Updated Analysis of Inmarsat and Iridium Aeronautical Services in the Same Oceanic Airspace.
Purpose and Scope of the Analysis

- Investigate Iridium AMSS/AMS(R)S and Inmarsat AMSS/AMS(R)S on separate aircraft in the same oceanic airspace
- Analysis is limited to Oceanic Airspace structured following DO-306 guidelines, since FANS-1/A datalink Air Traffic Service (ATS) has widespread approval for operations in oceanic airspace
- Conclusions are not applicable to other operational scenarios or airspace, including:
  - Polar, continental enroute, terminal, approach, and airport surface airspace as defined in Eurocontrol/FAA COCR document;
  - Simultaneous independent operation of Iridium and Inmarsat AESes on the same aircraft; and
  - All non-aeronautical terminals and non-aeronautical services
Conclusions

• The probability of Inmarsat AMSS/AMS(R)S causing a service interruption that would affect the availability of Iridium AMSS/AMS(R)S operating on separate aircraft in oceanic airspace is very small.

• In oceanic airspace, Inmarsat AMSS/AMS(R)S out of band emissions from one aircraft do not cause harmful interference to Iridium AMSS/AMS(R)S on another aircraft:
  - The functioning of Iridium AMSS/AMS(R)S is not endangered;
  - No serious degradation, obstruction or repeated interruption of the operation of Iridium AMSS/AMS(R)S.
Full disclosure, etc.

- This work was based on the volumetric interference approach briefed to AMCP WGA in 1998-2000…
- …and supported by Iridium, LLC (the *old* Iridium).
- The current effort has been updated to include DO-306 and new Inmarsat services and specs…
- …and has been jointly supported by Inmarsat and Honeywell Research & Technology Center funding.
- Representatives of Iridium Satellite, LLC (the *new* Iridium) have been briefed on the contents, conclusions and methodology of this study.
Interference Cases

- **Inmarsat uplink on Iridium downlink**
  - Subject of this analysis, oceanic airspace
- **Inmarsat uplink on Iridium uplink**
  - Subject of Inmarsat-Iridium discussions, not considered here
- **Inmarsat downlink on Iridium uplink**
  - No issue due to frequency separation
- **Inmarsat downlink on Iridium downlink**
  - No issue due to frequency separation
- **Iridium uplink on Inmarsat uplink**
  - No issue due to lower EIRP of Iridium
- **Iridium uplink on Inmarsat downlink**
  - No issue due to frequency separation
- **Iridium downlink on Inmarsat uplink**
  - No issue, Inmarsat satellite in back lobe of Iridium transmitters
  - No interference path to Inmarsat satellites via edge of earth
- **Iridium downlink on Inmarsat downlink**
  - No issue due to frequency separation
Overview of the downlink analysis methodology

- First, define the systems and their performance
- Second, define the airspace
- Third, build the models
- Fourth, assess the results, ...
- ...iteratively with interactions

Define Systems

- DO-210D
- ARINC 781
- DO-262A (draft)
- DO-270 (working)
- Iridium ICAO Tech Manual

Define Airspace

- DO-306
- Public Documents

Build Models

- Honeywell Internal Technical Documents

Assess Results

Interaction w/ stakeholders

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Released to ICAO ACP WGM June 18, 2008
Assumptions about Iridium

- TDM format defined to ICAO
- AES meets 25% $\Delta T/T$ aggregate from all sources without degradation, as required by ICAO SARPS
- AES meets link budget (SC215) including aeronautical margin and 25% $\Delta T/T$ aggregate from all sources.
- AES noise level of 630K (SC215)
- AES antenna below horizon -10 dBi (per GPS interference assumption)
- AES meets -72 dBm out-of-band susceptibility (SC215) constant throughout Inmarsat band
- Iridium AES operation over the entire 1616-1626.5 MHz band
- Iridium AES receive frequencies are assumed uniformly distributed over band
- Beam handoff approximately every 60 seconds with independent frequency selection
- Intra-beam handoff not considered
Assumptions about Inmarsat

• All current services – Classic, Swift 64(S64), and Swift Broadband (SBB)

• Intentional EIRP: 17 dBW Classic, 20 dBW SBB, 19 dBW S64

• DO-210D HSN emissions -70 dBc/4 kHz constant throughout Iridium band

• DO-210D or A781 IM performance

• AES: Minimally compliant with DO-210D, A781

• Idealized 12 dBi gain antenna pattern with circular cross section (larger than rectangular cross section)

• Assume -15 dB sidelobes (-3 dBic)

• Ignore victim aircraft below source flight level

• System

  • Frequencies are assigned at random from total available pool for service being considered
Assumptions about airspace

- Assume high-latitude (North Atlantic) oceanic airspace based on DO-306
  - High latitude means low elevation angle to Inmarsat satellite
  - Inmarsat AES antenna pattern has a large component toward parallel tracks to the south.
- 30 nmi / 30 nmi separation (along track / cross track)
- Uniformly-distributed RNP4 navigation performance
- Independent along track alignment of tracks and altitudes
- Single North Atlantic “box”
  - ~500 nmi along track (~1 hour flight time)
  - 120 nmi across track (5 North Atlantic tracks)
  - 13 flight levels (FL290 to FL410)
- Source (Inmarsat) aircraft uniformly distributed in altitude
Probability of Long-term interruption 30/30

- Independent frequency selections for each beam handoff

\[ p_{LTC} = p_S \times p_{SST} \times p_{F}^{[t/t_H]} \]
Why is this analysis conservative?

- The assumption that Inmarsat and Iridium terminals both only marginally meet the ICAO/RTCA requirements.
- The assumption that none of the Iridium margin can or will be used to increase the downlink $E_b/(N_0+I_0)$
- The RNP4 uniformly distributed assumption
- The idealized Inmarsat beam with constant gain
- The additional -15 dB sidelobe assumptions about the Inmarsat AES antenna.
- The uniform -10 dBi pattern assumption on the Iridium receive beam.
- The constant Inmarsat emissions level across Iridium operating band assumption.
- The constant Iridium out-of-band susceptibility level across the Inmarsat band
- No account taken of Iridium channelization
- The 100% Iridium equipage and usage in the airspace assumption.
Conclusions

• The probability of Inmarsat AMSS/AMS(R)S causing a service interruption that would affect the availability of Iridium AMSS/AMS(R)S operating on separate aircraft in oceanic airspace is very small.

• In oceanic airspace, Inmarsat AMSS/AMS(R)S out of band emissions from one aircraft do not cause harmful interference to Iridium AMSS/AMS(R)S on another aircraft:
  - The functioning of Iridium AMSS/AMS(R)S is not endangered;
  - No serious degradation, obstruction or repeated interruption of the operation of Iridium AMSS/AMS(R)S.
The bottom line

There should be no obstacle to operation of Inmarsat AMSS/AMS(R)S services and Iridium AMSS/AMS(R)S services in the same 30/30 RNP4 oceanic airspace.