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Radiocommunication Sector of ITU

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(07/2015)

Use of non-geostationary orbit mobile satellite systems to enhance maritime safety

M Series

Mobile, radiodetermination, amateur and related satellite services

International Telecommunication Union

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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Note*: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

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Use of non-geostationary orbit mobile satellite systems to enhance maritime safety

(2015)

1 Introduction

Agenda item 1.16 of the World Radiocommunication Conference 2015 (WRC-15) called for enhanced automatic identification system technology applications and enhanced maritime Radiocommunication. In particular Resolution **360 (WRC-12)**, invites ITU-R:

> *"to conduct, as a matter of urgency, studies on additional or new applications for maritime Radiocommunication within maritime mobile and mobile-satellite service allocations, and to identify potential regulatory actions to accommodate emerging maritime radiocommunication requirements."*

This Report continues the development of information related to the potential for mobile satellite communication systems to enhance radiocommunications for maritime safety in geographically-remote regions where traditional terrestrial maritime radio communication is not feasible.

2 Applications in the mobile satellite service

The referenced "*invites*" mentions applications within mobile satellite service allocations.

One such allocation is the frequency band 1 610-1 626.5 MHz. The frequency band is allocated to the mobile satellite service (MSS). As Article **1** of the Radio Regulations indicates the MSS is inclusive of the maritime mobile satellite service.

This allocation is already being utilized by MSS satellite systems. They are non-geostationary orbit (NGSO) systems and therefore are fully global in nature and typically have better latency characteristics as compared to geostationary orbit networks. This improved latency characteristic may be of particular benefit in maintaining the reliability of a connection in, or to, Internet-based systems and services.

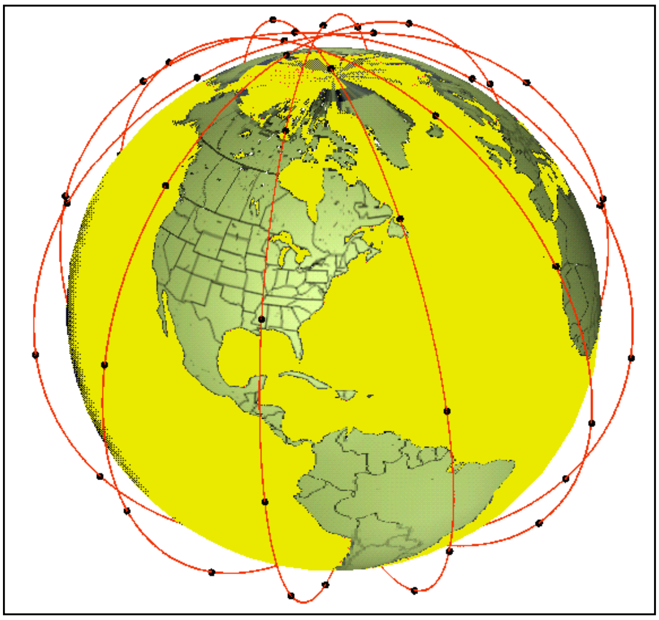
An example of such a system is the HIBLEO-2 satellite system. Some of the characteristics of this system are illustrated below.

2.1 The satellite constellation

The HIBLEO-2 satellite system employs 66 low earth orbit satellites that support user-to-user, user-to-gateway, and gateway-to-gateway communications. The 66 satellites are evenly distributed in six orbital planes with an 86.4° inclination, with one in-orbit spare for each orbital plane. Except for planes 1 and 6, the orbital planes are co-rotating planes spaced 31.6° apart. The first and last orbital planes are spaced 22° apart and form a seam where the satellites are counter-rotating. The HIBLEO-2 satellite constellation is depicted in Fig. 1. The satellites orbit at an altitude of 780 kilometres and have an orbital period of approximately 100 minutes 28 seconds.

FIGURE 1

HIBLEO-2 satellite constellation



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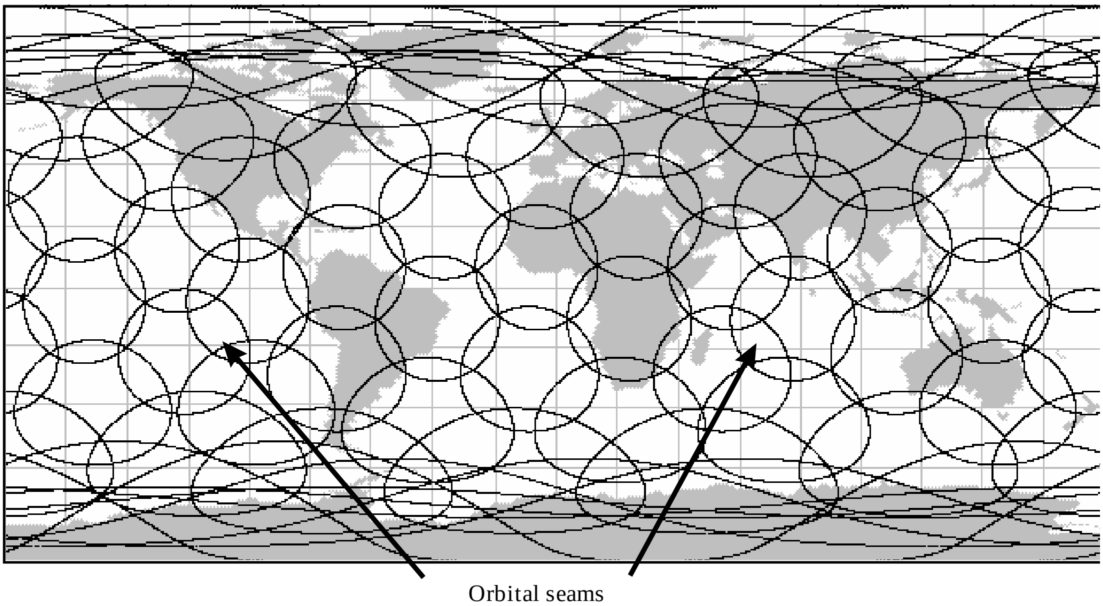
The near polar orbits of the HIBLEO-2 satellite constellation provide global coverage from pole-to-pole as depicted in Fig. 2. The seams between the counter-rotating orbital planes are clearly visible in this figure since the spacing of planes 1 and 6 results in greater overlap in the satellite footprints.

FIGURE 2

HIBLEO-2 satellite coverage



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All communication services are provided independent of latitude and longitude position on the globe. Ship-to-shore, shore-to-ship and ship-to-ship communications are provided by a constellation of low earth orbiting satellites with overlapping coverage areas, providing ubiquitous coverage. Figure 2 depicts the overlapping service coverage of the 66 satellites by each of the red circles and the direction of each polar orbit is depicted by the arrows at the centre of each coverage area.

Voice, data broadcast, and short burst data services are provided globally on a 24 × 7 basis. Service bearing communications is networked between the satellites in the constellation over the crosslinks. Crosslinks provide connectivity between satellites without going through a terrestrial earth station. Data is transferred to the ground through one of the teleport locations around the globe.

2.2 The satellite–to-subscriber link

The satellite-to-subscriber link uses three L-band antennas. The phased-array, main mission antenna projects 48 spot beams, or cells, on the Earth, with each beam being approximately 600 km in diameter. These cells are similar to terrestrial cellular coverage. Unlike terrestrial cellular where mobile users move through stationary cells, however, the HIBLEO-2 cells move across the mobile user of the satellite system. The average satellite visibility time for a stationary HIBLEO-2 user is about 10 minutes. The 66 satellite constellation has the potential to support a total of 3 168 spot beams; however, as the satellite orbits converge at the poles, overlapping beams are automatically shut down. Global coverage is provided by approximately 2150 simultaneous beams. The 1.6 GHz -band antenna uplinks and downlinks are designed to support a 16 dB voice link margin and a 27 dB paging link margin. The satellite footprint, consisting of the 48 beams, is approximately 4 700 km in diameter.

The on-board processing system of each satellite provides satellite control and supports communications routing. The satellite control includes the telemetry control, temperature control, power control, and fault management. The communications control is necessary for data routing, since the HIBLEO-2 satellite system employs a packet-switched network. The satellite constellation uses the HIBLEO-2 transfer mode (ITM) to pass packets of information through the network.

Each ITM packet includes a header containing the necessary information to route the packet to its destination. Each satellite routes the ITM packets to its feeder link, cross-link, or subscriber link. In order to avoid damaging routing delays, the ITM packet routing is performed by CMOS application specific integrated circuit gate-array technology rather than software.

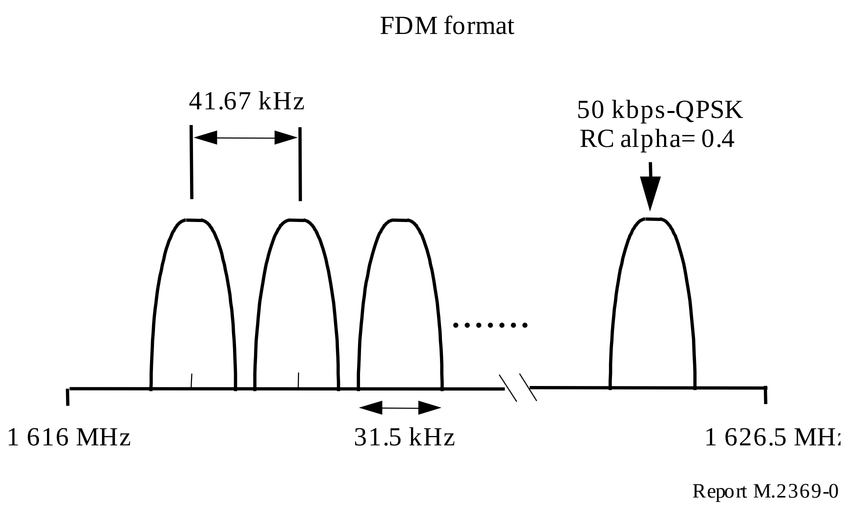
2.3 The subscriber link signal structure

HIBLEO-2 user terminals employ a time domain duplex (TDD) approach wherein they transmit and receive in an allotted time window within the frame structure. The TDD structure is built on a 90 ms frame and is composed of a 20.32 ms guard time, followed by four 8.28 ms up-link time slots and four 8.28 ms down link time slots, with some guard times interspersed. Since the system is TDD, the subscriber units transmit and receive in the same frequency band. The access technology is a frequency division multiple access/time division multiple access (FDMA/TDMA) method whereby a subscriber is assigned a channel composed of a frequency and time slot in any particular beam. Channel assignments may be changed across cell/beam boundaries and are controlled by the satellite.

The frequency band is multiplexed using a 41.666 kHz channel plan as depicted in Fig. 3.

FIGURE 3

HIBLEO-2 L-band frequency division multiplexing format



The system uses a 50 kbps data rate and a quadrature phase shift keying (QPSK) modulation format on the 8.28 ms time slots and the 41.66 kHz frequency division multiplexing channels. The data is first differentially encoded before application to the QPSK modulator. Hence, the exact description is differentially encoded quadrature phase shift keying (DEQPSK), although the spectrum characteristics are identical to QPSK. The DEQPSK modulation results in a 25 ksym/s symbol rate on the channels, which allows for a relatively narrow channel bandwidth. The modulation symbols are pre-filtered before application to the modulator, which further reduces the transmission bandwidth required. The L-Band signal parameters are summarized in Table 1.

TABLE 1

HIBLEO-2 L-band signal parameters

Multiplexing method	TDMA/FDMA
Duplex method	TDD
Modulation format	DEQPSK
Data rate	50 kbps
Symbol rate	25 ksym/s
Modulation prefiltering	Square root raised cosine filtering in the frequency domain with roll off factor = 0.4
Occupied BW per channel	31.5 kHz
Channel spacing	41.6666 kHz

2.4 Subscriber transmission characteristics

The HIBLEO-2 satellite system user terminal antennas are hemispherical with omni-directional gain patterns. While the maximum gain is less than 3.5 dBic, it is typically a maximum of 3 dBic.

After circuit losses, the maximum power delivered to the antenna by the typical implementation is 5W average during a time slot. The system provides the full average link margin at maximum power, but it is also capable of reducing transmit power and adjusting link margin according to the local fading conditions. This is accomplished with an adaptive power control system that can reduce the subscriber transmit power by up to 12 dB but can also be adjusted in 1 dB steps over the complete range. The effect of the power control is to allow the subscriber equipment to operate at the lowest power necessary to assure quality communications.

3 Applications

As specified in Resolution **360 (WRC-12)**, agenda item 1.16 seeks to enhance maritime safety through studies on additional or new applications for maritime radiocommunication.

The increasing global need for maritime radiocommunication for enhanced maritime safety applications, capacity concerns, and the increasing use of maritime communications further highlight the need to identify alternative means to satisfy such requirements. Such can be met by NGSO MSS applications including a separate and independent means of alerting and distribution of maritime safety information.

The NGSO MSS satellite system in the example above presently supports a number of maritime applications. The existing terminals provide services to rugged environments. It presently includes a specialized broadband platform. It is supporting the fishing industry as well as shipping and leisure industry.

In addition, it provides services to enhance ship operations, and crew welfare.

The system now supports specially designed high-speed terminals meant for maritime applications. It has true IP connectivity with up to three phone lines available. Thus it can provide simultaneous voice and data, and it is secure.

The size of vessels being served are twenty five feet and larger. Available terminals can also support multiple users at the same terminal.

The terminals associated with the NGSO MSS described above are being used for search and rescue, GPS chart plotting, and monitoring of vital shipboard functions.

Uniquely, the NGSO MSS system can provide full global coverage including all oceanic and Polar Regions.

Of particular interest is the capability to support distress communications. The network supports automatic recognition and routing of maritime distress and safety communications via highly reliable links. The network routes all ship-shore and shore-ship distress alert calls and messages immediately without any required human intervention. For ship-to-shore maritime distress and safety communications the maritime mobile terminal can utilize a series of unique addresses to automatically route messages directly to the associated maritime rescue coordination centre (MRCC). All maritime distress and safety communications generated by the maritime mobile terminal can be automatically identified and routed to the associated MRCC based upon the unique ID specified.

4 Remote coverage

As the agenda item for WRC-15 suggests satellites have the potential to provide service to remote locations. This is particularly true of NGSO MSS satellite systems. An example is the part of the earth above the Arctic Circle. Recently the lowest sea ice extent in recorded history was observed, and there are vast areas of open water where there used to be ice. Providing telecommunications in these areas is becoming more important due to the receding ice cap. As a consequence the maritime operating area is significantly expanding.

Today, tankers are using northern sea routes which transit through the Bering Strait and Sea, and small cruise ships are pressing even further into the Arctic. As the receding ice invites increased human activity in commercial and private ventures, there is increasing demand to ensure the safety, security and stewardship of maritime activity in Arctic waters.

Although winter sea travel is still severely limited due to extensive ice coverage across the region, recent summer and early autumn sea ice extent record lows have made seasonal maritime navigation more feasible. Economic development, in the forms of resource extraction, adventure tourism, and trans-Arctic shipping drives much of the current maritime activity in the region. The Arctic region contains an estimated 13 percent of the world's undiscovered oil and 30 percent of undiscovered gas. More than 35 percent of Alaska's jobs are tied to the energy sector, and onshore production of oil in Alaska is diminishing.

Arctic maritime operations require reliable command, control, communications, computers, and information technology (C4IT) capabilities. The Arctic region has been known at times for poor propagation of radio signals, geomagnetic interference, and limited satellite coverage and bandwidth. The NGSO MSS satellite systems have the capability as indicated in other sections to effectively address this requirement.

5 Regulatory considerations

Resolution **360 (WRC-12)** resolves to consider based on the results of ITU-R studies, additional or new applications for maritime radiocommunication within existing maritime mobile and mobile-satellite applications, and if necessary, to take appropriate regulatory measures. This section will examine whether any regulatory actions are necessary to accommodate emerging maritime radiocommunication requirements via NGSO mobile satellite systems.

The text in section 3 indicates that NGSO MSS satellite systems are today capable of delivering maritime services in the allocations where they are presently functioning. They host a variety of services. For the type of services indicated it does not appear that any regulatory change would be required.

However, recognizing that the inclusion of a service in the global maritime distress and safety system (GMDSS) is a result of decisions of appropriate international organizations, to the extent that there would be a future requirement to participate in the operation of the GMDSS some regulatory action may be necessary. For example, it appears that as ship routes in Polar Regions increase there may be a growing requirement to provide a means to support the GMDSS in these regions through use of NGSO MSS satellite systems that can provide the appropriate coverage. In addition such systems could provide enhance capability in oceanic regions. Further, it has to be taken into account that such systems must provide sufficient protection against services operating in adjacent frequency bands to prevent interference as described in reports ECC 171 and 226.

If there were a requirement to realize the GMDSS capability as described above, a few regulatory modifications may be necessary. The regulatory changes that would be necessary in the ITU-R could include:

– a footnote in the MSS allocations being used by NGSO satellite systems which provide for their use in the GMDSS;

– modification of Resolution **331 (WRC-12)** to provide for the use of NGSO MSS satellite systems to support the GMDSS.

6 Summary

This Report responds to the mandates of agenda item 1.16, *invites* 2 of Resolution **360 (WRC-15)**. It continues studies toward new applications for maritime radiocommunications within the mobile and mobile satellite service allocations. It addresses the concerns for enhanced radiocommunications for maritime safety and improved coverage and resilience in remote regions of the world not adequately served by traditional terrestrial maritime radiocommunication systems, as well as for communication solutions in these underserved areas.

This Report identifies the enhancement of maritime radiocommunication services provided by NGSO MSS systems, including remote areas and in the context of agenda item 1.16 of WRC-15 examined the need for any regulatory action.

The Report describes an example of how existing NGSO MSS satellite systems are today providing new maritime services and an extension of coverage (beyond that of more traditional geostationary satellite systems). The Report notes that no regulatory modifications are necessary for these services, as they are provided under the provisions of the existing Radio Regulations. However, it also notes that if for example there would be a requirement to include such systems in the GMDSS there may be regulatory modifications required.