must be provided by the solution developer. In addition, the adequate sensors can be

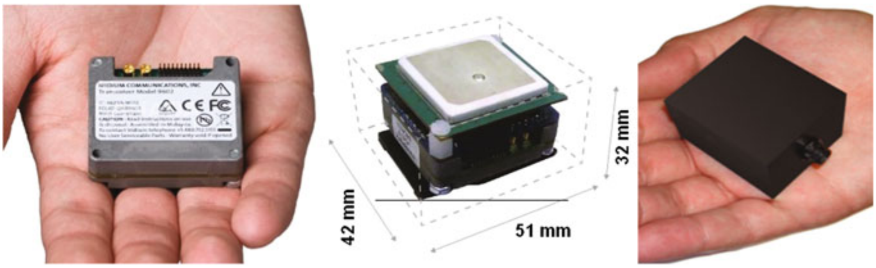

Fig. 2.46 Iridium miniature trackers. Courtesy of manuals: by Iridium and EX4U Telecom

connected to the 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, in which an 32 bit ARM processor with a fully user customizable LUA scripting language and internal dimensions 1.77 × 1.77 × 1.34″ (45 × 45 × 34 mm), including battery, modem and antenna are illustrated in Fig. 2.46 (Middle). It can transmit location from anywhere in the world and is built on the latest satellite, antenna, and electronics technology to track and monitor all mobiles in real time, in which a real size is depicted in Fig. 2.46 (Right).
   Features of this iridium tracker are: SiRFstarIV GPS with 163dBm sensitivity, AES 256-bit encryption, built-in 2.5 Ah Lithium Polymer battery and charger, battery fuel gauge, accelerometer and magnetic compass, integrated high-gain ceramic antenna dual tuned for Iridium (SAT) and GPS satellites, over the air configuration of the terminal, and Original Equipment Manufacturer (OEM) options available. This tracker is providing the following service: tracking of ships, containers, land vehicles and aircraft with fleet management, electronic driver log compliance, fuel monitoring and logistics, military mobiles and soldier tracking with encryption, and SCADA (M2M).
3. **Quake Q4000 Tracker**—Though the Iridium Q4000i is a small enough to fit in hand produced by the US company Quake. It is a two-way rugged modem 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. 2.47 (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. Technically, this is a SBD transceiver designed for use as basic unit for many mobile trackers using the Iridium network, such as ocean ships and container tracking and as well as for land vehicles and aircraft tracking. The Space Science Centre (SSC) at Durban University of Technology (DUT) leaded by author of this book in 2014 proposed to ICAO solution of Global Aircraft Tracking (GAT) by integration of Q4000 Terminal and Hirschmann antenna into GAT Network. In addition, this tracked 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 size: 3.91″ × 2.52″ × 0.63″ (99.3 mm × 64 mm × 15.9 mm) and weight is 375 lbs (170 g). In Fig. 2.47 (Middle) is shown 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.

Fig. 2.47 Iridium Mobile trackers with antenna. Courtesy of manuals: by Quake and Hirschmann

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 GPS/Iridium, Globalstar, Orbcomm, and GSM modem with numerous customization options including operating network, memory, inputs/outputs, CAN bus, and antenna detection, which is shown in Fig. 2.47 (Right). It incorporates an Application Programming Interface (API) that allows developers to utilize its functions to create customized onboard applications. It delivers reliable one or two-way data communications through multiple satellite and terrestrial networks.
   For mobile location and navigational applications, the Q-Pro is equipped with an advanced 50-channel GPS system. Thus, this self-contained flexible solution is designed for multiple applications and is an ideal option for any system developer of mobile and fixed applications. Mobile assets such as ships and containers, trucks, trains, and aircraft can also be more safely monitored and managed. It can be used for GST including for containers, trucks, trains, and aircraft tracking and monitoring.
5. **NAL Research Corporation 9602-LP Tracker**—This unit is a pocketsize, low-cost, satellite tracker designed by NAL Research Corporation to operate with the Iridium LEO satellite network, which is depicted in Fig. 2.48 (Left). It is a self-contained unit relying on an internal microcontroller/GPS receiver for satellite tracking operations. It measures 2.7″ × 2.2″ × 0.9″, weighs less than 5 oz and can be attached to high value, un-tethered or non-powered assets such as containers, buoys, barges, railcars, trailers, or even to a person. It is also being used by the militaries to track environmentally demanding platforms including helicopters, fixed-wing aircraft, unmanned aerial vehicles, rockets, high altitude balloons, seagoing ships, speedboats, ground vehicles, and hand-emplaced and air-deployed remote sensors. This unit is designed with ultra-low power consumption electronics. At standby mode, the unit draws less than 65A in the range of 3.5–5.5 V DC input. Therefore, with a 2A-Hr Li-battery (the size of an AA Alkaline battery), it is capable of delivering uninterrupted service of up to

two years with two reports per day. Battery life can be further extended by using a built-in motion sensor to reduce reporting frequency when a platform is not in motion. The 9602-LP unit can send either a standard or the 256-bit AES encrypted GPS report at a preprogrammed interval ranging from once every four seconds to once every seven days. The message interval can be changed remotely, while the unit is in the field. There is an available serial port that can be used to communicate with an external sensor or data terminal equipment (DTE) such as a Message Terminal or PDA. In addition, there are also seven discrete I/O connectors for external sensor interfaces as well. This unit also has a guarded Emergency switch to alert the recipient of an emergency situation as well as to indicate proper operation of the tracker. It has five LED indicators providing the status of power input, GPS fix, Iridium connection, SBD transmission, and emergency alert.

6. **TransMedia Technology GlobalTrack G200R Tracker**—This unit is also a pocketsize tracker designed by TransMedia Technology, in which modem is illustrated in Fig. 2.48 (Middle). Its radio system provides the following technical features: dual components in one G200R system (Iridium and GPRS-based), gives very low latency time sending data from worldwide to server in few seconds, provides auto switch between satellite and cellular (GSM) network what depends on land radio signal, and has very efficient Iridium air time control to save communication cost, so will be lower than SMS via GSM network.

This unit can interface up to 19 input or output pins for software configuration, five of them offer relay high power output, car ignition relay, siren, central lock, and car light. It also provides interfaces for vibration sensor, sensors for fuel level reading, temperature sensors, 1 analog output, 4 analog input interface, 1 serial port interface (RS232), GT-CAM video, RFID Reader, audio microphone and speaker interface (GSM phone communication only), power source interface for external device, and two LED status. This Iridium tracker and all other similar units can be connected to the Message Terminal (DTE), which is depicted in Fig. 2.48 (Right). The DTE has small keyboard and monitor, so vehicle driver can send SMS to dispatcher. Besides, this also enables WebTrack user to communicate directly with the driver as well as providing greater driver monitoring capabilities, including

Fig. 2.48 Iridium mobile trackers with message terminal. Courtesy of manuals: by NAL Research Corporation and TransMedia Technology

warnings when speeding. The integrated emergency button will send an immediate emergency message to the WebTrack user, or to their e-mail or cell phone, with the latest position information providing instant communication in such critical situations. The Message Terminal supports several different languages, which can be set by the WebTrack user.

7. **Naviset GT-10 Hybrid Tracker**—This terminal is universal hybrid GLONASS/GPS and GSM solution with Iridium embedded solution for mobile users, which is shown in Fig. 2.49 (Left). It is designed to control vehicles, fuel, and POL, to support up to eight temperature sensors with 1-Wire interface, to operate with several sensors at the same time, to connect any external sensors with AIN, DIN, 1-Wire, RS232/485 interfaces and is able to identify the driver of RF ID cards or touch memory keys. The main task of this tracker is to provide location of vehicles and to transmit data via GPRS or Iridium networks. The universal interface of data emulation allows integrating the terminal into any monitoring and support software. Thus, two SIM cards provide saving via voice and data to mobile operators inside GPRS roaming traffic and in case of WIFI network coverage as well. Thus, connection to Garmin navigators provides possibility for message exchange with a driver and connection of the two camcorders for providing a visual control of driver's cabin and situations around the vehicle. A voice solution provides communication between a driver and an operator in dispatcher office including listening of a driver's cabin.
8. **Naviset Seapoint**—This unique and hybrid GLONASS/GPS terminal with transition of its location through Iridium satellite network is navigation independent beacon designed for continuous operation in independent mode, control of the movable and stationary object location, transmission of status of the discrete, and analog sensors connected to the device at any point on the Earth's surface, in which modem is shown in Fig. 2.49 (Right). Locating coordinate data transmission can be performed both by an event and in automatic mode according to schedule. It supports the connection of discrete, analog, and frequency sensors with built-in temperature control.

Fig. 2.49 Iridium hybrid trackers. Courtesy of manuals: by Naviset

2.2 Global Little LEO GMSC Systems

Proposed Little LEO satellites are so-called because they are very small (measuring around 1 m^3 and weighing in at around 100 kg) and because they occupy what is known as a Low Earth Orbit (LEO) constellations. This means they occupy orbital slots between 700 and 1500 km from the Earth, which is low, relative to other satellite systems. The LEO system is a non-GEO solution offering fast inexpensive services and getting a foothold in the market well ahead of their big brothers. The majority of LEO ventures intend to use the satellites as either bent-pipe or store-and-forward systems. The bent-pipe system in real time relays all messages directly between users; while the store-and-forward approach means that a satellite receives information from a gateway, stores it in onboard memory, continues on its orbit and releases the information to the next appropriate ground station, or user.

The Little LEO Satellite users will be able to access their space and ground network via very small single or two-way satellite messaging devices incorporating an omnidirectional low-power antenna and weighing less than half a kilogram. In fact, the principle difference between the proposed offerings of Little LEO operators and other MSC systems is that they concentrate on providing data services, rather than handling real-time voice traffic. The kinds of services users can expect from a Little LEO satellite providers are messaging, including e-mail and two-way paging, limited Internet access and Fax. Important markets for Little LEO will include remote data transfer, digital tracking (for the transportation management market), environmental monitoring, and SCADA (M2M).

2.2.1 *Orbcomm Little LEO GMSC System*

ORBCOMM

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, in 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 meters, 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.

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 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 is presented in Fig. 2.50. 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) 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/gas extraction, pipeline operations, storage, custody transfer, and electric power generation and distribution;
2. Messaging for truck fleets, owner operators, and remote workers;

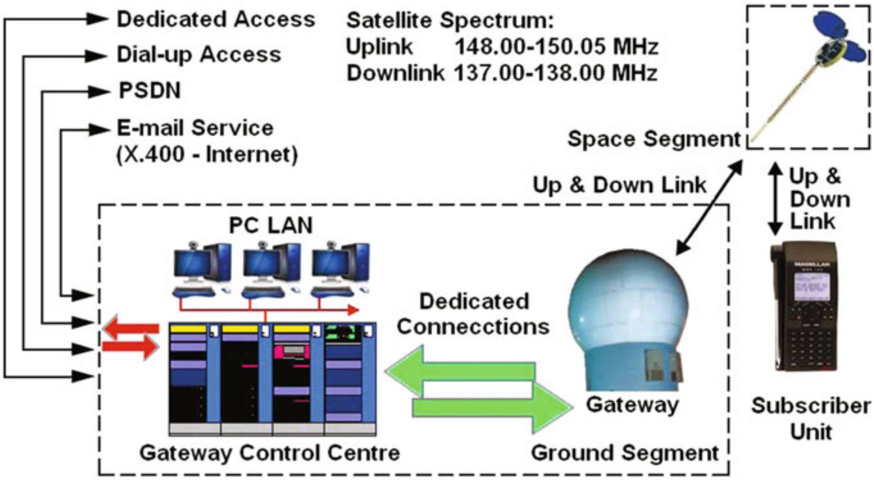

Fig. 2.50 Orbcomm system overview. Courtesy of manual: by Ilcev

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 via satellite network, in which almost global coverage is shown in Fig. 2.51. 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

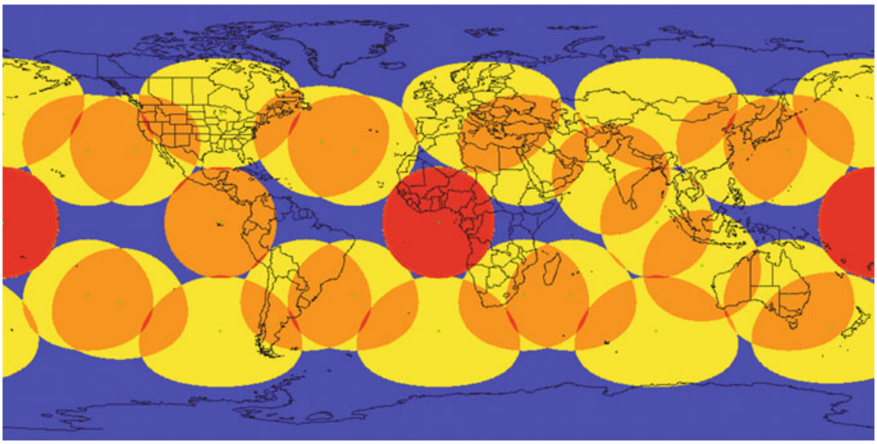

Fig. 2.51 Orbcomm satellites coverage. Courtesy of manual: by Lloyd

offer low-cost and high-quality service, in which staff is dedicated to fulfilling the specific needs of all potential users.

2.2.1.1 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). Thus, the main function of Orbcomm's satellites is to complete the link between the SCU and the switching capability at the NCC in the USA, or a licensee's GCC in other countries, shown in Fig. 2.52 (Left).

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.

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 is:

1. Planes A, B, and C are 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.

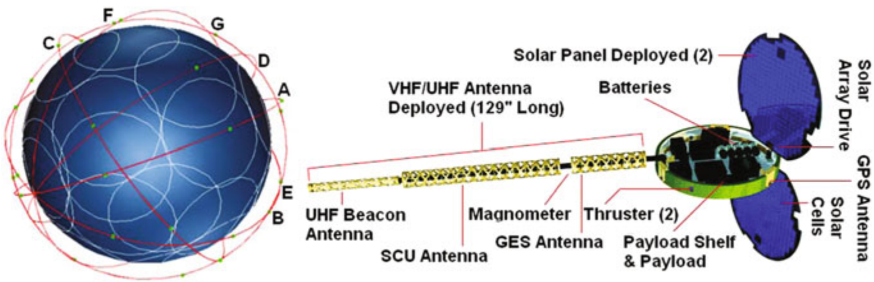

Fig. 2.52 Orbcomm little LEO satellite constellation and components of deployed satellite. Courtesy of WebPages: by Orbcomm

4. Plane G is inclined at 108° and contains two satellites in a near-polar elliptical orbit at an altitude varying between 785 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 5100 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. Each of the satellites is 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 EOL in a worst-case orbit. The satellite solar panels and antennas fold up into the disk (also called the "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. Figure 2.52 (Right) 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 148–149.9 MHz and transmits by 4800 b/s at 137–138 MHz and 400.05–400.15 MHz. The system uses X.400 (CCITT 1988) addressing and message size is typically 6–250 bytes (no maximum). The most important orbital parameters of the Orbcomm constellation are presented in Table 2.3. The 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 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. So, 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 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.

Table 2.3 Orbital parameters of Orbcomm spacecraft

Background Owner/operator: Orbcomm Global LP, USA Present status: operational Altitude: 775/739 km Type of orbit: LEO Inclination angle: 45°/70° Number of orbital planes: 4/2 Number of satellites/planes: 8/2 Number of satellites: 32/4 Little LEO Coverage: worldwide Additional information: System offers data and asset tracking messaging with 14 GES all over the world *Spacecraft* Name of satellite: Orbcomm Launch date: started in November 1998 Launch vehicle: Pegasus XL and Taurus Typical users: global mobile messaging service Cost/Lease information: approximately 900 M $	Prime contractors: Orbital Science Corporation Type of satellite: Microstar (Little LEO project) Stabilization: magnetic with gravity gradient assist Design lifetime: four years Mass in orbit: 1385 kg Dimensions stowed: 1.83 × 12.50 m circular Electric/SSPA power: 135 W (EOL)/ 10 W *Communications payload* Frequency bands: Service/feeder uplink 148.0–150.05 Service/feeder downlink 137.0–138.0 MHz Multiple access: FDMA/TDMA Number of transponders: six uplink Rx; two downlink Tx; Ka-band operation Channel capacity: 15 Gb/s total data rate Channel polarization: circular EIRP: varies over coverage area G/T: varies over coverage area Saturation flux density: high

(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 O-QPSK modulation in a TDMA format. The gateway Rx is designed to demodulate a 57.6 kb/s TDMA signal with an O-QPSK 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 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.

2.2.1.2 Ground Segment

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.

Gateways, 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 handheld 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 137–138 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 GCC terminals are located in a territory that is licensed to use the Orbcomm system and provide the following functions: locate wherever Orbcomm 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. **Network Control Centre (NCC)**—The NCC is responsible for managing the Orbcomm communications network elements and the US gateways through telemetry monitoring, commanding, and mission system analysis. It provides network management of Orbcomm's satellite constellation and is staffed 24 h 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.

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 h 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 is both mobile and fixed terminals used for connection to the Orbcomm satellite network through gateway stations. The SCU terminal is a wireless 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.

2.2.1.3 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 unit 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, in which the first generation of SCU terminal is depicted in Fig. 2.53 (Left). This 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

Fig. 2.53 Two generations of SCU terminals. Courtesy of manuals: by Orbcomm

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 unit 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.

2. **Stellar DS300 Terminal**—This device is a two-way satellite communicator for use with the Orbcomm network, which second generation of is illustrated in Fig. 2.53 (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 Fig. 2.53 (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, in which the third generation is depicted in Fig. 2.54 (Left). Mechanical features of this unit are 40 mm × 70 mm × 0.5 mm, which Mini PCI Express has 52-pin edge connector and 0.8 mm pitch. Its electrical usage at input voltage is 2.8–15 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 Fig. 2.54 (Right).

Fig. 2.54 Third generation of SCU terminals. Courtesy of manuals: by Orbcomm

2.2.1.4 Orbcomm Satellite Asset Tracking (SAT) and Fleet Management

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:

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 Fig. 2.55 (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, requests 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 is productive or needs maintenance, if oil pressure is within limits, and how it is being used in order to better allocate resources and

Fig. 2.55 Terminals for fleet management. Courtesy of manuals: by Orbcomm

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 s and poll response time is 2–3 min. This terminal provides reporting interval position, motion start/stop, condition-based fault codes, engine/idle hours, fuel consumption, battery voltage, antenna connect/disconnect and predefined 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 Fig. 2.55 (Right). In fact, this is ruggedized RT 6000 + provides visibility, control and decision rules to dispatch and operations centres, 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 Fig. 2.56. 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).

2.2.1.5 Orbcomm Satellite AIS (S-AIS) Service

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

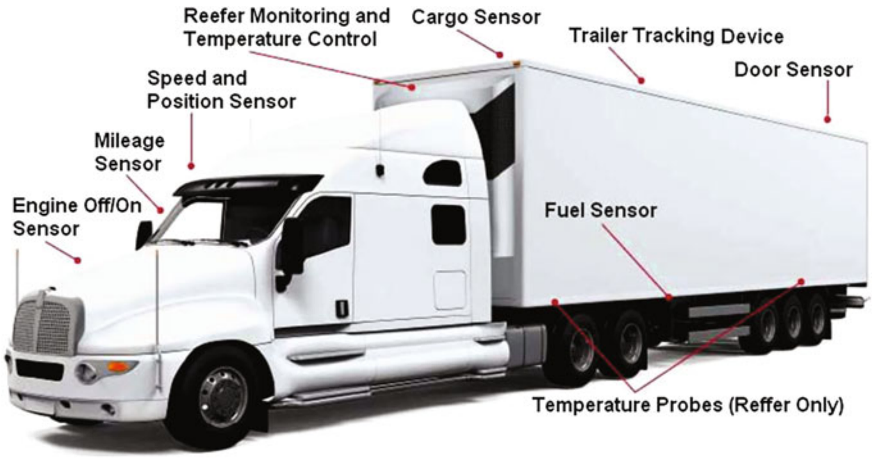

Fig. 2.56 Tracking sensors onboard truck. Courtesy of manuals: by Orbcomm

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.

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. 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 Fig. 2.57 is shown space and ground configuration of S-AIS integrated with R-AIS proposed by the 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

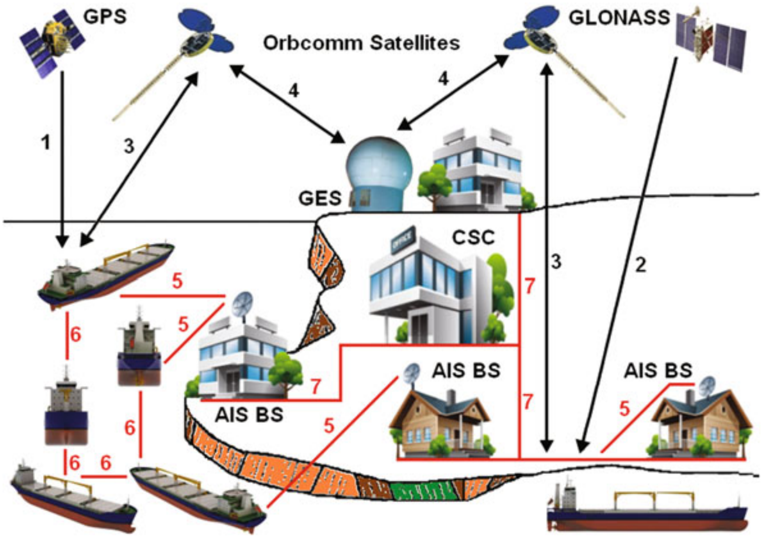

Fig. 2.57 Orbcomm satellite AIS (S-AIS). Courtesy of manuals: by Ilcev

R-AIS Base Station (BS) via radio link (5), while all these ships have AIS data communication via intership 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.

2.2.2 *Gonets Leosat Little LEO GMSC System*

Two Gonets Little LEO satellite tracking, communication and messaging systems have been proposed by the former Soviet Union, using both UHF and L/S-band transmission channels. Both systems are projected to offer true global coverage from high inclination 1400 km orbits and satellite footprint diameter of 5000 km. One system of them, Gonets-D, initially launched 8 satellites in LEO orbit, and already planed to add another 36 in the near future. Further, a series of Gonets-D1 (1–6, 12–14) satellites were launched to provide UHF and L/S-band communications channels.

2.2.2.1 Space Segment and Coverage

The first Gonets-D1 satellite was launched in December 2005 of a fleet of 12 satellites in 4 planes to provide Russia agencies with mobile e-mail and a short messaging system, which is illustrated in Fig. 2.58 (Left). Therefore, the Russian Little LEO satellite system "Gonets-D1 M" (hereafter Gonets) with an orbit constellation of 12 Gonets spacecraft and 4 regional gateways located in Russia can facilitate communications for data transmission, telematics services and messaging in integration with GPS/GLONASS systems for more than 200,000 fixed and mobile users, which second generation of Gonets-M spacecraft is shown in Fig. 2.58 (Middle). In Fig. 2.58 (Right) is illustrated the third generation of Gonets-M1 in development phase.

In Russia, there are problems with transferring GLONASS data from users to control and monitoring centres in areas outside of limited GSM/GPRS network coverage and also with other types of communications in such areas from mobile subscribers across the largest Country in the world including water areas. The current Gonets coverage with 12 satellites has blind spots especially in Southern Hemisphere, while new projected Gonets network with 24 spacecraft will provide almost full global coverage, shown in Fig. 2.59.

The diameter of each gateway radiovisibility zone shown in Fig. 2.60 (Left) is about 5000 km, which ensures 100% coverage of Russia's territory including its water exclusive economic area and much of Europe and Asia's territories. In the future Gonets operator has project to provide new constellation of 44 satellites, so in this case can be obtained full global coverage and waiting time for communication with subscribers will be minimized. Besides, similar to Globalstar and Orbcomm, Gonets needs to build many gateways (GES) globally and to cover all regions and Sea Areas. On the other hand, Gonets is planning to arrange inter-satellite link for its new generation of satellite constellation. In such a way, similar as Iridium, this system will not need to provide many gateway station worldwide, but just 1 or 2 or 1 gateway for each continent.

The Gonets satellites are on circular near-polar low orbits with orbiting period of about 114 min. The closer a Gonets subscriber is to either of the poles the less is waiting time for a possible communication session. This is multifunctional satellite

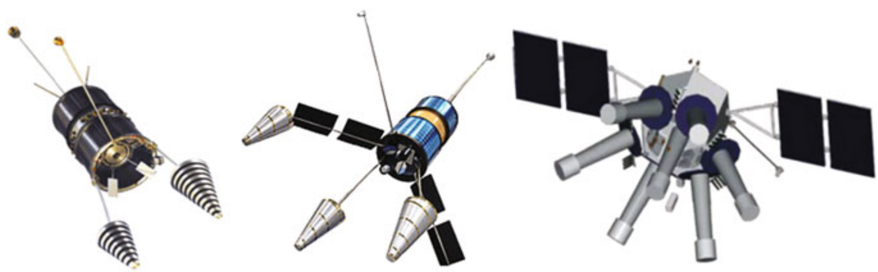

Fig. 2.58 Three generations of Gonets satellites. Courtesy of manuals: by Gonets

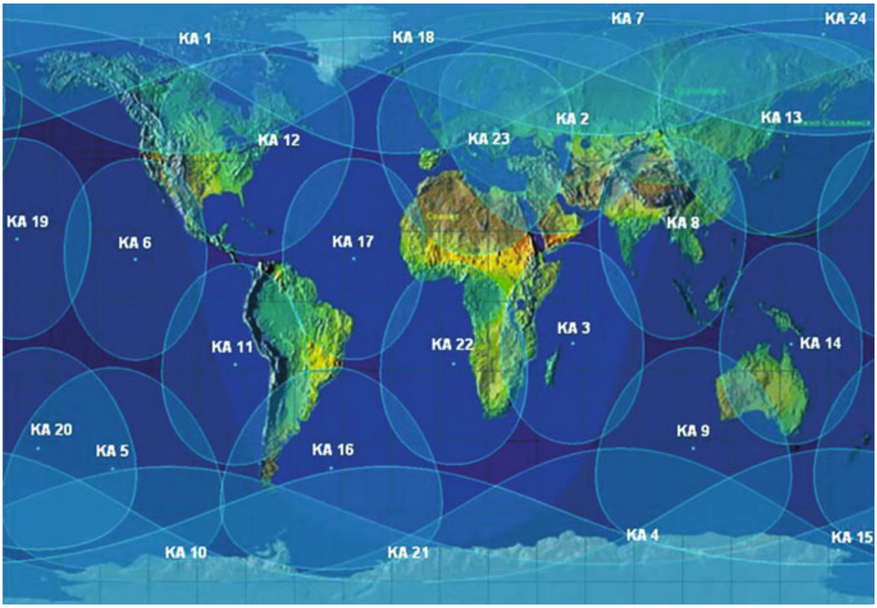

Fig. 2.59 Improved coverage with 24 Gonets satellites. Courtesy of manuals: by Gonets

Fig. 2.60 Gateway (GES) and Gonets-M spacecraft in orbit. Courtesy of manuals: by Gonets

system for fixed, mobile and personal satellite communications and data transmission with space crafts on low orbits is designated to provide communication services at any point of the globe including polar areas for the benefits of both state and private customers. The first generation of Gonets-D1 spacecraft is already abandoned; however, the second-generation Gonets-M is in currently providing service, which spacecraft is depicted in Fig. 2.60 (Right). As stated earlier, new Gonets-M1 is next-generation versions of the Gonets-M satellites. This satellite will feature a complete new satellite bus and the communications payload will have ten times the bandwidth of the older Gonets-M satellites and 30 times higher data

Table 2.4 Features of Gonets three generations spacecraft

Parameters	Gonets-D1	Gonets-M	Gonets-M1
Orbit life (Years)	1.5	5	10
Bitrates (kb/s)	2.4	9.6–64	64–1024
Transponders	1	14	50

transmission rate. Characteristics of all three generations of Gonets satellites are presented in Table 2.4.

Type of communication system is session half-duplex and Gonets-M subscriber terminal antenna is omnidirectional with the following bitrates: in downlink channel of about 76.8 kb/s and in uplink channel is up to 9.6 kb/s. The Gonets-M system provides satellite connectivity sessions are arranged both on schedule and in on-demand mode.

2.2.2.2 Ground and User Segments

Russia has enormous landmasses as the largest country in the world with biggest natural recourses and with very important Northern Sea Route for maritime transportation. In fact, New established shipping route by Russia is officially defined by Russian Legislation as lying east of Novaya Zemlya and specifically running along the Russian Arctic coast from the Kara Sea, along huge Siberian landscapes to the Bering Strait entering in North Pacific Ocean. In fact, ocean ships can travel from North Atlantic Ocean and Norwegian Sea via Southern Arctic Ocean coast to the entrance in Pacific Ocean. Thus, this entire sea route and coastal territory is covered by Gonets satellite network, which will play very important role in communication, tracking and determination of all ships passing Northern Sea Rote.

The Gonets network is using two military GNSS-1 constellations, such as the US GPS and Russian GLONASS, monitored by Gonets satellite ground facilities, which infrastructure is shown in Fig. 2.61. The Ground Segment of Gonets network also includes GSM/GPRS Network, but this is not an issue of discussion in this book. Therefore, all Gonets users have special units that are receiving VPT data from one of two GNSS spacecraft, and then units are transmitting positioning data, making it possible to track the movement of all mobile assets, such as ships, road and rail vehicles. Theoretically in this system can be included aircraft and helicopters as well. Over Russian territory, there are four Regional Gateways (RG) or GES terminals that are receiving data from and sending data to Gonets satellites. These 4 RG have two-way landline communication with Communication Control Centre (CCC) in Moscow and with Remote Monitoring Centre and Local Monitoring Centre.

Simpler to say, the positioning data are obtained in a Gonets terminal by a built-in GPS or GLONASS navigation module. Then the positioning data are sent via a Gonets satellite to a Gonets ground regional station, where it is transmitted to the Internet and further to the user's address. If the mobile asset is in the service

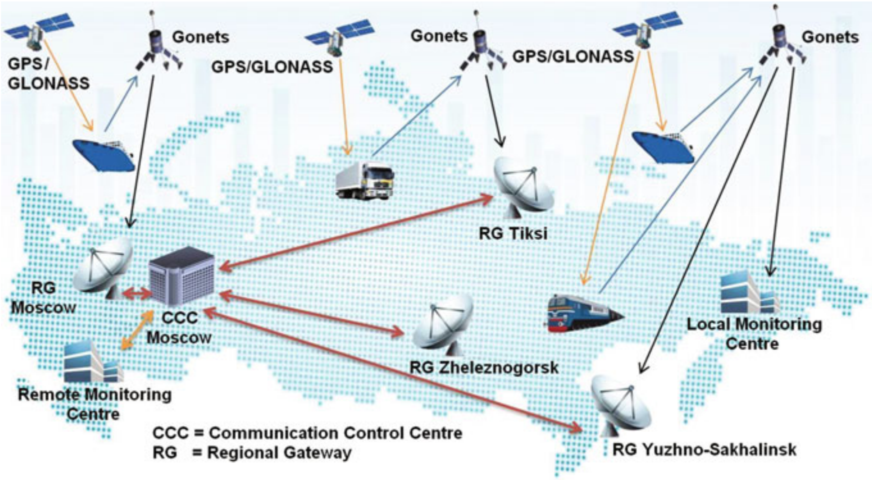

Fig. 2.61 Ground and user segments. Courtesy of manuals: by Gonets

area of a ground-based GSM network, the transmission of the positioning data is performed through the GSM channel, which is available in any Gonets terminal. Therefore, GLONASS/GPS network monitoring with Gonets system allows you to track the location of mobile objects anywhere in the world.

As stated above, Gonets LEO satellite system is designed for fixed, mobile and personal data communications via deployed onboard special Gonets transceivers for

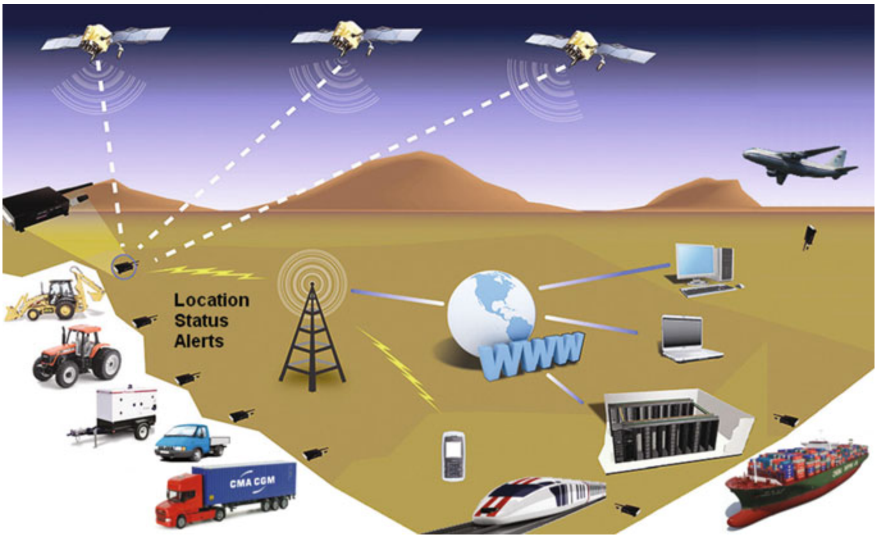

Fig. 2.62 Gonets mobile users for SAT and SCADA (M2M). Courtesy of manuals: by Ilcev

Satellite Asset Tracking (SAT), which configuration is illustrated in Fig. 2.62. The SAT and SCADA (M2M) facilities via Gonets network can be provided for contraction, agriculture, forestry, electrical aggregates, different machines, land vehicles, containers, trains, ships and in the future for aircraft and helicopters. The Gonets system provides satellite connectivity and location status alert for both mobile and stationary users connected via WWW Internet to their desktops, laptops, tablets and even smartphones, which communication sessions are arranged both on schedule and in on-demand mode.

2.2.2.3 Subscriber Terminals

The leadership of Gonets network is Gonets Satellite System public corporation as the operator of Russian satellite communication and relay systems, created by order of the Federal State agency of Russia Roscosmos. In fact, it is a telecommunications company operating on the Russian market for 19 years as the exclusive service provider and operator of the Russian LEO and relay satellite systems.

The composition of Gonets network based on Little LEO satellites, with orbit altitude of 1400 km and inclination of 82.5°, makes it possible to provide communication services at any location worldwide. In order to obtain a global attribute, this network should establish adequate numbers of gateway terminals around the world. This is particularly urgent in the regions of widespread Siberia and Far East where there are practically no alternatives to satellite communications employed in areas with low-developed infrastructure and low population density. In the workframe of Gonets-M experimental design solutions, new subscriber terminals meeting the requirements of satellite data communication market are developed. Services are offered to both mobile and fixed subscribers, which connected up to subscriber terminal as a satellite modem enabling communications with the mainland.

The range of Gonets subscriber satellite terminals include devices designed to enable data communication between different assets, both mobile and stationary. In Fig. 2.63a is illustrated mobile attended subscriber terminal for installations onboard ships and all kind of land mobile vehicles terminals, while in Fig. 2.63b is shown stationary subscriber terminal for installations in fixed locations. In Fig. 2.63c is depicted mobile and in Fig. 2.64d portable non-attended subscriber terminals, respectively.

As stated earlier, in accordance with the proposed location, Gonets satellite terminals are divided into mobile and stationary, which mobile model with main components is shown in Fig. 2.64 (Left) and (Right). Mobile terminals have inbuilt GLONASS/GPS function and allow to receive and send coordinate-time data at specified intervals to monitoring centers. In addition to monitoring of location, Gonets satellite terminals allow to provide personal communication (text messaging), telematics data transmission from monitoring objects, as well as sending alarms. The modifications of satellite terminals are divided into “Attended,” an operator (user) works with the terminal and “Non-attended” that a terminal operates

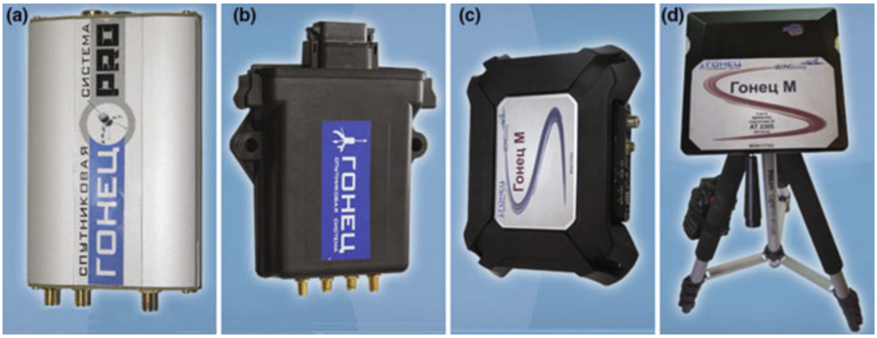

Fig. 2.63 Mobile and fixed subscriber terminals. Courtesy of manuals: by Gonets

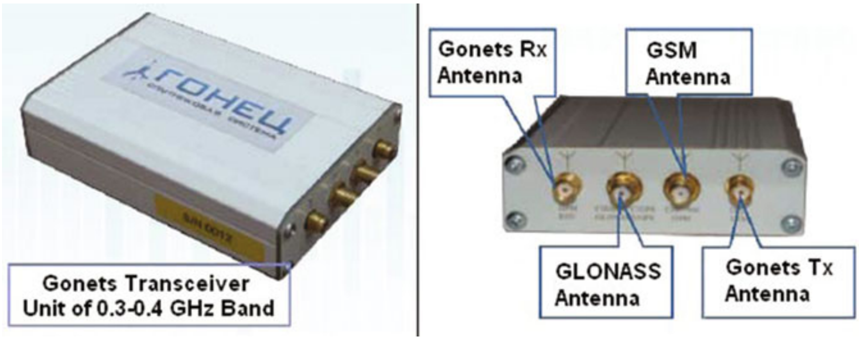

Fig. 2.64 Mobile unit with components. Courtesy of manuals: by Gonets

automatically, without the operator's involvement. The data exchange protocols provide multiple controls of information delivery, its reliability, and data security. On the other hand, the satellite channels are protected from unauthorized access, and individual, group or circular addressing can be facilitated.

All Gonets terminals have an alternative GSM communication channel, which makes for user cost savings. While the user is in the GSM service area, users employ the available terrestrial network. Once the user comes out of such GSM-covered area, the terminal starts to employ the Gonets satellite channel. Additionally, the presence of two communication channels in the terminals significantly improves the overall reliability of communications. The portable "Gonets" satellite terminals are equipped with rechargeable batteries.

The System designations of Gonets network are as follows: Global messaging between the system's subscribers; Transmission of positioning data obtained from GPS/GLONASS; Global messaging between system and external network subscribers; Circular messaging to groups of users; Data transmission from controlled assets to monitoring centers; and Voice connectivity in a Gonets satellite footprint (prospective service). The ground infrastructure consists of the System Control

Table 2.5 Technical characteristics of subscriber terminal

Parameters	Values
Position accuracy of GPS/GLONASS	Up to 10 m
Transmitter power	8–10 W
Modulation	Gaussian MSC (GMSC)
Power supply	AC 220 V–DC 12 V
Weight	100–300 q
Bitrates	
Subscriber satellite (kb/s)	2.4–9.6
Satellite subscriber (kb/s)	9.6–76.8

Centre (SCC), Communication complex control centre, Regional gateways, and Ballistic centre. The ground gateway (GES) terminals are located in Moscow, Zheleznogorsk, Yuzhno-Sakhalinsk, and Tiksi. Technical characteristics of subscriber terminals are presented in Table 2.5.

Gonets subscriber services may include development of corporative, administrative and private communication networks. Confidential satellite data transfer protocol makes data interception and corruption impossible thus ensuring confidentiality and reliability in the information delivery. Besides, it is hard to overestimate the advantages of satellite data communications in case of emergencies especially if ground-based communications have been damaged. In such situations, satellite communications are the only means to deliver critically important information and organize the elimination of adverse effects in shortest time possible.

Let's preserve nature for future generations environmental monitoring of remote ecological assets with Gonets network will make for creating complex environmental monitoring systems to observe the guarded natural areas condition, assess and forecast changes in the environment caused by various natural and anthropogenic influences. In fact, Gonets makes it possible to monitor ecologically important assets and areas no matter how far they are from the monitoring centre. Among application, fields are emergency warning systems for wildfires and natural assets contamination, emergency alert, meteorological data collection and many others.

2.2.2.4 Shipping and Fishery Monitoring Network

Gonets satellite tracking devices may provide communication service on various types of oceangoing vessels and can be used to addressing problems of the fishing fleet monitoring. These satellite data terminals mounted onboard different ships are capable of transmitting PVT data received from GLONASS/GPS about fishing vessels location with the necessary frequency, as well as ship's fishing log data in the required format.

In addition, it is possible to send text messages to e-mail addresses on the Internet, as well as mobile networks that will provide a personal communication to

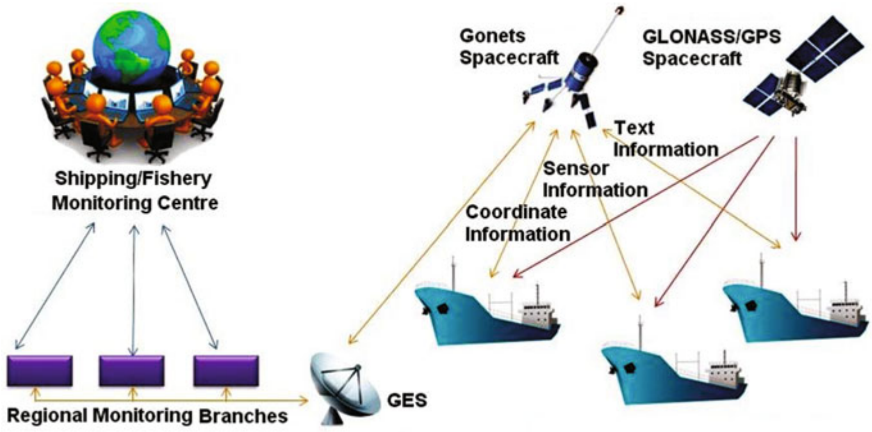

Fig. 2.65 Shipping and fishery monitoring network. Courtesy of manuals: by Gonets

crew vessels with the shore. It also has the ability to send SOS signals (alarm button). In Fig. 2.65 is depicted shipping and fishery monitoring network infrastructure that is performing different satellite information, such as text, sensor and coordinate and separately sending via gateway (GES) and Regional Monitoring Branches to Shipping/Fishery Monitoring Centre.

Monitoring fishing fleet data are transferred from onboard Gonets terminals via satellite to the Gonets regional station, and from there are forwarded by terrestrial channels (Internet) to the regional branches of Centre of Fishery Monitoring and Communications (CFMC). In sample shown in Fig. 2.66 is presented monitoring fleet of fishing vessels operating in regional Kamchatka Branch of CFMC.

The Gonets system has the following advantages: full global coverage including Northern latitudes, system is working even when vessel is rolling and GLONASS/GPS receivers increase the accuracy and reliability of the processed PVT data.

2.2.2.5 Transportation Monitoring and Fleet Management

Gonets satellite system facilities monitoring of vehicles at any latitude and longitude. Subscriber terminals with built-in navigation receivers can track both the position of the vehicle at a time, and the route of its movement (route mode). Coordinate data accessing occurs at predetermined time intervals. When using an attended subscriber terminal along with sending of coordinate information, can be arranged a personal communication on a vehicle (terminal is connected to a PC). When using non-attended satellite terminal, can be automatically collection of the data from telematics devices of vehicle and its transfer to the monitoring centre. In this case, the terminal is joined to the controller, which collecting from vehicle the sensor data of fuel level, container opening sensor, etc.

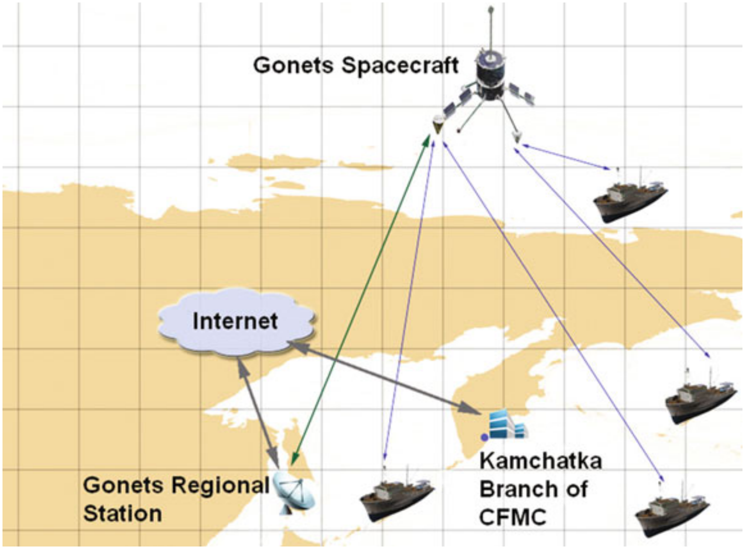

Fig. 2.66 Kamchatka branch of CFMC. Courtesy of manuals: by Gonets

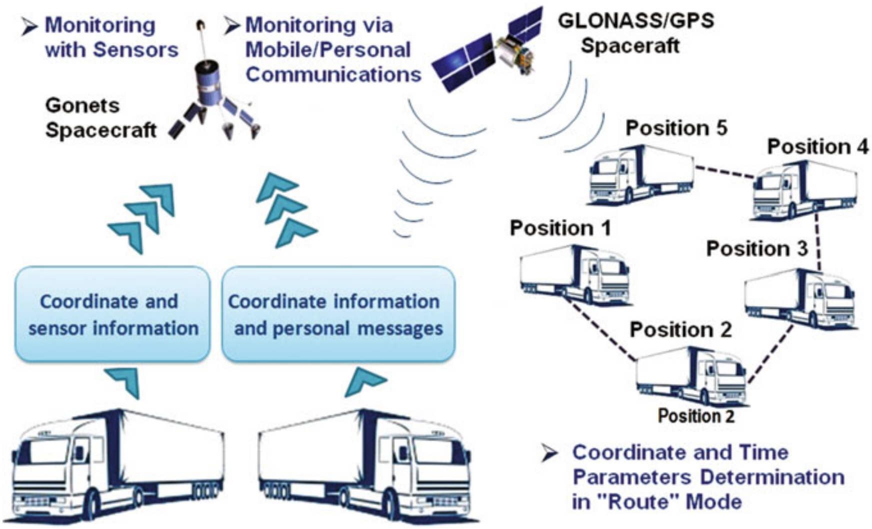

Fig. 2.67 Trucks fleet monitoring and management. Courtesy of manuals: by Gonets

Vehicle monitoring with Gonets Satellite System displays transportation assets location at any place worldwide including areas inaccessible to GSM networks, in which monitoring and management of fleet trucks scenario is illustrated in Fig. 2.67. At present ground-based communication networks provide coverage of

90–95% of Russian federal highways and if moving away from them and going along local roads, customer may often be out of GSM coverage. In its turn, Gonets Satellite System provides communications from any location on Earth, so any interested region or country can provide own monitoring and tracking of own mobile fleet via Gonets network. A transportation asset equipped with Gonets Satellite System terminal with an embedded positioning receiver can automatically receive and transmit positioning and tracking data by Gonets satellite channels to the user monitoring centre. At the same time, Gonets user terminal can be used as a satellite modem providing personal communications at the transportation asset.

2.2.2.6 Monitoring of Oil and Gas Infrastructures

Industrial asset monitoring based on Gonets network delivers very important information from any location worldwide. Gonets system subscriber terminal integrated into an M2M solution periodically reads out instrumentation data from sensors at assets under control.

The fixed Gonets units for SCADA (M2M) monitoring and management are sending data via ground Regional Stations (RS) or Regional Gateway (RG) and Internet network to the Monitoring Centre, which scenario is shown in Fig. 2.68. Before that, all monitored SCADA (M2M) data is received by fixed Gonets Subscriber Communicator (SC) terminals and temporarily stored in the terminal memory and its transmission is performed at Gonets satellite overflying or at an alarm circuit actuation, which infrastructure is shown in Fig. 2.69. As stated above, after that the memorized telematics data is then transmitted to the data processing centre via landline terrestrial telecommunications for further management decisions

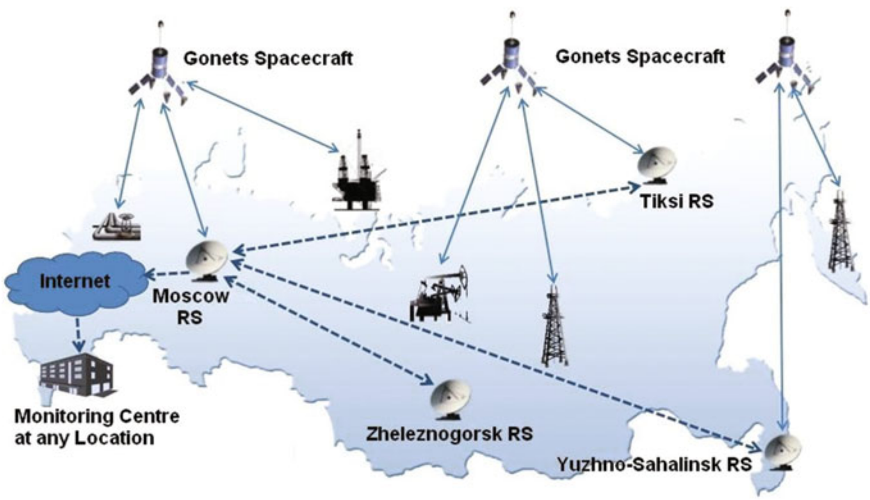

Fig. 2.68 SCADA (M2M) monitoring and management. Courtesy of manuals: by Gonets

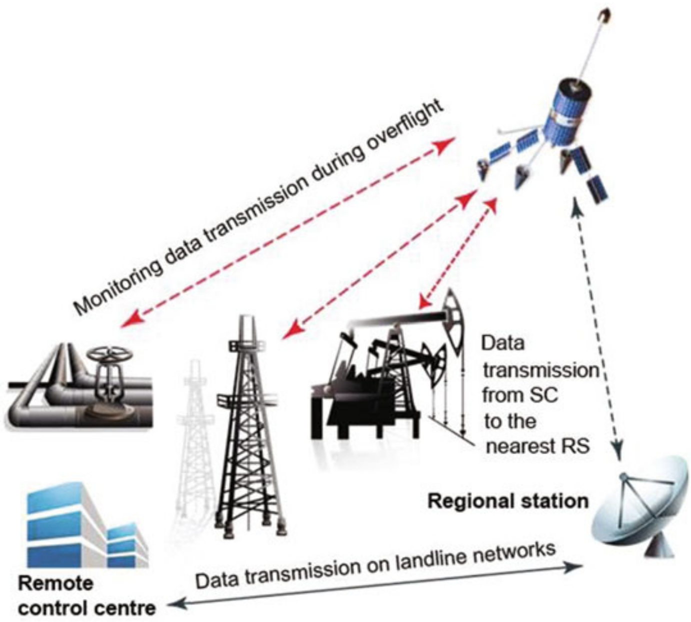

Fig. 2.69 M2M transmissions. Courtesy of manuals: by Gonets

and actions. Among the system application fields are oil and gas industry, power industry, various industrial assets in remote areas, guarded objects, etc.

With the help of Gonets satellite system can be built various monitoring and management systems of M2M stationary objects, such as: secured assets; power grid facilities; natural gas networks, pipelines, drilling platforms, borehole bushes; nuclear industry assets; meteorological stations; other environmental and industrial facilities.

The service is provided with use of Gonets unattended stationary subscriber terminal. The user terminal is connected to an external industrial controller that collects information from various sensors and other equipment. Then the data is passed into the Gonets terminal that generates a message to be sent via the Gonets system. Regular monitoring data as well as event messages (including alert signals) can be successfully transferred from any location on the globe.

With the help of Gonets satellite infrastructure, there is a possibility that various multi-level monitoring systems can be built as well. At this point, if sensors and other equipment are located over a large territory in a remote region, data can be first collected via wired and radio interfaces to a central control unit, connected to Gonets terminal as well. Thus, the accumulated and processed data can be transmitted then via the Gonets satellite system into the Internet and be obtained anywhere with Web-connection. By this way can be also built monitoring systems for environmental facilities, emergency warning systems, as well as any industrial system, where the sensors and other equipment are distributed over a vast territory

Fig. 2.70 M2M station. Courtesy of manuals: by Gonets

lacking communication infrastructure, and where it is expensive to equip each unit with a satellite terminal.

In Fig. 2.68 is illustrated example of M2M (SCADA) monitoring station with Gonets terminal equipment installation on the Azov gas condensate field Gazprom Dobycha near town Krasnodar in Southern Russia. Such kind of M2M station can provide reliable and cost-effective solutions for solving the following possible problems of monitoring systems for the oil and gas industry:

1. Control of booster pump station of gas transmission networks, shown in Fig. 2.70;
2. Control of the pipeline booster stations and data transmission from the sensors (flow, pressure, temperature, pressure drop on the filter, the temperature of the soil, the rate of corrosion, and others);
3. Control of geotechnical studies stations and data collection in control centers of service companies and their regional divisions;
4. Downhole bushes and pipelines monitoring, and data collection in control centers;
5. Signal communications support to petrol garages outside of the service areas of landline telecommunication networks;
6 Control the location and movements of personnel, as well as providing them with personal communication (text messaging); and
7. Optimization and cost saving of vehicle fleet operating, control of driving Safety, accounting and control of petroleum products transportation, control of the units of specialty vehicles and monitoring of ice situation.

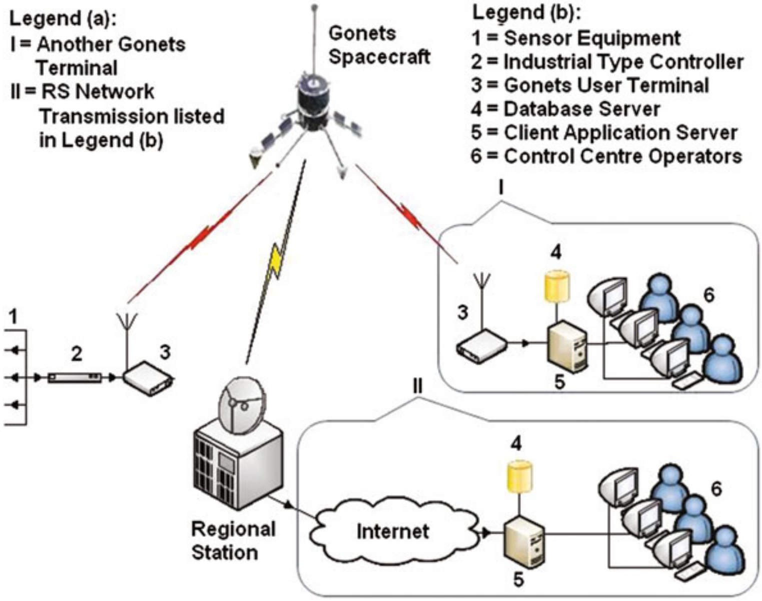

Fig. 2.71 Gonets M2M system. Courtesy of manuals: by Gonets

To be a clearer picture of M2M monitoring and management system design, in Fig. 2.71 is depicted the organization infrastructure for collecting and communication in monitoring systems with use of Gonets satellite network.

2.2.2.7 Gonets Global Wide Messaging System

The system "Gonets-D1 M" supports by standard mail protocols X.400 and SMTP/IMAP. E-mail messages can be transmitted both within the system, when is sent from one Gonets terminal to another one, and to/from external networks, which is shown in Fig. 2.70.

The Gonets transmission system shown in Fig. 2.72 (Left) is point-top-point messaging mode with or without assistance of GES terminal and in Fig. 2.72 (Right) is illustrated special service known as circular message to subscriber group of mobile or fixed terminals.

These both solutions can be connected in Gonets Inter-Regional Data Transmission (IRDT) to improve messaging transfer system.

Therefore, the geographical location of message sender and receiver is not limited, so in such a way, Gonets terminal connected to a PC, allows subscribers to send and receive text messages anywhere in the world. Prospective terminals

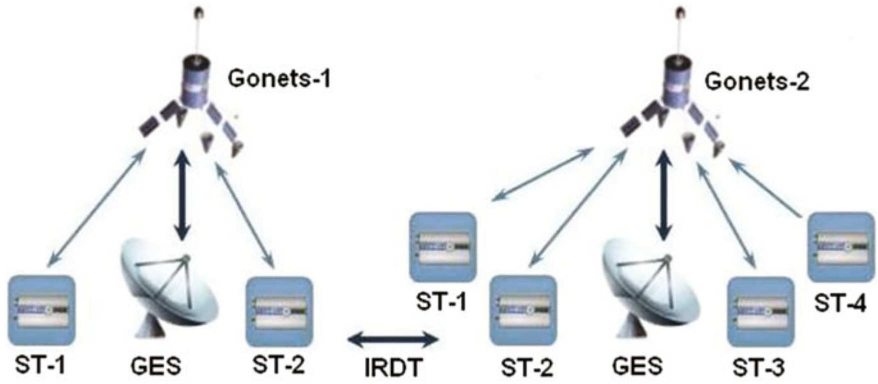

Fig. 2.72 Message service. Courtesy of manuals: by Gonets

passing tests at the moment will allow users to send file attachments. The transfer can be performed in personal and group modes. If the message recipient is in the spacecraft footprint, it is immediately transferred to him. If the recipient is in another region, the satellite transmits the message to the nearest ground regional station, where it is routed via the ground infrastructure according to the location of the message recipient.

2.3 O3b Networks Global MEO GMSC Systems

The O3b Networks is global satellite service provider developing next-generation satellite solutions for civilian mobile, fixed, and Internet service providers, as well as enterprise, private, agencies, and government customers. This satellite system provides billions of consumers and businesses in nearly 180 countries with low-cost satellite connectivity. The O3b is using Medium Earth Orbit (MEO) satellite constellation developed in 2014 for new GMSC service with the speed of fiber for fixed and mobile satellite communications customers. The name O3B satellite system refers to the "Other 3 Billion" and is primarily intended as a backhaul service for terrestrial cellular phones in remote countries that do not have a wire line infrastructure. They will also be serving existing, high-end maritime markets like the cruise and merchant shipping industry.

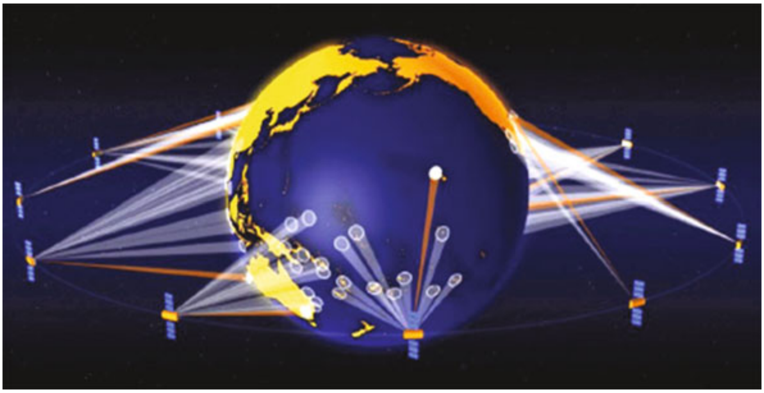

Fig. 2.73 O3b Space Segment. Courtesy of manual: by O3b

2.3.1 O3b Space Segment and Latency Features

The O3b Networks presently consists 12 satellites in a circular MEO constellation at a distance of about 8063 km from the Earth surface, which is illustrated in Fig. 2.73. In the near future O3b planed to launch additional 8 MEO spacecraft.

The O3b MEO satellites are High Throughput Satellites (HTS) with latency of 110–130 ms roundtrip, which comparison with GEO and LEO satellites is shown in Fig. 2.74. Thus, the HTS constellations are used for communications, whether commercial or in areas where traditional terrestrial infrastructure is unavailable or unreliable, circle the Earth in three orbits: GEO, MEO, and LEO. A GEO satellite follows the direction of the Earth's rotation from 36,000 km above the equator and appears as a stationary, static point to any observer or antenna tracking it on the ground surface. While used for applications such as broadcast communications and

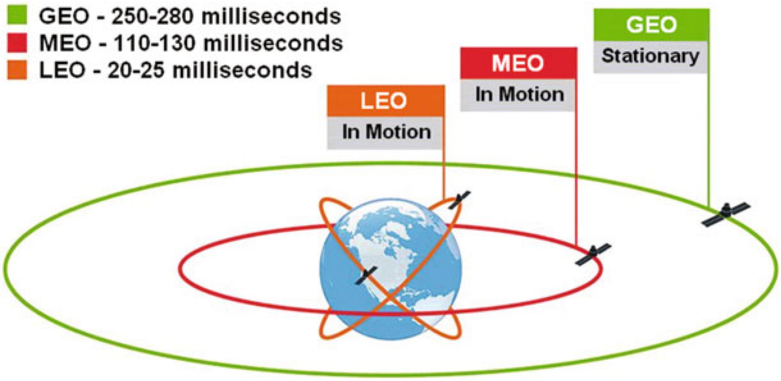

Fig. 2.74 Latency roundtrip for three satellite orbits. Courtesy of manual: by Harris Caprock

weather satellites, communication through a GEO system becomes more difficult as the ground observer's latitude increases the further North or South it travels due to occurrences such as atmospheric refraction, thermal emission, LOS obstructions and signal reflections from structures on the ground.

The LEO constellation applies to objects in motion from 700 to 2000 km above the Earth, which includes all manned space stations and the majority of satellites. Moving objects in a MEO system, often called "fiber-in-the-sky," at approximately 2000–20,000 km above the Earth. The primary difference between MEO and LEO satellite systems as compared to the majority of communications satellites in GEO constellations is altitude and latency. Location is everything, so MEO and LEO satellites travel overhead at all times, instead of tracking with a fixed point on Earth as GEO satellites do. This type of orbit allows them to provide constant coverage through a constellation of several satellites that are closer to Earth, offering a significant performance advantage with low latency. On the other hand, the LEO constellation need inter-satellite links to provide global coverage and their payload cannot carry heavy transponders for professional solutions, such as GEO for TV and Direct Broadcasting, DVB-RCS, GNSS and some military communication satellites.

The MEO constellations have the same disadvantages, in particular O3b is not really a global system, because its real coverage is between 45°N and 45°S latitude and it cannot be used as reliable system for all mobile applications. In addition, although O3b is providing HTS of about 100 Gb/s, very professional GEO satellites ViaSat-1 and EchoStar XVII provide more than 100 Gb/s of capacity, which is more than 100 times the capacity offered by a conventional Ku-band satellites. Thus, when it was launched in October 2011 ViaSat-1 had 140 Gb/s throughout, which is more capacity than all other GEO or MEO commercial communications satellites worldwide. Interest in using HTS Ku and Ka-band satellites is growing due to their unique capabilities to provide target satellite coverage, spectrum efficiency, lower cost per Mb/s and Ka-band satellites provide unprecedented throughput when compared to traditional C- and Ku-band satellites and by terrestrial networks.

In some presentations of O3b, system is described latency over GEO satellites as very bad influence on voice transmission. For the purpose of mitigation of this statements here will be introduced few techniques for improvement of latency over GEO satellites such as reduction of delays in voice transmissions. Latency-related service quality can be improved by giving the sending end the acknowledgment that it expects even before the distant end has received the word or group of words. Additional term that is used to describe this is protocol spoofing. The impact of latency is very much application-dependent and not just about the distance to the Earth. For example, GEO satellites have been used for decades as a backhaul to cellular networks and new satellites with the latest in echo cancellation and IP acceleration provide high-quality voice services that are perfectly acceptable for all mobile consumers. After cost, latency is another big reason why satellite networks are challenging for mobile operators. This affects the response time of cellular 3G/4G data applications when sent over satellite, which is resulting in wasted satellite capacity, link under-utilization and poor performance. At this point, there are limited solutions to improve latency, but what can be done is look at the application side to help mitigate the effects of latency. Besides, here caching also helps as a way of reducing latency.

Another method is Transmission Control Protocol (TCP) acceleration, which with the Intelligent Backhaul Optimizer (IBO), the 3G protocols is decoded to access the TCP connection for each mobile user data stream and applies TCP/IP acceleration. As well as minimizing latency, this also reduces satellite bandwidth needs, enhances mobile users' experience and network performance, increases network throughput and improves network response times and reliability. The TCP standard is subject to a number of limitations on a WAN that severely affect its performance, which expand accelerator's TCP acceleration (PEP) overcomes to increase performance for all TCP applications. However, employing the US NASA Space Communications Protocol Standard (SCPS) accelerator acts as a transparent TCP proxy to all TCP traffic to overcome latency by using a variety of techniques, such as enlarging transmission windows for higher throughput, overcoming TCP slow-start and advanced congestion-avoidance mechanisms. The piece of equipment that accomplishes the task of pacifying the sending end is called a protocol gateway The basic arrangement and operation of a protocol gateway is shown in Fig. 2.75 using the TCP/IP connection-oriented protocol from the Internet Protocol (IP) suite, so a protocol gateway converts between TCP/IP and a satellite protocol that is optimized for the delay and error rate properties of the satellite link.

Along with SCPS acceleration mode, a number of other features help deliver significantly better application performance for satellite users in a number of ways. Also as more satellite traffic is data transfer in nature, latency has very little, if any impact on most broadband, media, and mobility applications and the user experience. This is something that experts continue to watch as 4G and Long-Term Evolution (LTE) networks are deployed. So far, progress made on ground software to maximize IP and Web searching efficiency has minimized latency as a concern.

The optimization over satellite is conducting by Performance Enhancement Proxy (PEP) technology, which can mitigate the effects of GEO latency, help fill the

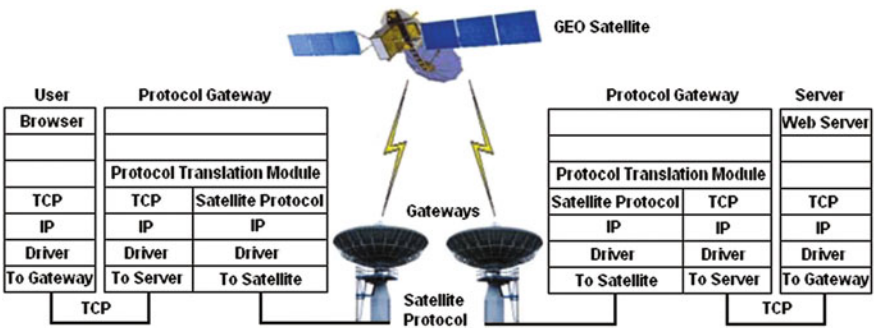

Fig. 2.75 Protocol gateway infrastructure of GEO satellite system. Courtesy of manual: by Ilcev

link with data and improve network performance. Installing a pair of PEP solutions at either end of a satellite link can trick each local network into believing the remote, satellite-linked network is right next door. However, not all PEP modes are alike, and bundled satellite modem PEP modes are constrained in their capabilities and deliver limited results.

Unlike simple PEP modes, the expand accelerators apply a mix of TCP acceleration, link conditioning, compression and specific acceleration techniques to increase the performance of applications despite the degraded conditions. They offer extensive caching, compression, and QoS capabilities to overcome congestion and latency on the WAN to provide the most effective use of the available bandwidth. Expand also offers advanced technologies such as packet fragmentation, which reduce the effect of large file transfers and similar applications on sensitive real-time traffic such as VoIP and server-based computing such as Citrix/MS Terminal Services/Virtual Desktop Infrastructure (VDI).

In addition, HTS constellations provide high bandwidth up to 140 Gb/s depending on size and frequency use per satellite, including up to 2 Gb/s within a spot beam. As stated above, except O3b MEO constellation, also GEO satellite systems such as ViaSat-1 and EchoStar XVII offer HTS at 100 Gb/s of throughout. While Non-HTS constellations provide 1–10 Gb/s throughout depending on number of transponders. In such a way, modern HTS constellations provide increased bandwidth for a lower cost per pit with preferred solution for point-to-point very high-speed broadband satellite communications. On the other hand, traditional Non-HTS constellation provides point-to-multipoint satellite communications such as television (TV) broadcasting as well as large VSAT networks. In Fig. 2.76 is illustrated comparison between HTS and Regular (Non-HTS) satellite coverage.

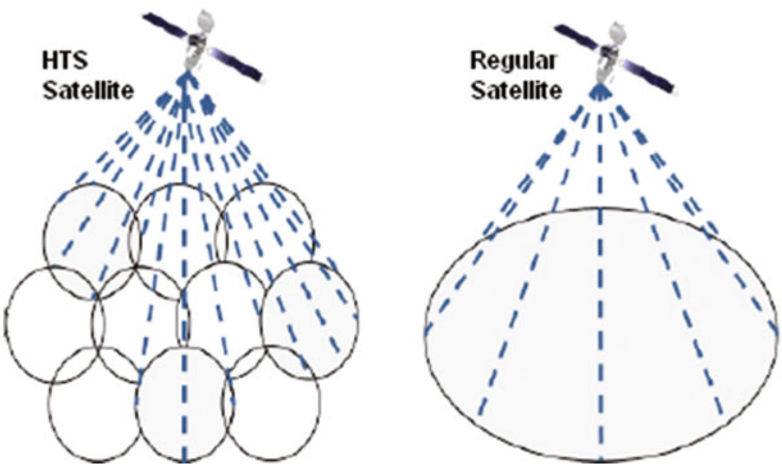

Fig. 2.76 Comparison of HTS and not-HTS satellite coverage. Courtesy of manual: by O3b

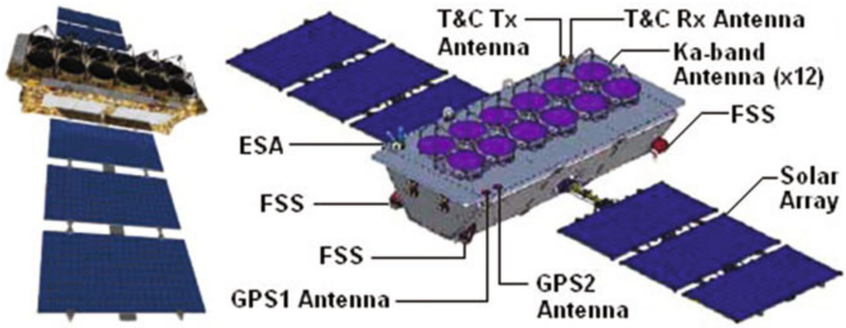

Fig. 2.77 O3b spacecraft with components. Courtesy of manual: by O3b

Each HTS O3b satellite contains 12 fully steerable Ka-band spacecraft antennas for spot beams of which 2 will target the terrestrial GES (Gateways) and 10 will target the coverage areas. Each beam will have a throughput capacity of 600 Mb/s in both directions. The beam footprints have a diameter of about 600 km on the Earth's surface between 45°N and 45°S latitudes and will be dynamically steered as the satellite moves around the Earth, to cover the required service areas and skip over the unpopulated or non-contracted areas. Eight MEO satellites will be spaced 45° apart in a non-inclined orbit at about 8062 km around the equator with 288 min orbit period.

The O3b Network provides the following features: Lifetime is 10 years; orbital inclination is <0.1°; ground period is 360 min with 4 contacts per day, in total 10 beams per region in seven regions are providing 70 remote beams per 12 satellite constellation; up to 1.2 Gb/s per customer beam (800 Mb/s × 2) and 84 Gb/s are available per eight initial satellite constellation; satellite beam coverage is 700 km in diameter; transponder bandwidth is 216 MHz or 2 × 216 MHz per beam; and channel bandwidth is 216 MHz. In Fig. 2.77 are illustrated O3b spacecraft (Left) and satellite components (Right).

Therefore, the O3b satellite network is focusing on higher capacity fiber-like latency and bandwidth that is significantly lower in cost. From its low altitude, latency is dramatically reduced bringing it on par with a long haul fiber transmission. Operators can now consider satellite technology for applications that are latency sensitive. Thus, O3b's Network Space Segment utilizes multiple spot beams coverage that significantly increases each satellite's capacity and decreases the cost of bandwidth.

2.3.2 O3b Ground Segment

The Customer Terminal Management (CTM) maintains a watchful eye on O3b Network when some warnings or problems occur O3b proactively troubleshoots and restores service where necessary. The CTM service is delivered from O3b's Network Operations Centre (NOC) in Manassas, Virginia, USA and is governed by strict service level agreements to underpin service uptime and availability. O3b's collocation service enables customers to leverage O3b's gateway facilities to host their specific users equipment, for example, security devices, accelerators or traffic shapers. Thus, O3b provides the usual collocation services for fixed and mobile customers including installation and smart hands capabilities. The ground collocation services leverage O3b's gateway facilities in the coverage area and Points of Presence to provide the convenience of local onsite collocation service. However, installation and commissioning services leverages O3b's Network Management expertise to provide a fast, proactive and expert response and resolution to System issues.

The O3b ground segment provides a global satellite communication network of gateways (GES) strategically located on the Internet backbone enabling flexible, reliable, and secure connectivity options for fixed and mobile customers, which current locations inside O3b satellite coverage are illustrated in Fig. 2.78. Light blue dots are gateways (GES) or teleports location, while dark blue dots are Points of Presence (POP). As stated earlier, the O3b satellites provide standard service between 45°N and 45°S latitudes, and beyond this area the service for all customers is limited. The limited service area of O3b satellites is between 45°N and 62°N, so entire Canada, northern Europe, and Russia are out of standard coverage. At this point, O3b satellite network is not fitted at all to be service operator for professional mobile users such as maritime and aeronautical transportations systems. The second limited area between 45°S and 62°S is not important for mobile communications.

The O3b ground segment offers the collocation service at its gateway facilities in order to enable additional customer provided functionality, which gateway facilities are shown in Fig. 2.79 (Left), while corporate customer facilities are depicted in

Fig. 2.78 O3b ground segment. Courtesy of manual: by O3b

Fig. 2.79 Gateway and corporate customer facilities. Courtesy of manual: by O3b

Fig. 2.79 (Right). This service enables all customers to conveniently house their equipment alongside the O3b solution in a secure and environmentally controlled equipment room. Thus, customers can purchase one or multiple rack units in order to house their equipment how is proposed in O3b technical specification.

2.3.3 O3b Users Segment

The O3b users segment provides serves for the following mobile and fixed applications: Offshore, Maritime, Mobile Backhaul, IP Trunking, and Government.

1. **Offshore Communications**—This service is known as O3b Energy offers the performance of fiber with the flexibility of satellite delivered cost-effectively and reliably. O3bEnergy is one of satellite solution that matches offshore customers with their sea and road transport systems, which is designed to meet the performance needs of communication network in the future, which integrated scenario with SES GEO satellite system is illustrated in Fig. 2.80. The O3bEnergy system offers reliable and unlimited scalable bandwidth inside of standard service coverage. It directly addresses crew productivity with cloud and big data systems, centralization for multiple platforms and even onboard crew welfare and retention. The O3b's satellite beams can blanket a region that contains multiple platforms, providing high throughput to major regional POP stations. With O3bEnergy, fixed and mobile customers get scalable, cost-effective data rates from 20 Mb/s to 400 Mb/s per site. In such a way, the system utilizes Internet, leased line and IP/MPLS connectivity and state-of-the-art modem technology including satellite DVB-S2 standard Adaptive Coding and Modulation (ACD) and header compression to provide fiber-like performance.
2. **Maritime Communications**—This service is known as O3bMaritime offers possibility for some improvement in maritime communications, in particular for cruise vessels. On shore, the old days of voice communications as the primary

Fig. 2.80 Offshore fixed and mobile applications. Courtesy of manual: by O3b

means of staying connected are long gone and the same is now true at sea. At this point, for the first time, O3bMaritime delivers impressive broadband experience at sea providing unrivaled guest satisfaction, increased revenue generation, enhanced crew welfare and the potential for greater onboard ship IT operational efficiency for cargo and cruise operators. The new O3bMaritime solution of high-speed service to cruise ships and luxury yachts in the Caribbean area uses the latest technology in advanced stabilized tracking antennas and high-speed model technology. Thus, O3b's service and solution provider partners can arrange a fully managed end-to-end service including the equipment at the O3b gateway infrastructure, shipboard equipment, site survey, installation, commissioning, daily monitoring and maintenance services.

In Fig. 2.81 is depicted new solution of O3b steerable beams tracking of ships and in particular cruise vessels. The satellite beams follow tracks on ship's normal route and beam tracking updates in real-time if the ship has to change course. This system is maintaining ship within beam centre, receives latitude and longitude updates on 2 h intervals via in-band or out-of-band channel by the 1.2 or 2.2 m stabilized terminals. Dual tracking antennas provide seamless handover at end of pass and in case of blockage and so-called GigE interface to the LAN in the ship's data centre. Third hot-standby spare antenna and spare modem are for redundancy, while Internet access at major peering points from O3b regional gateways. With connectivity speeds of the system is providing over 500 Mb/s and round trip latency of 130 ms; however, there are connectivity options Up to 350 Mb/s from shore-to-ship direction and up to 50 Mb/s in reverse direction. Same as is available onboard oceangoing ships today, new O3bMaritime system provides broadband connectivity in its limited coverage. Namely, existing 3G and 4G devices will work as seamlessly at sea as they do on land. Voice calls carried over O3b's low latency network will sound clear with no delay. Network response will be fast and all

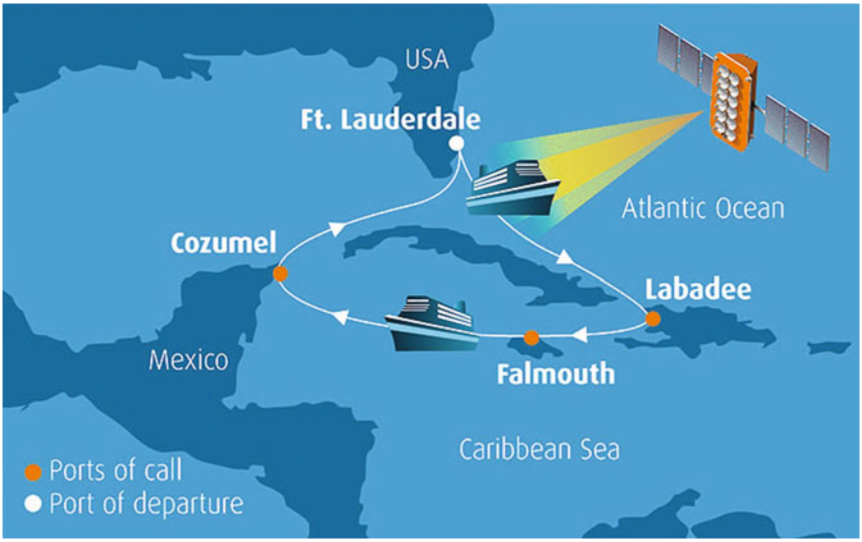

Fig. 2.81 Steerable beams tracking of cruisers. Courtesy of manual: by O3b

applications bandwidth can be supported. Music downloads and live video streaming, Skype and other VoIP services can all be carried with performance and experience comparable with an office or home environment.

However, the O3b Network is not so ideal as is introduced in their presentation. In fact, as stated above, modern ViaSat-1 GEO satellite constellation provides up to 1 Gb/s speeds for use in maritime, oceanic and other corporate applications such as oil and gas platforms. In addition, author of this books as ex-master mariner is very positive that O3b service for ships can be used on cruise vessels just for entertainment and because of limited coverage cannot provide service for oceangoing ships at all. Presently maritime industry has better service and global coverage provided by Inmarsat, Iridium and VSAT operators.

3. **Trunking Communications**—This O3bTrunk connects carrier networks to IP Trunking remote and emerging geographies at unparalleled speed, quality, and low cost. Using O3b's network of international POP terminals, regional gateways, and local satellite access, O3b delivers high-speed, carrier-grade access between the core network and the global Internet backbone. Optimized with a variety of user network solutions, O3b has scalable bandwidth offerings to provide flexible solutions tailored to keep costs in line with revenue.

As stated earlier, O3b satellite network provides O3bCell service as mobile backhaul with high-performance 3G and 4G to rural areas. Finally, O3bGovernment works with local and international technology partners and solutions integrators to deliver the flexible, secure and cost-effective broadband solutions necessary for defense, border security, humanitarian response, diplomacy and rural development.

2.3.4 O3b Users Terminals

In this section will be introduced three versions of O3b satellite terminals:

1. **Comtech O3bTrunk + VSAT Station**—This terminal is O3b fiber alternative for fixed and mobile trunking applications, which is depicted in Fig. 2.82a. O3bTrunk+ meets the growing demand for Internet connectivity in underserved regions and onboard mobiles, providing an alternative in areas that are already served by fiber. This terminal combines the latest innovations in modem and application acceleration technology from Comtech EF Data and advanced signal processing from EMC Satcom Technologies. Combining both technologies enables capacity in a single beam to increase up to 50% and its service scales up to 1.3 Gb/s throughout.
2. **Gilat meoEdge VSAT Station**—This is high-performance MEO/O3b satellite terminal for fixed and mobile applications, which is depicted in Fig. 2.82b. The O3b VSAT is product supported by the most advanced modulation technologies such as DVB-S2 ACM and with MF-TDMA DVB-RCS-based and DVB-S2 ACM Continuous Carrier (SCPC) access scheme. This terminal offers high-speed Internet service, VoIP, video conferencing, mobile backhaul and corporate data network applications with service rates up to 24 Mb/s.
3. **ViaSat MEOLink VSAT Station**—This IP trunking terminal enables fixed, mobile and ISP providers to offer fiber-like performance for high-speed Internet services over O3b's MEO satellite constellation, which is shown in Fig. 2.82c. This terminal includes precision tracking antennas, the high-speed DVB-S2 MEOLink modem, and an advanced uplink power control system, which operations are coordinated with the fully automated MEOLink monitor and control system. Integrated ACM with modulations up to 32 APSK enables Ethernet data rates up to 810 Mb/s in each direction. To optimize forward channel efficiency based on the application, the MEOLink modem can be used in point-to-point and point-to-multipoint networks.

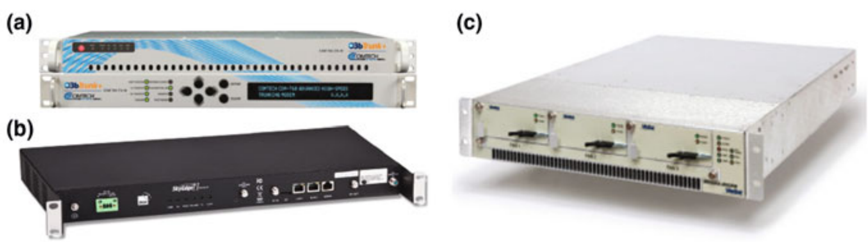

Fig. 2.82 O3b fixed and mobile terminals. Courtesy of manual: by O3b

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