Status of AIS Frequencies Nationally and Internationally:

Improving satellite detection of AIS

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Technical eXchange on AIS via Satellite (TEXAS II)
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Status of AIS Frequencies Nationally and Internationally: Improving satellite detection of AIS

The original document contains color images.
Where things stand – where we’re headed – where do we want to go?

• Both AIS frequencies were originally used for other purposes
  – What other purposes? How does that legacy affect us now?

• Most maritime frequencies, AIS included, are shared with other users

• AIS transmissions were never designed for satellite detection
  – How will growing congestion of the band (e.g. Class B, encrypted STEDS, Search & Rescue, Aids to navigation) affect satellite detection?
  – Is this a problem needing to be addressed? If so, how?

• Where do we need to go?
  – Clear existing AIS frequencies from other uses? Dedicated satellite frequency?
  – Will other Administrations support or oppose these initiatives?
  – Is good engineering practices instead of a regulatory solution sufficient?
### 1997 International Telecommunications Union World Radio Conference

ITU Radio Regulation Appendix 18 – Table of transmitting frequencies in the VHF maritime mobile band (excerpt)

<table>
<thead>
<tr>
<th>Channel designator</th>
<th>Notes</th>
<th>Transmitting frequencies (MHz)</th>
<th>Inter-ship</th>
<th>Port operations and ship movement</th>
<th>Public correspondence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ship stations</td>
<td>Coast stations</td>
<td>Single frequency</td>
<td>Two frequency</td>
</tr>
<tr>
<td>24</td>
<td>m), o)</td>
<td>157.200</td>
<td>161.800</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>84</td>
<td>m), o)</td>
<td>157.225</td>
<td>161.825</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>25</td>
<td>m), o)</td>
<td>157.250</td>
<td>161.850</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>85</td>
<td>m), o)</td>
<td>157.275</td>
<td>161.875</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>26</td>
<td>m), o)</td>
<td>157.300</td>
<td>161.900</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>86</td>
<td>m), o)</td>
<td>157.325</td>
<td>161.925</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>27</td>
<td></td>
<td>157.350</td>
<td>161.950</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>87</td>
<td></td>
<td>157.375</td>
<td>…</td>
<td>x</td>
<td>…</td>
</tr>
<tr>
<td>28</td>
<td></td>
<td>157.400</td>
<td>162.000</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>88</td>
<td></td>
<td>157.425</td>
<td>…</td>
<td>x</td>
<td>…</td>
</tr>
<tr>
<td>AIS 1</td>
<td>l)</td>
<td>161.975</td>
<td>161.975</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIS 2</td>
<td>l)</td>
<td>162.025</td>
<td>162.025</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Public correspondence = old marine radiotelephone operator
AIS frequencies are shared with many other users – US and internationally

AIS is in a band of FIXED & MOBILE users

<table>
<thead>
<tr>
<th>156.8375-174</th>
<th>156.8375-174</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FIXED</strong></td>
<td><strong>FIXED</strong></td>
</tr>
<tr>
<td><strong>MOBILE</strong> except aeronautical mobile</td>
<td><strong>MOBILE</strong></td>
</tr>
<tr>
<td>5.226 5.229</td>
<td>5.226 5.230 5.231 5.232</td>
</tr>
</tbody>
</table>

Article 5 - ITU Radio Regulations

1959 World Administrative Radio Conference made it that way

The frequency 156-8 Mc/s is the international safety and calling frequency for the maritime mobile VHF radiotelephone service. Administrations shall ensure that a guard-band of 75 kc/s on each side of the frequency 156-8 Mc/s is provided. The conditions for the use of this frequency are contained in Article 35.

In the bands 156-025-157-425 Mc/s, 160-625-160-975 Mc/s and 161-475-162-025 Mc/s, each administration shall give priority to the maritime mobile service on only such frequencies as are assigned to stations of the maritime mobile service by that administration (see Article 35).

Any use of frequencies in these bands by stations of other services to which they are allocated, should be avoided in areas where such use might cause harmful interference to the maritime mobile VHF radiotelephone service.
US Frequency Allocation (not to scale)
AIS 1 – within band designated for auction in 1999
AIS 2 – within Federal band
AIS 2 is Cleared First

- **Before 2004, AIS 2 was a federal land mobile all-government-agency frequency with dozens of users**
- **Land mobile narrowband mandate enabled this rapid reallocation**
- **NTIA & its Interdepartment Radio Advisory Committee directed all non-AIS uses be phased out by the end of:**
  - **2004:** coastal
  - **2005:** 200 nm of navigable waterways
  - **2006:** All others
  - **Jun 07:** Exceptions & waivers

- **Today this frequency is exclusively AIS nationwide**
  - Others using the frequency don’t belong there and must vacate if discovered

Non-AIS licenses in early 2005
Band which included AIS 1 was auctioned in 1999

FCC required auction winner & USCG to negotiate AIS frequency

- **March 2001:** FCC Maritime Area auction winner MariTEL – signed MOU establishing an AIS frequency on AIS 1 for (VPCA #1-9)
  - **2002:** MariTEL management changed
  - **2003:** MOU terminated, filed $267M claim & complaint in US District Court
  - **2004:** Dist. Court dismissed complaint
- **2004:** FCC adopts AIS 1 for AIS exclusively in VPCA #1-9 (similar to MOU)
  - **5 incumbents remain until 2013**
AIS 1 - What about the Mountain States?

- VPCSA #10-42 winners not required to negotiate AIS frequency
  - Required to set aside some frequencies for public safety (not AIS 1)
  - Slowly building out non-AIS systems on AIS 1 and other frequencies
    - Numbers of radio sites unknown
  - 7 pre-auction incumbent sites
    - Includes mobiles
    - Most are 50w

- 2004 FCC sought comments on allocating AIS 1 nationwide
  - Draft Order “On Circulation” since Nov 2007
    - Same Order addresses Class B AIS
  - Decision expected to be favorable
AIS 2 is cleared US-wide, and AIS 1 may eventually be

- How many non-AIS radio sites are there currently on AIS 1?
  - Don’t know for certain, but there should not be many
  - Only 12 pre-auction licensees exists
  - Number of sites in Mountain Zone auction areas unknown
    - Absent rulemaking, could become large
- How powerful are these sites?
  - 50 watts into antenna (47CFR80.215)
  - USCG will oppose high power waivers
- Will sites be phased out?
  - Depends upon pending FCC decision
  - Note though 10-yr license term and lack of requirement to negotiate AIS frequency
What about Canada?

- **AIS 1 & 2 exclusively AIS in all waterway areas**
- **Few non-AIS systems on AIS 1 & 2 in inland areas but there may be some**
  - Some land mobile channels may overlap AIS
  - No documented requirement to clear AIS channels
    - Industry Canada, Nov 2007
- **Good USCG working relationship**
  - with Canadian CG,
  - Transport Canada,
  - Industry Canada &
  - St Lawrence Seaway
  - Though annual radiocommunications meetings with these agencies have been neglected
What about Mexico?

- Both AIS frequencies available in coastal areas
  - AIS base stations are being built out
  - Believe significant number of non-AIS users on both frequencies inland
- State Dept approved negotiation w/Mexico on AIS frequencies
  - High Level Consultative Commission on Telecommunications
  - Agreement in principal exists to
    - Remove AIS 2 frequency from International Boundary & Water Commission agreement.
    - Clear AIS 2 nationwide for AIS
    - Coordinate AIS base stations
  - Negotiations suspended July 08 awaiting replacement of key Mexican personnel
Can AIS frequencies continue to be shared with land mobile users?


Equal Co-Channel Operation on Each AIS Channel

Satellite Operating at Capacity (80% Detection); Co-channel operation on One AIS channel
What about the International Telecommunications Union?

• **ITU 2007 World Radio Conference**
  – Authorized AIS 1 & AIS 2 as satellite uplink frequencies, on secondary basis
    • Satellite detection now legal, but no protection from radio interference
  – Kept matter on agenda for WRC 2011
    • Agenda 1.10 Port & Ship Security

• **ITU Study Group WP5B**
  – ITU studies prerequisite to WRC-11 frequency allocation proposals
  – Studies include:
    • Adjacent channel interference
    • AIS slot congestion
    • 3rd AIS satellite frequency channel
    • AIS MSG #27 for satellite detection
  – No studies yet on impact of reallocating AIS 1 & 2 worldwide for exclusive AIS use
What about the International Maritime Organization?

• **July 2008 Navigation Subcommittee**
  – noted that, up to now, the issue of satellite detection of AIS as such had never been discussed in detail and as such, there was no policy direction on this issue.
  – recalled that matters relating to freely available AIS generated ship data and the attendant security risks had been considered previously.
  – invited the Committee to **take a clear decision on whether it was supporting the issue of satellite detection of AIS**, taking into account that:
    1. in principle, everyone who would be able to receive these signals could use the information collected, also for commercial activities; and
    2. there might be a need to subsequently specify modifications to the shipborne AIS Class A equipment.

• **Maritime Safety Committee considers the question late November 2008**
What about AIS slot congestion?

ITU-R Report M.2084 – JSC, Target ship located in the mid Atlantic Ocean

Norwegian Defence Research Establishment RTCM 2008 presentation “AIS Modeling and a Satellite for AIS Observations in the High North)”
How solid is Bjørn Narheim’s “wall”?

NDRE’s RTCM 2008 presentation
“AIS Modeling and a Satellite for AIS Observations in the High North”

How do results correlate with predictions?
How do results correlate with predictions?
If signal processing cannot handle up to 25 transmissions per slot

- **Short term:**
  Satellite detection
  Statistics with Coastal Offloading of AIS 2
  (Rescue21 and/or NAIS channel mgt)

- **Long term:**
  Third AIS Channel
Coastal Offloading

- AIS channel management is accomplished by rectangular boundaries
- Telecommand by AIS Msg22 or DSC
- New freq channel needs to be found from existing maritime VHF channel

AIS channel management regional boundaries

- Offload one channel only (i.e. AIS 2)
- Planning must be meticulous
  - Program retained in AIS even after power reset or it leaves the area
  - Program reset in AIS after 5 weeks or 500 nm away from telecommand

USCG Rescue 21 buildout summer 2008
### Long term - Proposed MSG 27 on exclusive satellite channel

<table>
<thead>
<tr>
<th>Slot composition</th>
<th>Bits</th>
<th>Standard</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp up</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training sequence</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start flag</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data field</td>
<td>96</td>
<td></td>
<td>Data field is 168 bits for other single-slot messages. This field is shortened by 72 bits to support the satellite AIS system buffer.</td>
</tr>
<tr>
<td>CRC</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>End flag</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satellite AIS system buffer</td>
<td>96</td>
<td></td>
<td>Propagation time delay difference = 87 bits Bit stuffing = 4 bits Synch jitter (mobile station) = 3 bits Synch jitter (mobile/satellite) = 1 bit Spare = 1 bit</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Number of bits</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message ID</td>
<td>6</td>
<td>Identifier for this message (similar to all other messages)</td>
</tr>
<tr>
<td>Repeat indicator</td>
<td>2</td>
<td>Repeat indicator value should be 3</td>
</tr>
<tr>
<td>User ID</td>
<td>30</td>
<td>MMSI number</td>
</tr>
<tr>
<td>Position accuracy</td>
<td>1</td>
<td>As defined for Message 1</td>
</tr>
<tr>
<td>RAIM Flag</td>
<td>1</td>
<td>As defined for Message 1</td>
</tr>
<tr>
<td>Navigational status</td>
<td>4</td>
<td>As defined for Message 1</td>
</tr>
<tr>
<td>Longitude</td>
<td>18</td>
<td>Longitude in 1/10 min (±180º, East = positive, West = negative)</td>
</tr>
<tr>
<td>Latitude</td>
<td>17</td>
<td>Latitude in 1/10 min (±90º, North = positive, South = negative)</td>
</tr>
<tr>
<td>SOG</td>
<td>6</td>
<td>Knots (0-62); 63 = not available = default</td>
</tr>
<tr>
<td>COG</td>
<td>9</td>
<td>Degrees (0-359); 511 = not available = default</td>
</tr>
<tr>
<td>Status of current GNSS position</td>
<td>1</td>
<td>0 = Position is the current GNSS position; 1 = Reported position is not the current GNSS position = default</td>
</tr>
<tr>
<td>Spare</td>
<td>1</td>
<td>Set to zero, to preserve byte boundaries</td>
</tr>
</tbody>
</table>

- proposing channel 16 guardband Channel 75 or 76
- 3 minute reporting interval

### Modified AIS packet bit structure for satellite reception

### Proposed new data field for AIS satellite detection – Message 27
How essential is it to clear AIS 1 & 2 of other users?

• Within the US
  – Should the move off AIS 1 be speeded up? (That may require funding)
  – It could require asking FCC Commissioners to speed decision (draft rule “in circulation” since Nov 2007)

• Within North America
  – Should we begin negotiations with Canada? With others? (Mexico on hold)

• Internationally
  – Should we propose at WRC 11 that AIS 1 & 2 be exclusive AIS worldwide?
    • Would require active support from interested parties (satellite providers, DoD and Administrations outside US) to succeed
    • Would require funding for ITU studies
  – Opposition from land mobile radio community
How essential is it to address slot congestion problem?

• What affect will Class B population have?
  – USCG NPRM Vessel Requirements for Notices of Arrival and Departure, and Automatic Identification System (USCG-2005-21869)
  – Should satellite detection of Class B AIS be encouraged or discouraged?
  – Note authorization of Class B also held up by FCC Commissioners

• What affect will uncontrolled binary message / BFT population have?

• How essential will a third AIS channel for satellite detection be? What should the US position be?
  – Note IMO & International Chamber of Shipping concerns
  – Would require active support from interested parties (satellite providers, DoD, Administrations outside US) to succeed
  – May require existing Class A AIS units be modified
Questions?