WORKING GROUP PAPER OUTLINE

BACKGROUND

Aeronautical telemetry is a specialized, but key use of the radio spectrum that supports the testing of commercial and military aircraft, missiles of various types, and space systems. Although the ordinary citizen is not aware of this use of spectrum, neither the air traffic system, space systems, nor systems that are needed for national defense would work without the live test results that are transmitted using aeronautical telemetry. As these systems become more complex, more spectrum is needed to transmit the required test data. However, while these data transfer needs increase, spectrum that has been used by aeronautical telemetry for decades has been reallocated or is vulnerable to reallocation for popular consumer services, such as digital broadcasting, broadband communications, and satellite services. As a result, in many countries, almost no spectrum is available for use by aeronautical telemetry. Many of these reallocations have been accomplished through international processes. This ensures international harmonization on the use of common frequency bands for such services and also pressures individual countries to meet those common allocations.

One approach to overcoming these problems is to find additional spectrum for use by telemetry. Insofar as the spectrum bands now used by telemetry are extremely crowded, such additional spectrum will have to be found at higher frequencies than are now used for aeronautical telemetry. Insofar as competing services have successfully received allocations using international processes, and for economy of scale, it would be desirable to identify internationally-recognized frequency bands that could be used by aeronautical telemetry. In support of this objective, a resolution was introduced at the 1997 World Radio Conference (WRC 97) to consider this objective at a subsequent WRC. In response, WRC 2000 included in the preliminary agenda for WRC 2005/6 an item "to consider spectrum requirements for wideband aeronautical telemetry in the band between 3 GHz and 30 GHz". In support of this, Working Party (WP) 8B of the International Telecommunications Union (ITU) is now seeking information on existing and planned future wideband aeronautical telemetry systems that operate at frequencies above 3 GHz, with the objective for providing adequate spectrum for use by aeronautical telemetry throughout the world.

There will be a number of technical challenges to be faced by telemetry systems that operate at higher frequencies. In order to fully identify these challenges, to propose acceptable solutions to them, and to encourage exchange of information and ideas on this issue among its membership, the International Consortium for Telemetry Spectrum (ICTS) established a working group at its June 2001 meeting to prepare a report on technical implications of this WRC proposal. This initial draft of an outline of the working group paper is being circulated to working group members for comment. In order to fully inform the ICTS membership and to establish reasonable bounds for the technical analysis, this draft also proposes to outline existing practices, the spectrum allocation process, information transfer requirements, and candidate expansion bands within the 3-30 GHz frequency range.

1. INTRODUCTION

a) Uses of telemetry
b) Aeronautical telemetry
   - Definition
   - Need for increasingly large bandwidth
   - Position of aeronautical telemetry vs other services - specialized use
   - Loss of spectrum to other services : DAB, IMT-2000, MSS

c) Need for common ground by the international aeronautical TM community
   - Spectrum availability threatened by global interests that act through international organizations
   - Need for common spectrum to attain economy of scale in TM equipment
   - Facilitate international sales of aeronautical systems and seamless testing of these systems everywhere

d) Telemetry Spectrum Augmentation proposal
   - Outline WRC and the WRC process
   - Outline current spectrum availability
   - Outline current deficiencies and future needs
   - Discuss the augmentation proposal
   - Discuss need to support proposal in WG-8 in order to place item on agenda
   - Outline need to identify technical challenges and solutions to those challenges

2. EXISTING ALLOCATION & USE OF SPECTRUM BY AERONAUTICAL TM

a) In any country, spectrum is allocated to specified services: Fixed, Mobile, Satellite, Radiolocation, Radionavigation, etc.
b) Aeronautical TM is not recognized as a distinctive service - it is one use of the Mobile Service
c) Allocations vary between countries but are influenced by International allocations
   - Different services can share spectrum
   - Many countries further restrict aeronautical TM to a limited number of bands
   - Aeronautical TM not necessary an exclusive use of those restricted bands

d) Information on existing use of spectrum for aeronautical TM is available for only a limited number of countries
   - Found in L-Band (Generally within 1425-1535 MHz) and S-Band (Generally within 2200-2450 MHz)
   - Limited commonality between countries in bands assigned for aeronautical TM use, in sharing with other uses, and in conditions placed upon use
   - Outside of U.S. and, provisionally, FSU countries, most of L-Band once used by aeronautical TM is now allocated to DAB
   - In some countries, much of the available spectrum is available only on a non-interference basis
   - Generally, spectrum that is now available cannot adequately serve demands for aeronautical TM data transfer
   - In the future, greater rates of data transfer, thus spectrum, will be required

e) Because of these considerations and those outlined in the introduction, it is necessary to identify spectrum that is available to users in multiple countries outside these bands

3. SPECTRUM ALLOCATION PROCESS

a) National spectrum allocations
   - Each country has sovereignty over use of spectrum in its own territory
   - Each country administers allocations through its own processes
   - Administration is through one or more departments, agencies, and/or commissions

b) International allocation process
   - Spectrum allocation is regulated and coordinated among countries under the International Telecommunications Convention
   - The International Telecommunications Union (ITU) is the intergovernmental organization that administers the convention
   - Outline structure of the ITU
   - Outline structure of the Radiocommunications Sector (ITU-R)
   - Discuss role of World Radio Conferences (WRCs) and the process that supports them
   - Outline the role of Working and Study Groups

- Discuss the role of Working Party (WP) 8B in considering the Telemetry Spectrum Augmentation WRC-06 agenda item
- Discuss the need to establish requirements for coordinated telemetry spectrum in WP 8B in order to ensure that Telemetry Spectrum Augmentation is to be placed on the WRC 06 agenda
- Emphasize the need for interested parties to participate in their national WP 8B discussions to ensure that this issue receives proper attention
- Interested parties need to identify appropriate contacts in their own national administrations and work with them to ensure that the issue receives appropriate attention at WRC 06 and to ensure that their own national requirements are considered there
- Preferred approach is to identify internationally harmonized bands that can be shared with other uses - any attempt to obtain exclusive allocation to telemetry would encounter opposition

4. INFORMATION TRANSFER REQUIREMENTS

a) Uses of aeronautical telemetry
   - Flight testing of commercial and military aircraft (manned/unmanned)
   - Flight testing of experimental aircraft
   - Flight testing of missiles
   - Weapons engagement testing
   - Testing and monitoring of space launch vehicles

b) Required data rates (we have some data for U.S. requirements; need data from other countries)
c) Ability of existing spectrum to meet needs
   - Using current practices
   - Using advanced modulation, data compression, real-time control, networking
   - Remaining needs for spectrum augmentation

5. CANDIDATE BANDS

a) Need more information to fully identify candidates
b) Preliminary assessment based on data that is available on the internet
c) Assessment identifies bands which have primary allocation to Mobile Service with no prohibition on Aeronautical Mobile Service - structured around U.S. allocations and European Radiocommunications Committee (ERC) Recommendation 25 for common European Table of Allocations
d) Recommended Bands (Preliminary Assessment)
   - C-Band (4.4-4.9 GHz)
   - Ku-Band (14.5-15.3 GHz)
   - K-Band (Various bands between 21.4 and 27.5 GHz; based on U.S. and ITU allocations)

6. TECHNICAL CHALLENGES AND POTENTIAL SOLUTIONS

a) Channel Characteristics
   - Include absorption, fading, ducting, Doppler
   - Channel limitations become more challenging as frequency increases
   - Absorption should not be a major issue at C-Band
   - Need to systematically collect measurement data and develop good fading models to assess feasibility of overcoming adverse channel effects
   - Investigate ducting effects
   - Investigate Doppler effects on receiver tracking
   - Investigate how narrow beamwidths affect fading

b) Mitigation of Adverse Channel Effects (Absorption, fading, Doppler)
   - Investigate use of advanced modulation and multiplexing techniques (FQPSK, GMSK, SOQPSK, CODFM))
   - Error correction coding

- Equalization
- Diversity (polarization, space diversity, antenna height)

c) Transmitter Technology
   - Need to determine feasibility of developing transmitters that meet power transmission requirements for telemetry subject to limitations on size, weight, and input power
   - Investigate limits on use of established semiconductor technology
   - Monitor developments on new wide-bandgap semiconductor technologies

d) Transmit Antenna Technology
   - Identify types of antenna that could produce omnidirectional patterns
   - Investigate effects of test vehicle structure on antenna patterns
   - Investigate use of microstrip and micropatch antennas
   - Investigate use of antennas that track the receiver antennas

e) Receive Antenna Technology
   - Beamwidths narrow with frequency since we need to maintain receive antenna apertures at higher frequencies in order to receive sufficient signal
   - Determine limitations on use of mechanically-scanned antennas as frequency is increased
   - Investigate techniques to acquire and track transmitters at higher frequencies
   - Investigate electronic scanning techniques in different bands
     - Variable beamwidth antennas (to support test vehicle acquisition)
     - Neural network beamforming
     - Piezoelectric control of antenna shape and beam patterns
     - Electronically controlled height variation for diversity

7. POSSIBLE APPROACHES AND ALTERNATIVES

a) Near term
   - There has been limited use of lower C-Band for telemetry operations in the past, but little information is available about this
   - The lower C-Band is used to transmit analog video – this might serve as a basis for designing telemetry systems for use in that band
   - NASA has implemented a hybrid video/telemetry system in which the same antenna is used for the C-Band video and the L- or S-Band telemetry – telemetry signal is used for tracking
   - It thus might be feasible to set up a hybrid C-Band L/S-Band telemetry system using the L- or S-Band signal for antenna tracking
   - The U.S has established a Science and Technology program to investigate implementation of aeronautical telemetry in the C-Band

b) Far term
   - Use of satellite relay
     - Can lower absorption loss
     - Might mitigate tracking difficulties
     - Latency issue
   - General approaches that could facilitate telemetry use at any frequency
     - Use of mission channel uplink for real-time control of downlink data stream
     - Use of packet networking

8. SUMMARY

a) Aeronautical telemetry needs increasingly large amounts of bandwidth
b) At the same time, spectrum historically used by telemetry is being lost to uses that serve larger groups and which generate more revenue – many countries have inadequate available spectrum for telemetry and must share available spectrum on a disadvantaged basis

c) Desirable for the international TM community to cooperate in identifying and obtaining common spectrum to attain economy of scale in development and sale of TM systems, to promote seamless testing of aeronautical systems internationally, and maintain a common front against competition from global providers of other services
d) There is a proposed WRC 06 agenda item that would facilitate those goals – this agenda item needs common support
   - Work with national spectrum administrations
   - Participate in WP 8B
e) More information is needed to identify candidate bands – a preliminary assessment is given
f) There are a number of technical challenges that need to be overcome in order to implement TM at higher frequencies – challenges are discussed
   - Channel effects
   - Transmitter technologies
   - Transmit and receive antenna technologies
g) Some candidate near and far term approaches are discussed