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TECHNOLOGY FOR USE BY AERONAUTICAL MOBILE TELEMETRY (AMT)

Introduction

This work investigates the technical implications of conducting aeronautical mobile (AMT) telemetry operations in the 3 to 30 GHz region of the spectrum. It identifies issues, problems, and technical obstacles to conducting such operations. In addition, demand for higher data rate requirements grew fast in the last decade, and the trend is expected to continue at an even faster rate in the future. To alleviate this spectrum congestion problem, Agenda Item 1.5 was created for the next World Radio Conference 97 (WRC-07) to consider spectrum requirements for wideband aeronautical telemetry in the bands between 3 and 30 Gigahertz (GHz).

AMT is an enabler for the worldwide aerospace industry. The industry depends on aeronautical mobile telemetry spectrum for flight-testing. Telemetry spectrum is used for transmission of real-time data from test vehicle and provides:

- Data from the aerospace vehicle to ground
- Video of cockpit or project information
- Monitoring of flight research and test parameters
- Telemetry allows testers to conduct safe, effective, and efficient missions by displaying & analyzing data in real-time

Summary

It is necessary to operate below 16 GHz in the immediate to near term

- Transmitters are commercially available up to about 6 GHz
- Technology is available to develop transmitters up to about 16 GHz
- Relatively little problem with atmospheric attenuation
- Practical links can be maintained up to 10 GHz without special measures
- Might be maintained up to about 16 GHz with advanced signal processing and/or other measures

Can consider operating in the 16-30 GHz range for longer term needs

- No current technology operates above 15.3 GHz
- Atmospheric absorption effects increase with frequency
- Continuing technological developments should lead to practical transmitters in the future

A draft CPM text element is included in the last paragraph of this document

Technical Considerations on Selection of Spectrum

This document concerns primarily the downlink so that the transmitter is the (airborne) test vehicle and the receiver is the ground station. Communication (or link) performance depends on the availability of adequate signal power relative to noise power (or density) at the receiver end. There are a number of technical considerations in trying to decide what bands could be used for telemetry.

- Transmitter considerations
- Atmospherics and Fading
- Tracking
- Antenna Tolerance

Transmitter Considerations

The capability of generating sufficient power (e.g., 5 or 10 Watts) in the range of 3 – 30 GHz for aeronautical telemetry application (using small and light solid state devices) is an issue. Commercial AMT transmitters are available up to about 6 GHz. It appears that no such transmitters are available beyond about 6 GHz.

Small high-power semiconductor devices are available up to about 16 GHz. Such devices might be used in telemetry transmitters but further research is needed. Continuing technological developments should lead to practical transmitters above 16 GHz in the future. There are also physical limitations on AMT Transmitters (in some cases, smaller transmitters are needed to support many tests), including:

- Size 16 cu in (250 cc)
- Weight 14 oz (400 gm)

Atmospherics and Fading

Atmospheric attenuation is due to absorption by atmospheric gas or rain. Atmospheric attenuation is negligible in the current telemetry spectrum, but it is significantly higher in the 3-30 GHz band. Atmospheric attenuation is probably the most problematic channel characteristic that distinguishes the 3-30 GHz band from the current telemetry bands. Statistics of atmospheric attenuation have been well documented.

With regard to channel characteristics, high frequency channels are known to be vulnerable to fading and atmospheric attenuation and signals of higher data rates to be used on such channels are more vulnerable to frequency selective and fast fading. (Fading that affects the different spectral components unequally is called frequency selective fading.) Also, the design of receivers for coherent reception of signals is generally difficult in part due to the lack of experimental data in the super-high frequency bands

Achieving successful communication in severe fading and atmospheric attenuation requires special techniques. Intensive signal processing techniques could extend performance even under rainy conditions up into the 7.5-15 GHz range.

Tracking

Although, an increase in frequency results in improved antenna gain, the extra gain is needed in order to compensate for link deficiencies due to fades and attenuation. This makes antenna diameters stay the same even though the frequency is increasing. The additional antenna gain from the use of higher frequencies results in reduced beamwidth, and this will increase acquisition and tracking difficulty. For a given location uncertainty, the search time increases inversely with the square of the beamwidth. Due to extremely narrow beamwidth, vehicle signal acquisition and tracking may be difficult. The current (mechanical) auto-tracking mechanism or its simple improvement may not directly be applicable to the super-high frequencies. Also, required tracking loop response time decreases proportionally to the reduced beamwidth. This requires increased loop bandwidth with corresponding noise performance degradation.

Antenna Tolerance

As frequency is increased, the surface tolerance of reflector antennas must also be improved in order not to suffer a loss of gain. It is possible to build large antennas with greater accuracy and better surface tolerance. However, the expense is increased by the need for greater precision in the manufacturing of the reflector and by the need for greater stiffness and the size and power of the motors required to control the antenna.

The efficiency factor for an antenna also falls as frequencies are increased. This is well understood and accepted, and is a result of some of the factors above. There are also defocusing effects and increased side effects of diffraction around the edges of the antenna structures and feed structures as the frequency is increased.

Conclusion (and draft CPM text element)

Decisions made under Agenda Item 1.5 need to be guided by technical considerations. In consideration of using higher frequencies for aeronautical telemetry it is imperative to consider atmospheric effects at these frequencies and the available technology. For this reason, it is necessary for WRC-07 to identify spectrum for AMT operations below 16 GHz for use in the immediate to near term. WRC-07 should also consider identifying AMT spectrum in the 16-30 GHz range for longer-term needs.