REPORT ITU-R M.2120

Initial estimate of new aviation AM(R)S spectrum requirements

(2007)

1 Introduction

As part of its work on Agenda item 1.6 of the 2007 World Radiocommunication Conference (WRC-07), ITU-R considered allocations to the aeronautical mobile (R) service (AM(R)S) in some portions of the 960-1 164 MHz and 5 000-5 150 MHz bands. Based on available studies, two distinct types of aeronautical applications require AM(R)S spectrum. The first, like the current VHF AM(R)S, requires longer propagation distances (e.g. out to radio line-of-sight), moderate bandwidth, and a number of distinct channels to allow for sector-to-sector assignments. The second type, supporting surface applications at airports including data links – is distinguished by a high data throughput, however only moderate transmission distances and it is expected that a single resource can be shared at multiple geographic locations. Based on the technical characteristics of the spectrum being considered, it is expected that the former applications will be accommodated in some portion of the 960-1 164 MHz band, while the latter will be implemented in some portion of the 5 000-5 150 MHz band.

Administrations and the International Civil Aviation Organization (ICAO) performed studies in order to scope the amount of spectrum needed for each frequency band. The results, while preliminary, provide an order of magnitude of expected spectrum requirements. In addition, the studies point to the difficulty of fitting a new system into spectrum that is currently utilized for other systems, especially when aircraft integration is taken into account.

2 Aircraft system integration

Integration of radio servces and related equipment onto an aircraft is one of the most difficult challenges faced in implementing a new aviation system. A large number of radio frequency (RF) links, many supporting safety of life functions, already exist on the aircraft.

This makes compatible introduction of a new system difficult. Separation in frequency, together with tight filter and waveform spectral characteristics help, however in some cases sufficient isolation between systems cannot be achieved. In those cases, one approach is to connect the systems to a “blanking bus” such that when one system is transmitting, other system receivers are effectively turned off. This approach is obviously facilitated by transmitters that have short transmitter on-times.

The 960-1 164 MHz band is heavily used by aviation for systems such as distance measuring equipment (DME), tactical air navigation systems (TACAN), secondary surveillance radar (SSR), aircraft collision avoidance systems (ACAS), and automatic dependent surveillance-broadcast (ADS-B; either via 1090 Extended Squitter or the 978 MHz Universal Access Transceiver (UAT)). As a result, introducing a new system in that band will prove challenging. One recent success however, was the introduction of the UAT. Aircraft integration of that system was facilitated by forcing the UAT aircraft transmissions to be very short in time. This was accomplished through the use of a wideband (approximately 1 MHz) channel, though the per-aircraft data rate was only about 400 bits/second. As a result, the UAT transmitter on-time was only about 400 microseconds; an aircraft-throughput-to-bandwidth multiplier of 2 500[1]. Analysis and test showed that the other on-board aircraft radiosystems could operate safely in the presence of that type of UAT radiotransmission.

Based on this experience, one approach to providing aircraft compatibility for the new AM(R)S system planned for the 960-1 215 MHz band may be to limit the on-time of system transmission. The implications of such an approach are explored later in this paper. In contrast, for the AM(R)S system planned for the 5 GHz band, the only other near-frequency on-board system would be the microwave landing system (MLS). Frequency management will be used to ensure protection of the MLS, and in addition, since the AM(R)S will be used just for surface operations, the MLS will likely not be in use during the time periods when the AM(R)S is active. As a result, it is not expected that a similar bandwidth multiplier to facilitate on-board integration will be required for the 5 GHz AM(R)S system.

3 Radiocommunications operating concepts and requirements

In conjunction with ICAO, a joint study was initiated to identify potential future radiocommunications technologies to meet AM(R)S safety and regularity of flight communications requirements; in particular supporting Air Traffic Services (ATS) and safety related Aeronautical Operational Control (AOC) communications. That Future Communications Study (FCS) had two main activities:

a) to identify the future requirements based on emerging global future Air Traffic Management (ATM) concepts taking into account the needs of civil aviation and State aircraft; and

b) to identify the most appropriate technologies to meet these communication requirements.

The results of the first activity are assessed in a document entitled the Communication Operating TConcepts and Requirements (COCR).

That COCR assisted in completion of the second activity by allowing key requirements to be matched against candidate technologies – existing or future. To achieve this goal the COCR identified the requirements placed on the communications that take place through the aircraft and ground radios. In developing the COCR an approach was taken to make it technology-independent.

The operational requirements were drawn from the ATM and AOC operating concepts expected to be implemented in the highest density airspace regions of the world to achieve the required capacity, safety and security. In particular, the ICAO Global ATM Operating Concept and the International Air Transport Association (IATA) ATM Roadmap were considered.

4 AM(R)S for portions of the 960-1 164 MHz band

The COCR was also used as a starting point for assessing new AM(R)S spectrum requirements. In particular, the COCR provided insight into future air/ground and air/air communications – functions that might be accommodated in a portion of the 960-1 164 MHz band. Under the assumptions of the COCR, the maximum per-aircraft data throughput was estimated to be approximately 20 000 bit/s.

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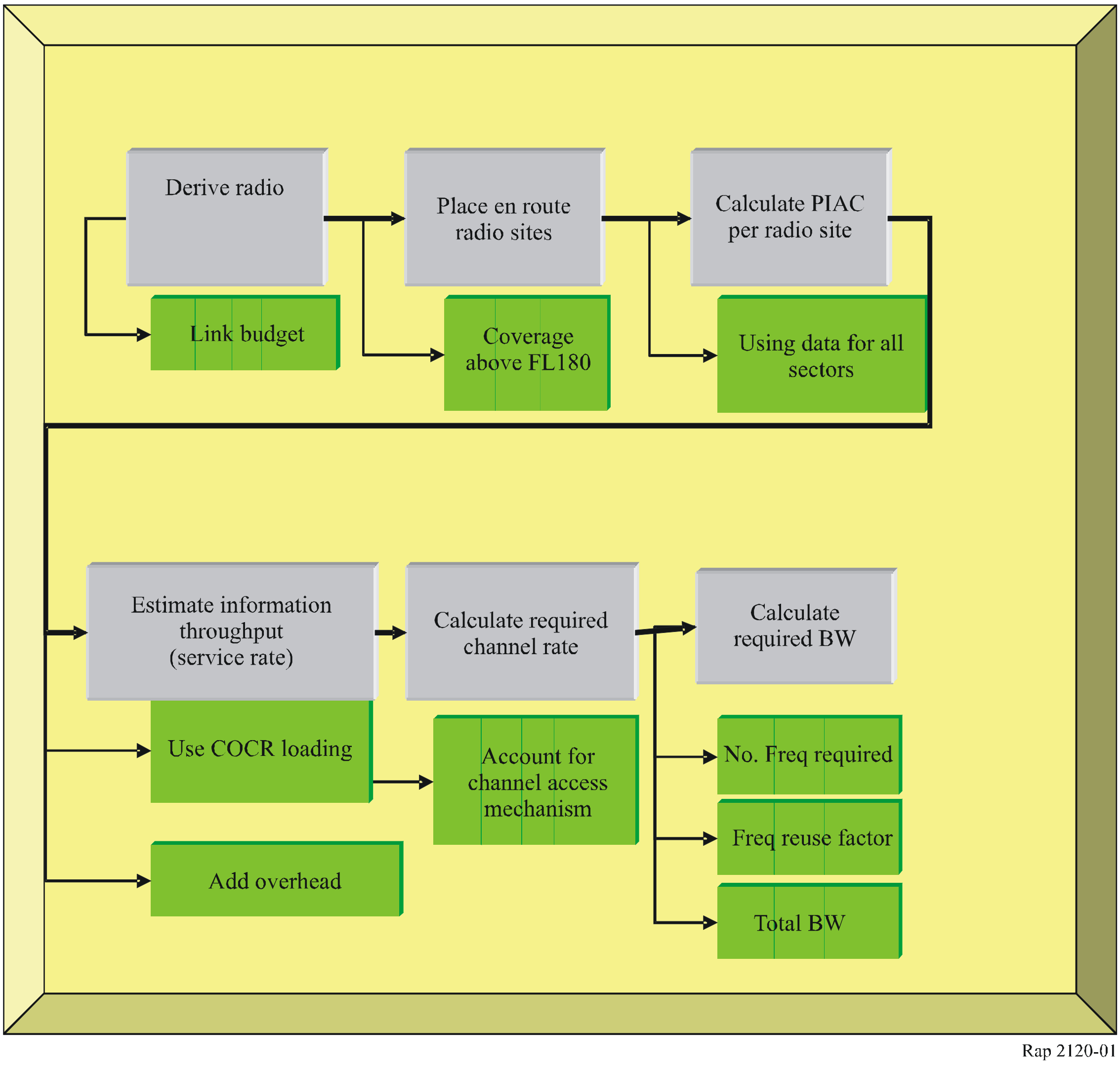
[1] It should be noted that while this per-aircraft bandwidth multiplier may seem large, a single UAT channel is utilized to accommodate all aircraft, making the overall UAT system very spectrum efficient.

The next task involved trying to determine the amount of spectrum required to accommodate a full airspace of aircraft, each transmitting 20 000 bit/s. In order to accomplish that, the process outlined in Fig. 1 was utilized. Important simplifying assumptions were that the communications were only occurring above 18 000 feet, "clean" spectrum could be used (i.e. the new AM(R)S would not share spectrum with other systems), and no account was made of the aircraft integration problems noted above. Under those assumptions, the study estimated that approximately 10 MHz was required for those en route communications. Later calculations using the same clean spectrum/ignoring integration assumptions estimated that for the full aeronautical domain approximately 15 MHz would be needed.

FIGURE 1

Analysis process



As stated in the study however, this is not the complete answer. In particular, the new AM(R)S system will have to share spectrum with other aviation systems, and as noted above aircraft integration issues must be considered. As a result, some form of bandwidth multiplier will be required. Since the particular technology to be used for the future communications system has not been defined, no final studies can be accomplished.

One estimate that was made, however, based on the UAT development success noted above, was to assume the aircraft transmissions needed to be accomplished in the same 400 µs deemed acceptable for UAT. Under that approach, for a per-aircraft throughput of 20 000 bit/s, a 50 MHz channel would be needed. Noting that the data throughput estimate did not take into account any of the error correction coding that was required to ensure UAT operation in its dense interference environment, that 50 MHz estimate was increased to 60 MHz. This value will need to be confirmed as the new communications system is developed.

5 AM(R)S for portions of the 5 000-5 150 MHz band

Estimates for surface spectrum requirements were determined in a different manner as the COCR did not address that domain. Instead, throughput estimates are based on a review of current surface communications requirements at a major airport in the United States. Those throughput requirements are then assumed satisfied using the candidate surface system technology (based on the Institute of Electrical and Electronics Engineers (IEEE) Standard 802.16e), and an overall spectrum requirement is derived. The result of that study is that approximately 60 MHz is required to support those surface applications using an 802.16e-based technology. It is important to note that those estimates are preliminary and closely tied to the assumptions made in the study. In addition, due to time constraints that report addressed only part of the expected surface communications requirements. In particular, bandwidth to support new aircraft-derived messages is not estimated as those applications have not yet been fully defined. Given these limitations, it is expected that the total aeronautical spectrum requirement for the surface domain will be on the order of 60-100 MHz in the near future.

6 Conclusion

While studies to determine appropriate technologies to support the future communication system continue, initial estimates of new AM(R)S spectrum requirements have been determined. Those estimates take into account evolving aeronautical applications, and integration of a new system on an aircraft. The estimates are:

– approximately 60 MHz in some portion of the 960-1 164 MHz band; and

– approximately 60-100 MHz in some portion of the 5 000-5 150 MHz band.

These estimates will be refined as studies progress.