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Use and examples of mobile-satellite service systems for relief operation in the event of natural disasters and similar emergencies

M Series

Mobile, radiodetermination, amateur and related satellite services

International Telecommunication Union

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REPORT ITU-R M.2149-1

Use and examples of mobile-satellite service systems for relief operation in the event of natural disasters and similar emergencies

(Questions ITU-R 286/4 and ITU-R 227/4)

(2009-2011)

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1 Introduction

This Report describes how mobile-satellite service (MSS) systems can provide disaster relief radiocommunications. In addition, it provides descriptions of the operating and planned MSS systems which can provide such operations.

The wide coverage area of an MSS system is particularly helpful as the location and time of occurrence of a disaster event is unpredictable and as an MSS system operation is typically independent of local telecommunications infrastructure which may be lost by the disaster event, and given that MSS systems have wide-area earth coverage, they can provide for disaster relief telecommunications. Furthermore, most mobile earth stations (MESs) are battery powered and so can operate for some period of time even if the local electricity supply is non-functioning and moreover some MESs also come with solar and/or wind chargers.

Since MSS systems do provide very large coverage areas, spectrum coordination is accomplished on a regional or global basis. Each system is constrained to operate on frequencies authorized by Administrations as identified in Recommendation ITU-R M.1854.

1.1 The impact of orbits and satellite network architecture on coverage

All low Earth orbit (LEO) and geostationary-satellite orbit (GSO) MSS systems provide service to very large coverage areas compared to terrestrial-based systems. In addition, some LEO MSS systems can also provide full earth coverage, including coverage of the polar areas, provided that some conditions are met. The coverage of a LEO system depends on the inclination of its orbit, as well as the architecture of the system. Systems with satellites orbiting at lower inclination angles may not be able to cover polar regions, while systems with satellites orbiting at higher inclination angles close to 90º can cover the polar regions.

Two different LEO system architectures have been employed. One is the bent-pipe architecture, by which the satellite acts like an RF transponder between the user terminal and a gateway. This architecture requires that both the user terminal and a gateway station are visible to the satellite at the same time in order to allow the user terminal to access to the system.

The second architecture is based on forming a “network in the sky” through use of inter-satellite links (ISLs). The satellites perform on-board processing and routing operations. Such a system provides full earth coverage and does not require a terrestrial gateway in the footprint of the serving satellite. The “network in the sky” provides wide area coverage without the accessibility constraints mentioned with respect to the bent pipe architecture. In fact a single gateway any place in the world is sufficient to provide access to the system, however for more than one gateway accessibility is ensured.

The bent-pipe architecture is also used for GSO MSS. However, with GSO MSS, the visibility limitation is of practically no constraint in view of the fact that at least one gateway station is always visible.

Some currently operational GSO MSS systems also have a multiple high gain spot beam design, which provides the capability of digital beam forming and allows reconfiguration of the coverage and distribution of the system resources (spectrum and power) as and when needed. GSO MSS systems can provide wide-area coverage without the use of ISLs or multiple gateways.

2 Modes of usage of MSS systems for disaster relief communications

There are two modes in which MSS systems can be applied for disaster relief communications. One is to operate the MSS system directly, providing portable handheld or transportable telecommunications between MSS terminals and the global infrastructure. The other is to interface between a local terrestrial-based system and the global infrastructure, by providing satellite-based backhaul services.

2.1 Direct application of the MSS in disaster relief operations

The MSS systems currently in operation are able to provide voice and data radiocommunications and access to the Internet. Further, these systems can facilitate access to public and private networks external to the MSS system. Some currently operating LEO systems as well as a GSO system support an application known as "short message service" (SMS) that provides the ability to transmit or broadcast short text messages directly to handheld terminals. The GSO system also supports geo mobile packet radio service (GMPRS) which is the GPRS service over a satellite directly to handheld terminals thereby enabling such handheld terminals to access Internet.

MSS systems are also well suited to providing the distribution of information over widespread areas and of collecting information from remotely located transmitters over these same widespread areas.

The information disseminated can be used to warn of impending disasters or to announce relief provisions. Information useful in predicting impending disasters can be easily collected using unattended, remotely located transmitters. MSS systems may be used in conjunction with sensor or local environmental data collection systems to transmit such data back to a central location that would be responsible for making decisions based on this retrieved data.

2.1.1 Practical use of an MSS system for application of video image transmission

One possible example of applications for disaster relief communications using a GSO MSS is transmission of static or moving picture of suffered area in order to inform the rescue centre of the sufferers and/or a stricken area as a real on-going event and to help the centre to consider relief actions. It is thought to be very effective to see the actual scene in real time image for urgent relief activities. For the purpose of the transmission of video image, an MSS system, that has an ability to transfer data in the rate of more than 64 kbit/s at least, could be used.

Here two types of transmission of static and/or moving picture are shown. One is the use of integrated services digital network (ISDN) and another is the use of internet. It should be noted that ISDN is used in Japan and certain European countries.

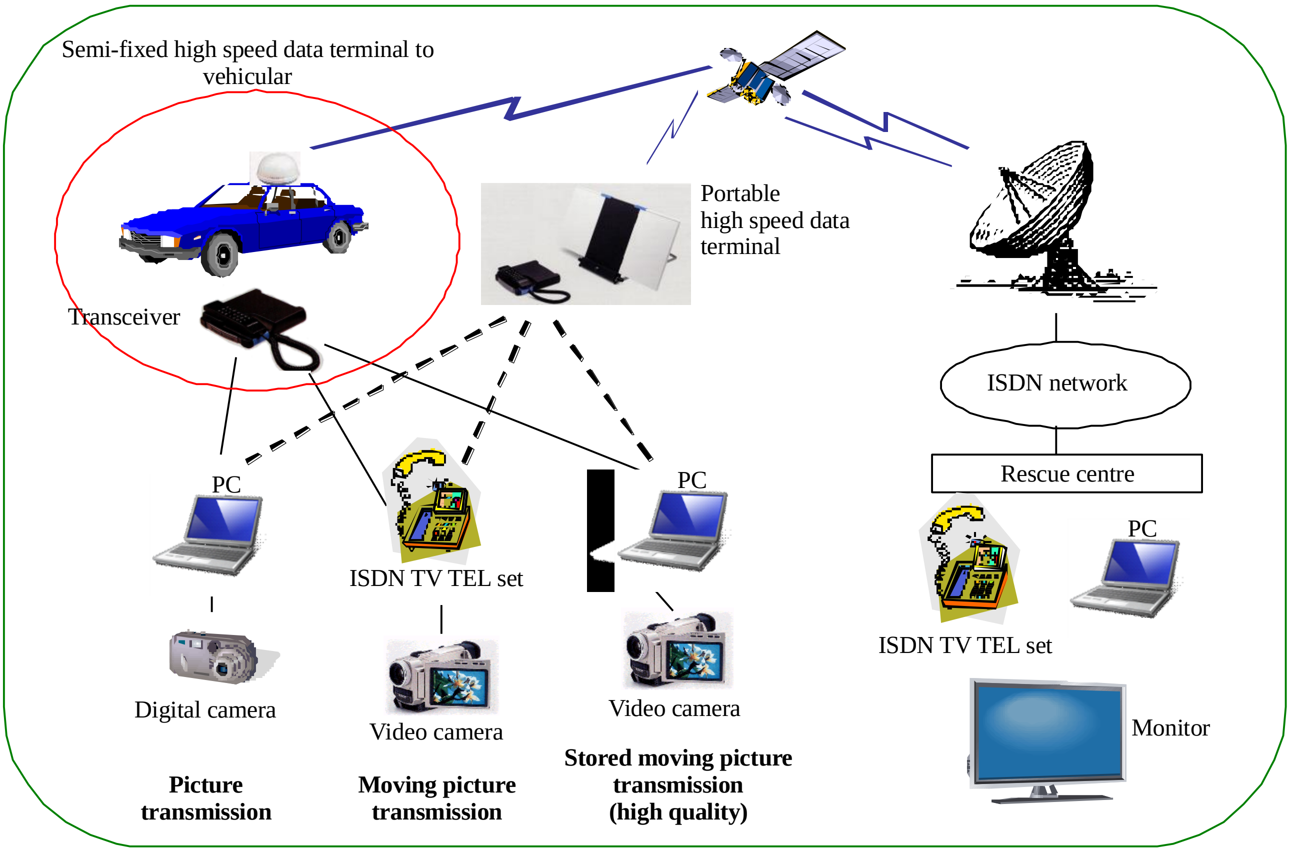
Use of ISDN

Here ISDN is used to transmit data of pictures in 64 kbit/s between rescue centre and stricken area. Example system and general concepts of the network structure are depicted in Fig. 1. The MSS earth station has function to process No. 7 signalling system and also ISDN protocol. The MSS terminal can be used in the stricken area as a portable high speed data terminal, that can be easily transportable and installable, or a semi-fixed high speed data terminal to vehicular. The MSS terminal has interface port of ISDN user interface and serial data port to connect with personal computer (PC). ISDN video phone has a function to connect to user ISDN switch on the terrestrial side and it has connection port with handy digital video camera. This video processing function realizes transmission of real time moving picture and is easy to operate. Another way to transmit static or moving picture is to use PC with some suitable application software, that processes capturing video image, coding the video data, storing it in PC's hard disc, and transfer the stored data to addressed user's PC when the link between two PCs is once connected through the MSS system.

This kind of system can be easily and urgently deployed and catch the required information on sufferers and disaster in the stricken area.

FIGURE 1

Example-Static and/or moving picture transmission with use of MSS via ISDN network



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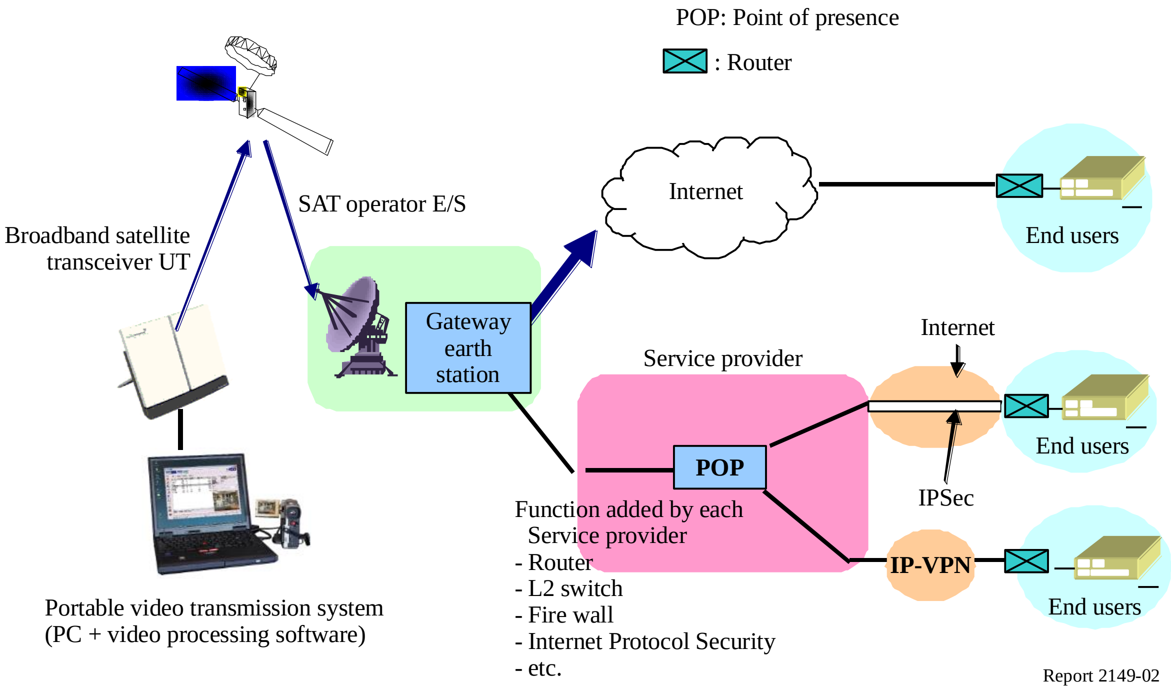
Use of Internet

Here Internet is used to transmit data including video information in packet data transmission base between rescue centre and stricken area with use of TCP/IP. One example system and general concepts of the network structure are depicted in Fig. 2. The MSS earth station has function to process TCP/IP. The MSS terminal can be used in the stricken area as a portable packet data transmission terminal, that can be easily transportable. The MSS terminal has data port to connect with PC. A way to transmit static or moving picture is to use PC installed with some video processing application software, whose function has capturing video image, coding the video data, storing it in PC's hard disc, and transfer the stored data to addressed user's PC when the link between two PCs is once connected through the MSS system.

FIGURE 2

Example-static and/or moving picture transmission with use of MSS via Internet



2.2 Combining terrestrial and satellite network components

2.2.1 Satellite component for backhaul of emergency terrestrial services

One example of disaster relief radiocommunications using an MSS component is the backhaul of traffic from an emergency terrestrial replacement system to the global network. A small cellular telephone system or pico-cell can be set up to provide emergency terrestrial radiocommunications over a limited area, thus replacing the function of non-functioning or destroyed terrestrial facilities. Radiocommunication with the rest of the world is provided through satellite links to gateway earth stations.

Figure 3, depicts the MSS linked cellular pico-cell system used as a backhaul for a cellular pico-cell. The backhaul can be provided by GSO or non-GSO MSS system. In this example, the MSS linked cellular pico-cell consists of multiple voice-only satellite phones and one voice/data satellite phone. This provides for multiple simultaneous voice links or a combination of voice links with one 9.6 kbit/s data link.

The multiple voice-only satellite phones and one voice/data satellite phone have been placed into a large movable case for easy deployment to disaster areas or other remote locations in need of satellite communications.

The cellular pico-cell system consists of:

– Pico-cell control unit (integrated mobile switching center /home location register /visitor location register/base station controller).

– Modular base transceiver station (BTS) (transmit and receive) units.

– Bank of six MSS phones for communications with the terrestrial telephone network via satellite. One of the voice channels can be used for data instead of voice.

The pico-cell control unit:

– Controls the operation of the BTS unit.

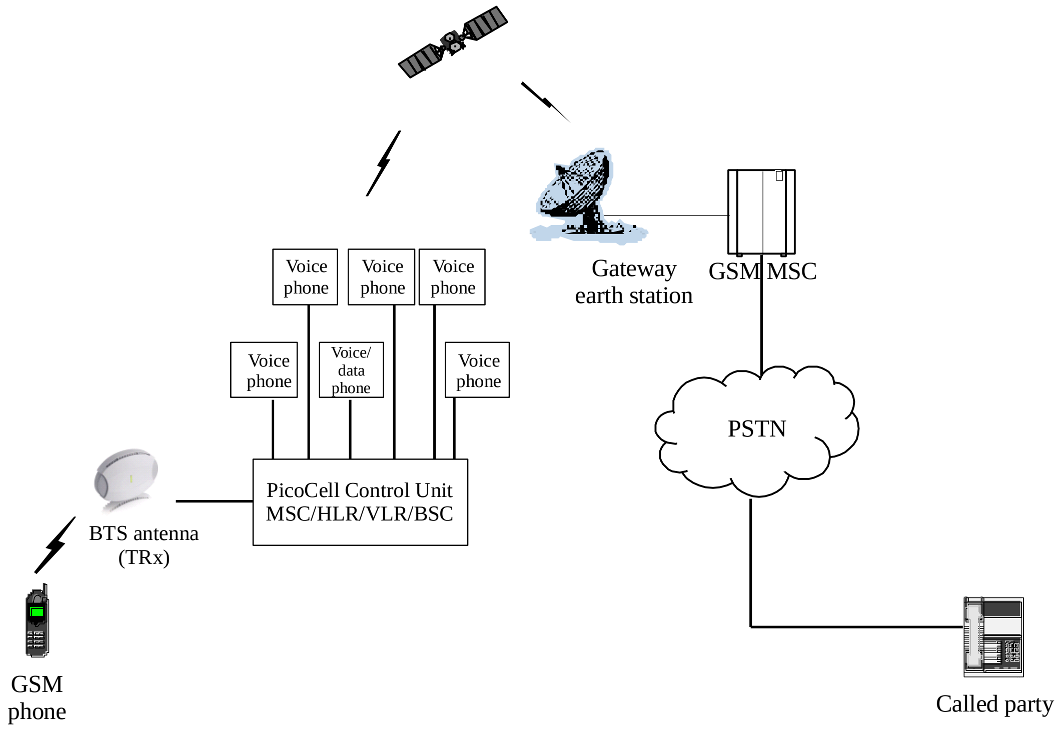
– Allows local phones to communicate directly with each other.

– Provides links between local cell phones and other telephone networks.

This pico-cell solution is scalable on both the pico-cell control unit side which can handle many more BTS units and the MSS side, where additional 2 way trunks can be provided. At the MSS gateway earth station, a special control unit to interface between the MSS links and the global system for mobile communications (GSM), networks is installed.

FIGURE 3

Cellular pico-cell linked to the public switched telephone network (PSTN) through an MSS system



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2.2.2 Satellite component for emergency backhaul for private terrestrial networks

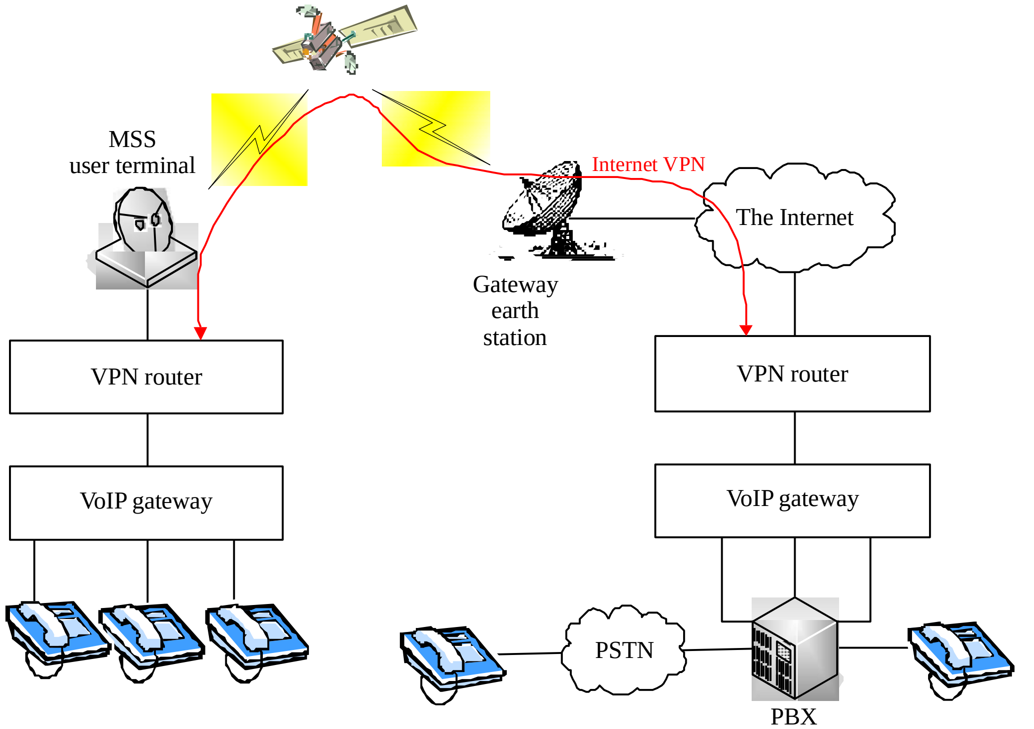
An MSS satellite link can be used also to provide emergency radiocommunication to a private network, thus replacing the function of non-functioning or destroyed terrestrial facilities. Radiocommunication with the rest of the world is provided through satellite links to Gateway earth stations. Such use of the Internet protocol (IP) virtual private network (VPN) in combination with an MSS system is useful and available in the event of disasters.

Figure 4, depicts the MSS linked internal telephone line system used as a backhaul for the fixed telephone network. The MSS linked internal telephone line system consists of several voice channels only through a satellite IP network by using Voice over IP (VoIP) configuration if allowed by concerned Administrations. This provides several simultaneous voice links. The capacity of telephone channels depends on the capacity of MSS link and voice coding method (ITU-T Recommendation G.729 a is sufficient for communication instead of ITU-T Recommendation G.711).

Figure 4 shows how a call would be handled.

FIGURE 4

Internal telephone line system linked to PSTN through an MSS system



2.2.3 MSS networks with complementary ground component

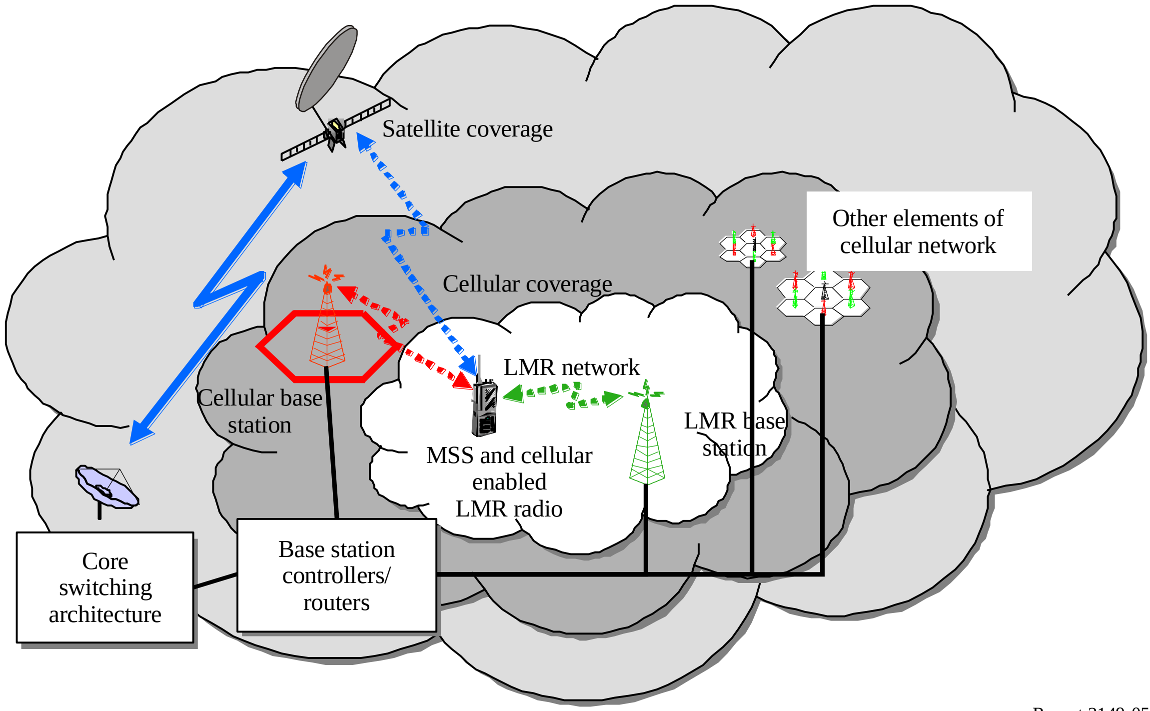
A number of MSS satellite networks are being developed with a complementary ground components (CGC) that are suited to enhancing radiocommunications in disaster and emergency situations. In such networks the ground and satellite components are controlled by the same satellite network management system and the ground component uses the same portions of MSS satellite frequency band as the associated operational mobile-satellite system. ITU-R is conducting studies in accordance with Recommendation 206 (WRC-07) – Consideration on the possible use of integrated mobile-satellite service and ground component systems in some frequency bands identified for the satellite component of International Mobile Telecommunications.

An integrated mobile satellite and terrestrial network would consist of one or more multi-spot beam MSS satellites and an in-band network of terrestrial base stations and user terminals. Figure 5 is an illustration of such an integrated network. The user terminals would be capable of communicating with the mobile satellite or a terrestrial base station using the same MSS frequency band. Thus, whereas the service provided by current generation MSS systems may be unavailable in urban areas due to signal blockage, an integrated mobile satellite and terrestrial network can provide the wide-area coverage of an MSS system as well as the urban coverage of a terrestrial system. All satellite and terrestrial communications are managed by a common network control system to maximize efficiency, manage frequency use, and to ensure availability of spectrum resources where needed.

A public safety architecture could use a flexible system to accommodate different technologies. This approach permits an existing land mobile radio (LMR) system to also use the resources of the integrated satellite and terrestrial network. This approach makes available different radiocommunication modes, allowing one mode to provide services when another mode might be unavailable. Such solutions are only beginning to be tested, but it is apparent that traditional LMR systems can be provided along with a satellite and terrestrial handset that automatically switches between cellular and satellite systems (depending on which is available).

FIGURE 5

Integrated MSS, cellular and LMR network



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To ensure adequate coverage and capacity in the case of emergencies, satellites capable of serving small and hand-held user devices and with the ability to provide advanced features such as push-to-talk capabilities, the ability to focus capacity to affected areas and to provide high-speed radiocommunications would be beneficial.

Several countries have recognized the benefits of such complementary ground systems and have authorized a ground component to MSS for the purpose of providing these kinds of services.

3 Examples of MSS systems which can provide disaster-related communications[1]

This section provides examples of MSS systems which can provide disaster-related communications.

3.1 Iridium (HIBLEO-2)

The full description of the HIBLEO-2 system can be found in the ITU-R Handbook – Mobile Satellite Services. The following is a summary of the systems capabilities which make it

[1] Some MSS operators have entered into agreements with the ITU for provision and facilitation of telecommunications services during emergencies and disaster situations and for relief operations (see http://www.itu.int/en/ITU-D/Emergency-Telecommunications/Pages/PartneringforDisasterReduction.aspx).

particularly suitable to applications of disaster relief operation and early warning of natural disasters and other emergency events.

– a network in the sky architecture, using ISLs, combined with satellite on-board processing and routing, resulting in full global access to the system through a single gateway;
– no reliance on local regional infrastructure, gateway or ground routing for full global operation, thereby ensuring total independence of terrestrial infrastructure for mobile-to-mobile communications and a single commercial gateway located in Tempe, Arizona, which is needed for connection to the outside world;
– a 66 satellite, circular, low Earth orbit (LEO) constellation arranged in 6 polar planes, with 11 active satellites per plane plus one in reserve, at an altitude of 780 km, to provide ubiquitous full global coverage, including the polar areas and including all oceans (see Fig. 6).

FIGURE 6

HIBLEO-2 constellation (viewed from the Equator)

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– Personal communication services to handheld equipment of users in motion;
– 16 dB average link margin to provide duplex voice personal communications services to handheld terminals of users in motion, with availabilities of more than 80% under heavy shadowing, and more than 95% availability under medium shadowing (see Recommendation ITU-R M.1188);
– paging services with higher link margin than the above to provide in building services, which can be used with operator cooperation to extend voice services to in-building;
– short burst data (SBD) services is an extremely robust and efficient method for sending or receiving, in real time, small amounts of data (e.g. global positioning system (GPS) coordinates, seismic or atmospheric sensor data) that might be crucial to a disaster recovery or disaster prediction operation. GPS engines have been integrated directly into the HIBLEO-2 transceiver, with the transceiver programmed to automatically transmit the position fix data at fixed intervals;
– short messaging services (SMS);
– communications security ensured through digital voice;
– lawful interception (LI);
– geo-location with a 20 km resolution.

3.2 Globalstar (HIBLEO-4)

A complete description of the HIBLEO-4 MSS system can be found in § 5.5 of the ITU-R Handbook – Mobile Satellite Services. The characteristics and available services are summarized below. As with other MSS systems, the HIBLEO-4 system is ideally suited to providing disaster warning and relief communications.

– The HIBLEO-4 system employs a 48 spacecraft LEO constellation to provide complete coverage of land masses and some ocean areas between ±70º latitude and reduced coverage at latitudes greater or less than ±70º;

– connections to other mobiles as well as to the rest of the world are available through a network of gateway earth stations, which must be located within the serving satellite's footprint;

– the Globalstar system utilizes 48 spacecrafts with 1 414 km orbital altitudes and 52º inclination. Eight orbits with 6 equally spaced satellites comprise a Walker 48/8/1 configuration to provide coverage within ±70º latitude;

– connections using satellite diversity provide 96% availability to mobile terminal users;

– service is provided to handheld, vehicular and fixed terminals to suit the needs of all users located in remote or underserved areas;

– two-way data communications at rates up to 128 kbit/s can be provided;

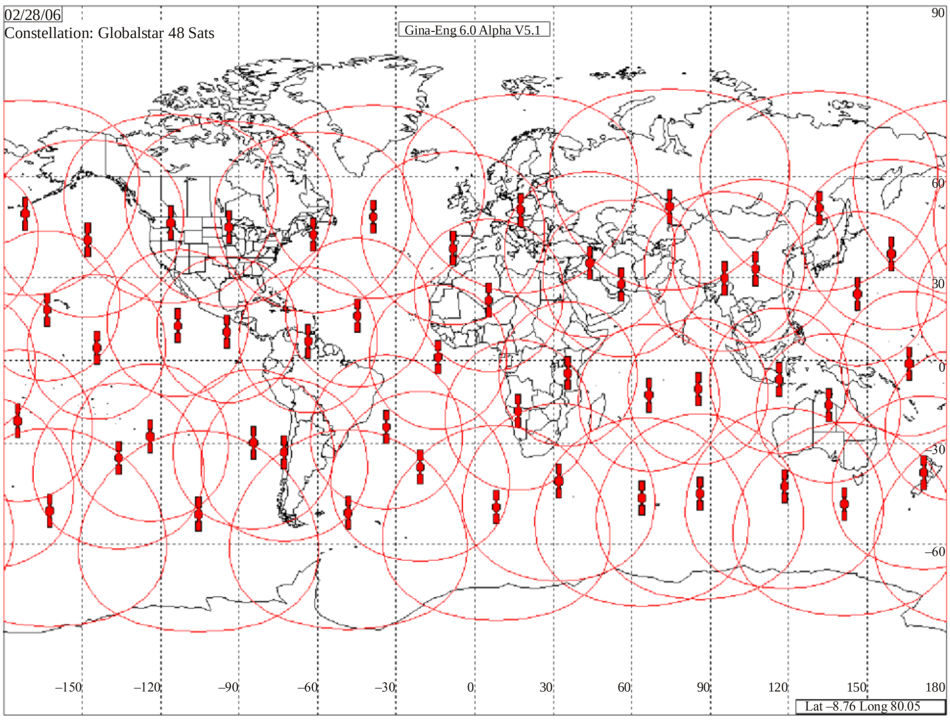
– simplex transmission can be used to transmit location, weather, geologic and many other types of data from remote, often unmanned locations to central data collection points;

– user terminal position can be determined to within 10 km.

Typical coverage is shown in the accompanying Fig. 7.

FIGURE 7

Typical ground tracks of Globalstar at an instant in time



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3.3 Inmarsat

A description of the Inmarsat MSS system can be found in the ITU-R Handbook – Mobile Satellite Services. The characteristics and available services are summarized below.

Inmarsat constellation consists of 11 geostationary satellites as of 2009, with additional satellites to be launched to evolve and enhance the available services. Inmarsat satellites carry services on their global, regional and narrow spot beams. The beam coverage is shown in Figs 8 and 9.

FIGURE 8

Inmarsat global-beam and regional-beam coverage

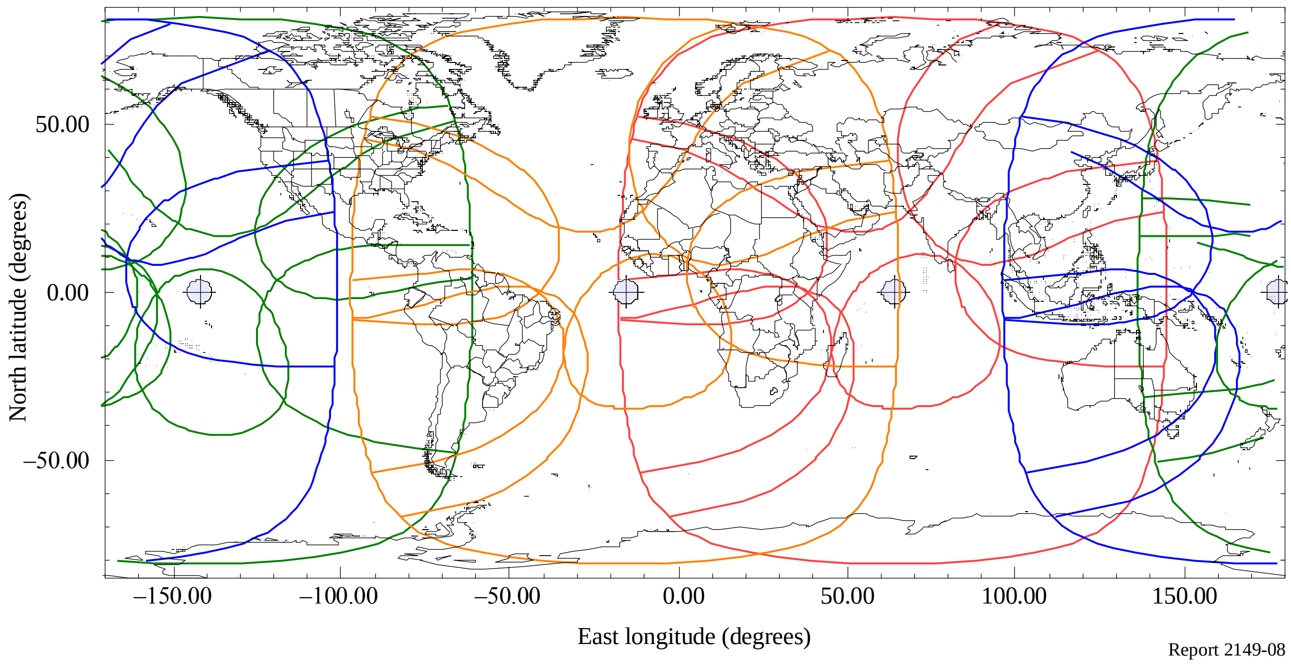
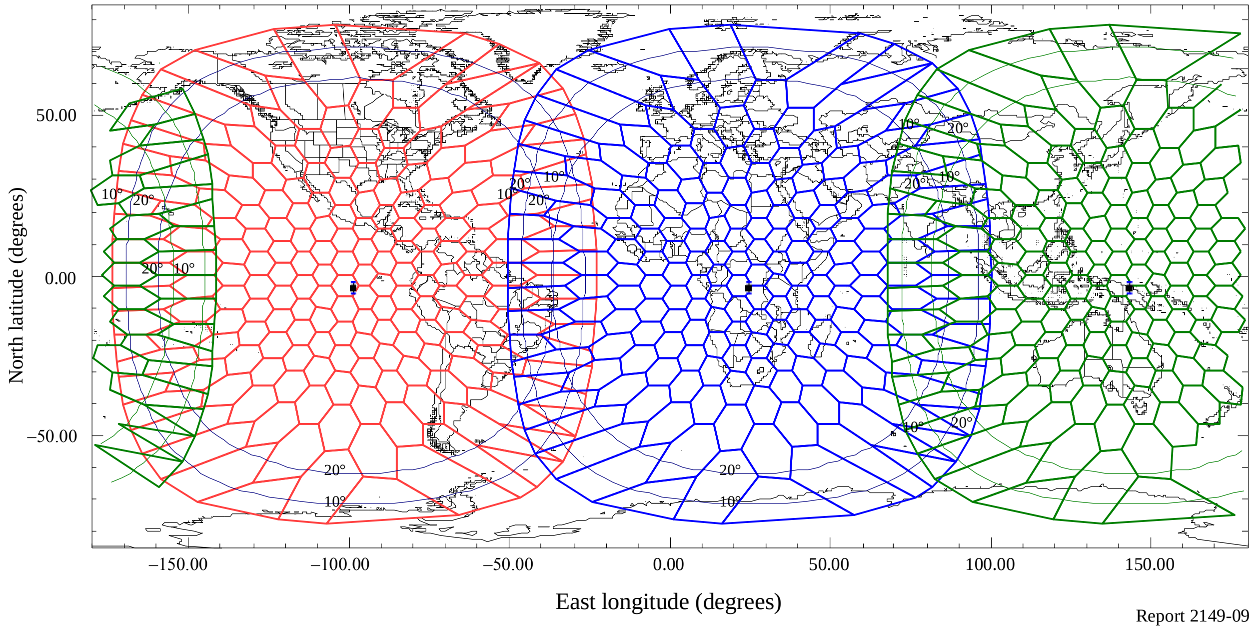


FIGURE 9

Inmarsat narrow spot-beam coverage



Inmarsat systems currently provide both circuit switched and packet switched communications to users ranging from handheld mobile terminals, personal terminals, semi-fixed terminals to vehicular terminals, providing connectivity in terrestrial, maritime and aeronautical environments.

The circuit switched services provide voice, telex, fax, data (up to 64 kbit/s) and Integrated Services Digital Network (ISDN) services whereas the packet switched services provide short burst data service and data connectivity up to 492 kbit/s.

The ground segment consists of a number of land earth stations (LESs) providing the connection to the terrestrial communications network. Global and regional spot beam services consisting of voice, fax, telex, low speed data, data and ISDN are connected to the terrestrial networks through the LES network.

Inmarsat is currently the only provider of MSS voice and data communications for the Global maritime distress and safety system (GMDSS) that is approved by the International Maritime Organization (IMO). Services for the GMDSS are provided by Inmarsat B, Inmarsat C, and Inmarsat Fleet 77. Services provided by Inmarsat or the GMDSS include voice, telex and data for distress, urgency and safety alerts and messaging, provision of maritime safety information e.g. navigation and weather warnings.

In the context of emergencies and natural disasters, Inmarsat services can help both in the early warning stage and in dealing with the aftermath. Inmarsat terminals can easily be deployed to set up an early warning network where the data observed by the monitoring sensors are transmitted to a central command centre, similar to the supervisory control and data acquisition (scada) applications.

Inmarsat terminals also offer easy connectivity in areas dealing with an emergency or the aftermath of natural disasters. Especially in areas where the local infrastructure is damaged, such systems can easily provide a viable substitute.

3.4 Thuraya

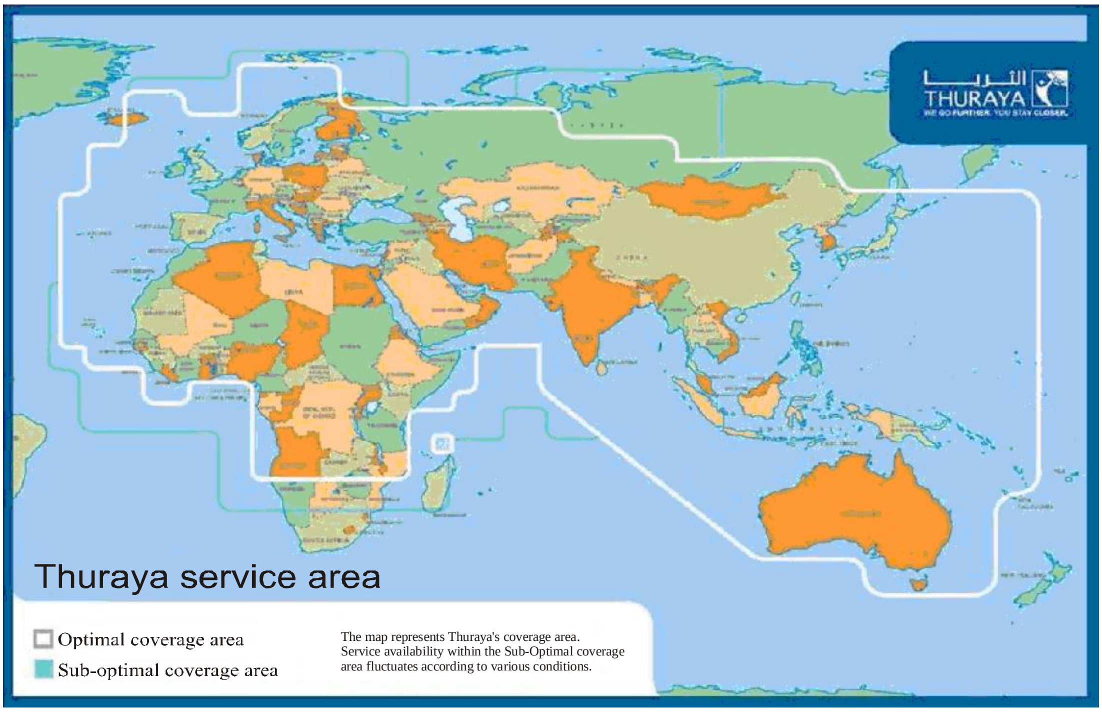
A description of the Thuraya MSS system can be found in the ITU-R Handbook – Mobile Satellite Services. Thuraya operates a global mobile personal communications by satellite (GMPCS) system. Thuraya satellite network is based on use of multiple high gain spot beams technology with digital beam forming capability which allows configuration of any size and shape of beams and form it in any part of the satellite footprint. Thuraya's system architecture requires only one gateway for the full operation of the complete system. Thuraya's satellite has the capability of supporting single hop calls. Thuraya's system employs on-board processing and the capability to distribute system resources (power and spectrum) as and when needed in part of the coverage. Thuraya satellite handsets were the first in the world to offer GMPRS, providing continuous Internet connectivity. This service was developed and pioneered by Thuraya.

– Thuraya's system is currently based on two geostationary satellites that offer a geographical coverage of around 140 countries spanning Europe, Africa (except few countries in the Southern part of Africa), Asia and parts of the Pacific region. Thuraya has also added the East Asia Pacific region to its coverage with the launch of Thuraya-3 satellite in early year 2008 (see Fig. 10);

– Thuraya's system provides different services including voice, SMS, facsimile, low rate data (9.6 kbit/s), GMPRS (up to 60 kbit/s), high-speed data (up to 444 kbit/s) and location based services (based on GPS) using different types of terminals. Thuraya's built-in GPS receiver in the handheld terminals allows position information to be sent as SMS which facilitates rescue operations and disaster management. Thuraya offers GPS distance and direction display as a standard feature across its range of handsets;

FIGURE 10

Thuraya coverage area



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– Thuraya’s product range includes handheld terminals, portable data terminals, semi-fixed terminals, fixed terminals, payphones, maritime and vehicular terminals and all are available with solar chargers:
  – Thuraya’s two handheld terminal types (satellite only) and (satellite and GSM) are similar in size to cellular handsets and can be easily used during emergency and disaster relief operations due to their light weight and small size. The Thuraya handheld terminals support GMPRS (with speeds up to 60 kbit/s) in addition to voice, SMS and facsimile;
  – Thuraya’s high speed data terminal support speeds up to 444 kbit/s and is an effective tool for meeting the data communication and streaming requirements during emergency and disaster relief operations due to its light weight and small size. One of the applications supported by Thuraya’s high speed data terminal is streaming i.e. guaranteed quality of service up to 384 kbit/s on demand for high bandwidth applications like video streaming. Thuraya’s high speed data provides streaming bandwidth flexibility for uplink and downlink, this streaming capability could be used for telemedicine during emergency and disaster relief activities;
  – Thuraya netted communications is a powerful, world-first, integrated communication solution incorporating Thuraya satellite handsets, GSM and UHF/Microwave/WiFi Radio technology and is extremely useful application during disaster events;
  – Thuraya has commercial operational roaming agreements in place with around 275 GSM networks/operators all over the world allowing Thuraya subscribers to roam within partner GSM networks. Thuraya's roaming service enables GSM subscribers to access the latest mobile satellite technology using a Thuraya handset; and
  – the Thuraya country code (+88216) is open in more than 180 countries/networks.
– Thuraya has a number of partnership agreements in place with different international organizations and non-governmental organizations (NGOs) associated with relief activities for provision and facilitation of telecommunication services during emergencies and disaster situations and for relief operations.
– Thuraya also has the capability to implement specific Zones within a country to connect traffic originating from such Zones to the dedicated Emergency Centre within the country.
– Thuraya system has a module which could be used by third party developers and manufacturers to develop special equipment with a number of capabilities particularly helpful for emergency and disaster relief situations, e.g.:
  – a Fully secure capability, that allows viewing any of Thuraya handsets being used in the world through maps, satellite images and aerial photography. Maps and imagery can also be viewed through Google maps, Windows virtual Earth and pictorial representation. This capability can provide Current Position report of a single unit together with where it has been over the previous week. There is also a live follow capability, which allow for continuous updates on the locations of multiple users belonging to a single group;
  – the combination of the updated positioning capability and the dynamics of the above capability allow for a number of other features that are also useful for disaster relief. Two levels of alerts: basic position reports and emergency SOS requests for immediate assistance, where an automatic relays of SOS messages to multiple user defined e-mail addresses and mobile phones, text messages from user may also be sent to centre to aid identification of assistance required. Timely incident reporting on inclement weather, terrorist or other threats as they occur, detailed travel advice and risk assessment for every country worldwide is also provided;

– an assistance capability which provides full global 24*7 voice assistance in emergency or for prior briefing, this capability is the ultimate in personalized SOS services. In the event of an emergency or when faced by threats, you can call on a specialist security advisor who will advise, assist and co-ordinate effective response through to appropriate external services such as police, fire, ambulance, coastguard, embassies as well as relaying to friends, family and employers. All the time the security specialist will be able to know exactly where you are from the emergency SOS report on his screen.

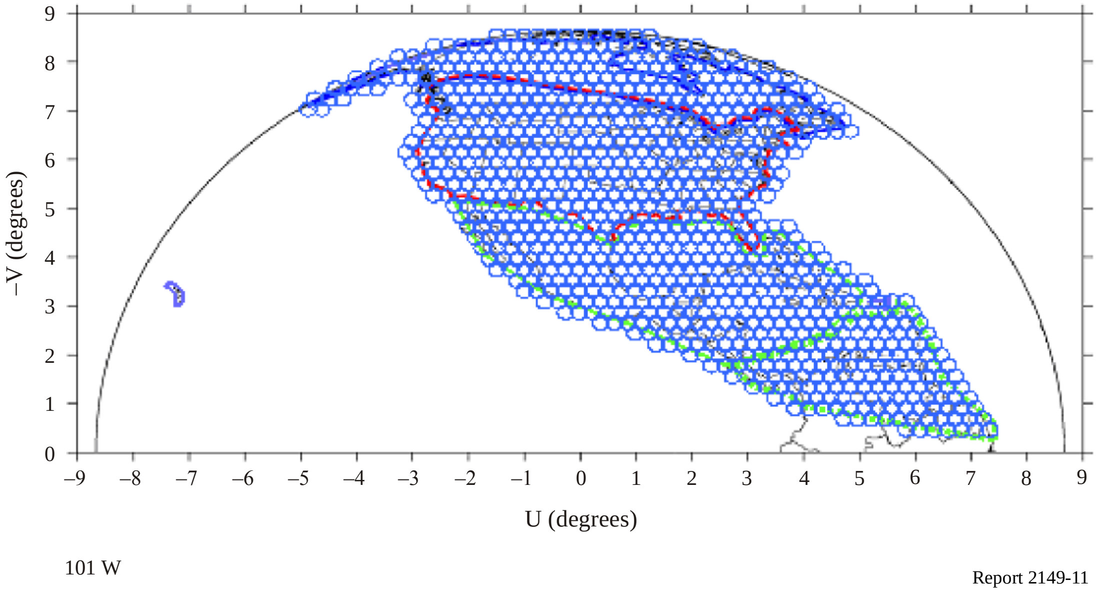
3.5 SkyTerra

A description of the Canadian MSAT-1 system can be found in § 5.3 of the ITU-R Handbook – Mobile Satellite Services. The MSAT-1 system and the nearly identical United States of America MSAT-2 system are both now operated by SkyTerra. Both systems use geostationary satellites to provide mobile communication services, including voice, dial-up data, fax, dispatch radio, and packet data services in Canada, the United States of America including Alaska, Hawaii and Puerto Rico, and the Caribbean. Mobile terminal types include fixed terminals that can be used for backup communication links, vehicle mounted mobile terminals that can be used both for backup communications and for communications in areas where other means are unavailable, and suitcase-size transportable terminals that can be rapidly deployed in any location as required. These units have been deployed following hurricanes and other disasters in North America.

A replacement system uses two advanced geostationary MSS satellites, one Canadian (at 107.3° W) and one from the United States of America (at 101° W). The coverage area is similar to that of the MSAT satellites, but with much greater e.i.r.p. and *G*/*T* and covers the service area with approximately 300 spot beams. See Fig. 11. These satellites are equipped with 22 m L-band reflector antennas enabling the use of cell phone size mobile terminals as well as compact transportable or fixed terminals to provide economical and reliable voice and high-speed data service. Further, the satellites are part of an integrated MSS system which employ a satellite component and ground component where the ground component is complementary to the satellite component and operates as and is an integral part of the MSS system. In this system the ground component is controlled by the satellite network management system, and the ground component uses the same portions of MSS frequency bands as the associated operational mobile-satellite system. This system provides the benefits of in building coverage in urban areas via the terrestrial cellular component, ubiquitous coverage in rural and wilderness areas via the satellite component, and finally high capacity emergency and disaster services in areas when the terrestrial service is incapacitated.

FIGURE 11

SkyTerra coverage



3.6 TerreStar

TerreStar plans to operate an MSS communication network with an integrated ancillary terrestrial component. The TerreStar-1 geostationary MSS satellite was launched in July 2009 and located at 111° W. Construction has begun on a second geostationary MSS satellite, TerreStar-2.

The initial TerreStar coverage area will include Canada, the continental United States of America, Hawaii, Puerto Rico and the US Virgin Islands. The continental United States of America and all the major population areas of southern Canada are planned to fall within the primary service area, with other regions, including Northern Canada and Alaska covered, in the secondary service area (Fig. 12).

TerreStar's proposed ground segment will consist of 2.0/2.2 GHz band mobile-user terminals and ancillary terrestrial component base stations, two geographically separated 14/11 GHz gateways located in Canada and the United States of America, and a number of 2.0/2.2 GHz band calibration earth stations located across North America.

TerreStar-1 has an 18 m diameter 2.0/2.2 GHz band antenna which, in conjunction with ground-based beam forming will provide highly spectrally efficient service with ground coverage facilitated by hundreds of dynamically reconfigurable spot beams. The flexibility of the proposed satellite and network will allow for the development of a range of mobile terminal form factors driven by and tailored to network characteristics and specific end-user requirements.

TerreStar is developing an open network chipset architecture to enable the 2.0/2.2 GHz band frequencies to be incorporated into a wide range of mobile devices, including universal mobile telephone service (UMTS) mobile phones/personal digital assistants, handsets used in public safety land mobile radio networks, and private government networks. Handsets are being developed to support voice, data and internet access, and to seamlessly integrate satellite and terrestrial facilities, ensuring continuous interoperable communications during times of crisis. To make sure that the requirements for handheld radio systems are met efficiently, terminals are being designed to be as flexible as possible. TerreStar, through its MSS with ancillary terrestrial component (ATC) system and unique chipset, which is expected to switch between the MSS-ATC network and terrestrial

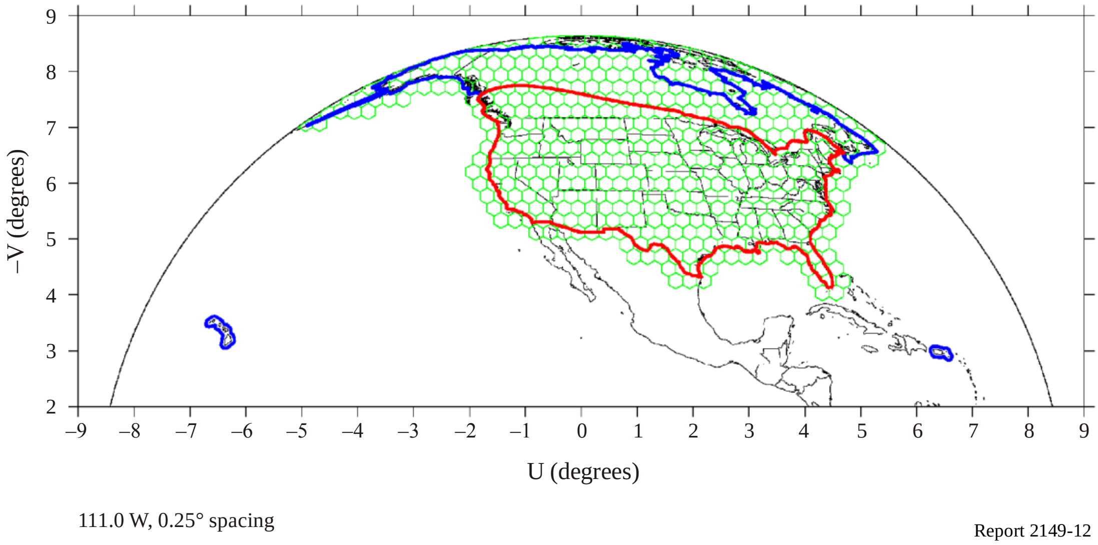
GSM and UMTS networks, will allow consumers to utilize previously separate or incompatible systems.

Ubiquity, interoperability and survivability were critical design considerations during development of TerreStar's network infrastructure design. The network is designed to provide first responders robust communications and situational awareness when disparate interagency networks used by fire, emergency medical service, police and government agencies must collaborate as emergency responders. The network being designed is expected to support:

– creation of ad hoc work groups with web-based administrative control over access for individuals or groups; gateway integration of third party networks; configuration of collaborative applications and calling features including creation of portals for users, managers and application administrators;
– various terminal types ranging from small handheld devices to rugged handheld phones, vehicle mounted mobile phones, and laptop computers;
– voice, data and web applications including streaming video, multicast push to talk and real time document collaboration;
– prioritization of traffic based on capacity, mission and security considerations.

FIGURE 12

TerreStar coverage



In local, regional or national emergency situations, the TerreStar network is expected to be able to dynamically allocate up to 15% of the entire satellite downlink power in a single spot beam, or up to 25% of the satellite power to a cluster of spot beams. The real time, dynamic allocation of bandwidth during times of heavy use or terrestrial network failure will be complemented by TerreStar's ability to pre-allocate user prioritization ensuring connectivity for high-priority users and first responders.

3.7 DBSD North America, Inc.

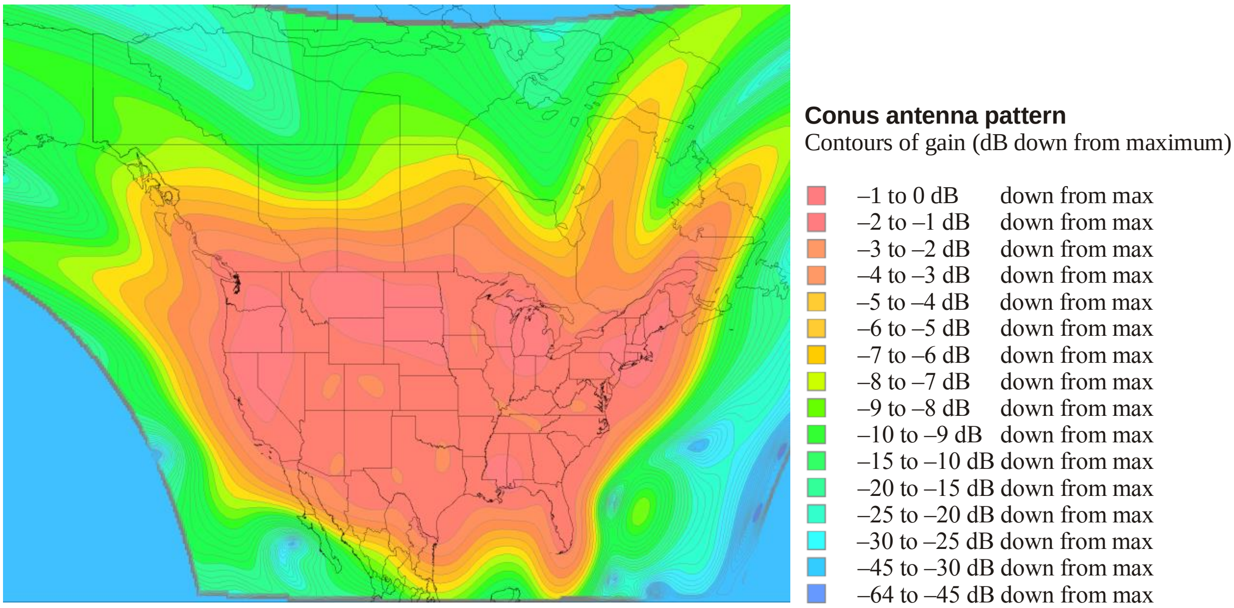
DBSD North America, Inc. (DBSD) plans to operate a mobile satellite services network with an ATC in the United States of America. The ICO G1 satellite was launched on April 14, 2008, and occupies an orbital slot at 92.85º W longitude, which covers the entire United States of America, Puerto Rico and the United States of America. Virgin Islands. ICO G1 also has the ability to cover additional geography in North America outside of the United States of America; however, DBSD is not currently authorized to provide services outside the United States of America.

The ICO G1 system uses the 29.25-30 GHz band for the feeder uplinks and the 18.55-18.8 GHz and 19.7-20.2 GHz bands for the feeder downlink between ICO-G1 and a single United States of America gateway station located in North Las Vegas, Nevada.

The DBSD satellite uses an S-band 12 m, multi-element phase-array antenna for both receive and transmit functions. In conjunction with the ground based beam forming (GBBF) subsystem, the S-band phase-array antenna provides DBSD with the flexibility of generating a virtually infinite number of beam configurations over the service area. For example, the antenna is capable of forming a single beam over North America, or up to approximately 250 spot beams. The reference configuration is 135 spot beams, in both receive and transmit directions, across the service area. Using this reference configuration, Fig. 13 shows possible coverage over the continental United States of America ("CONUS"), Alaska, Hawaii, and United States of America territories.

FIGURE 13

ICO G1 footprint and contours



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The DBSD system is being designed to be capable of supporting a full set of mass-market service offerings to urban and rural United States of America customers, including voice, video, Internet and telematics (vehicle tracking), while addressing growing national security and public safety service needs by providing a service offering to supplement existing terrestrial networks. The system is being designed to:

– support a full portfolio of mass-market wireless services, including traditional voice, text messaging, e-mail and other narrowband data applications;

– support a variety of broadband applications, including multicast data and/or video from the satellite segment, as well as two-way broadband depending upon the level of terrestrial segment deployment;

– provide an integrated satellite-terrestrial service enabling ubiquitous coverage in the United States of America and potentially other countries in North America;

– utilize handsets similar in size to current cellular phones and other portable devices (such as laptops or PDAs);

– support a wide variety of radio protocols, such as code division multiple access (CDMA), long term evolution (LTE), worldwide interoperability for microwave access (WiMax), GSM, ground mobile radio (GMR), digital video broadcasting – Satellite services to handhelds (DVB-SH) or orthogonal frequency-division multiplexing (OFDM), allowing for the integration of a wide variety of services and devices; and

– leverage the proximity to the Personal Communications Services (PCS) and Advanced Wireless Services (AWS) spectrums with a flexible network architecture facilitating integration with local terrestrial partners.

DBSD and other leading United States of America based MSS operators have engaged in a collaborative development agreement with Qualcomm to develop an open chipset architecture that will enable 2.0/2.2 GHz band frequencies into a broad range of commercial wireless devices, such as mobile phones, smart phones, public safety radios and consumer electronic devices.

DBSD's satellite coverage, combined with the capability of a complementary ground component network to provide coverage and capacity to dense urban areas, allows for unique capability to support critical missions related to homeland security and disaster relief. Satellite capability will provide coverage in times when terrestrial networks are inoperable due to man-made or natural events, and the GBBF system provides the flexibility to provide real-time dynamic allocation of bandwidth to a focused geographic area in time of emergency for priority users and first responders.

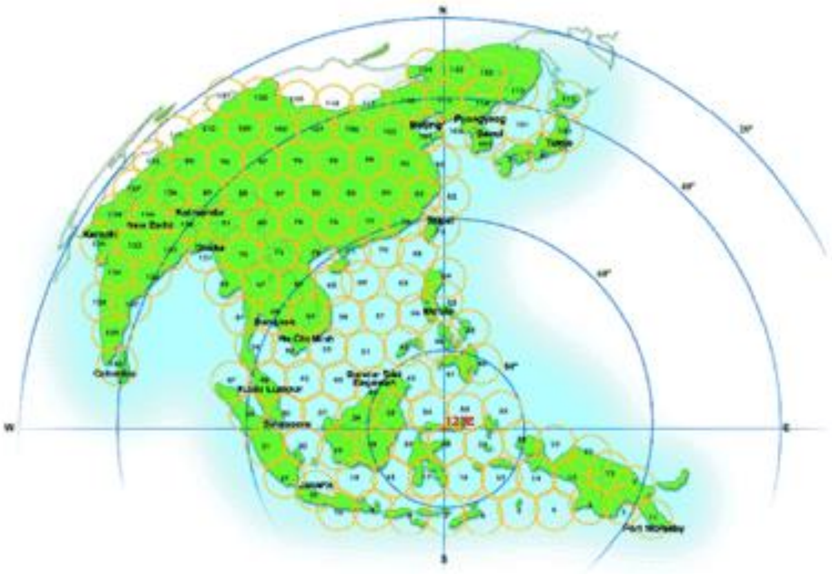
3.8 ACeS

ACeS system has been in operation since year 2000 as the world first personal handheld MSS with coverage area of South-East Asia. ACeS system is member of GMPCS family and it is operated in the frequency band of 1 525-1 544/1 545-1 559 MHz (space-to-Earth) and 1 626.5-1 645.5/ 1 646.5-1 660.5 MHz (Earth-to-space).

The system has dual mode (GSM/satellite) capability that allows the user to roam on any GSM network worldwide. The ACeS system is operated using the Garuda-1 geostationary satellite, located at 123 E, with two 12 m antennas to provide 140 satellite spot beams that cover some countries in Asia-Pacific of ITU Region 3, as shown in the Fig. 14 of ACeS GARUDA-1 satellite service coverage. The system provides voice, data and tracking services.

FIGURE 14

ACeS Garuda-1 satellite service coverage



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The services

Voice service

– The mobile voice service is provided by a handheld terminal type of communication, with full mobility for the user. The system is dual mode (GSM/satellite) mobile terminal, which is developed for mobile applications. It provides mobile voice, data and fax capability up to 2 400 bit/s. It is also capable of utilizing the GSM network and comes with a full mobile docking accessories kit, hands free kit and speaker phone. It can also be used in-door using cradle form to serve semi fixed application.

– The fixed voice service is provided by a small dimension, compact and portable terminal that is connected to telephone line. This fixed voice service is developed to fill the telecommunications gap in particular, the rural areas as a fixed wireless application (FWA) for telephony capability.

Data service

Data service supports a nominal data speed up to 230 kbit/s. It is equipped in a compact and portable terminal. This service is mostly also used for the news gathering applications.

Tracking service

The tracking service is basically SCADA that provides location reporting and customized information as required by the customer. It can also be used for voice telephony applications. The service is used on ship, truck, train or any moving object for fleet management purposes.

Countries covered by ACeS network

– India, Sri Lanka, Bangladesh, Pakistan, parts of Afghanistan, Nepal, Bhutan, Myanmar.

– Thailand, Cambodia, Laos, Viet Nam, Malaysia, Singapore, Indonesia, Philippines, Brunei Darussalam, Timor Leste, Papua New Guinea.

– China (People's Republic of), Japan, Rep. of Korea, D.P.R. of Korea.

3.9 Solaris Mobile

Solaris Mobile operates a payload in the bands 1 980-2 010 MHz (Earth-to-space) and 2 170-2 200 MHz (space-to-Earth) on board the W2A satellite at the orbital position 10°E. The satellite was launched in 2009 and brought into use early 2010.

Solaris Mobile's system is designed for providing video, radio, data and two-way communications to mobile and portable devices – such as handhelds, notebook size devices and vehicular platforms, as well as a variety of interactive services for public interest applications. Currently, communications are limited to vehicular platforms only. Data and communication providers operating in areas such as security communications or crisis management, can similarly benefit from the integrated satellite-terrestrial network that Solaris Mobile will operate, enabling them to maximize their coverage and portfolio of services.

The provision of public interest services were foreseen from the design stage of the Solaris Mobile network. Solaris Mobile can provide public interest services, including:

- public service broadcasts;
- voice and data services for emergency services;
- high-speed mobile Internet;
- location-based and interactive services;
- monitoring of rescue operations in remote locations; and
- environmental monitoring and protection.

Further, in the event of a natural or man-made disaster, the Solaris Mobile Space Segment architecture allows for all of the satellite's power to be delivered into a single beam or across separate beams in a single channel or two 5 MHz channels. Such flexibility means that connectivity can instantly be deployed within the area of need in support of health, safety or other public services, ensuring that the satellite resources can be delivered to those who need them, when they need them. Solaris Mobile enables:

- efficient and effective communications and supporting information technologies for public safety and civil contingency services;
- rapid and accurate collection, exchange and dissemination of information relating to public safety and civil contingency communications; and
- essential communications contingency in the event of terrestrial network infrastructure failure.

Prioritization can be achieved through both:

- circuit-switched traffic by prioritization of channels; and
- packet-switched traffic by prioritization of data packets.

This enables the continued delivery of a robust communications service to critical users in the event of increased user volumes or outages in the terrestrial network. In addition to the prioritization of traffic, ensuring its availability for those that need it when they need it, the transparent nature of the Solaris Mobile infrastructure facilitates the creation (in real time if IP based) of closed user groups. Closed user groups are a common feature of today's corporate VPNs, however, the ability to modify a closed user group in "real-time" is a concept of significant importance to emergency services.

To ensure the continuation of network services in the event of a network outage, the W2A S-band payload has on-board redundancy of all active components. This covers both the feeder link and service link components in both the satellite-receive and transmit paths.

Redundancy of the ground segment

Given the proximity of the MSS 2 GHz spectrum to the mobile service 3G spectrum, many user terminals will incorporate radio devices capable of operating across both bands. In the event of a terrestrial network outage, user terminals would thus be able to switch to the MSS 2 GHz band ensuring the continuation of service in a manner akin to switching between GSM 450 MHz, 850 MHz, 900 MHz, 1 800 MHz and 1 900 MHz networks.