Recognition of Iridium mobile satellite system as a GMDSS service provider

Submitted by IHB

SUMMARY

Executive Summary: This document provides up-date details of the application for consideration of Iridium Satellite LLC to become a Global Maritime Distress and Safety System (GMDSS) mobile satellite services provider, which are relevant to WWNWS-SC

Action to be taken: Paragraph 2.

Related documents: NCSR 3/11 dated 27 November 2015

1. See attached document.

2. The Sub-Committee is invited to note the information provided and take action as appropriate.

INTERNATIONAL MARITIME ORGANIZATION

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SUB-COMMITTEE ON NAVIGATION, COMMUNICATIONS AND SEARCH AND RESCUE
3rd session
Agenda item 11

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ANALYSIS OF DEVELOPMENTS IN MARITIME RADIOCOMMUNICATION SYSTEMS AND TECHNOLOGY

Recognition of Iridium mobile satellite system as GMDSS service provider

Submitted by the International Mobile Satellite Organization (IMSO)

SUMMARY

Executive summary:	This document provides in annex IMSO's report on the technical and operational assessment of the application by the United States to recognize and use the Iridium mobile satellite system in the Global Maritime Distress and Safety System. The report is provided in response to the request by MSC 94 that IMSO should undertake the technical and operational assessment of the Iridium mobile satellite system (MSC 94/21, paragraph 9.20).
Strategic direction:	5.2
High-level action:	5.2.5
Planned output:	5.2.5.7
Action to be taken:	Paragraph 8
Related documents:	MSC 92/9/2; MSC 94/21, MSC 94/9/3, MSC 94/9/4; NCSR 1/28, NCSR 1/12 and NCSR 1/12/2; resolution A.1001(25) and MSC.1/Circ.1414

Background

1 Resolution A.1001(25) provides that maritime mobile satellite systems shall be notified by Governments for possible recognition for use in the Global Maritime Distress and Safety System (GMDSS).

2 The Maritime Safety Committee, at its ninety-second session, considered a notification by the United States of an application by the Iridium mobile satellite system for recognition and use in the GMDSS (MSC 92/9/2) and having noted that, in principle, there were no objections, agreed to refer the matter to the Navigation, Communications and Search and Rescue Sub–committee (NCSR) for evaluation.

3 The NCSR Sub-Committee subsequently received a detailed application from the United States at its first session (NCSR 1/12) and agreed that the Committee "*could consider and decide which independent body should produce a technical and operational assessment . . . and invite that body to . . . provide a report to the NCSR Sub-Committee for evaluation*" (NCSR 1/28, paragraph 12.9.2).

4 The Committee, at its ninety-fourth session, therefore:

.1 agreed that the International Mobile Satellite Organization (IMSO) should undertake the technical and operational assessment of the Iridium mobile satellite system;

.2 agreed that IMSO should provide a technical and operational assessment report for consideration by the NCSR Sub-Committee;

.3 agreed that the scope of the evaluation was to assess compliance with the criteria set out in resolution A.1001(25), taking into account the guidance laid down in MSC.1/Circ.1414;

.4 noted that IMSO would convene a Group of Experts and, in order to enhance transparency of the process, would make information available to Member States with regard to the selected experts who would carry out the technical and operational assessment; and

.5 instructed the Secretariat to oversee the work of IMSO during the evaluation process (MSC 94/21, paragraph 9.20).

Report on the technical and operational assessment of Iridium

5 The annex to this document is the report on the technical and operational assessment by IMSO of the application to recognize and use the Iridium mobile satellite system in the GMDSS.

6 The report is based on information provided by Iridium Communications Inc. to the Group of Experts, Special Adviser to the Director General and IMSO Directorate during a number of meetings, two field visits to Iridium locations in the United States and documentary evidence provided to IMO.

7 IMSO notes and acknowledges the open access and degree of disclosure of technical and operational information provided by Iridium.

Action requested of the Sub-Committee

8 The Sub-Committee is invited to consider the information provided in the report annexed to this document and make recommendation to the Committee, as appropriate.

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ANNEX

REPORT ON THE TECHNICAL AND OPERATIONAL ASSESSMENT BY THE INTERNATIONAL MOBILE SATELLITE ORGANIZATION OF THE APPLICATION TO RECOGNIZE AND USE THE IRIDIUM MOBILE SATELLITE SYSTEM IN THE GMDSS

1 Background

1.1 Chapter IV of the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended, includes regulations for the carriage of radio equipment operating within the Global Maritime Distress and Safety System (GMDSS). The regulations, inter alia, require the carriage of equipment capable of performing 9 specific safety-related functions in vessels subject to the Convention (SOLAS regulations IV/4 and 6.1). Subsequent regulations in part C of the chapter designate particular frequency bands and types of equipment that a vessel may use to perform the required functions. These regulations make provision for the use of satellite communications within the GMDSS, referring specifically to the Inmarsat geostationary satellite services, which were the only such services available when the Convention was amended to include the present chapter IV.

1.2 The Organization has been considering a review of the GMDSS for some years and, as preparation for that review, adopted resolution A.1001(25) on *Criteria for the provision of mobile satellite communication systems in the Global Maritime Distress and Safety System (GMDSS).* This resolution reflects the Organization's desire to prepare for the inclusion of other satellite services in the GMDSS as soon as such services can offer the necessary levels of capability, reliability and robust operation.

1.3 Resolution A.1001(25) provides that maritime mobile satellite systems shall be notified by Governments for possible recognition for use in the GMDSS. The Maritime Safety Committee, at its ninety-second session, considered a notification by the United States of an application by the Iridium mobile satellite system for recognition and use in the GMDSS (MSC 92/9/2) and having noted that, in principle, there were no objections, agreed to refer the matter to the Sub-Committee on Navigation, Communications and Search and Rescue (NCSR) for evaluation. The NCSR Sub-Committee subsequently received a detailed application from the United States at its first session (NCSR 1/12) and agreed that the Committee "*could consider and decide which independent body should produce a technical and operational assessment . . . and invite that body to . . . provide a report to the NCSR Sub-Committee for evaluation*" (NCSR 1/28 paragraph 12.9.2).

1.4 In response to the debate taking place within the Committee and Sub-Committee, IMSO took steps to enable it to respond positively and speedily to any request that might be made by the Committee for it to undertake the technical and operational assessment of the Iridium mobile satellite system. Information concerning these preparations was provided to the Committee (MSC 92/9/3) and NCSR (NCSR 1/12/1). Following this, the Committee received a submission by the United Kingdom and the United States (MSC 94/9/4) proposing that IMSO perform the technical and operational assessment on the application to recognize and use the Iridium mobile satellite system in the GMDSS.

1.5 The Committee, at its ninety-fourth session, therefore:

.1 agreed that IMSO should undertake the technical and operational assessment of the Iridium mobile satellite system;

.2 agreed that IMSO should provide a technical and operational assessment report for consideration by the NCSR Sub-Committee;

.3 agreed that the scope of the evaluation was to assess compliance with the criteria set out in resolution A.1001(25), taking into account the guidance laid down in MSC.1/Circ.1414;

.4 noted that IMSO would convene a Group of Experts and, in order to enhance transparency of the process, would make information available to Member States with regard to the selected experts who would carry out the technical and operational assessment; and

.5 instructed the Secretariat to oversee the work of IMSO during the evaluation process (MSC94/21 paragraph 9.20).

2 Conduct of the assessment by IMSO

2.1 As the Committee had noted, IMSO immediately established an international Group of Experts and provided information concerning the composition of that Group to the NCSR Sub-Committee, at its second session (NCSR 2/23, annex 12, item 8). The membership of the Group of Experts, including two Government-seconded experts, is listed in annex 1.

2.2 The Group of Experts met on a number of occasions. They organized their own work and schedule of meetings. The principal focus of their work was largely technical. They undertook a review of all relevant documentation, including International Maritime Organization (IMO) requirements, International Electrotechnical Commission (IEC) type-approval test standards and International Telecommunications Union (ITU) regulations. Members of the Group, accompanied by a member of the International Mobile Satellite Organization (IMSO) staff, also carried out a field visit to Iridium locations in the United States, where they observed limited demonstrations of network and equipment functionality, and received extensive briefings from Iridium expert personnel.

2.3 The Director General of IMSO also appointed a Special Adviser to, inter alia:

.1 act on his behalf to undertake, direct and control the technical and operational assessment of the Iridium mobile satellite system . . . ;

.2 supervise and direct the work of the independent Group of Experts, seeking their advice as required;

.3 establish and control a Project Schedule (time line) . . . ; and

.4 prepare the technical and operational report to NCSR 3, incorporating information prepared by the Group of Experts as appropriate, for review and approval by the Director General.

IMSO Member States and the IMO Secretariat were informed by the IMSO Director General of the Special Adviser's appointment on 22 June 2015.

2.4 The Special Adviser to the Director General led a second field visit to the Iridium Technical and Operational Center at Tempe, Arizona, accompanied by one of the Group of Experts and a Technical Officer from the IMSO Directorate. This visit focussed on examining Iridium's compliance with the requirements of resolution A.1001(25) and viewing further demonstrations of equipment and operational functionality, as listed in paragraph 5.5.6.

In addition, as part of the operational focus he brought to the overall project, the Special Adviser established contact with the International Hydrographic Organization (IHO) and World Meteorological Organization (WMO) to determine their position in relation to the possible broadcast of Maritime Safety Information (MSI) via Iridium. The Director General attended the 7th session of the IHO World Wide Navigational Warning Sub-Committee (WWNWS 7) in August 2015. He provided a briefing on the status of this assessment project and participated in discussions on the use of the Iridium system for broadcasting MSI. This session was attended by Iridium, while they made a presentation on Iridium satellite system, who also attended the 22nd session of the ICAO/IMO Joint Working Group on the Harmonization of Aeronautical and Maritime Search and Rescue (Canada, August 2015).

2.5 All members of the Group of Experts and the Special Adviser were required to sign Non-disclosure Agreements before participating in the assessment exercise, in order to ensure the protection of Iridium's confidential proprietary information. Although some of this information has been used to support the conclusions of this report, none of this information has itself been included in this report.

2.6 This report is based on information provided by Iridium Communications Inc. to the Group of Experts, Special Adviser and IMSO Technical Staff (hereafter referred to collectively as the Assessment Team) during a number of meetings, two field visits to Iridium locations in the United States, and documentary evidence provided to IMO. IMSO has not sought to duplicate in this report the extensive information provided by Iridium in their initial application (NCSR 1/12, annex), but makes reference to it throughout this report.

2.7 IMSO notes and is grateful to Iridium for the open access and degree of disclosure of technical and operational information provided to the assessment team by Iridium. The company has willingly provided relevant information with respect to the spacecraft, including access to actual satellites in the laboratory, backup and test equipment and facilities, signalling and communication protocols, operational arrangements and business planning. This has enabled the assessment team to achieve a good understanding of the Iridium constellation and network, both now and as it is expected to evolve, on which to base this assessment.

3 Evidence by the sponsoring Government – Iridium Corporate Status

3.1 The Iridium network is owned and operated by Iridium Communications Inc., a United States company publicly traded on the NASDAQ exchange (ticker symbol IRDM).

3.2 Resolution A.1001(25) includes a requirement that the sponsoring Government(s) should provide evidence to show that "*there is a well-founded confidence that the company concerned will remain viable for the foreseeable future and will remain in a position to deliver the required services over an extended period, in keeping with the expectations of the Organization and the maritime industry as to the continuity, durability and reliability of the service*" (resolution A.1001(25), annex, paragraph 2.2.2.3). In this regard, IMSO notes that:

.1 in presenting the Iridium application to the Committee, the United States said: "*The applicant has been providing continuous services for over 13 years, and there is no reason to believe that the provider would not be able to continue doing so in the future*." (NCSR 1/12, paragraph 2.3). This wording is in accordance with the guidance provided for proposing Governments in MSC.1/Circ.1414, annex, paragraph 10; and

.2 Iridium has provided the information that, in November 2015, the Company "*has a customer base of more than 781,000 billable subscribers globally.*

Of these, more than 50,000 are in the maritime market, with roughly 10,000 devices used aboard SOLAS class vessels. Additionally, the Iridium network is currently utilized for Ship Security Alert (SSAS) and Long-Range Identification and Tracking (LRIT) communications around the globe". Additionally: "*Iridium Communications Inc. has a demonstrated track record of growing revenue, earnings and operating margin year on year. Iridium Communications Inc. is in good financial standing, with total revenues of $408.6 million in 2014 with net income of $75 million*".(NCSR 1/12, paragraph 2.2.2.3 updated).

3.3 In relation to the continuity and durability of the Company's communication services, IMSO further notes that Iridium has a programme under way to design, build and launch a second-generation satellite constellation and ground infrastructure. The first satellites in this "Iridium NEXT" programme are scheduled to launch in April 2016. This second-generation network will be fully compatible with existing subscriber devices and maritime terminals, and the company has said it is expected to ensure continuity and reliability of service to at least 2030.

3.4 Although some questions have been raised concerning the funding of this second-generation programme and some practical aspects of the in-space replacement of satellites in the constellation, **IMSO assesses the statements made by the United States Government and the Company itself as providing the Organization with sufficient confidence that Iridium** "***will remain viable for the foreseeable future and will remain in a position to deliver the required services over an extended period***"**, as required by resolution A.1001(25), annex, paragraph 2.2.2.3.**

3.5 Resolution A.1001(25) requires two further commitments to be made by a sponsoring Government concerning commitments that must be made by the applicant satellite system provider at a corporate level. These are:

.1 paragraph 2.2.2.2: "*the charging policies and provisions of resolution A.707(17), as amended, on Charges for distress, urgency and safety messages through the Inmarsat system, are complied with*",

In document NCSR 1/12, the United States refers specifically to the statement made by Iridium in its application that: "*As an authorized provider of GMDSS communication Iridium Communications will fully comply with the charging policies and provisions as described in resolution A.707(17), Recommends 1 and 2, for communications utilizing the Iridium network*"*; and*

.2 paragraph 2.2.2.4: "*the provider of the satellite system is ready to submit any recognized services to oversight by IMSO and sign the required Public Services Agreement (PSA) with that organization*"*.*

In document NCSR 1/12, annex, Iridium states: "*Iridium Communications is ready to submit any recognized services to oversight by IMSO upon receiving authorization by the IMO to provide GMDSS communications*"*. And:* "*Upon approval by IMO, Iridium will conclude a Public Services Agreement (PSA) with IMSO, arranging for the oversight of the recognized services by IMSO*"*.*

These statements are unequivocal and IMSO assesses that they are sufficient to meet the requirements of resolution A.1001(25), annex, paragraphs 2.2.2.2 and 2.2.2.4.

4 Technical description of the Iridium Satellite Communications System

4.1 Space Segment

4.1.1 The application is based upon the capabilities and performance of Iridium's current satellite constellation, although this is known to be in the latter stages of its useful operational life. The Iridium NEXT programme provides for a follow-on service that will offer continuation of the present capabilities, with greater capacity and total backwards compatibility with the present satellites, existing ground infrastructure and terminal equipment. The remarks that follow are expected therefore to apply equally to the next generation of satellites (Note: the Iridium NEXT satellites are currently scheduled to launch, 2 on the first rocket and in batches of 10 on each subsequent rocket, beginning April 2016 and completing before the end of 2017).

4.1.2 The Space segment of the Iridium network comprises 66 satellites in low earth orbit (LEO), plus a number of in-orbit spares. These satellites are flown in 6 orbital planes with 11 operational satellites in each plane. The constellation design provides for 1 spare satellite in each plane. Although the constellation is now degraded by age and some of the spare satellites have been brought into full or partial use, 2 satellites remain as in-orbit spares. Iridium NEXT will provide 66 operational satellites, plus one in-orbit spare in each orbital plane, plus an expected 9 spare satellites on the ground ready for launch, if required.

4.1.3 End-to-end measured call performance for the 30-day period 23 September to 22 October 2015, calculated from the actual success rates of multiple auto-diallers at one location in Leesburg, Virginia (see section 8), was measured as 99.16%. The highest daily performance during this period was measured at 99.64%. The Assessment Team believes that these actual measurements provided by Iridium may be of more value in this context as a proxy for availability than the more theoretical figures calculated using the formula developed by the ITU and currently used to report the availability of the legacy system, in view of the absence of a more suitable analytical approach which would properly reflect the performance of the Iridium LEO constellation and network. Although it is recognized that these observed figures apparently fall short of the requirement of 99.9% given in resolution A1001(25), paragraph 3.5.4, the contribution made by the launch of some of the next generation satellites is expected to raise the measured call performance to above the 99.9% threshold, and the matter of availability should be assessed again at that time.

4.1.4 **IMSO therefore assesses that the early next generation satellite launches will contribute to providing an adequate end-to-end level of service availability and in-orbit reserve capacity (see also 5.1.4 below). This will not necessarily require deployment of the whole of the next generation constellation. However, it is important to note in this context that the launch programme for the Iridium NEXT satellites means that the constellation is expected to have been fully replaced by the time that IMO is in a position to take a final decision on the Iridium application.** This assessment is made with the understanding that, in view of what follows in the rest of this report, neither the NCSR Sub-Committee nor the MSC may be ready to take a final decision on the application by Iridium to participate in the GMDSS until 2017, at the earliest.

4.1.5 The Iridium LEO satellite orbits are at a height of 780 km (485 miles) above the earth, at an inclination of 86.4 degrees to the equatorial plane. This gives the satellites an orbital period of approximately 100 minutes. The six orbital planes are arranged equidistantly around the equator and they precess, or move, around the world as each orbit is completed. Thus, the satellites are at their furthest apart as they cross the equatorial plane and are closest together as they pass close to the poles. The close conjunction of satellites over the poles means that some satellites must be switched off in these regions to avoid interfering with or even damaging the radio receivers in other satellites close by. However, some satellites continue to operate

and provide full communication capability over the poles. Those satellites that have been switched off as they approach the poles are switched on again as they move away from the pole and get further apart in space.

Figure 1. Schematic diagram of the Iridium constellation showing the six orbital planes.

4.1.6 Each Iridium satellite has a number of antennas: two small fixed antennas looking ahead and astern in the orbit, used to communicate with the two satellites immediately ahead and astern of the satellite in the orbit; two small gimballed antennas, used to communicate with the satellites in adjacent orbits on either side; three large phased-array antennas, used to provide the communications with mobile user terminals, and four gimballed feeder link antennas, used to provide the main communications with the Iridium ground stations (teleports). Each of the large phased-array antenna panels has sixteen (16) spot beams, giving the satellite a total of 48 spots, each with a diameter on the ground of approximately 250 miles. The spots move across the surface of the earth as the satellite moves in orbit relative to the earth, and a terminal at sea communicating with the network will hop from one satellite to the next throughout the duration of its call, as the satellites move overhead.

4.1.7 Each satellite is connected by a 10 Mbit/s data link to the four adjacent satellites via its four inter-satellite links (ISLs). There are four signalling communication channels through which the satellites communicate with each other. Not all satellites will be able to see a teleport ground station at all times, because of the geographic distribution of those teleports, so a satellite that is not in direct communication with the ground at any given moment will pass its communications to the ground via a chain of other satellites in the constellation until it reaches one that can see a ground station. The delay that is caused by this process, or "latency", is not more than 500 milliseconds, and is not significant for maritime distress and safety communications.

4.1.8 End-to-end latency of the Iridium network is monitored on a continuing basis by the United States Federal Aviation Administration (FAA) and several other Air Navigation Service

Providers (ANSPs) which have approved Iridium as a provider of air traffic control communications to aircraft operating in oceanic and remote regions. The Iridium network underwent almost two years of operational evaluation before the FAA approved Iridium to provide aeronautical mobile satellite route services (AMSRS) in 2011. The Assessment Team has seen some of the FAA reports, including an evaluation by the FAA Evaluator "Tiger Team" showing that approximately 95% of mobile terminated voice calls via the Iridium system were connected within 20 seconds and over 99% of mobile terminated voice calls were connected in about 30 seconds. These figures compare well with those for similar AMSRS provided by the legacy system monitored by the same FAA study. The figures for data messages, monitored in United States oceanic Flight Information Regions (FIRs) are summarized in the following table:

Airspace	Best Performing Aircraft	Worst Performing Aircraft
New York FIR	99% of SBD messages received in 90 seconds	95% of SBD messages received in 240 seconds
Oakland FIR	99% of SBD messages received in 90 seconds	98% of SBD messages received in 240 seconds
Anchorage FIR	99% of SBD messages received in 120 seconds	97% of SBD messages received in 240 seconds

Notes:

.1 SBD = Short Burst Data.

.2 The typical message size was less than 220 bytes.

.3 The better results correlate with more recent avionics installations on aircraft, while the lower performance numbers were typically from older aircraft installation.

Iridium has suggested that these figures could be made available to IMSO as an additional indicator for evaluation of network performance that could be used in developing the organization's annual report on the GMDSS performance of Iridium, if Iridium were to be approved for participation in the GMDSS.

4.1.9 The Assessment Team has reviewed the effect on distress and safety communications of a satellite failure in space. The situation with a LEO constellation using inter-satellite links (ISLs) is entirely different from that experienced with a geostationary constellation. The failure of a satellite in LEO orbit and using ISLs can be mitigated by a number of factors, including:

.1 if the failure is with one of the inter-satellite links, the satellite can continue to operate fully using the remaining three ISLs;

.2 if the failure is wholly or partly to one of the three phased-array antenna panels, the other antennas on the same space craft, and those on adjacent satellites may have their power adjusted to reduce the size of the gap in coverage that would otherwise be caused;

.3 if the failure is to the feeder link to the teleports then it is possible to re-route traffic through another satellite with a functional feeder link antenna to and from another teleport; and

.4 if an entire satellite were to fail, the service would be taken up by the adjacent satellites until an in-orbit spare could be drifted into location. The time taken for this to happen depends on the position of the spare satellite in relation to that which has failed. If the spare satellite is in the same orbit as the failed

satellite, then a drift might be accomplished within a few weeks. But if a satellite that is in a different orbital plane has to be used, as is possible given the present aging state of the constellation, the orbital drift combined with a change of altitude might take up to eighteen months to complete.

4.1.10 The question therefore arises as to what effect a "hole" in the constellation might have on operational distress and safety communications? Iridium has discussed this in detail in their application document (NCSR 1/12, annex, section 3.6). Given a failure of the main L-band communication service links using the phased-array antenna panels on a satellite, the "hole" in service would be completely restored by adjacent satellites when the failed space craft was between the pole and either 55 degrees North or South latitude, because of the closer proximity of the satellites in those latitudes. In the latitudes from 55 degrees North to 55 degrees South, the satellites are further apart and adjacent satellites will not provide full coverage over the "hole". The length of time during which service would not be available to a user in those latitudes varies from 5.6 minutes when the space craft is on the equator to 1.3 minutes when the space craft is at 50 degrees latitude. These represent the maximum periods when a user would be unable to send a successful distress alert/call or receive maritime safety information or distress alert relays.

4.1.11 Iridium has recognized the potential effects of such a short break in service on maritime distress alerting and has proposed technical methods to eliminate the impact of such a hole. **The Assessment Team has therefore recommended that Iridium requires manufacturers to design maritime terminals to continue to attempt transmission of a distress alert until an internal network acknowledgement message has been received by the terminal.** The Assessment Team also notes that the GMDSS has been designed specifically to allow for the exceptional failure of one means of distress alerting in a ship by requiring the carriage of at least two independent methods of distress alerting.

4.1.12 With regard to the receipt of maritime safety information, the current International SafetyNET broadcast has been implemented to take account of the short term non-availability of reception by providing for automatic 6-minute repetitions of vital messages. **A similar provision for repeat transmissions in the Iridium MSI broadcast service and distress alert relays would easily allow for a short term non-availability of reception of the type discussed above.**

4.1.13 The permutations available for restoring service in the event of the simultaneous failure of two adjacent satellites are too complex for analysis in this assessment, but they include, as for a single satellite failure, increasing the power and moving adjacent satellites out of their present orbit to minimise the size of the area of service non-availability. Although what has happened in the past is no certain guide as to what may happen in the future, the history of the Iridium network so far does not lead to a well-founded expectation that such a double failure is probable in the period before Iridium NEXT satellites are in space to bolster the robustness of the constellation in time for a final decision on approval by the Committee.

4.2 Ground Segment

Teleports

4.2.1 The Iridium network has five (5) geographically dispersed Teleport Network (TPN) sites (4 in North America and 1 in Norway) for commercial services, with one further site currently under construction in the Russian Federation. Teleports are used for satellite tracking, telemetry and support functions as well as handling the ground-space-ground communications with the satellite for collecting of health and safety information from satellites and delivery of corrective actions to satellites.

4.2.2 Multiple antennas and duplicate equipment are provided at each teleport site to provide redundant links to the satellites, thus mitigating the effect of failures and allowing equipment to be taken off line for maintenance. The geographical spread of sites in the Teleport Network provides a measure of resilience against catastrophic disasters caused by climate, geology, war or civil unrest, or failure of the local terrestrial infrastructure.

Gateway

4.2.3 The primary commercial Iridium gateway is located at Tempe, Arizona, which provides some satellite and network control, and operates as a switching centre to provide connectivity between the Iridium network and terrestrial networks. Other gateways in the Iridium network are not currently used for the provision of distress and safety traffic although the Technical Support Center (TSC) can be commissioned to restore the capabilities of the Tempe gateway in the event of a catastrophic failure of the primary commercial gateway.

4.2.4 Each teleport interconnects the satellite constellation with the Iridium gateways to transfer voice and data communications to and from Iridium user terminals. The gateway controls system access, call setup, mobility management, billing and tracking, and maintaining relevant information about user terminals such as user identity and location. The gateway routes communications received from both the satellites and teleports to the public switched telephone network (PSTN), Internet, virtual private network (VPN) or leased lines for end delivery to users via the terrestrial networks.

Satellite Network Operations Centre (SNOC)

4.2.5 The satellite constellation is flown and controlled by the Satellite Network Operations Centre (SNOC) at Leesburg, VA. This coordinates telemetry, tracking and control via the teleports and manages the health and safety of the whole constellation.

Technical Support Centre (TSC)

4.2.6 Iridium operates a Technical Support Centre (TSC) at Chandler, Arizona for development, testing and verification of all elements of the Iridium communication systems. The site even accommodates a laboratory which replicates the Iridium network, including gateway, teleports, SNOC as well as real-size satellites that are connected to each other via cables. TSC also collects information from auto-diallers for monitoring and performance analysis purposes.

4.3 Maritime Mobile Terminals

4.3.1 GMDSS-compliant maritime mobile terminals operating in the Iridium network are not yet available although several thousand ships currently use the Iridium "Pilot" maritime terminal and some handheld terminals for business communications today. Iridium is working with potential manufacturers, including those with long experience of the design and build of GMDSS-compliant radio equipment, to develop the required specifications and ensure that such terminals are brought to the market within the same time scale as the IMO final approval process is expected to take.

4.3.2 The maritime mobile terminal design will be derived directly from proven satellite terminal technology that has been used successfully over the Iridium network for many years. However, full GMDSS compliance cannot be guaranteed or completely assessed until maritime mobile terminals are available, and the production of such terminals will not happen before an IMO Performance Standard and an IEC Type Approval Test Standard have been developed. Careful management by IMO, IEC and Iridium will be required to coordinate this evolutionary process.

4.4 Spectrum

4.4.1 Iridium has provided the following information regarding the spectrum allocations used by its network:

.1 the Iridium network uses radio frequency assignments that have been coordinated and notified in accordance with the provisions of the ITU Radio Regulations;

.2 the service links between the mobile terminals and the satellites use assignments in the frequency band 1616.0 – 1626.5 MHz (L-band). The Iridium service links are unique in that Iridium's uplink and downlink use the same frequencies and are in the same allocation; the uplink being primary and the downlink secondary. This arrangement was made at the 1992 World Radio Administrative Conference (WARC 92). In conformity with footnote Nos 5.364 and 5.365, both assignments have been fully coordinated under No 9.11A and Notified under No11.32;

.3 the system also uses inter-satellite communication links to inter-connect the in-orbit satellites in the band 23.15 – 23.55 GHz (K-band);

.4 the system operates through feeder links in the bands 19.4 – 19.6 GHz (space to Earth) and 29.1 – 29.3 GHz (Earth to space) (Ka-band) for connection to the public switched network via the gateway.

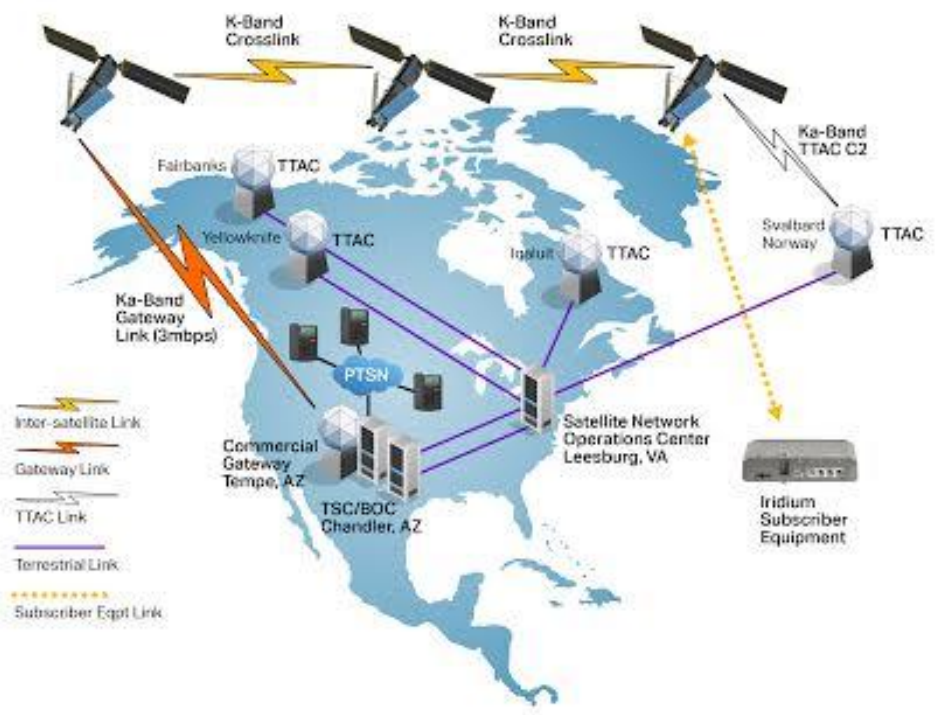

Figure 2. The Iridium Network

.5 the spectrum used for the Iridium satellite service is regulated according to Nos 5.359, 5.364, 5.365, 5.366 and 5.367 of the Radio Regulations. No 5.364 specifies sharing conditions and coordination requirements for Mobile Satellite Services (MSS) (Iridium) earth stations in the Earth to space direction. No 5.365 requires coordination for the space to Earth transmissions.

.6 the required coordinations have been carried out and the Iridium System service link spectrum was notified to the Radiocommunication Bureau of the ITU (ITU-BR) in 1998. An indication of this may be found in the ITU-BR International Frequency List (IFL) and thereby the frequency assignments in the Notification are entitled to protection; and

.7 coordination with Fixed services in the countries indicated in No 5.359 has also been carried out.

4.4.2 This means that the ship-to-shore link has been assigned *primary status by the ITU*, and it is this link that will carry the Distress Alert. While the shore-to-ship link has a *secondary* assignment, it has been fully coordinated and notified under the requirements of No 9.11A of the ITU Radio Regulations.

4.4.3 The issue of frequency coordination for, *inter alia,* the Iridium satellite system was discussed briefly by the eleventh session of the Joint IMO/ITU Experts Group on Maritime Radiocommunication Matters (Draft report dated 22 October 2015). The discussion has been reflected in Appendix 2 of the report of that session which contains the "Preliminary Draft Outcome of the Detailed Review of the Global Maritime Distress and Safety System (GMDSS)". Paragraph 4.12 of Appendix 2 of that Report states:

> "*Concern was expressed regarding frequency coordination. This should not lead to any change to the GMDSS Modernization Program under IMO, since the coordination should be carried out in accordance with the relevant procedures of the Radio Regulations.*"

4.4.4 **IMSO understands this to mean that the spectrum assignments used by Iridium have been properly coordinated and notified to, and assigned by ITU, and are therefore fully recognized by ITU-BR. If any further coordination is deemed necessary, it should be carried out in accordance with the relevant procedures of the ITU Radio Regulations. The level of protection afforded to the use of those frequencies is considered to be sufficient for GMDSS operational purposes.**

5 GMDSS-specific technical issues

5.1 Robustness of the Iridium network

5.1.1 The Assessment Team has considered whether the Iridium network, as a whole, is sufficiently robust, and can be relied upon to provide the high level of continuity of service required for GMDSS operations, in general, and Distress and Safety operation, in particular. Almost every part of the network is at least duplicated and in many cases multiple duplicates are provided. Measures available for recovery from failures in space and in the teleports have been discussed elsewhere in this Report (sections 4.1 and 4.2 above).

5.1.2 However, one potential single point of failure is the primary commercial gateway at Tempe, Arizona. If this gateway was to fail, all distress and safety traffic, including mobile-to-mobile, would cease to operate, as, although there is some internal redundancy, there is not currently any

external "hot" back-up for this essential part of the network. The Iridium TSC at Chandler, Arizona has about 80% of the equipment needed for it to act as an operational back-up facility, but has not been configured to provide immediate restoration of service in the event of a catastrophic failure of the primary commercial gateway. Although Iridium is aware of this vulnerability, and has committed to the eventual configuration of the Chandler site as an operational back-up for the commercial gateway at Tempe, the current assessment is that it may take up to 5 years from mid-2015 for the Chandler site to be capable of operating as a full back-up for Tempe. After discussion with the Assessment Team, Iridium is examining other ways of mitigating this risk, including alternative operational procedures for maritime safety services. In this regard it is noted, however, that the commercial gateway has been in successful continuous operation since 1999 without experiencing a complete failure. In spite of this, the Assessment Team believes that, given the configuration of the Iridium network, the lack of a "hot" back-up for the commercial gateway poses an unacceptable risk that needs to be resolved in order to meet the requirements of resolution A.1001(25), paragraphs 3.6.1 and 4.1.1.1. There is the further concern that Chandler is only 5 miles from Tempe and, although the area is not generally subject to natural disasters, catastrophic flooding is not unknown in that part of Arizona.

5.1.3 A further potential single point of failure is the SNOC at Leesburg, Virginia. The SNOC monitors the utilization of the satellite constellation, managing the health and safety of the satellites, and controls the satellite network elements. In the case of a catastrophic event or total power outage at the SNOC, arrangements are in place for the Back-up Operations Center (BOC) located at the TSC in Chandler, Arizona, to take over control of the SNOC operations, assuming responsibility for monitoring the network and maintaining the health and safety of the constellation. Procedures to accomplish this are in place and are exercised twice a year.

5.1.4 There are four modes for the BOC:

.1 Active – in which the BOC is fully active, monitoring the network and maintaining the health and safety of the constellation;

.2 Shadow or "Hot" – the BOC is in a hot standby mode, receiving telemetry from the constellation in parallel with the SNOC: the system is up and running at the BOC and could take over within minutes if the SNOC were to go offline;

.3 Offline or "Warm" – the BOC is inactive and the command consoles are offline; but the servers and administrative nodes are running and being fed by automated processes every four hours to keep the data at the BOC synchronized with the SNOC. From this mode the BOC can be started up and running within 2 to 4 hours; and

.4 Passive – equipment is switched off and the BOC is completely unmanned.

These actions are accomplished through a formal internal Iridium procedure and performed by trained BOC personnel.

5.1.5 **It is IMSO's assessment that, overall, the Iridium network has the potential to be sufficiently robust to begin GMDSS operations once some (but not necessarily all) of the Iridium NEXT satellites have been successfully launched and brought into service but that Iridium should be encouraged also to bring forward the investment necessary to provide a full back-up for the Leesburg, and Tempe facilities.**

5.2 Current status of the constellation

5.2.1 Although the Assessment Team has been made aware of the detailed current status of the Iridium constellation, some of that information is considered to be Iridium's proprietary information and is therefore not made public. The current status of the constellation was discussed in paragraph 4.1.2 above.

5.2.2 With regard to the deployment of the second generation satellite constellation, Iridium has provided the following information:

> "*Iridium NEXT Deployment: Implementation of a new satellite constellation is a large-scale project with many moving parts. While the current schedule is provided, projected dates may change. Iridium's overarching goal is to have the network fully deployed in 2017. The launch schedule consists of 8 launches, the first being out of Yasny, Russia with Kosmotras on a Dnepr rocket. The first launch, with two satellites, is scheduled for April 2016. The remaining 7 launches, with 10 satellites each, will be with SpaceX at Vandenberg Air Force Base, California.*"

5.2.3 The most important issue in this respect is that, bearing in mind the launch programme for the Iridium NEXT satellites, and the likely progress of Iridium's application through the Maritime Safety Committee and its subsidiaries**, according to Iridium's current plans, it is expected that the second-generation satellites will be in space and coming into operation before the Committee takes its final decision as to Iridium's participation in the GMDSS.**

5.3 GMDSS terminal design and production

5.3.1 The design, manufacture and testing of Iridium maritime mobile terminals for use in the GMDSS was discussed in section 4.3 above. A key element of this programme will be development of the necessary standards to allow Administrations to accept these terminals for use in the GMDSS.

Figure 3. Current Iridium handheld and maritime mobile satellite terminal equipment

5.3.2 Following a United States submission to MSC, a new unplanned output on "Performance Standards for shipborne GMDSS equipment to accommodate additional

providers of GMDSS satellite services" has been agreed and included in the 2016-2017 biennial agenda of the NCSR Sub-Committee with a target completion in 2016. This will be considered at NCSR 3 in 2016 under agenda Item 12, providing that the Assembly agrees to the proposed High-Level Action Plan. However, it is expected that IMO work on the Performance Standard will probably complete at NCSR 4 in 2017 and the Performance Standard be adopted at MSC 98 in June 2017.

5.3.3 Iridium is also working with IEC to begin development of the appropriate type-approval test standard. The average time for producing an IEC standard is about 3 years. If there has been interest in IEC to produce a technical standard incorporating the IMO Performance Standard, working in parallel with IMO, an IEC draft could be ready for June 2017. It then takes about 18 months to go through the IEC voting processes so a standard could potentially be published at the end of 2018.

5.3.4 Existing IEC requirements for environmental testing are expected to apply to Iridium maritime mobile terminals for use in the GMDSS.

5.3.5 Iridium is developing, in cooperation with some manufacturers, a "Terminal Developers' Guide". This document will provide information on mandatory and recommended aspects of terminal design for GMDSS equipment. The initial draft Developers' Guide is expected to be completed by the end of 2015. It is possible that there may be a need for Iridium to produce some form of generic guidance for ship equipment installers, and Iridium is aware of this potential requirement.

5.3.6 **It is IMSO's expectation that a type-approved GMDSS-compliant Iridium maritime mobile terminal is unlikely to be available on the market before 2019.**

5.4 Prioritization and Pre-emption

5.4.1 An important requirement of resolution A.1001(25) is the provision of means for prioritization of Distress, Urgency and Safety calls and messages, and giving them immediate access to the network, if necessary by pre-empting ongoing communications of lower priority. The Assessment Team has reviewed in detail the arrangements being put in place by Iridium in this respect, including examining the software protocols by which these capabilities are implemented and successfully performing live test demonstrations of both prioritization and pre-emption in the field.

5.4.2 Iridium has already implemented a number of levels of priority within its network, four (4) will be made publicly available to coincide with the four levels of priority defined in the ITU Radio Regulations, article 53 and required by resolution A.1001(25), paragraph 3.3.1, as follows:

.1 distress calls, distress messages and distress traffic;

.2 urgency communications;

.3 safety communications; and

.4 other communications.

There is some divergence of implementation of these four levels of priority because the legacy satellite service operator numbers them from 3 to 0 as opposed to the Radio Regulations themselves which number them from 1 to 4. Iridium requested guidance from the Assessment Team as to the correct interpretation of the regulations, while indicating that their system could

implement either 3 to 0 or 1 to 4. Recognizing that Iridium has already implemented a solution according to the ITU Radio Regulations, the Assessment Team has advised Iridium to use the numbering as provided in the ITU Radio Regulations. In practice, this is expected to lead to difficulties in operational interpretation even though in almost every case operational systems define these levels of priority by using words rather than numbers. This divergence of interpretation is likely to pose a risk for machine-to-machine communication platforms in the future.

5.4.3 Prioritization and pre-emption of calls, and access control, were demonstrated using a standard Iridium type 9555 handset with a SIM card configured to operate in the Safety Voice Service currently in use in aviation, and using non-Iridium consumer mobile devices. Both the 9575 and 9555 handsets were used to demonstrate caller identification. A call from the 9575 handset to a non-Iridium device showed the Iridium number (Rec. ITU E.164) and a call from the 9555 handset to a non-Iridium device showed an ICAO number, demonstrating the ability to use an MMSI for caller identification.

5.4.4 **The Assessment Team made live test transmissions of a number of calls with different priorities and observed correct priority handling and pre-emption actions being taken by the network in every case**.

5.5 Distress Alerts

5.5.1 The Assessment Team originated emergency messages using the Red SOS Button facility on an Iridium 9575 "Extreme" handset and other demonstration equipment. This test demonstrated the ability of the network to react to and handle correctly a Distress Alert type of message originated by a single push of a button and using the short burst data service. Only four (4) out of five (5) test transmissions by the Assessment Team using the Red Button were apparently successful. Although one message failed, it is not clear whether this was a system failure or a problem with the test device and associated application. The small number of demonstrations conducted was intended to be indicative of functionality rather than performance. Acknowledgement messages confirming receipt of the test distress alerts were received back. This is the functionality that will be built in to GMDSS-compliant maritime mobile terminals.

5.5.2 A distress alert and call-back was demonstrated using a standard Iridium type 9575 "Extreme" handset. This demonstration was done by prior agreement with an emergency call handling centre or "central alerting post" (CAP). The test also demonstrated the transmission of location information to the CAP, and the ability to transmit location information to other non-Iridium devices by SBD or SMS.

5.5.3 Distress alerting was also demonstrated using development equipment to send an SBD message through the network to a dedicated application and display device. This message, displayed on a web page, showed "Mayday", the MMSI, ship's name, Global Positioning System (GPS) location and time stamp.

5.5.4 The Short Burst Data (SBD) system by which these alerts were transmitted is properly defined as a "store and forward" system. This is generally understood to mean that the system stores a message for a finite time, usually of several seconds and sometimes minutes, before forwarding the message for transmission. In the Iridium system, this is not the case and, although messages will be stored in the satellite before they are forwarded via other satellites to a teleport for onward transmission via the ground networks, this process takes only milliseconds and so the system does not perform as a "store and forward" system is normally understood to perform. In the shore-to-ship direction, messages with a higher priority will always be transmitted before any other messages in a queue.

5.5.5 In all, the Assessment Team was able to observe live demonstrations of actual capabilities via the Iridium network as follows:

.1 routine call from shore-to-ship (connected in 13 seconds);

.2 pre-emption of a voice call in progress from a mobile terminal;

.3 transmission of GPS position data using the SBD service from a mobile terminal; and

.4 transmission of a distress alert activated on a mobile terminal with a "Red Emergency Button" (delivery acknowledged within 10 seconds when successful).

In all of these tests, the terminal identity was transmitted successfully.

5.5.6 In order to preserve the integrity of the maritime distress and safety services, access to some of these capabilities may be restricted to authorized entities. In particular, the Iridium Safety Voice service, which may be used to place priority voice calls in the ship-to-shore direction in an emergency situation, offers the ability to limit access to the service through the use of a Subscriber Identity Module (SIM) card. This platform is used for air traffic control applications at present.

5.5.7 Although these functionalities are not yet specifically applied to the maritime environment, the Assessment Team is satisfied that the capabilities they have observed and examined will provide a sound basis for the implementation of both prioritization and pre-emption in the GMDSS. However**,** based on the results observed in the live demonstrations, **the Assessment Team believes that the success rate of distress alert transmissions needs to be shown to have improved before the Maritime Safety Committee takes a final decision on the Iridium application**.

5.5.8 One further aspect of priority call and message handling was considered by the Assessment Team: satellite capacity. Given the ability of each first generation satellite~~s~~ to handle up to 1000 calls or messages simultaneously, and the effective implementation of the priority and pre-emption functions described above, combined with the large increase in the number of simultaneous calls that the second generation satellites will be able to handle, the Assessment Team does not believe that network capacity and congestion will be issues for the maritime distress and safety services for the foreseeable future.

6 Iridium operation in the GMDSS

This part of the Assessment Report focusses on the performance by the Iridium system of the current nine (9) functions required by chapter IV of SOLAS, which include the 6 functions specifically required by resolution A.1001(25). Some of the nine functions required by SOLAS chapter IV are not suitable for satellite communications, but they have been included in this assessment in order to provide a complete overview of Iridium's capabilities.

6.1 Transmission of ship-to-shore distress alerts/calls

6.1.1 The distress alert function, at present, is implemented for land mobile and aeronautical users. Aeronautical alerts are terminated to Air Traffic Control (ATC) and land mobile alerts terminate the distress alert at a commercial distress communications handling company located in the United States. All maritime distress priority communications will be terminated at a suitable Maritime Rescue Co-ordination Centre (MRCC). In the first instance, because not all Rescue Coordination Centres (RCCs) are able to respond adequately at all times, it is probable that one

or more associated RCCs will be used, with their agreement, as points of input for distress alerts to the international maritime search and rescue network, with those MRCCs being selected on the basis of their geographical location and operational capability.

6.1.2 The functionality of a distress alert "Red Button" is currently only implemented on the Iridium 9575 "Extreme" handset. Successful tests of that functionality by the Assessment Team were described above in section 5.5 above.

6.1.3 The Distress Alert originated using the Red Button is a single data packet sent via the Iridium SBD service. The Assessment Team has advised Iridium that the maritime Distress Alert should preferably be implemented in GMDSS compliant maritime mobile terminals so that the Red Button is "press and forget", which means that the Distress Alert data packet should contain all the information needed by an MRCC to prosecute a search and rescue operation if the MRCC is unable to establish follow-on communications with the originating vessel.

6.1.4 A full description of distress alert and call routing within the Iridium network is provided in document NCSR 1/12, annex, paragraph 3.1.1. If a distress call is not delivered to, or answered by an RCC, the Iridium Network Operations Centre staff at the Tempe Gateway will receive a visual and audible notification and will then be able to take action to deliver the alert to another RCC by alternative means. This functionality has not yet been implemented.

6.1.5 Total network latency for the delivery of a ship-to-shore distress alert, call or message is reported by Iridium to be "*less than 60 seconds more than 95% of the time for users that have a dedicated connection to an Iridium gateway*". These figures are primarily derived from Iridium's aeronautical experience. MRCCs will not generally have a dedicated connection to the gateway because such connections are extremely expensive and most prefer the resilient routing provided by the public switched networks. However, provision is being made for direct connection to each of the first level RCCs mentioned in paragraph 6.1.1, if they request it. Experience shows that latency times for delivery to MRCCs using the public switched networks are not expected to be significantly different from those for MRCCs using a dedicated connection, and will, therefore, meet the standard required by resolution A.1001(25).

6.1.6 In the distress alert distribution scenario described, the first level MRCCs will act as the "First RCC" within the terms of the International Convention on Maritime Search and Rescue, 1979, as amended (SAR Convention), and will either handle the distress event themselves or pass it on to a "Responsible RCC", if and when they are able to do so. Thus, the distress message handling arrangements that are envisaged for the Iridium network will be entirely in accordance with the provisions of the SAR Convention.

6.1.7 In order to enable rapid direct dialling to any MRCC, Iridium will assign a short dialling code to every MRCC and a user-selected short code will be installed in every maritime mobile terminal installed in GMDSS ships. This will, for example, enable the ship's staff to contact an RCC of their choice at any time from any position in the World.

6.1.8 The Assessment Team also reviewed the provisions for ensuring that no terminal is prevented from placing a distress alert or call, even if it has been barred from using the network for commercial reasons. Iridium has three (3) kinds of status for terminals in this regard:

Active	in which the terminal is fully functional in the network and all authorized services can be used;
Suspended	in which state a terminal can only send a distress alert; a special dial code will be provided when required to enable distress calls to be made; and
Deactivated	in which state the terminal can only send a distress alert.

Any Iridium terminal, whether it is Active, Suspended or Deactivated, will be able to send a Distress Alert via the Iridium network.

6.1.9 The potential effects of some possible failures within the network, both in space and on the ground, have been described in paragraphs 4.1.9 and 4.1.10, and section 5.1 above. The Assessment Team has made a consequential recommendation with regard to the operation of maritime mobile terminals: that they should continue to transmit a distress alert at specified intervals until an acknowledgement message is received from the network. Iridium will bring this recommendation to the attention of manufacturers of maritime mobile terminals.

6.1.10 **It is assessed therefore that maritime distress alerting has the capability to operate satisfactorily over the Iridium network, to the standards required by the Organization, when it has been fully implemented.**

6.2 Reception of Shore to Ship Distress Alerts

6.2.1 Shore-to-ship distress alerts can be received by a ship in a number of different ways via the Iridium network:

.1 the primary method is likely to be via an "all ships" broadcast. Such a broadcast can be originated by an MRCC addressed to an entire NAVAREA or more usually to a user-defined area set up dynamically by the RCC itself. It is common for MRCCs to address such messages to a relatively small area around their Search and Rescue Datum, and enlarge the area in subsequent broadcasts if they receive an inadequate response from ships in the initial area. This capability will be provided by the Iridium network; and

.2 alternatively, either a data message or a voice call could be addressed to a particular ship. This is not always an easy option since the appropriate address (e.g. telephone number) of the vessel must be known before the call can be placed. It is usual for an RCC to know only the MMSI of ships in the vicinity of a distress event. The Assessment Team has invited Iridium to consider ways in which the MMSI could be translated into a telephone number automatically within their system, thus avoiding that difficulty. Iridium is working to implement this recommendation.

6.3 Transmission and reception of ship-to-ship distress alerts

6.3.1 The GMDSS was particularly designed so that ships should make distress alerts and calls to the shore (normally an MRCC). Making a ship-to-ship distress call is almost exclusively something that happens on VHF Channel 16 between ships in sight of one-another. It is not a function that will normally be undertaken via satellite. As with other satellite systems, the Iridium network is not optimized for mobile-to-mobile calls, although such calls are not difficult to make. However, in order to make a successful ship-to-ship call it is necessary to know the telephone number of the ship being called. Even placing an MF– or VHF-DSC call requires knowledge of the called ship's MMSI. In fact, there are very few scenarios in which a ship in distress will know the number of another ship that is in a position to assist, and which cannot more effectively be called on VHF Channel 16.

6.3.2 It is not possible to originate an "All Ships" call from a mobile terminal, with or without assigning a high priority to the call.

6.4 Transmission and reception of search and rescue coordinating communications

Search and rescue coordinating communications may be originated either by the shore (an MRCC) or by a ship or ships (such as a vessel designated "on-scene coordinator"). An MRCC may attach Distress priority to a call by using two-stage access – User Identification (ID) and Personal Identification Number (PIN) – to identify itself to the network. The Iridium network may be useful in either of these situations since both the shore authority and the on-scene coordinator will be in a position to know the telephone number for vessels that have been requested to assist in a search and rescue operation. Data communications may also be used in this situation if preferred by the MRCC or ships involved.

6.5 Transmission and reception of on-scene communications

The situation in respect of "on-scene" communications is similar to the transmission and reception of search and rescue coordinating communications, except that in this case all communications will be ship-to-ship. The Iridium network may be used if each ship knows the telephone number of every other ship with which it needs to communicate. However, VHF Channel 16 will usually be a better option for such communications.

6.6 Transmission and reception of signals for locating

Locating is a function that is generally performed in the GMDSS by either a Search and Rescue Radar Transponder (SART) or an Emergency Position Indicating Radio Beacon (EPIRB). It is not a function that Iridium will be expected to perform under the terms of resolution A.1001(25), although some possibilities for locating maritime mobile terminals may exist within the Iridium system.

6.7 Transmission and reception of Maritime Safety Information (MSI)

6.7.1 Maritime Safety Information is defined as: *navigational and meteorological warnings, meteorological forecasts and other urgent safety-related messages broadcast to ships* (SOLAS regulation IV/2). Iridium is in the process of designing a maritime safety information broadcast system, in cooperation with the World Meteorological Organization (WMO), the International Hydrographic Organization (IHO) and the International Ice Patrol (IIP), which are among the parent organizations under which the MSI Providers carry out their operations.

6.7.2 Transmission of MSI by ships to shore authorities is accomplished using the general communication capabilities of the Iridium system. Messages can be addressed to relevant shore authorities (hydrographic offices, meteorological offices or other shore authorities) using the contact details published in Lists of Radio Signals and elsewhere.

6.7.3 The Iridium shore-to-ship MSI broadcast system will be based on an overlay of 26,636 "Global Delivery Areas" (GDAs). Each GDA is a hexagon some 150 km across. Broadcast messages can be addressed to one or any group of GDAs, contiguous or not. Iridium will pre-define lists of GDAs that encompass each NAV/MET Area. The list of GDAs for each area could be expanded to include a zone around the outside of each area of any distance, to accommodate the requirement for a ship to be able to receive MSI for an area before it enters that area. The zone around any given area can be chosen to be any size or shape, and so could be chosen to include all adjacent NAV/MET Areas, if required. A similar, but smaller zone is already used by the legacy satellite service provider to accommodate diurnal and other small movements of the geostationary satellites. The pre-defined group of GDAs for each NAV/MET Area will be known as a Broadcast Coverage Area (BCA).

6.7.4 In addition, Iridium provides a capability for an authorized user to transmit messages to user-defined areas, either Rectangular or Circular, as required by resolution A.1001(25), annex, paragraph 4.9.4.3.

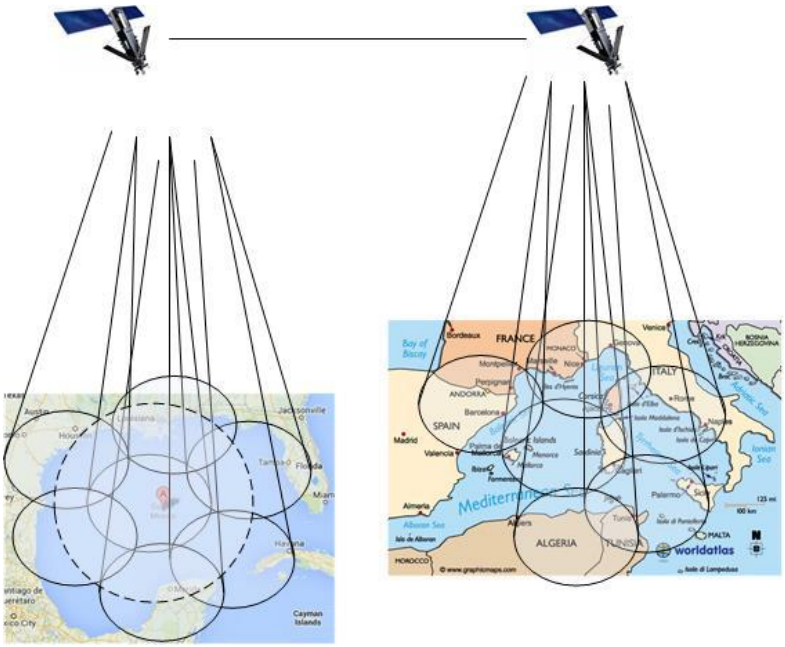

Figure 4. Broadcasts to a user-defined area (central point plus radius) and a pre-defined area (such as a NAV/MET Area).

6.7.5 The Assessment Team performed test broadcasts to groups of GDAs and observed the correct broadcast and handling of the test messages. This test included a broadcast to a user-defined circular area, such as is commonly used by Search and Rescue authorities.

6.7.6 The definition of Coastal and other broadcast areas can easily be accomplished using the same methodology as for NAV/MET Areas.

6.7.7 Programming a mobile terminal to receive the current and next NAV/MET Area, and facilities for logging messages that have been received, are functions that will require suitable software in the GMDSS-compliant maritime mobile terminals. These functions exist in the Inmarsat C system and it should not be difficult to develop similar functionality in Iridium terminals.

6.7.8 Only authorized entities will be allowed to input messages for transmission, in a similar manner to the existing broadcast system. Access will likely be limited by requiring a two-stage access procedure using a password and PIN. Authorized MSI providers are expected to be able to input messages for broadcast using email, a web interface or transmitted data.

6.7.9 Iridium was not in a position to state the exact cost of using such a broadcast system at the time of writing this document, but has stated formally that the company will fully comply with the charging policies and provisions as described in resolution A.707(17), Recommends 1 and 2. This recommendation includes provisions for charging for MSI broadcasts. The matter of additional charges for MSI broadcasts if a second provider is brought into the GMDSS is currently under consideration by IMO, WMO and IHO.

6.7.10 Iridium is in discussion with the MSI providers through WMO and IHO concerning the provision of a capability to allow the MSI providers to monitor the broadcasts they originate.

6.7.11 **It is assessed that the Iridium system includes the necessary building blocks on which an operationally effective MSI broadcast service can be implemented.** The work needed to complete this evolution can easily be completed within the time that the Committee will need to finalize its decision in relation to Iridium's participation in the GMDSS.

6.8 Transmission and reception of general radiocommunications

Within the GMDSS, General Radiocommunications are those communications between ship stations and shore-based communication networks which concern the management and operation of the ship and may have an impact on its safety. Maritime mobile Iridium terminals will be capable of conducting general communications both as voice calls and data messages, in both the to- and from-ship directions.

6.9 Transmission and reception of bridge-to-bridge communications

Bridge-to-bridge communications are normally initially carried out using VHF Channel 16, and relevant VHF bridge-to-bridge working channels. The Iridium system could be used for bridge-to-bridge communication if the calling ship knew the telephone number of the ship it wished to call. But this would be most unusual and relatively costly, since VHF communication in this instance would be free of charge. Bridge-to-bridge communications are, therefore, normally not carried out via satellite communications.

7 Coverage

The Iridium network provides complete coverage of the globe from pole to pole and in all longitudes.

8 Availability

8.1 One particular issue arising from resolution A.1001(25) is the calculation of availability which, inter alia, is used for the annual report to the NCSR Sub-Committee by IMSO. The resolution states: "*The availability of any mobile satellite system or service is defined as the percentage of time in which the system or service as a whole is available for access to and communications through the system. . .*". The formula for calculating the availability given in that resolution is taken from the ITU and gives a good understanding of availability, but it is open to interpretation regardless of the type of constellation being considered.

8.2 IMSO believes that the most useful picture of the availability of the Iridium LEO constellation should take into account the operation of the satellites, both individually and acting together as a network in space, as well as all the elements of the ground infrastructure, including the teleports and the network and satellite control functions up to, but not including, the public switched networks to which they inter-connect.

8.3 Iridium undertakes a continuous programme of live monitoring of the network, using banks of auto-diallers that place repeated calls through the Iridium network and measure and record call success and failure rates, latencies, and many other statistics relevant for network management. **IMSO recommends that IMO authorise IMSO to use data from this or a similar monitoring programme to assess and review availability on an annual basis.**

9 Potential additional GMDSS functionality

9.1 In reviewing the possible uses of the Iridium network in the GMDSS, the Assessment Team became aware that there may be a potential for using suitably type-approved waterproof Iridium handsets in liferafts and lifeboats. This could offer additional benefits if the Iridium network is eventually approved for use in maritime safety applications.

9.2 The Assessment Team also believes that there may be an opportunity for authorized shore authorities to obtain information on the geographical location of some Iridium terminals either from Iridium itself or by polling the terminal they are trying to locate. This capability would probably only be made available to recognized Search and Rescue entities engaged in a search and rescue operation.

9.3 Similarly, it may be possible in the future to calculate a possible position for an Iridium terminal using Doppler data developed from the relative movement of the satellite and the terminal.

10 Compliance with other IMO requirements for the GMDSS

In addition to resolution A.1001(25), a significant number of other resolutions and circulars have some bearing on the operation of Iridium within the GMDSS. These additional requirements are not reviewed in detail in this report, although the majority of what they cover has been dealt with in the foregoing paragraphs. A non-exhaustive list of these references was developed during the work of the Assessment Team and has been provided to Iridium.

11 Oversight of Iridium services by IMSO

11.1 It is a requirement of resolution A.1001(25) paragraph 2.4.1 that, if approved by the MSC for the provision of communications services within the GMDSS, Iridium must agree to accept oversight of those services by IMSO. Iridium's commitment to accept this oversight is quoted in paragraph 3.5.2 above.

11.2 IMSO has made preparations for undertaking such oversight by developing a Reference Public Services Agreement (RPSA) to be signed by any and all satellite operators approved for the provision of communications services within the GMDSS. Since the matter was first presented to NCSR 1, Iridium and IMSO have discussed the Reference PSA and it is anticipated that Iridium will sign the document if the MSC decides to approve its participation in the GMDSS.

12 Conclusions

12.1 The assessment of IMSO in relation to each of the requirements of resolution A.1001(25) is summarized in the attached table (Annex 2). In the table, each requirement that applies to the Iridium application is annotated as MET, Partially MET or WILL BE MET. It is clear from this assessment that Iridium has put in place many of the technical, operational and engineering preparations that are necessary before the Iridium satellite communications system could be approved for participation in the GMDSS. However, there remain some areas in which the company needs to make further preparations before receiving approval to participate in the GMDSS. Many of the requirements that have not yet been met relate to the capabilities of mobile earth stations (maritime mobile terminals), which have not yet been developed (but see section 5.3 above), and the broadcast of maritime safety information.

12.2 Iridium has made significant progress towards achieving full compliance with resolution A.1001(25). The company should be congratulated and encouraged to continue to prepare its services for final approval in due course.

12.3 Finally, it should be noted that resolution A.1001(25) was drafted at a time when only geostationary satellite systems could offer the relevant mobile communication capabilities and functions. Many of the requirements of that resolution have been drafted in a way that is more-or-less specific to the functioning of communication satellites in the geostationary orbit. It is, therefore, recommended that the Organization considers undertaking a review of that resolution to broaden its applicability in the context and within the same timescale as the ongoing review and modernization of the GMDSS.

Annex 1

MEMBERSHIP OF THE GROUP OF EXPERTS

1 Independent Consultant Experts

Ms Betty Bonnardel-Azzarelli (France)
Dr Ismail Cicek (Turkey)
Mr Howard Feldman (United Kingdom)

2 Government Seconded Experts

Mr Sergey Starik (Russia)
Mr Qu Yijiang (China)

3 United States Observers

Captain Glenn Hernandez (United States Coast Guard)
Mr Brad Benbow (United States Coast Guard)

4 Project Administrator

Mr Jon Bilbao (Spain)

SPECIAL ADVISER TO THE DIRECTOR GENERAL OF IMSO

Mr Andy Fuller (Consultant, Former Deputy Director General of IMSO)

MEMBERS OF IMSO STAFF

Captain Moin Ahmed (Director General)
Captain Ozkan Istanbullu (Technical Officer)
Mr Halil Keskin (Technical Officer)

Annex 2

CRITERIA AND REQUIREMENTS FOR MOBILE SATELLITE COMMUNICATION SYSTEMS OPERATING IN THE GMDSS **- extracted from resolution A.1001(25) and annotated to show Iridium compliance**		
Resolution A.1001(25) paragraph	**Resolution A.1001(25) text**	**IMSO Assessment**
1	**DEFINITIONS**	
2	**RECOGNITION OF MOBILE SATELLITE COMMUNICATIONS SYSTEMS FOR USE IN THE GMDSS**	
2.1	The evaluation and recognition of satellite systems participating, or wishing to participate in the GMDSS are undertaken by the Organization.	
2.2	Application for Recognition	
2.2.1	Satellite system providers wishing to participate in the GMDSS should apply to the Organization, through a Member State, for recognition as a radio system providing maritime distress and safety satellite communication capabilities for use in the GMDSS. Such applications should be notified to the Organization by Governments, either individually or in cooperation with other Governments. The application will be reviewed by the Maritime Safety Committee (MSC) in relation to its policy for the expansion of satellite services in the GMDSS. If the MSC decides that there are no objections in principle to the application, it will forward the application to the COMSAR (now NCSR) Subcommittee for evaluation. Recognition of the satellite provider to operate in the GMDSS will be undertaken by the committee on the basis of the evaluation report.	Requirement MET (para 1.3 and NCSR 1/12)
2.2.2	The Governments concerned should make available to the Organization all necessary information to enable it to evaluate the satellite system in relation to the criteria indicated below. In particular, Governments proposing such satellite systems for possible recognition and use in the GMDSS should provide evidence to show that:	
2.2.2.1	the satellite system conforms with all the criteria specified in this annex;	Requirement PARTIALLY MET
2.2.2.2	the charging policies and provisions of resolution A.707(17), as amended, on Charges for distress, urgency and safety messages through the Inmarsat system, are complied with;	Requirement WILL BE MET once IMO approval has been received (para 3.5.1)

2.2.2.3	there is a well-founded confidence that the company concerned will remain viable for the foreseeable future and will remain in a position to deliver the required services over an extended period, in keeping with the expectations of the Organization and the maritime industry as to the continuity, durability and reliability of the service; and	Requirement MET (para 3.2)
2.2.2.4	the provider of the satellite system is ready to submit any recognized services to oversight by IMSO and sign the required Public Services Agreement (PSA) with that organization.	Requirement WILL BE MET once IMO approval has been received (para 3.5.2)
2.3	**Verification and Evaluation**	
2.3.1	The COMSAR Sub-Committee should verify and evaluate the information, seeking clarification as required direct from the service provider concerned, and decide whether the satellite system meets the criteria established by this resolution. In reaching its decision, the COMSAR Sub-Committee should take into account the provisions of the relevant regulations of chapter IV of the 1974 SOLAS Convention, as amended and the criteria established by this resolution.	In Progress (para 1.5)
2.3.2	Recognition by the Organization should be recorded in an MSC resolution entitled Statement of Recognition of Maritime Mobile Satellite Services provided by [Company Name], detailing the specific services provided by the company which have been recognized by the Organization. A copy of the statement of recognition should be provided to IMSO.	IMO activity
2.3.3	If, following evaluation, the Organization is unable to recognize the company or the service(s) offered for the GMDSS, the Organization should communicate this decision to the company and IMSO in writing, setting out the reasons for the decision and any actions the company may take to achieve recognition in the future.	IMO activity
2.4	**The Public Services Agreement**	
2.4.1	Recognized services are subject to oversight by IMSO according to the rules and arrangements set out in the public services agreement (PSA) concluded between the service provider and IMSO. No maritime satellite system should be used in the GMDSS unless it has first been recognized by the Organization in accordance with the above procedure and the service provider has signed a PSA with IMSO.	IMSO activity (para 3.5.2 and section 11)
2.4.2	IMSO should conduct its oversight of the recognized services on a continuing basis.	IMSO activity (section 11)
2.4.3	Responsibility for ensuring compliance with the standards established by this annex, other relevant mandatory international instruments and, to the extent necessary, those recommendations, resolutions and procedures of IMO and ITU which are of a recommendatory nature insofar as they relate to the provision of GMDSS services, rests with IMSO under the terms of the Public Services Agreement.	IMSO activity (section 11)

2.5	**Reports** At least once a year, IMSO should make available to the Organization a report on availability, performance and other relevant information in respect of each recognized service, for the period since the preceding report, in accordance with section 3.5.2 of the criteria indicated below.	IMSO activity
3	**CRITERIA AND REQUIREMENTS FOR THE RECOGNIZED MOBILE SATELLITE COMMUNICATIONS SYSTEM**	
3.1	***Functional Requirements**** ***Satellite systems for maritime distress and safety communication services and forming part of the GMDSS radio systems specified in chapter IV, regulation 5 of the 1974 SOLAS Convention, as amended, should provide capabilities for at least the following maritime distress and safety communications:*** Notes: ** – Resolution A.801(19) "Provision of Radio Services for the Global Maritime Distress and Safety System (GMDSS)", annex 5 "Criteria for use when providing Inmarsat shore-based facilities for use in the GMDSS";* *– Resolution A.887(21) "Establishment, Updating and Retrieval of the Information Contained in the Registration Databases for the Global Maritime Distress and Safety System (GMDSS)";* *– Resolution A.694(17) "General requirements for Shipborne Radio Equipment forming Part of the Global Maritime Distress and Safety System (GMDSS) and for Electronic Navigational Aids";* *– IMO International SafetyNET Manual;* *– Resolution A.664(16) "Performance Standards for Enhanced Group Call Equipment"; and* *– Appropriate IEC Standards and ITU Recommendations.*	
3.1.1	ship-to-shore distress alerts [data]/calls [voice]	Requirement partially MET awaiting availability of type approved terminal (section 5.5 and para 6.1)
3.1.2	shore-to-ship distress relay alerts [data]/calls [voice]	Requirement partially MET Awaiting availability of type approved terminal (section 6.2)
3.1.3	ship-to-shore, shore-to-ship and ship-to-ship search and rescue coordinating communications	Requirement partially MET Awaiting availability of type approved terminal (sections 6.3, 6.4, 6.5)
3.1.4	ship-to-shore transmissions of Maritime Safety Information (MSI)	Requirement partially MET Awaiting availability of type approved terminal (para 6.7.2)

3.1.5	shore-to-ship broadcasting of Marine Safety Information (MSI)	Requirement WILL BE MET when the proposed broadcast system has been implemented by Iridium and the MSI Providers (section 6.7)
3.1.6	ship-to-shore, shore-to-ship, and ship-to-ship general communications	Requirement partially MET Awaiting availability of type approved terminal (section 6.8)
3.2	Capacity. The satellite system should be designed to provide sufficient channel and power capacity to process effectively, with the availability stated in section 3.5, the maritime distress, urgency, safety and general communication traffic estimated to be required by the ships using the system.	Requirement MET (para 5.5.8)
3.3	**Priority access**	
3.3.1	Satellite systems in the GMDSS should be capable of processing maritime distress, urgency, safety and routine communications in accordance with the message priority as defined by the ITU Radio Regulations. The order of processing these communications should be: .1 distress .2 urgency .3 safety; and .4 routine (general communications)	Requirement MET (section 5.4)
3.3.2	In implementing these four levels of priority:	
3.3.2.1	Distress alerts (data) and distress calls (level 1) (voice) should be given priority treatment by providing immediate access to satellite channels. For store and forward systems, distress alerts and calls should be placed ahead of all other traffic.	Requirement MET (section 5.4)
3.3.2.2	Satellite systems used for providing other mobile satellite communications in addition to maritime communications should be capable of automatically recognizing requests for maritime communications from: -- maritime mobile terminal -- recognized entities of critical importance for safety at sea, such as MRCCs, hydrographic and meteorological offices, medical centres, etc., registered with the earth station. The system should process such maritime communications in the ship-to-shore and shore-to-ship directions for levels 1 to 3 with priority over other communications.	Requirements MET (section 5.4)
3.3.2.3	In processing maritime distress, urgency, safety and routine communications, the satellite system and the earth station should be capable of:	
3.3.2.3.1	automatically recognizing the message or access priority for ship-to-shore communications;	Requirement MET (para 5.4.3)

3.3.2.3.2	automatically recognizing the message or access priority for shore-to-ship communications, if any are provided, from, as a minimum, recognized entities of importance for safety at sea, registered by the earth station;	Requirement WILL BE MET when 'recognized entities' have been registered (para 5.5.4)
3.3.2.3.3	preserving and transferring the priority;	Requirement MET (para 5.5.2 and 5.5.3)
3.3.2.3.4	giving distress alerts and distress calls immediate access, if necessary by pre-empting ongoing communications of routine priority;	Requirement MET (para 5.5.3 and 5.5.5)
3.3.2.3.5	automatically recognizing maritime distress communications and automatically routeing maritime distress alerts and distress calls directly to an associated MRCC, or responsible RCC if this capability exists; and	Requirement WILL BE MET when 'associated' RCCs have been selected and incorporated into the network (paras 6.1.1, 6.1.6, 6.1.7)
3.3.2.3.6	processing maritime urgency and safety communications in the ship-to-shore and shore-to-ship directions with the required priority, for example by allocating the first vacant channel, if no channel is immediately available.	Requirement MET (para 5.5.3 and 5.5.5)
3.3.2.4	Selection and use of message or access priority for urgency and safety transmissions by maritime mobile terminals should preferably be automatic and should be restricted to calls to special, recognized entities such as medical centres, maritime assistance, hydrographic and meteorological offices, etc., registered with the earth station. The earth station should automatically route such calls directly to the relevant entity.	Requirement WILL BE MET - function not generally now in use
3.4	**Coverage area**	
3.4.1	The definition of the coverage area is given in section 1.3.	
3.4.2	The coverage area is to be delineated on a map and also described in relation to the sea areas defined in chapter IV, regulation 2 of the SOLAS Convention. Documentation on the coverage area of the satellite system, as defined in section 1.3, should be forwarded to the Organization.	Requirement MET coverage is GLOBAL (Figure 1 and section 7)
3.4.3	Information on coverage areas for satellite systems forming part of the GMDSS should be published by the Organization in the GMDSS Master Plan.	IMO activity if approved
3.5	**Availability**	
3.5.1	The satellite system should provide continuous availability for maritime distress and safety communications in the ship-to-shore and shore-to-ship directions.	Requirement WILL BE MET During replacement of existing satellites (paras 4.1.3 and 4.1.4)

3.5.2	The availability of the space segment, provision of spare satellite capacity and the network control function (i.e. the network availability), as defined in section 1.4 above, should be monitored by IMSO, which should report on the recorded availability of the system to the Organization at least once every year.	IMSO activity when MSC has agreed to methodology for reporting availability (section 8)
3.5.3	Service providers should advise their associated RCCs and IMSO of planned outages of recognized services and advise ships of scheduled downtime and known interruptions in service, and supply any other relevant network information. Service providers should also advise IMSO of unscheduled interruptions in any recognized services, as soon after the commencement of the interruption as possible, and when the recognized services have been restored.	Requirement WILL BE MET once IMO approval has been received
3.5.4	Network availability. The complete mobile satellite communication network, including earth stations for the recognized services, is expected to achieve at least 99.9% availability (equivalent to a total of 8.8 hours down time per year).	Requirement WILL BE MET during replacement of existing satellites (para 4.1.3)
3.6	**Restoration and Spare Satellites**	
3.6.1	Spare satellite capacity and arrangements prepared in advance should be provided to ensure that, in the event of a partial or total satellite failure, the recognized maritime distress and safety communication services in the area concerned can be restored to their normal availability, not more than one hour after the failure occurs.	Requirement MET (para 4.1.9 to 4.1.13)
3.6.2	Full information on the means and arrangements prepared for restoration of the maritime distress and safety communication services in the event of a satellite failure should be notified to IMSO. IMSO and the service provider should conduct exercises from time to time to prove the efficiency and effectiveness of these planned arrangements.	Requirement WILL BE MET when the PSA has been signed with IMSO (para 3.5.2)
3.7	**Identification** The satellite system should be capable of automatically recognizing and preserving the identification of maritime mobile earth stations.	Requirement MET (para 5.4.3)
3.8	**Information to be made available to SAR authorities.** For all distress urgency and safety communications, the maritime mobile terminal identification number or Maritime Mobile Service Identity (MMSI) should be an integral part of the distress alert and be provided to the RCC with the alert. When available, all additional registration, commissioning or other data relevant to the search and rescue or prosecution of a false alert should be referenced to this number and made available to the proper SAR authority or RCC upon request.	Requirement WILL BE MET when maritime distress alerting has been fully implemented.

3.9	**Reception of distress alerts.** The satellite system should allow for addressing a maritime distress alert to a specific MRCC chosen by the ship's operator and covering the area concerned, but should also provide for automatic routeing of manually initiated maritime distress alerts. Means should be provided to allow the MRCC to easily identify the system and specific mobile station from which an alert or other priority message has been received, to enable the MRCC to establish shore-to-ship communications with the ship concerned.	Requirement WILL BE MET- specific addressing will be implemented in maritime mobile terminals (para 6.1.7)
3.10	**Control of maritime mobile terminals** Access control arrangements for controlling and giving, or temporarily denying, access by maritime mobile terminals to the system should at all times allow maritime mobile terminals access for transmission of maritime distress alerts/calls and distress messages.	Requirement MET (para 6.1.8)
3.11	**Test facilities** The system should provide facilities making it possible for maritime mobile terminals to test the distress capability of their stations without initiating a distress alert/call.	Requirement WILL BE MET requires change to the gateway and implementation in maritime mobile terminals (section 5.3)
4	**CRITERIA AND REQUIREMENTS FOR EARTH STATIONS**	
4.1	Functional Requirements	
4.1.1	Earth stations serving the GMDSS should:	
4.1.1.1	be in continuous operation;	Requirement MET But risks exist because of lack of robust back-up facilities. (para 5.1.4)
4.1.1.2	be connected to an associated RCC;	Requirement WILL BE MET when associated RCCs have been connected to the network (para 6.1.1, 6.1.5 and 6.1.6)
4.1.1.3	keep continuous watch on all appropriate satellite communication channels; and	Requirement MET - see also 4.4.3 below (section 4.2)+
4.1.1.4	be capable of transmission and reception of at least the maritime distress and safety communications services included in paragraph 3.1.	Requirement MET (section 6)

4.2	**Priority**	
4.2.1	The earth station should be capable of automatically recognizing the priority of ship-to-shore and shore-to-ship communications, and should process maritime mobile communications while preserving the four levels of priority specified in paragraph 3.3.1.	Requirement MET (section 5.4)
4.2.2	Priority access should be given for distress alerts and calls in real time. In any case, distress alerts and calls should be given priority treatment by providing immediate access to satellite channels, and distress alerts and calls for store and forward systems should be placed ahead of all routine traffic. Any satellite system designed for use in the GMDSS should be able to recognize the four levels of priority and give appropriate access for communications in the ship-to-shore direction and in the shore-to-ship direction for distress, urgency and safety traffic originated by RCCs or other Search and Rescue Authorities.	Requirement MET (section 5.4)
4.2.3	Limitations in existing public switched networks concerning facilities for indication and use of priority access codes might necessitate special arrangements such as use of leased lines between, for example, MSI providers and the earth station, until such facilities become available in the public switched network.	Requirement MET - leased lines and other bespoke connections are available if required (para 4.2.4)
4.3	**Pre-emption** Satellite systems participating in the GMDSS should make arrangements to ensure that it will always be possible for an MRCC to obtain an immediate connection to a maritime mobile terminal and that the MRCC could use the systems for SAR alerting and communication without any delay. This may be achieved by a process of pre-emption or by other suitable means approved by IMSO.	Requirement MET (section 5.4)
4.4	**Routeing of maritime distress alerts**	
4.4.1	The satellite system should have reliable communication links to one or more associated MRCCs. These links may be implemented directly between the MRCC and an earth station, or some other suitable point in the system's network. The arrangements between the system and the MRCC are subject to approval by the national administration.	Requirement WILL BE MET- discussions taking place with SAR authorities (section 6)
4.4.2	The system's network should be capable of automatically recognizing maritime distress and safety communications and of routeing, as far as possible automatically, maritime distress alerts/calls directly to the associated MRCC, via a highly reliable communication link. In cases where capability exists, the system may route alerts directly to the responsible RCC as defined in the IAMSAR Manual.	Requirement MET (para 6.1.1 and 6.1.5)

4.4.3	The earth station or other relevant part of the system's network should be provided with an aural and visual alarm to alert a designated responsible person in the event that automatic connection to the MRCC cannot be achieved within 60 seconds. In this case, all necessary action should be taken to immediately inform the MRCC of the details of the distress alert or call. Personnel should always be available to react to such an alarm so as to ensure that the distress alert or call can be forwarded to an MRCC within 5 minutes of the alarm being triggered. All messages with distress or urgency priority should sound an alarm at the earth station or other relevant part of the system's network, which should require manual cancellation.	Requirement WILL BE MET when these functions have been implemented (para 6.1.4)
4.4.4	The MRCC should be provided with reliable communication links to the system's network for efficient handling of shore-to-ship distress alert relays and distress traffic, preferably via dedicated communication links.	Requirement WILL BE MET - discussions taking place with SAR authorities (section 6)
4.5	**Identification** The system should be capable of automatically identifying ship earth stations. If other identification than the Maritime Mobile Service Identity (MMSI) is used in the system, the means should be provided 24 h per day to easily identify the ship and to provide the MRCC with all the appropriate additional information necessary for effecting the rescue, including the MMSI number where available.	Requirement MET capability demonstrated but maritime-specific implementation required (para 5.4.3)
4.6	**Voice communication systems**	
4.6.1	The communication links for mobile-satellite voice communication systems should be connectable to the public switched network in accordance with relevant ITU-T Recommendations.	Requirement MET (para 4.2.4)
4.6.2	Satellite systems using the public switched network for routeing maritime distress calls and distress traffic to and from MRCCs should, upon receipt of ship-to-shore or shore-to-ship distress alerts/calls or distress traffic, immediately attempt to establish the connection necessary for transfer of the distress alert or distress message.	Requirement WILL BE MET when maritime distress functionality has been fully implemented. (para 5.5.4)
4.7	**Data communication systems**	
4.7.1	The communication links for mobile-satellite data communication systems should be connectable to the public data communication network in accordance with relevant ITU-T Recommendations. The system should provide the capability to transfer the identity of the calling subscriber to the called subscriber. Maritime distress alerts/calls and distress messages should include the ship identity and the earth station identity, or other means of identifying the point of access to the satellite network.	Requirement WILL BE MET when maritime distress functionality has been fully implemented (para 4.2.4)
4.7.2	Satellite systems using the public switched network for routeing distress alerts/calls and distress traffic to and from MRCCs should, on receipt of ship-to-shore or shore-to-ship distress alerts/calls or distress traffic, immediately attempt to establish the connection necessary for transfer of the distress alert or distress message.	Requirement WILL BE MET when maritime distress functionality has been fully implemented. (para 5.5.4)

4.8	**Store and forward systems** Satellite systems using store and forward communication systems should:	
4.8.1	make an initial attempt to deliver a ship-to-shore or shore-to-ship message within 60 seconds for any maritime distress alert or distress traffic, and within 10 minutes for all other maritime messages, from the time the receiving station receives the message (the message should include the ship identity and the earth station or system identity); and	Requirement MET (para 5.5.4)
4.8.2	generate notification of non-delivery immediately once the message is considered non-deliverable, for maritime distress alerts and distress messages not later than 4 minutes after reception of the alert or message.	Requirement WILL BE MET when maritime distress functionality has been fully implemented.
4.9	Facilities for broadcasting Maritime Safety Information	
4.9.1	Satellite systems forming part of the GMDSS should technically be capable of offering facilities for broadcasting Maritime Safety Information (MSI) from MRCCs and authorized providers of MSI, such as Hydrographic Offices and Meteorological Offices, to ships at sea.	Requirement MET (section 6.7)
4.9.2	Such facilities for broadcast of MSI should provide for automatic, continuous and reliable reception on board ships and should, as a minimum, fulfil the requirements specified in sections 4.9.3 to 4.9.8 below.	Requirement WILL BE MET when the MSI broadcast service has been implemented (section 6.7)
4.9.3	The facilities should provide for recognition and processing of the four levels of priority specified in paragraph 3.3.1.	Requirement WILL BE MET when the MSI broadcast service has been implemented (para 5.4.2)
4.9.4	It should be possible to address the broadcast of MSI to all properly equipped ships within a specified area for at least the following types of areas:	
4.9.4.1	the entire region covered by the satellite or system over which the transmission is made;	Requirement WILL BE MET when the MSI broadcast service has been implemented (para 6.7.3)
4.9.4.2	the NAVAREAs/METAREAs as established by the International Maritime Organization (IMO), the International Hydrographic Organization (IHO) and the World Meteorological Organization (WMO) respectively; and	Requirement WILL BE MET when the MSI broadcast service has been implemented (para 6.7.3)
4.9.4.3	a temporary area chosen and specified by the originator of the MSI message, including circular or rectangular user-specified areas appropriate for broadcast of distress alert relays and search and rescue coordinating communications.	Requirement WILL BE MET when the MSI broadcast service has been implemented (para 6.7.4)

4.9.5	The facilities should provide for transmission of at least the types of Maritime Safety Information required by SOLAS, as follows:	
4.9.5.1	search and rescue coordination information, including distress alert relays;	Requirement WILL BE MET when the MSI broadcast service has been implemented (para 6.7.1)
4.9.5.2	navigational warnings; and	Requirement WILL BE MET when the MSI broadcast service has been implemented (para 6.7.1)
4.9.5.3	meteorological warnings and forecasts.	Requirement WILL BE MET when the MSI broadcast service has been implemented (para 6.7.1)
4.9.6	The facilities for broadcast of navigational and meteorological warnings should include possibilities for:	
4.9.6.1	scheduling the broadcast at fixed times or transmitting messages as unscheduled broadcast transmissions; and	Requirement WILL BE MET when the MSI broadcast service has been implemented (para 6.7.11)
4.9.6.2	automatic repetition of the broadcast with time intervals and number of broadcast transmissions as specified by the MSI provider, or until cancelled by the MSI provider.	Requirement WILL BE MET when the MSI broadcast service has been implemented (para 6.7.11)
4.9.7	The facilities should provide for marking MSI messages with a unique identity, enabling the shipborne equipment that receives these broadcasts to automatically ignore messages already received.	Requirement WILL BE MET when the MSI broadcast service has been implemented (para 6.7.11)
4.9.8	The broadcasting service should in addition provide facilities for broadcasts similar to NAVTEX to coastal areas not covered by the International NAVTEX Service, in accordance with the identification system (i.e. the identification characters B1, B2, B3, B4) used in the International NAVTEX Service.	Requirement WILL BE MET when the MSI broadcast service has been implemented (para 6.7.6)
5	**ADDITIONAL RECOMMENDED CAPABILITIES**	
5.1	Mobile satellite service providers are encouraged to:	
5.1.1	route Automatic Location Identification (ALI) and Automatic Number Identification (ANI) in accordance with appropriate ITU-T Recommendations, with distress calls originating from MSS terminals routed directly to the RCCs responsible for voice and data calls;	Non mandatory Technically possible but not implemented

5.1.2	automatically route information contained in registration databases in accordance with resolution A.887(21), in a recognizable format and including the distress call to the responsible RCC, once means are established for doing so; and	Non mandatory Means not yet established for doing so
5.1.3	be capable of retrieving maritime safety information in a timely manner from NAVAREA, METAREA, other relevant coordinators, and the International Ice Patrol Service, in a standard format and process established by those coordinators.	Non mandatory MSI Providers have not yet established the standard format and process for doing so
6	**NOVEL TECHNIQUES**	
	Satellite systems may be permitted to use novel techniques to provide any of the capabilities required by this resolution. Approval to use such novel techniques for a period of up to 12 months may be given provisionally by IMO in order to allow early introduction and proper evaluation of the technique. Final recognition of a novel technique may be given by the Organization only after receiving a report allowing full technical and operational evaluation of the technique.	No novel techniques proposed by Iridium
7	**LEGACY SERVICES**	not applicable

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