UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Washington, D.C. 20230

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Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

FILED/ACCEPTED

DEC - 1 2006

Federal Communications Commission
Office of the Secretary

RE: Amendment of the Commission's Rules Regarding Maritime Automatic Identification Systems, WT Docket No. 04-344; Petition for Rule Making Filed by National Telecommunications and Information Administration, RM-10821, and Amendment of the Commission's Rules Concerning Maritime Communications, PR Docket No. 92-257

Dear Ms. Dortch:

Enclosed please find an original and eight (8) copies of the late-filed comments of the National Telecommunications and Information Administration, U.S. Department of Commerce, in the above-referenced proceeding. Please direct any questions you may have to the undersigned at (202) 482-1816.

Respectfully submitted,

Kathy D. Smith
Chief Counsel

enclosures

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Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Amendment of the Commission's Rules Regarding Maritime Automatic Identification Systems	)	WT Docket No. 04-344
	)	
Petition for Rule Making Filed by National Telecommunications and Information Administration	)	RM-10821
	)	
Amendment of the Commission's Rules Concerning Maritime Communications	)	

COMMENTS OF THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

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December 1, 2006

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Executive Summary

The Automatic Identification System (AIS) is an essential tool, in the national interest, to provide vessel information critical to maritime safety and homeland security. The National Telecommunications and Information Administration (NTIA) believes that to provide the coverage necessary for AIS, there must a nationwide allocation of Channel 87B for exclusive AIS use. An exclusive nationwide allocation would allow the more efficient satellite detection of AIS signals, a method which is necessary to extend the coverage of AIS. In addition, an exclusive allocation will ensure that co-channel, non-AIS signals, will not interfere with the transmission or reception of AIS signals.

With respect to the authorization of AIS base stations, NTIA believes that because these stations perform an inherently governmental function, AIS base stations must only be authorized for Federal use.

Finally, NTIA believes that the Commission should expeditiously adopt certification standards for Class B AIS transmitters by incorporating by reference the applicable International Electrotechnical Commission (IEC) standards. In addition to the IEC standards, the Commission should attempt to ensure the accuracy of user programmed information transmitted over Class B AIS devices by providing that the transmission of inaccurate information is a violation of Commission rules that will subject the offending party to appropriate fines and penalties.

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COMMENTS OF THE
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

The National Telecommunications and Information Administration (NTIA), an Executive Branch agency within the Department of Commerce, is the President's principal adviser on domestic and international telecommunications policy, including policies relating to the nation's economic and technological advancement in telecommunications. NTIA is also responsible for managing the federal government use of the radio frequency spectrum. NTIA, in coordination with the United States Coast Guard (Coast Guard), submits these comments in response to the Federal Communications Commission's (Commission or FCC) Further Notice of Proposed Rule Making in the above-captioned proceeding.[1]

[1] *See* Amendment of the Commission's Rules Regarding Maritime Automatic Identification Systems, *Report and Order and Further Notice of Proposed Rulemaking and Fourth Memorandum Opinion and Order*, WT Docket No. 04-344, RM-10821, FCC 06-108 (released July 24, 2006).

I. INTRODUCTION

NTIA commends the Commission for designating very high frequency (VHF) maritime Channels 87B (161.975 MHz) and 88B (162.025 MHz) for the Automatic Identification Systems (AIS) in the United States. The designation of Channels 87B and 88B is, as the Commission has noted, an important tool for maritime safety and homeland security.[2] Having found that frequencies should be allocated for exclusive AIS use, the Commission seeks in the *Further NPRM* comment on whether Channel 87B should be allocated exclusively for AIS use throughout the country, or only in the nine designated "maritime" VHF Public Coast Service Areas (VPCSAs). In addition, the Commission requests comment on the authorization, operation and coordination of AIS base stations, and equipment certification standards for Class B AIS equipment. As explained more fully below, in response to the questions raised by the Commission, NTIA believes that: (1) there should be a nationwide allocation of Channel 87B for exclusive AIS use; (2) AIS base stations should only be authorized for federal government use; and (3) the Commission should expeditiously adopt certification standards for Class B AIS devices by incorporating by reference the applicable International Electrotechnical Commission (IEC) standards.

II. DISCUSSION

A. AIS Channel 87B Should be Allocated on a Nationwide Basis.

The FCC's Order in this proceeding provided that Channel 87B should be designated for

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[2] *Further NPRM* at ¶ 2.

exclusive AIS use in the nine maritime VPCSAs.[3] The nine maritime VPCSAs exclude an area in the United States roughly equivalent to the Mountain Time Zone. The Commission recognized that it may consider a nationwide AIS allocation (*i.e.*, the entire U.S.) for Channel 87B, but believed that it did not have sufficient record evidence to provide for such an allocation. Accordingly, the Commission issued the instant *Further NPRM* to elicit comments on, among other things, the requirements for a nationwide AIS allocation on Channel 87B.

There are compelling safety and national security reasons to designate Channel 87B for AIS on a nationwide basis. The Commission has already found that AIS is both an important tool for combating terrorism and a major enhancement in maritime navigation technology to support maritime safety.[4] Based upon the importance of AIS to homeland security and maritime safety, the Commission believes that it "[s]hould adopt rules that will best ensure that AIS is deployed widely, quickly, reliably and cost-effectively, and in a manner that will maximize its capabilities."[5] Because of the potential for co-channel interference and/or the degradation of AIS signal reception from non-AIS transmissions, this goal cannot be fully attained unless the Commission designates AIS Channel 87B on a nationwide basis. NTIA notes that Channel 88B is a federal government frequency and is already available for AIS use throughout the nation.

The Maritime Transportation Security Act of 2002 (MTSA) authorized the Coast Guard to implement a system to collect, integrate, and analyze information concerning vessels operating

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[3] *Id.*

[4] *Id.*at ¶ 23.

[5] *Id.*

on or bound for waters subject to the jurisdiction of the United States.[6] Following the MTSA, the *National Plan to Achieve Maritime Domain Awareness* (MDA Plan), was created as one of eight plans developed in support of the National Strategy for Maritime Security, as directed by National Security Presidential Directive-41/Homeland Security Presidential Directive-13.[7] The MDA Plan outlines the national priorities for achieving MDA as well as near-term and long-term objectives.[8] The plan calls for a reorientation and integration of legacy systems and operational concepts with current and emerging sensor capabilities and applicable procedures. These capabilities will be fused in a common operating picture (COP) that is available to maritime operational commanders and accessible as appropriate throughout the federal government, and shared by federal, state and local agencies with maritime interests and responsibilities. Among other things, the MDA Plan recommends using the latest technology to improve capabilities, enhance information collection and maximize its use. The MDA Plan specifically calls for the strengthening of "open ocean surveillance and reconnaissance capabilities to better verify AIS data."[9]

Current land-based AIS facilities provide only limited, line-of-sight coverage and do not

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[6] Public Law 107-295, 116 Stat. 2109, 2082 (2002) (codified at 46 U.S.C. § 70114). A Coast Guard primary operational goal is persistent wide area surveillance of vessels and the ability to track vessels within 2000 nautical miles of the United States. *See* NTIA Comments in WT Docket 04-34, at p. 23, n. 57 (filed Dec. 29, 2004).

[7] Maritime domain awareness is the effective understanding of anything associated with the global maritime domain that could affect security, safety, economy or environment of the United States.

[8] The MDA Plan is available at www.dhs.gov/xprevprot/programs/editorial_0753.shtm.

[9] MDA Plan at 16.

provide the long-range coverage.[10] In an effort to carry out the MTSA's goal of obtaining information about vessels at a distance offshore, the long-range component of the Coast Guard's Nationwide AIS ("NAIS") acquisition project proposes to provide the capability, through usage of a low earth orbit (LEO) communications satellite system, to receive, process and relay AIS signal data to extend AIS system signal reception capability beyond the coastal waters of the United States. The development and implementation of the AIS satellite capability is critical for long-range tracking of vessels required by the MTSA, and is in accordance with the MDA Plan.

In order to evaluate actual satellite detection of AIS signals, the Coast Guard entered into a contract with a commercial entity, ORBCOMM, a global data satellite communications company that is authorized for a LEO satellite network in the Non-Voice Non-Geostationary Mobile Satellite Service (NVNG MSS).[11] This initiative will test the technical and operational feasibility of spaceborne AIS receivers. ORBCOMM will provide AIS monitoring services on a demonstration basis using a satellite that is scheduled to be launched within the next several months. The LEO satellite will receive and decode AIS messages, and relay the resulting information via satellite feeder (non-AIS) links to specified earth stations.

In order to analyze general technical issues relating to satellite detection of AIS signals, the Coast Guard engaged the U.S. Department of Defense Joint Spectrum Center (JSC) to study

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[10] The Department of Homeland Security and the Coast Guard Research and Development Center, in conjunction with a commercial contractor, are exploring various methods to extend the range of land-based AIS coverage. Preliminary reports demonstrate that, with specific configurations, it is possible for land-based stations reliably to receive AIS signals from approximately 350 nautical miles.

[11] U.S. Coast Guard Contract No. HSCG23-04-C-ADA001.

the issue, and to prepare a report for the International Telecommunication Union-Radiocommunications Sector (ITU-R), "Satellite Detection of Automatic Identification System Messages."[12] This Report finds that several key technical factors distinguish satellite AIS detection from conventional ship-to-ship and ship-to-shore AIS detection, specifically receiver sensitivity, antenna gain pattern, and reliability requirements. Unlike conventional terrestrial AIS operations that may be able to co-exist with other co-channel transmitters through geographical separation, because the satellite antenna beam covers a very large geographical area, the satellite antenna receives not only AIS ship transmissions, but also non-AIS signals transmitted on the AIS frequency.[13] The JSC study shows that, the reception of the non-AIS signal causes degradation in AIS signal detection.[14] While satellite detection of AIS signals is still possible in the presence of co-channel non-AIS signals, blockage of the AIS satellite receiver for the transmission periods of the non-AIS transmitters will occur. This degradation in AIS receiver performance, is both unpredictable and unmanageable and will significantly decrease the effectiveness of the AIS system, and defeat the purpose, of using the satellite detection to obtain more information on ships at a distance from the United States in accordance with the MTSA and the MDA Plan.

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[12] This Report was discussed and approved through the normal processes and is now an ITU-R approved Report, Report ITU-R M. 2084. While this Report has not yet been published by the ITU-R, the Draft New Report from Working Party Group 8B (Doc. 8/176E, 19 Sept. 2006), which was adopted as the Report *(Report)*, is attached hereto as Exhibit A.

[13] *Report* at 5, 29.

[14] *Id.* at 29-35.

In addition to unwanted VHF co-channel signals causing potential interference to the satellite detection of AIS signals, it must be considered that radio propagation characteristics in the VHF band frequently cause signals to travel far beyond the radio horizon predicted by standard conventional radio propagation models such as the model used in Part 80 of the Commission's Rules.[15] On the one hand, this can have positive effects for AIS in that signals can be received at longer distances than originally anticipated. Tropospheric scatter propagation can cause VHF signals to travel hundreds of miles, which is much farther than the general "over the horizon" range normally associated with VHF transmissions. For example, while experimenting with various techniques for extending the range of AIS coverage, the Coast Guard received AIS reports at distances that often exceeded 350 nautical miles (nm), and sometimes exceeded 450 to 500 nm. More work and experimentation is necessary to determine whether receiving signals over these, or greater distances might be possible. On the other hand, however, this phenomenon can also have significant negative effects on AIS signals in that (non-AIS) interfering signals can also travel greater distances and cause harmful interference to AIS signals at great distances.[16] This is another example of how non-AIS signals can cause harmful interference, even if the transmission source is hundreds of miles away. Obviously, extended propagation modes are beneficial to AIS reception only when there is no competing (non-AIS) use of the AIS frequencies.

Finally, in accordance with the mandate in the MDA Plan to employ new technologies to

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[15] 47 C.F.R. §§ 80.751 – 80.773.

[16] In addition to tropospheric scatter, initial Coast Guard propagation studies involving ducting show that

improve MDA, especially with relation to long-range tracking, there must be flexibility to experiment with new methods and technologies to achieve the desired capabilities. If there is a potential for co-channel interference because there is not an exclusive, nationwide AIS allocation, this may have an unintended and undesirable effect on development and experimentation with new AIS technologies.

The Commission has recognized that AIS is a critical component of our Nation's homeland security, as well as an important tool for enhancing maritime safety.[17] As such, the Commission must be very cautious to assure that AIS transmissions are as free from co-channel interference as possible. Obviously, harmful interference to AIS signals could conceivably have an impact on homeland security, and could conceivably endanger the safety of life and property while traveling on our Nation's waterways.[18] Accordingly, because of the distinct possibility that non-AIS transmissions on AIS channels in the non-maritime VPCSAs could cause interference to AIS operations, such transmissions should not be authorized, and the AIS allocation should be Nationwide.

It may be some time before large-scale satellite detection of AIS signals and other technologies are implemented due to the need for because additional study, evaluation and regulatory approval is necessary. Therefore, rather than making the requisite exclusive nationwide allocation for AIS on Channel 87B immediately, a phased approach may be possible.

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coverage over the Gulf of Mexico can be vastly expanded from anomalous propagation effects.

[17] *Further NPRM* at ¶ 1.

[18] Another consideration is that there may be lakes and rivers in the areas not covered by the nine maritime VPCSAs that could benefit from AIS for safety of navigation and security purposes. Non-AIS transmissions in these

NTIA therefore suggests that only those operations which are currently transmitting on Channel 87B in the non-maritime VPCSAs should be allowed to continue operations until such time as a final determination is made that they must vacate the channel. Similarly, no new maritime or land mobile operations on Channel 87B in non-maritime VPCSAs should be authorized under existing geographic licenses, by new authorizations, waivers, or otherwise. In addition, currently authorized operations on Channel 87B in non-maritime VPCSAs should be required to provide, if they have not already done so, the site location information for their transmitters normally required for site-specific licenses. In this manner, existing users can be located and an analysis of the impact of their operations vis-à-vis AIS operations can be studied.

This suggested alternative approach in no way indicates that the exclusive AIS nationwide allocation is not necessary or desirable in the public interest. To the contrary, the exclusive allocation presents the only manner in which the MTSA and MDA Plan can be implemented. This alternative approach merely sets forth a plan whereby a smooth transition, in a timely manner, can be implemented.

B. AIS Base Stations Should Be Authorized for Federal Government Use Only.

As the Commission noted in its *Further NPRM,* the IEC is in the process of developing AIS base station equipment standards.[19] The base station standard, IEC 62320-1 Ed.1, is currently in the Final Draft International Standard (FDIS) stage. Once this standard is finally adopted and published, the Commission need not take any further action. No action is necessary

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areas could prevent the use of AIS.

[19] *Further NPRM* at ¶ 4.

by the Commission because, as explained below, the base stations serve to control the AIS, an inherently federal government function. Only federal government entities should be authorized for base stations, and thus, there would be no need for FCC certification standards for AIS base stations.[20]

Until such time as the AIS base station standard is developed, the Commission has requested comment on the licensing and use of AIS base stations. At the outset, it must be noted that AIS base stations are an integral part of the overall AIS. One of the primary purposes of AIS, as stated by IMO Resolution MSC.74 (69), Annex 3, is to improve the safety of navigation by assisting in the efficient navigation of ships, protection of the environment, and operation of Vessel Traffic Services (VTS). In order to serve these purposes, the following functional requirements must be satisfied: (i) ship-to-ship communications for collision avoidance; (ii) communications from littoral states to obtain information about a ship and its cargo; and, (iii) communications to facilitate VTS (traffic management). Requirement (i) is satisfied by shipborne AIS; requirements (ii) and (iii), however, require the use of AIS base stations by the competent authority, which in the instant case would be the federal government.

The AIS base stations function to control all of the aspects of the AIS network, and allow for overriding certain shipborne AIS functions. Base stations manage the AIS VHF Data Link by managing communications traffic on AIS through various means to provide for the safety of navigation, to obtain information necessary for VTS and national security purposes, to transmit

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[20] Radio frequency equipment sold to the federal government is subject to spectrum certification through

safety related messages, and to serve as an aid to navigation. It is the control function that AIS base stations perform (*i.e.,* control of the AIS) that is at issue here. The control function is used to protect the integrity of the AIS, and manage the navigation signals. Moreover, the IEC in its base station standard specifies that "it is the responsibility of the competent authority to ensure proper operation" of the base station.[21] It is therefore clear that the AIS base stations serve an "inherently governmental" function and, as such, only federal government entities should be authorized for AIS base stations.[22] Because the Commission does not issue authorizations for federal government stations, the Commission should not license any AIS base stations.[23] Accordingly, the Commission should not consider any issues relating to licensing such as eligibility, license terms, or permissible communications.

C. The FCC Should Incorporate the IEC Standards For Class B AIS Equipment Certification Into Its Certification Rules and Should Ensure the Accuracy of AIS Information.

Low-cost, Class B AIS devices designed to assure compatible operations (*i.e.,* interoperability) within all standards established for AIS are intended to provide a less expensive alternative to Class A AIS devices while still providing vessel information critical to navigation

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the NTIA and does not require FCC certification.

[21] IEC 62320-1 Ed.1, § 6.1.

[22] The AIS base stations serve the function of an aid to navigation. Pursuant to 14 U.S.C. § 83, private aids to navigation are prohibited unless authorized by the Coast Guard. The Coast Guard could, therefore, allow the use of an AIS base station by a non-federal entity provided there is authorization by the Coast Guard providing that the operation of the AIS base station is, at all times, operated under the control of the federal entity.

[23] Another reason that only federal government entities should be licensed for base stations involves requisite frequency coordination for AIS base stations. The NTIA, through the Interdepartment Radio Advisory Committee, has a coordination process in place for federal licensees. Any proposed AIS base stations will be carefully coordinated to assure that no harmful interference is caused.

safety and maritime security. Class B AIS devices differ slightly in features and nature of design, which reduce their cost (on average half the cost of Class A AIS devices); however, Class B AIS device performance is somewhat limited. Class B AIS devices report at a fixed rate (every 30 seconds) as opposed to the Class A AIS devices which report at a variable rate (2-10 seconds dependent on speed and course change). Class B AIS devices consume less power, but also transmit at lower power (2 watts as compared to 12 watts of Class A AIS devices), thus affecting their broadcast range. Despite these design limitations, and after extensive testing by the Coast Guard Research and Development Center, the Coast Guard has determined that AIS Class B devices can operate properly and safely with Class A AIS devices and offer the same AIS benefits.[24] Class B AIS devices broadcast and receive virtually the same vessel identification and other information. Class B AIS devices have the same ability to see targets that a radar may not be able to detect (*e.g.*, around the bend, in sea clutter, foul weather). For these reasons, the Coast Guard has concluded that AIS Class B devices enhance navigation safety and assist in collision avoidance comparable to Class A AIS devices. The Coast Guard has indicated that it will consider Class B AIS device use in forthcoming regulatory actions regarding AIS carriage.[25]

The IEC recently adopted and published an international standard, IEC 62287-1, that sets forth requirements and test procedures for Class B AIS device. NTIA fully supports the

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[24] *See* ITU-R Study Group Report "Performance Assessment and Interoperability of Proposed Class B AIS With Existing Class A AIS System Using Simulation Software" (September 9, 2005).

[25] *See e.g.*, Unified Agenda of Federal Regulatory and Deregulatory, Department of Homeland Security USCG, 1222 Vessel Requirements for Notices of Arrival and Departure and Automatic Identification System (USCG-2005-21869), 71 Fed. Reg. 22676 (April 24, 2006).

Commission's position that accommodating Class B AIS devices under the Commission's rules "will advance the Commission's goal of insuring that AIS is deployed widely, quickly, reliably, cost-effectively, and in a manner that will maximize its capabilities."[26] Accordingly, NTIA endorses the Commission's proposal to amend Part 80 of the Commission's Rules, as proposed in the new § 80.231, to incorporate by reference the IEC 62287-1 standard and provide for the certification of Class B AIS devices that comply with that standard.

NTIA urges the Commission to provide for the certification of Class B AIS devices on an expedited basis. To meet the Commission's goal of attempting to ensure AIS is deployed "widely, quickly and cost-effectively, and in a manner that will maximize its capabilities"[27] certification of Class B AIS devices must commence as soon as possible. Any delay in certifying Class B AIS devices will delay the number of vessels employing AIS. Furthermore, until it is clear that the Commission has standards for the certification of Class B AIS devices, manufacturers will hesitate to design and build the equipment. This will lead to delay in the availability of Class B AIS devices, and the resultant delay in having Class B AIS devices available and operational. Therefore, in order to ensure that Class B AIS devices are available and operational, certification standards must be adopted as soon as possible.

The Commission has also requested comment on an issue critical to the operation of AIS -- ensuring the accuracy of AIS data transmitted via Class B devices. Experience with Class A AIS devices has demonstrated that problems occur when improper static information is being

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[26] *Further NPRM* at ¶¶ 23, 63.

[27] *Id.*

transmitted by the AIS device. The most obvious problem is an inability to identify the ship that is making the transmission because of an improper Maritime Mobile Service Identity ("MMSI"). Under the IEC Standard 62287-1 at 6.4, a Class B AIS device can only transmit once an MMSI is assigned. If an MMSI is not assigned, the device will not transmit. Moreover, 6.7.2 of the IEC Standard provides that "it shall not be possible for the user to alter the MMSI once programmed." Accordingly, the MMSI and other static information must be properly entered for the unit to function, especially since the user will not have the ability to change the information once it is entered.

Because improper static information transmitted by a Class B AIS device will degrade the usefulness of the AIS, the Commission must assure, to the fullest extent possible, that static information entered into the Class B AIS device is accurate. Pursuant to § 80.102 of the rules, all maritime stations are required to identify themselves, and an MMSI is an acceptable means of identification. If an improper MMSI is given, then the station is not being properly identified. Under § 19.2 of the International Telecommunications Union Radio Regulations, all transmissions with false or misleading identification are prohibited. Similarly, in the case of a licensed station, under § 303(m)(1)(d)(2) of the Communications Act of 1934, as amended, it is prohibited to transmit a call sign which has not been assigned by a proper authority. Under these circumstances, the Commission should provide for strict penalties if a Class B AIS device transmits improper static information. Therefore, the Commission should provide in its rules that entering an improper MMSI or other improper static information in a Class B AIS device is prohibited and will subject the violating party to the penalty and forfeiture provisions of Part 1, Subpart A of the Commission's Rules.

In order to attempt to ensure that proper MMSIs and other static information are entered into Class B AIS devices, in addition to the IEC 62287-1 standard, the Commission should add a requirement to the certification standards for Class B AIS device: This requirement would consist of a statement in the user manual, and a conspicuous label on the device, that provides clear and concise information on how to enter and confirm static data, notification that once data is entered it may not be changed by the user, and a warning that it is a violation of the Commission's rules to input an MMSI that has not been properly assigned, or to enter any improper static information. NTIA recommends that the MMSI be entered into the Class B AIS device prior to the time that the user takes possession of the device.

Finally, consistent with the provisions for certification of Class A AIS devices, NTIA believes that the Commission should require the Class B AIS devices to receive Coast Guard certification prior to filing for certification with the Commission. The Coast Guard certification should be a prerequisite for the FCC certification. In this manner, the integrity of the VHF data link will be maintained, and the Coast Guard will have the flexibility to ensure that the Class B AIS devices meet future security regulation.

III. CONCLUSION

In conclusion, NTIA believes that there must a nationwide allocation of Channel 87B for exclusive AIS use; AIS base stations must only be authorized for federal use; and the Commission should expeditiously adopt certification standards for Class B AIS devices by incorporating by reference the applicable IEC standards

NTIA hereby submits the foregoing comments and requests the Commission to take action consistent with the views expressed herein.

Respectfully submitted,

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STUDY GROUPS

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Working Party 8B

DRAFT NEW REPORT ITU-R M.[SAT_DET_AIS][1]

SATELLITE DETECTION OF AUTOMATIC IDENTIFICATION SYSTEM MESSAGES

1 Introduction

In the early 1990s, the International Association of Maritime Aids to Navigation and Lighthouse Authorities (IALA) first proposed the development of a universal shipborne system to improve the maritime safety and efficiency of navigation, and to help protect the marine environment. Subsequent to that proposal, the International Maritime Organization (IMO), the ITU, and the International Electrotechnical Commission (IEC) adopted a new navigation system now known as the Automatic Identification System (AIS) to help achieve these goals. The primary purpose of the AIS is to facilitate the efficient exchange of navigational data between ships and between ships and shore stations to significantly improve safety of navigation and promote improved control and monitoring of maritime events. The technical characteristics of the current AIS system using time division multiple access (TDMA) techniques in the VHF maritime mobile band are described in detail in Recommendation ITU-R M.1371.

As described in that recommendation, the AIS is designed to operate autonomously and automatically to exchange short messages among ships, coast stations, and navigational aids within a 20 to 30 NM range primarily using a self-organizing form of TDMA. Messages include data such as ship identification, location, course and speed.

Under requirements of the International Convention for the Safety of Life at Sea (SOLAS), the installation and use of AIS is mandatory on all ships of 300 gross tons or more engaged in international voyages. In 2008, this requirement expands to include all ships of 500 gross tons or more engaged in national voyages. AIS equipments designed for this mandatory carriage requirement are designated as Class A units. A lower power version intended for voluntary carriage, called Class B, is under development. Since its introduction, the AIS has proven very successful in meeting the original goals set by the IALA.

[1] This Report should be brought to the attention of the International Maritime Organization (IMO), the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), and the Comite International Radio Maritime (CIRM).

Recently, a need has evolved for the capability to detect and track ships at distances from coastlines that are larger than can be accomplished by normal terrestrial VHF communications. Requirements of these long-range applications such as better handling of hazardous cargo, improved security, and countering illegal operations suggest a need to detect approaching ships at distances of 200 NM from shore and beyond.

This report introduces satellite detection of AIS as one means of accomplishing long range ship detection. The report addresses its technical feasibility, examines satellite capacity under various conditions and examines possible methods for improving satellite capacity. The remaining portions of this document are organized into eight subsections as follows: operational and technical characteristics of AIS, overview of satellite detection of AIS, link budget analysis, intra-system interference analysis (Class A only, Mixed class A and Class B, and non-uniform ship distribution), compatibility with incumbent mobile systems, techniques for improving performance and sharing, and summary.

2 Operational and technical characteristics of shipborne AIS

To assist in functionally describing and understanding the nature of satellite AIS detection, the basic characteristics of conventional terrestrial AIS as described in Recommendation. ITU-R M.1371 are summarized in the following paragraphs.

AIS functions as a ship-to-ship and ship-to-shore communication system in which AIS-equipped ships periodically transmit short fixed-length TDMA messages including data such as identification, location, course, speed, and other status information. The associated AIS receivers aboard ships and shore stations detect this information from all nearby ships, thus providing a comprehensive picture of the local environment to supplement radar and other navigation aids.

The TDMA signal structure is based on a one minute frame divided into 2 250 time slots with each message nominally occupying one time slot. In the normal mode, these identification messages are periodically transmitted alternately on two VHF maritime channels that have been designated for this purpose. Ship location is obtained from an on-board electronic position-fixing device. TDMA timing is obtained from the GNSS receiver built in the AIS station. With the two channels, the total capacity of AIS is 4 500 one-slot messages per minute.

AIS is designed around an access scheme called self-organizing TDMA. Through this technique, the system functions without a central TDMA controller, as is typical in fixed-assignment TDMA schemes. By continuously sensing the AIS signals in the local environment and "announcing" its next intended transmission slot, coordination is achieved by all participating ships in the local environment and conflicts in use of a given time slot are minimized. Other TDMA access schemes are also used for certain message types.

The RF and data technical parameters of AIS are summarized in Table 1. As described in the table, the basic message length is 256 bits with the last 24 bits serving as a buffer to accommodate propagation and repeater delays, timing jitter and extra bits due to bit stuffing. Typically, the last 20 bit positions are empty. The characteristics of antenna and associated transmission line parameters to be installed on AIS equipped ships are not defined in the basic ITU recommendation but are added herein to more fully define the AIS characteristics. In practice, two types of antennas are in common use, a 1/2 λ dipole and a 5/8 λ end-fed monopole with gains ranging from 2 to 4.5 dBi. In order to be conservative for this study, the ½ λ dipole is assumed having a maximum gain of approximately 2 dBi with a simple cosine-squared elevation gain pattern. The transmission line type and length varies with the installation. For purposes of this paper, a 3 dB loss is assumed to account for cable and other miscellaneous losses associated with the AIS ship transmitter. The default data packet bit structure is shown in Table 2.

 13.11.06

TABLE 1

Overview of Shipboard AIS Technical Parameters

AIS parameters	Values
Frequencies	161.975 and 162.025 MHz
Channel bandwidth	25 kHz
Platforms	Class A Ships, Class B Ships, Coast Stations, Navigation Aids
Power	12.5 W (Class A); 2 W (Class B)
Antenna type*	1/2 λ dipole
Antenna gain*	2 dBi with cosine-squared vertical elevation pattern; Minimum gain = −10 dBi
Cable loss*	3 dB (estimated)
Receiver sensitivity	−107 dBm for 20% Packet Error Rate (PER) (minimum) −109 dBm for ≤20% PER (typical)
Modulation	9 600 b/s GMSK
Multiple access mode	TDMA (Self-organizing, random, fixed and incremental)
TDMA frame length	1 Minute; 2 250 time Slots
TDMA slot length	26.7 ms; 256 bits (see Table 2)
Message types	22 Types
Message length	1 to 5 slots with 1 slot being the dominate type
Periodic message interval	2 sec to 6 min transmit intervals (see Table 3)
Required D/U protection ratio	10 dB at PER = 20%**

* Typical parameters not defined in Rec. ITU-R M.1371.

** Parameter specified in IEC 61993-2.

TABLE 2

Default Data Packet Bit Structure

Power ramp up	8 bits	
Training sSequence	24 bits	Necessary for synchronization
Start flag	8 bits	
Data	168 bits	Default length
Cyclic redundancy code	16 bits	Necessary for error detection
End flag	8 bits	
Buffer	24 bits (typically, the last 20 bit positions are empty)	Necessary to accommodate bit stuffing, propagation and repeater delays, and jitter
Total	256 bits	

To accommodate the various functions performed by AIS, 22 message types are defined in the standard, which can be grouped into four categories: dynamic, static and voyage, safety and administrative, and data. The dynamic messages, transmitted periodically, comprise the largest volume of traffic in the AIS environment. One key variable is the rate at which the different platforms transmit these periodic messages. For several platform types a range of reporting intervals are defined in the standard depending on the ship dynamics such as speed and course. Table 3 summarizes the message reporting intervals for the various platforms.

TABLE 3

AIS message reporting intervals

AIS platform	Reporting interval
Dynamic information	
Coast station	3 1/3 to 10 sec interval (10 sec nominal)
Class A ship	2 sec to 3 min interval (approx. 7 sec average) (see Table 4)
Class B ship	5 sec to 3 min interval (30 sec nominal)
Search and rescue aircraft	10 sec interval
Aid to Navigation	3 min interval
Static and voyage information	6 min interval
Safety & administrative messages	As required
Data message	As required

As will be shown later, the message reporting interval plays an important role in the performance of satellite detection of AIS. As shown in Table 3, the reporting interval for Class A ships varies over a wide range from every 2 seconds to every three minutes depending on the dynamic status of the ship. In order to determine a long term average transmission interval for Class A ships, it is necessary to have an estimate of the distribution of the ships among the various dynamic status situations. Table 4 lists the status categories, their respective reporting interval and an estimate of the percentage of ships in each category at any given time. From this data, an overall estimate for the reporting interval was determined.

TABLE 4

Class A shipborne mobile equipment reporting intervals

Ship's dynamic conditions	Nominal reporting interval	Percent of total
Ship at anchor or moored and not moving faster than 3 knots	3 min	28
Ship at anchor or moored and moving faster than 3 knots	10 s	
Ship 0-14 knots	10 s	30
Ship 0-14 knots and changing course	3 1/3 s	12
Ship 14-23 knots	6 s	30
Ship 14-23 knots and changing course	2 s	
Ship - 23 knots	2 s	
Ship - 23 knots and changing course	2 s	
Average for all ships	~7 s interval	

3 Satellite detection of AIS

In concept, satellite detection of AIS would involve use of one or more satellites in low earth orbit (LEO) to receive and decode AIS messages, and relay the resulting information via satellite feeder links to appropriately located earth stations. Satellite altitudes in the range of 600 to 1 000 km are typical for LEO satellites. A functioning satellite AIS detection system is not currently in place and the operational and technical parameters for such a system have not been defined. Consequently, it is necessary for purposes herein to assume reasonable and technically achievable parameters.

An initial demonstration system will consist of a single (LEO) satellite in polar orbit at an altitude of 950 km. For later operational systems, it is envisioned that a relatively small constellation of LEO satellites would be used; consequently satellite coverage of a given ship location will not be continuous. Full global coverage and the use of a modest number of earth stations necessitate the need to use store and forward techniques for the received AIS data. However, for detection and monitoring of ships up to several thousand nautical miles from a coast, the large satellite footprint on the Earth allows real time download of data during the visibility period of the satellite.

Several key technical factors distinguish satellite AIS detection from conventional ship-to-ship and ship-to-shore AIS detection, specifically receiver sensitivity, antenna gain pattern, and reliability requirements. Measured data reported for AIS shipborne receivers show that off-the-shelf receivers are typically more sensitive than the receiver sensitivity required in the AIS specifications. Using low noise amplifiers and optimum detection schemes, further improvement in AIS satellite receiver sensitivity is possible. Countering these improvements, however, is the need for larger than optimum receiver bandwidths to accommodate Doppler shifts of up to about ±3.5 kHz. Taking these factors into account, a baseline sensitivity of –118 dBm for a 1% packet error rate (PER) and –120 dBm for a 20% PER are used herein for the AIS satellite receiver.

The initial satellite system will use a wide beam satellite antenna. Broadbeam antennas used on LEO satellites can generally be categorized into two groups. One commonly used type is one in which the peak gain is directed omni-directionally towards the horizon with lower gain towards the sub-satellite point. With this type of antenna, the change in antenna gain with off axis angle partially compensates for the changes in propagation loss resulting in a lower variation in signal level as off-axis angles vary. The other antenna category is of a more conventional type with peak gain directed towards the sub-satellite point. For purposes of this study the latter type is assumed having a peak gain of 6 dBi and a –3 dB beamwidth of 100 degrees. For the gain pattern of the main lobe, a model often used in ITU-R studies is used herein as follows:

$$G(\theta) = G_{MB} - 12 \cdot (\theta/\theta_{3dB})^2$$

where

$G(\theta)$ = Satellite antenna gain (dBi) at off axis angle θ (Deg)

G_{MB} = Satellite antenna main beam gain (dBi)

θ_{3dB} = Satellite antenna –3 dB beamwidth (Deg)

The performance requirements of AIS satellite detection are also significantly different than the terrestrial counterpart. Conventional AIS, like most communications systems, aims to successfully receive and decode most of the associated transmitted messages with moderate to high reliability. For purposes of monitoring ships using satellite detection of AIS, high communications reliability is not required. For ships within a few hundred nautical miles of a coast, updates of the ship locations every hour may be sufficient and for ships further at sea, location updates every four hours or even every twelve hours may be sufficient. As will be shown later, intra-system interference results in the loss of a very large percentage of received AIS ship messages. For example, for a single satellite overpass, up to 99% or more of the AIS ship messages can be lost and the goal of updating ship

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