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**APT REPORT ON**

**BROADBAND WIRELESS AIR-TO-GROUND COMMUNICATIONS LINKS WITH PASSENGER AIRCRAFT**

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1. **Introduction**

The emergence of ‘smart phones’ and the associated global demand for *ubiquitous* wireless connectivity around the world, including public expectations for ‘anywhere – anytime’ connectivity has grown to the point where lack of coverage, poor building penetration and even just comparatively slower bit-rates are frequently seen as a serious shortfall in service quality.

Cellular telephone systems have evolved from analogue to digital technologies, and network infrastructure (i.e. base-stations) is being more widely deployed - not just in outdoor locations across the landscape, but throughout public buildings, shopping malls, and within road/rail tunnels.

Business and consumer usage has expanded to encompass not only traditional voice and text communications modes, but applications of the Internet, news and weather, comparative shopping, online fulfilment, social interactions, entertainment of all types, personal navigation, office/business applications, photography and recording of life’s minutiae of every description. The advertising and retail industries have extensively built on this ubiquity of service to promote and expand their business models; while service and transport industries are using it to dramatically improve customer service levels; and many other industries have harnessed the opportunities brought by the smart-phone in ways we could never have anticipated at the time of launching that first Apple iPhone. Today, most users rely so much on the convenience, connectivity and information aspects of their smart phone that lack of service often results in frustration, discomfort, and even personal anxiety.

In response to growing consumer demand, many public transport services now also offer free or low-cost wireless connectivity to passengers. For example, many buses and trains offer in-vehicle Wi-Fi, with the vehicle connection to the Internet being provided via public cellular networks.

While network operators are continuously expanding the coverage ubiquity of mobile broadband service on land, provision of equivalent services on passenger ships and aircraft is just emerging. Today, some of the larger cruise ships have commenced fitting distributed antennas and wireless broadband base-stations supported by satellite-based backhaul to land networks.

In contrast, the connected passenger aircraft market has been slower to develop, and remains rather limited - with just a few airlines fitting a modest number of aircraft, and national arrangements settled in only a few countries. Moreover, some services offered to date have fallen short of user and airline expectations (low data rates, connection drop-outs, high user-tariffs, and excess equipment weight/aerodynamic drag affecting aircraft performance efficiencies.)

It was recognized that connection of passenger aircraft to national and global telecommunications services could be provided either by satellite systems or by Direct-Air-to-Ground Communications (DA2GC) links, these two solutions could be seen as complementary to each other.

There are several discussions on air-to-ground communication systems, known as Direct Air-to-Ground Communications (DA2GC) systems, so far. For examples, Report ITU-R M.2282-0 gives technical characteristics and operational features of the systems for public communications with aircraft in some countries. APT/AWG/REP-56 was created in order to identify the future needs of special communications for social, industrial and economic development which could be satisfied by services and applications on aircraft and vessel. APT/AWG/REP-63 is also based on the questionnaire that is designed for administrations as well as operators and other partners to provide the information of direct air-to-ground communication.

**Scope**

This report provides technical, operating and regulatory aspects associated with broadband wireless links to passenger aircraft to the Asia-Pacific region, to facilitate improved and seamless broadband access for use by both the travelling public and aircraft operators (including crews).

1. **Operations scenarios**

**3.1 Connecting aircraft to the world**

The critical back-haul connection between passenger aircraft and the global telecommunications network can be implemented either via direct air-to-ground systems (while over land) and/or via satellite systems.

However, a particular consideration is the requirement of many countries that all telecommunications traffic originating or terminating within their national territory shall be accessible for national crime investigation purposes. This requirement typically relies on a specific facility within each country, and is more readily met via direct air-to-ground (terrestrial) links within the country being over-flown, than by satellite links that often rely on a gateway earth station located in some other country and for which the traffic would need to be mirror copy from the gateway to the ground interception centres located in the relevant country. Nonetheless, the terrestrial versus satellite link backhaul options are clearly complementary – and may be considered as having distinct geographic roles, as shown in the following conceptual diagram:

*12nm territorial boundary*

*Figure 2 direct air-to-ground and satellite roles in broadband links to passenger aircraft*

In addition, passenger aircraft registered in their country-of-origin are frequently considered part of the ‘national territory’ of their home country. As such, some countries may require direct access to air-to-ground telecommunications for criminal investigation purposes even when the aircraft is in-flight over international waters.

Of note, while satellite links are clearly needed for the long-haul trans-oceanic routes, they may also be relatively costly and experience increased latency in the case of the short-haul and medium-haul routes supporting more frequent and larger numbers of passenger aircraft.

**3.2 General Air-to-Ground Scenario**

The Air-to-Ground Communication application comprises the broadband wireless terrestrial feeder links between aircraft in flight and respective national telecommunications networks in countries being overflown.

Broadband Direct-Air-To-Ground-Communications (DA2GC) is a type of the Air-to-ground applications, which is digital two-way radio communications system in which base stations in the land mobile service communicate with base stations on aircraft.[[1]](#footnote-1)

To enable passengers to use their smart-phones (at minimum power level) within the cabin of a passenger airliner, a compact base-station is fitted on-board, along with a distributed antenna running the length of the cabin (i.e. leaky feeder). Typically, the base-station will rely on the frequency bands already identified for IMT by the ITU-R, and commonly provisioned in today’s smart-phones. An alternative option may be to provide a Wi-Fi service within the cabin, via an on-board Wi-Fi Access Point (AP), since most modern smart-phones can also connect to Wi-Fi services.

*Terrestrial network*

*Overflying passenger aircraft*

*Broadband air-to-ground link*

*On-board distributed antenna*

*Onboard microcell or AP*

*Figure 1 General Air-to-Ground Scenario*

On-board Wi-Fi access points are already being used to broadcast pre-recorded news and entertainment content to passengers on many aircraft, via their own personal tablets and smartphones. However, connections to the Internet need a broadband back-haul link to national telecommunications networks, enabling access to a wider range of applications, as well as terrestrial voice and data services. The aim is to provide equivalent seamless connectivity to passengers in the air as available to users on the ground.

**Air-to-Ground activities in APT countries**

At ITU level, Technical characteristics and operational features of the systems for public communications with aircraft in some countries can be referred to the Annexes of ITU-R Report M.2282-0, Systems for public mobile communications with aircraft, the revision of which is now being developed by ITU-R WP5A. At APT level, the potential radio services and applications on-board aircraft was discussed and can be referred to the APT/AWG/REP-56. Air-to-Ground activities outside APT countries can be found in the Annex.

In Japan, the direct air-to-ground communication (DATGC) system with aircraft, which achieves over 100 Mbit/s transmission speed, is being studied. In the system, the 40 GHz band facilitates broadband wireless communications on airplanes and on the ground. As shown in Fig. 3, airplanes fly over ground tracking antennas arranged at regular intervals. The details of the system can be explained by references to Report [ITU-R M.2282-0](https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2282-2013-PDF-E.pdf) and [APT/AWG/REP-56](https://www.apt.int/sites/default/files/Upload-files/AWG/APT-AWG-REP-56-APT_Report_on_service_and_application_onboard_aricraft_and_vessel.docx).



*Figure 3: Over 40 GHz Wave Broadband Wireless Direct Air-to-Ground Communication System in Japan*

**Key operating issues**

Today’s passenger airlines operate in a highly cost-competitive environment, and typically seek to maximize the efficient utilization of aircraft over both domestic and international routes. This means a strong focus on issues such as aircraft weight and fuel consumption; ground maintenance downtime and operational service availability; seat quantity and occupancy; and crew operating requirements - to note just a few. To minimize on-board equipment complexity and weight, and to avoid undue additional duties for flight crews, several matters are relevant:

* sufficient production/market scale for air-to-ground equipment/systems to encourage development efforts toward minimising both weight and cost; and
* harmonized regulatory frameworks applicable to passenger aircraft operating across national borders, particularly in relation to certification, operations and licensing; and
* harmonized frequency arrangements, to minimize systems technical design and operational complexity.

Achieving these objectives involves consideration of such issues as: adopting common technical standards covering technology, radiofrequency emission levels and antenna patterns; securing mutual recognition of technical authorizations/certifications; achieving agreement on common system operating procedures; recognition of legal/regulatory obligations while over-flying national territories; and various other matters.

**5.1 Altitude limits related to the inflight communication services**

In the past, passenger use of entertainment systems and personal electronic devices (PEDs) on-board commercial aircraft was generally restricted by aircraft operators to the ‘cruise’ portion of flight only – primarily so that passengers’ attention is not diverted from the flight safety briefing, and purportedly to protect the critical take-off and landing phases of flight (involving precision electronic navigational aids) from errant radiofrequency emissions and interference. This restriction has generally been implemented in the form of a ‘minimum altitude’ limit of 3000m AGL as a convenient threshold. Coincidentally, after take-off, aircraft typically achieve an altitude of 3000m at some considerable distance from the point of departure – and generally beyond urban zones (even for most metro airports). This circumstance is potentially relevant to coverage planning for air-to-ground systems, since it infers that air-to-ground base-stations can generally be deployed in regional areas only:

3000 m

*Figure 4: Achieving 3000m altitude levels*

Some airline operators have begun to consider the possibility of offering ‘gate-to-gate’ connectivity for passengers, enabling reliable connection continuity on loading ramps between terminal and aircraft, and as an incentive to attract greater airline patronage. This may dictate the need for base-stations located nearby airports.

**Recent regulatory development:**

Until the FAA decision of December 2013 and the EASA decision 2014/029/R of September 2014, air safety rules did not allow Personal Electronic Devices in transmitting mode (T-PEDs) to be switched on below 3,000 meters/10,000 feet.

These decisions have now lifted this limitation (subject to certain steps to be carried out by the airline) and apply to aircrafts registered respectively in the US and Europe. Whereas we expect other Civil Aviation Authorities (CAAs) to adopt similar rules, it must be noted that a pre-requisite to allow Wi-Fi services from G2G on a given airline will be to ensure that the CAA of the State of Registry allows the use of T-PEDs below 3,000 meters.

**5.2 National border implications**

**Compliance with national technical regimes.** Where there are *differing* national regulatory and technical regimes between neighboring countries, aircraft need to track their position against national borders to trigger on-board system adjustments (power, mode, etc), according to relevant national regulatory requirements - or even to deactivate air-to-ground systems over certain countries. While such adjustments might be undertaken by aircrew, as an additional duty, they are more usually implemented as an automatic function via a connection to the aircraft [ARINC] data bus that provides aircraft heading, altitude, air-speed and positional information (amongst other data). However, this requirement adds to complexity – since on-board passenger connectivity systems had to store relevant mapping and regulatory data to enable proper technical compliance as the aircraft passed over national borders. Clearly, differing national regulatory regimes lead to functional and processing complexity, and greater development and equipment costs. Notably, however, direct air-to-ground links located within relevant national borders can instead readily implement regulatory compliance via control channel signalling.

**Customer experience implications.** Any service variability due to differing national regulatory regimes is undesirable from the perspective of passenger usage experience – for example, variable connectivity (lower bit-rates), differing connection modality, and periodic session drop-outs throughout flights. As such, consensus on harmonised licencing and regulatory regimes applicable to broadband air-to-ground systems, particularly between neighboring countries, will contribute to a more beneficial passenger experience.

**5.3 National legal and regulatory obligations**

As noted above, many national administrations require that all telecommunications originating or terminating within their territorial boundary must be accessible for criminal investigation purposes – often including not only session metadata (originating/terminating parties, time/date, duration, etc), but also real-time traffic interception. This typically involves a requirement to route traffic via one or more ground interception centres located within the relevant country and designed to facilitate access under relevant legal authorisations and protections.

In addition, other regulatory obligations may differ between countries, and may impact the air-to-ground systems architecture and traffic routing procedures – such as:

* mandatory routing of emergency assistance calls (for example, calls to the special numbers 911, 112, 000, etc) – requiring automatic connection of calls via shortest practical route to relevant public safety agencies (or call-handling centre) within the national territory;
* exclusive dealing prohibitions – in context of telecommunications, this generally requires that if services (eg. roaming) are offered to one class of users, they must be equivalently offered to all other classes of users;
* third-line forcing prohibitions – in context of telecommunications, this disallows a refusal to provide services if the user does not firstly acquire some other service from the same supplier; and
* there may also be other regulatory requirements enacted in various countries that must be taken into account.

In general, existing terrestrial fixed/mobile network operators within respective countries will have already established the facilities, functional norms and operating protocols certified to meet such national regulatory obligations as a normal part of their national network operations.

**Relevant Technical Issues**

The key technical aspects of air-to-ground systems discussed in this section relate to:

* ensuring effective inter-working and control signalling between airborne equipment mounted within/on passenger aircraft and corresponding terrestrial and/or satellite network infrastructure relevant to each country or area over which the aircraft is flying; and
* adopting common mechanical arrangements, that satisfy relevant airworthiness certification requirements, while minimizing weight and aerodynamic drag, and simplifying maintainability including rapid swap-in/swap-out of modules; and
* agreed common wireless technology characteristics (including emission levels, receiver performance, and antenna characteristics) and equipment functionality (such as Doppler compensation, and auto-configuration based on geographic position-detection); and
* harmonized spectrum utilization, including frequency bands and channel arrangements, to facilitate non-complex airline operations throughout the region, and easy redeployment of passenger aircraft to alternative routes in response to varying passenger load demands/needs.

**6.1 Region-wide Systems Inter-working**

To maximise seamless and transparent region-wide operations, establishing agreement on a harmonised air-to-ground technology platform is needed. The adoption of IMT-Advanced (LTE) technology for air-to-ground systems is already gaining broad international favour, and now appears to be the most popular and preferred choice for service operators and national administrations.

In addition, to simplify in-air operations and maximise passenger usage experience, establishing agreement on harmonised emission levels/power flux densities, out-of-band emissions, and minimum antenna elevation levels, is also necessary.

The antenna pattern and performance may be a particularly unique feature of air-to-ground links. In general, and to provide a reliable radiocommunications link with over-flying aircraft approaching/departing from all sky directions, both the airborne and ground antennas should exhibit an illumination pattern that varies with elevation-above-horizon:

* higher gain and linear (vertical) polarization for lower elevations between about 5-25⁰ above horizon; and
* lower gain and circular polarization for higher elevations between about 25-90⁰ above horizon.

*3000m agl*

*10000m agl*

*25⁰ ah*

*34 km*

*21 km*

*5⁰ ah*

*0 km*

*Linear pol*

*Circular pol*

*Figure 5 Antenna Elevation Angle versus Polarization*

Such an antenna pattern may also enable co-existence with other terrestrial services, such as coordinated sharing with fixed wireless systems utilizing highly directional antennas.

**6.2 Mechanical and electrical aspects**

Air-to-ground equipment modules developed for mounting in passenger aircraft should be sufficiently ruggedized and reliable, and include appropriate mounting/anchoring features to withstand the vibration and physical shock environment typically experienced by aircraft in flight. These mechanical aspects of the equipment are subject to formal ‘airworthiness certification’ that will be granted by the civil aviation authority of the country where the aircraft are registered.

The equipment must also conform with standardized physical mounting methods, dimensions, and maximum weight, to enable simple and rapid fitting to a wide variety of aircraft. Further, power and electrical signaling cables must meet a range of mechanical, electrical and chemical (including smoke/fire aspects) requirements, and be terminated with standardized plugs for direct connection to other aircraft equipment. The equipment should also be designed for rapid swap-in/swap-out in the event of module failure, to minimize impact on aircraft operating schedules and ground-maintenance time.

Finally, to minimize adverse impact on aircraft fuel usage and operating costs, the air-to-ground equipment intended for mounting in/on an aircraft should be specifically designed to achieve minimum necessary size, weight and aerodynamic drag (for externally-mounted antennas).

**6.3 Other technology issues**

Several technology aspects should also be considered for possible harmonization, to ensure a uniform approach is adopted throughout the Region:

* Doppler (airspeed) compensation – while determining airspeed and consequent Doppler compensation necessary for proper receiver operation can be achieved by computational means and GPS data within the airborne equipment, an alternative and simpler approach is to take the airspeed indication directly from the aircraft avionics data bus, and apply it as a frequency scaling correction factor;
* Altitude above ground detection – airlines may seek to continue the practice of prohibiting diversion of passenger attention to other activities, until the delivery of safety- related information is completed. It is believed that the activation referring in the section is related to the inflight communication service (internet or mobile) delivered to passengers. This altitude information may also be automatically derived from the aircraft avionics data bus;
* Geo-position detection – this information may be required for purposes of implementing particular national regulatory requirements, by matching against aircraft position against geographic national border location information. While this can also be derived directly from GPS data, it is also available from the aircraft avionics data bus;

**Spectrum Issues**

To allow for cross-border roaming between countries, where bands assigned to local network operators may differ, modern smart-phones typically include multiple frequency bands. However, this means designing handsets to accommodate multiple filters, amplifiers and other radiofrequency components, along with sufficient intelligence to implement scanning and search algorithms, and to allow devices to ‘discover’ valid national networks that have established roaming agreements with the handset’s home network.

Not only do these multiple filters and radiofrequency components increase complexity, but the associated development effort is only cost-effective in the case of the very large sales volumes (tens of millions of units) associated with the global cellular handset market. Such scale is unlikely to apply to the on-board air-to-ground equipment destined for the global passenger aircraft market (estimated to be a few tens of thousands). Therefore, the regional/global harmonization of the frequency bands for use by broadband air-to-ground applications is important. Also to enable seamless inter-regional and cross-border flight operations, and unfettered day-to-day re-scheduling of aircraft to alternative routes, APT administrations may consider harmonization of frequency arrangements with other regions.

Considering the frequency bands for the broadband back-haul connection between the on-board air-to-ground equipment and the terrestrial IMT network including both the downlink and uplink directions should be further studied. Sharing studies should be conducted to ensure co-existence with existing MS, FS, and MSS systems and to ensure identification of compatibility measures including technical, operational, and regulatory measures. Specially, since the direct air-to-ground scenario is totally different than the typical IMT scenarios, it should be carefully discussed whether the frequency bands identified for IMT scenario by ITU-R can be directly used in this air-to-ground scenario.

Frequency usage associated with providing broadband wireless links (air-to-ground, A2G) to passenger aircraft to facilitate improved and seamless broadband access for use by both the travelling public and aircraft operators[[2]](#footnote-2) is also being studied in ITU-R WP5A and can be referred to the [working document towards a preliminary draft new report on broadband air to ground systems](https://www.itu.int/dms_pub/itu-r/md/15/wp5a/c/R15-WP5A-C-1065%21N07%21MSW-E.docx) with the title *Frequency usage in the land mobile service for broadband direct air-to-ground (A2G) communications links with passenger aircraft*.

Some efforts have been made in some countries and the studies in different frequency bands summarized as the Table below:

Table: *Examples of studies on spectrum for broadband terrestrial and satellite with integrated terrestrial service to aircraft*

|  |  |  |
| --- | --- | --- |
|  | Link | Frequency Band |
| ECC | DA2GC | 5855-5875 MHz (TDD)1 |
| MSS+CGC | 1980-2010/2170-2200MHz (FDD)2 |
| USA  | Systems for public communications with aircraft | 849-851/894-896 MHz |
| Japan | DA2GC | 40GHz Band3 |

Note 1: Refer to ECC report 214.

Note 2: Refer to ECC Report 233. “*ECC Decision ECC/DEC/(06)09[1] designates the bands 1980-2010 MHz and 2170-2200 MHz for use by systems in the Mobile Satellite Service (MSS), including those supplemented by a Complementary Ground Component (CGC)*.” The details can be referred to the Annex. Further technical studies, sharing studies and regulatory considerations are required.

Note 3: The use of 40GHz is under initial study in Japan.

**Additional regulatory requirements**

**8.1 Access for crime investigation**

As noted earlier, many countries already require that all telecommunications traffic within their national territory can be made accessible for national crime investigation purposes. This is sometimes referred to as a ‘legal interception’ requirement, and is usually achieved via one or more terrestrial teletraffic routing nodes specifically established within each country for this purpose. Clearly, connection to these nodes is likely to be more easily achieved by direct air-to-ground systems located within each country, while satellite systems could be used where aircraft are flying over international waters.

**8.2 Recording of user terminal devices and traffic metadata**

In some countries, aside from any interception requirement, regulatory provisions exist that require relevant metadata (such as: user terminal identity; origin/destination parties; time, date and duration of each call/session, as a minimum) to be recorded by a facility located within the borders of the relevant country for every call/session/transaction carried by a telecommunications network providing services within the national territory. Such requirements further infer that direct air-to-ground services may be more readily able to meet such requirements, while satellite systems are used where aircraft are flying over international waters.

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**ANNEX**

**AIR-TO-GROUND ACTIVITIES OUTSIDE APT COUNTRIES**

**1.** **Air-to-Ground activity in Europe**

European Commission issued a mandate in 2014 to the CEPT to undertake further studies on the use of the unpaired 1900-1920 MHz and 2010-2025 MHz bands[[3]](#footnote-3), including possible use for broadband DA2GC. In addition (based on proposals by Lufthansa), and to further facilitate competition, the CEPT also undertook compatibility/sharing studies between broadband DA2GC in the frequency band 5855-5875 MHz, along with several other bands (2400-2483.5 MHz and 3400-3600 MHz)[[4]](#footnote-4).

Since then, a number of trials have been completed in Europe using the 1900-1920 MHz and 5855-5875 MHz bands. Subsequent to these trials, commercial plans for using these particular bands do not yet seem to have emerged, despite efforts to stimulate the market via ECC Decisions (15)02[[5]](#footnote-5) and (15)03 specifically addressing the use of these bands to support DA2GC systems. In this regard the industry expressed concern that TDD technology was not preferred for the air-to-ground application due to the relatively large ‘aerial’ cell radius (often > 100 km) and the related need for longer guard-times between up/downlink modes that would result in reduced system capacity and performance and finally, in July 2018 ECC published its decision to withdraw the previous ECC Decision (15)02 on the harmonised use of Broadband Direct Air-to Ground Communications (DA2GC) systems in the frequency band 1900-1920 MHz[[6]](#footnote-6).

Notably, there is also growing consensus on assigning the band 5850-5925 MHz for harmonised global use by intelligent transport systems (eg. vehicle-to-vehicle collision avoidance, et al).

In Europe, following ECC Decision ECC/DEC/(06)09, Mobile Satellite Service (MSS) systems operating on 1980-2010 MHz / 2170-2200 MHz frequency bands are being developed and might be used to provide communication to aircraft in the future, which may include a Complementary Ground Component (CGC), for which technical studies and further regulatory considerations are required.[[7]](#footnote-7) It is also noted that the frequency bands 1980-2010 MHz / 2170-2200 MHz are allocated to the Fixed Service, Mobile Service, and Mobile Satellite Service on a co-primary basis in the ITU-R Radio Regulations (with no priority given to any service).

In addition, the CEPT ECC has undertaken further useful studies and the ECC subsequently issued a Recommendation on that matter:

* ECC Report 233 (May 2015): *Adjacent band compatibility studies for aeronautical CGC systems operating in the bands 1980-2010 MHz and 2170-2200 MHz*;
* ECC Recommendation (10)01: *On guidelines for compatibility between complementary ground components (CGC) operating in the band 2170-2200 MHz and EESS/SOS/SRS Earth stations operating in the band 2200-2290 MHz*.

The European standards body ETSI has also published several other technical reports and a harmonized European standard:

* ETSI TR 103 054 V1.1.1 (2010-07) *System Reference Document on Broadband Direct-Air-to-Ground Communications operating in part of the frequency range from 790 MHz to 5150 MHz*; FM48(10)003
* ETSI TR 101 599 V1.1.3 (2012-09) *System Reference Document on Broadband Direct-Air-to-Ground Communications System employing beamforming antennas, operating in the 2.4 GHz and 5.8 GHz bands*; FM48(12)036
* ETSI TR 103 108 V1.1.1 (2013-07) *System Reference Document on Broadband Direct-Air-to-Ground Communications operating in the 5.855 GHz to 5.875 GHz using 3G technology*; FM48(13)037
* ETSI EN 303 339: *Broadband Direct Air-to-Ground Communications; Equipment operating in the 1900 to 1920 MHz and 5855 MHz to 5875 MHz frequency bands; Fixed pattern antennas; Harmonised standard covering the essential requirements of article 3.2 of Directive 2014/53/EU*

**2. Air-to-Ground Activities in the United States of America**

In the United States of America, an air-to-ground system has been established with more than 1500 commercial aircraft and 5000 business aircraft now equipped, based on the Aeronautical Mobile Service (AMS) band 849-851/894-896 MHz:

851.0

849.0

850.5

896.0

894.0

895.5

A

A

B

B

In addition, in late 2012 the FCC also considered a proposal for A2G Communications at 14.0-14.5 GHz (sharing with FSS uplink, whereby ground-stations avoid transmissions into the geostationary arc). This system is intended to support high-speed broadband internet connectivity for airplane passengers using smartphones, tablets, and laptops – the full range of wireless devices as already used on the ground.

1. Refer ITU-R WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW REPORT ON BROADBAND AIR TO GROUND SYSTEMS, Frequency usage in the land mobile service for broadband direct air-to-ground (A2G) communications links with passenger aircraft, https://www.itu.int/dms\_pub/itu-r/md/15/wp5a/c/R15-WP5A-C-1065!N07!MSW-E.docx. [↑](#footnote-ref-1)
2. The frequency not to be used for safety related aspects, and operation and navigation of the aircraft. [↑](#footnote-ref-2)
3. Refer ECC Repot 209 *Compatibility/sharing studies related to Broadband Direct-Air-to-Ground Communications (DA2GC) in the frequency bands 1900-1920 MHz / 2010-2025 MHz and services/applications in the adjacent bands* [↑](#footnote-ref-3)
4. Refer ECC Report 210 *Compatibility/sharing studies related to Broadband Direct-Air-to-Ground Communications (DA2GC) in the frequency bands 5855-5875 MHz, 2400-2483.5 MHz and 3400-3600 MHz* [↑](#footnote-ref-4)
5. This decision has been withdrawn in July 2018 due to lack of express within the 2015-2017 timeframe for taking up the opportunity for a European Broadband DA2GC system in the band 1900-1920 MHz band [↑](#footnote-ref-5)
6. Refer to ECC Decision (18)01: “ECC Decision on the withdrawal of ECC Decision (15)02 on ‘The harmonised use of broadband Direct Air-to-Ground Communications (DA2GC) systems in the frequency band 1900-1920 MHz’” [↑](#footnote-ref-6)
7. ECC Report 214 *Broadband Direct-Air-to-Ground Communications (DA2GC)*, 30 May 2014 [↑](#footnote-ref-7)