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Technical Report

Electromagnetic compatibility and Radio spectrum matters (ERM) System Reference Document (SRDoc); Broadband Direct-Air-to-Ground Communications System employing beamforming antennas, operating in the 2,4 GHz and 5,8 GHz bands

Reference
RTR/ERM-034

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Executive summary

The ever-increasing take-up of broadband services around the globe has led to an explosion of data carried over mobile networks over the last few years, as users increasingly expect and demand to be able to access high-speed internet services on their own mobile devices wherever they travel.

Airline passengers represent a small but important sector of the overall mobile market, since many high-value business customers are frequent travellers and would like to be able to connect to the internet, send and receive e-mails, etc. when travelling on continental, as well as long-haul flights. The provision of information and entertainment services is also a popular service enjoyed by both business and private users during flights. Last but not least, the availability of broadband connections to aircraft in flight can provide additional airline information data to supplement the information already available via existing communications channels. Such usage would be limited to non-safety related data streams, which are known in the aviation industry as "non-mandatory ACARS messages", (see clause 3.2).

In order to meet these user demands, a communications link must be established between the aircraft and the ground which has sufficient capacity to allow for large numbers of passengers to simultaneously access the various services, including streaming video. Up until now, with the exception of two North American service providers, the only means of providing aircraft backhaul has been through the use of satellite links. This has several disadvantages, including limited bandwidth, cost of capacity and round-trip delays. A broadband Direct Air-to-Ground (DA2G) communications solution overcomes these drawbacks and is highly suitable for use over landmasses, including the majority of European routes. Work has already begun within CEPT to identify spectrum for such an application. Three DA2GC system proposals have been presented to CEPT. One of these proposals is the system described herein.

The present document describes a novel broadband DA2G communications system which makes use of adaptive beamforming antennas in order to achieve the desired system performance whilst maintaining lower transmit power levels than would otherwise be necessary. This feature also facilitates co-frequency sharing with other systems by minimising interference into other services and, at the same time, reducing the impact of incoming interference on the achievable link performance. For these reasons, the described system has initially been designed to be capable of operating in any 20 MHz block of contiguous TDD spectrum (or 2 x 10 MHz FDD) within the ISM frequency bands around 2,4 GHz and/or at 5,8 GHz (currently used for a number of licence-exempt applications).

From the point of view of enabling a timely and cost-effective deployment of the system across Europe, it would be preferable if a licence-exempt or lightly licensed regime could be applied. However, the appropriate regulatory framework will depend on the outcome of studies being carried out within the CEPT.

For the system described in the present document, the 5,8 GHz band is currently considered as a possible band for an early introduction in CEPT countries, and, more specifically, the portion of the band from 5 855 MHz to 5 875 MHz since this upper part of the 5,8 GHz band is not designated for radar use in Europe. (Radar systems operate in the bands immediately below this range, which would present a much more difficult sharing scenario). The scope of the present document is restricted to the aforementioned frequency bands (2,4 GHz and 5,8 GHz), for the reasons stated.

Introduction

The present document has been developed to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT).

The present document is intended to provide sufficient information on the design and operational features of the described broadband DA2G communications system to enable due consideration within the relevant CEPT Working Groups and Project Teams and, in particular, to aid in necessary sharing studies in the frequency bands currently under consideration for a new harmonised designation for such systems.

Status of pre-approval draft

The present document has been developed and approved within TC BRAN, has been subject to an internal enquiry within ERM and is currently undergoing further revisions to resolve comments received, prior to submission for final approval by ERM for publication as an ETSI Technical Report.

Table 1: Document Status

Target version	Pre-approval date version (see note)				
V1.1.1	**a**	**s**	**m**	**Date**	**Description**
V1.1.1	0.0.1			20th December 2011	Submitted to TC BRAN#69
V1.1.1	0.0.2			22nd December 2012	Created in TC BRAN#69
V1.1.1	0.0.3			16th February 2012	Further revisions by Rapporteur
V1.1.1	0.0.4			21st February 2012	Submitted to TC BRAN#70
V1.1.1	0.0.5			21st February 2012	Includes changes agreed in TC BRAN#70 meeting
V1.1.1	0.0.6			21st February 2012	Clean version approved by TC BRAN#70 for consideration in ERM#46
V1.1.1	0.0.7			22nd February 2012	Presented to ERM#46 and submitted to ETSI internal enquiry process
V1.1.1	0.0.8			12th April 2012	Incorporates comments from enquiry process for consideration in resolution meeting
V1.1.1	0.0.9			17th April 2012	Result of first resolution meeting
V1.1.1	0.0.10			18th April 2012	Includes changes from 2nd resolution meeting
V1.1.1	0.0.11			2nd May 2012	Further revision for consideration in final resolution meeting
V1.1.1	0.0.12			4th May 2012	Further changes incorporated from final resolution meeting (copy sent to CEPT)
V1.1.1	0.0.13			31st May 2012	Version incorporating final changes resulting from discussions in CEPT PT SE44
V1.1.1	0.0.14			1st June 2012	Clean version of final draft submitted to ERM#47
V1.1.1	0.0.15			19th June 2012	Version approved by ERM#47 for publication

1 Scope

The present document describes a system designed to provide broadband DA2G communications, which may require a change of the present frequency designation / utilisation within CEPT or some changes to the present regulatory framework for the proposed band(s) regarding either intended or unwanted emissions.

The preferred regulatory approach would be for this system to operate on a non-interference and unprotected basis within the bands 2 400 MHz to 2 483,5 MHz and/or 5 855 MHz to 5 875 MHz. However, it is recognised that there is a high density and large variety of licence-exempt applications already deployed in the 2,4 GHz band in CEPT countries and a number of important applications (including ITS applications and BFWA) also are deployed or planned in, or adjacent to the 5,8 GHz band.

The present document includes, in particular:

- Market information.
- Technical information.
- Regulatory issues.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ERC Report 25: "The European table of frequency allocations and utilisations in the frequency range 9 kHz to 3000 GHz".

[i.2] ETSI EN 300 328 (V1.8.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

[i.3] ETSI EN 302 502 (V1.2.1): "Broadband Radio Access Networks (BRAN); 5,8 GHz fixed broadband data transmitting systems; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

[i.4] ETSI TS 136 104: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (3GPP TS 36.104)".

[i.5] ETSI TS 136 101: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (3GPP TS 36.101)".

[i.6] ECC Document FM48(11)024 and its Annex: "Spectrum demand for Broadband Direct Air-to-Ground Communications (DA2GC)".

[i.7] ITU Radio Regulations (Edition of 2008).

[i.8] ECC Document FM48(11)043 Annex 6: "Candidate bands for Broadband DA2GC".

[i.9] ECC Document SE44(12)013 Annex 1: "Results of the compatibility studies between Broadband Direct-Air-to-Ground Communications (BDA2GC) as described in ETSI TR 103 054 and outdoor RLANs in the frequency band 2400-2483.5 MHz".

[i.10] ECC Document SE44(11)019: "LS from SE24 on technical information on RLAN systems in the frequency band 2400-2483.5 MHz".

[i.11] ECC Recommendation (06)04: "Use of the band 5 725-5 875 MHz for Broadband Fixed Wireless Access (BFWA)".

[i.12] CARMEN project on Carrier grade Mesh Networks.

NOTE: Available at http://www.ict-carmen.eu/.

[i.13] EC Decision 2008/671/EC of 5 August 2008 on the harmonised use of radio spectrum in the 5875-5905 MHz frequency band for safety-related applications of intelligent transport systems. .

[i.14] Directive 2004/52/EC of the European Parliament and of the Council of 29 April 2004 on the interoperability of electronic road toll systems in the Community.

[i.15] Commission Decision 2009/750/EC of 6 October 2009 on the definition of the European Electronic Toll Service and its technical elements.

[i.16] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

[i.17] Cisco White Paper on "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update", 2011-2016.

[i.18] ECC Document FM48(11)038: "Compatibility analysis between DA2G and Systems in the Band 5850-5870 MHz".

[i.19] "Promoting the Shared Use of Radio Spectrum" by Pearse O'Donohue, Head of Unit, Radio Spectrum Policy, DG Information Society and Media, European Commission.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Aircraft Station (AS): entity onboard aircraft providing the radio, control and telecommunication functionalities for broadband DA2G communication

Direct Air-to-Ground (DA2G): direct radio link between an Aircraft Station (AS) and a Ground Station (GS)

Forward Link (FL): within the DA2G communication system the link from the Ground Station to the Aircraft Station

Ground Station (GS): entity on the ground providing the radio, control and telecommunication functionalities for broadband DA2G communication

ISM frequency bands: bands which are designated in the ITU Radio Regulations [i.7] to industrial, scientific and medical applications

Reverse Link (RL): within the DA2G communication system the link from the Aircraft Station to the Ground Station

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACARS	Aircraft Communications Addressing and Reporting System
AS	Aircraft Station
ATPC	Automatic Transmit Power Control
BFWA	Broadband Fixed Wireless Access
BIPT	Belgische Instituut voor de Postdiensten en de Telecommunicatie
BT	British Telecom
CEPT	European Conference of Postal and Telecommunications Administrations
DA2G	Direct-Air-to-Ground
DA2GC	Direct-Air-to-Ground Communications
DSRC	Dedicated Short Range Communication
e.i.r.p.	Effective Isotropic Radiated Power
ECC	Electronic Communications Committee
FCC	Federal Communications Commission
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FSS	Fixed-Satellite Service
GSMOBA	GSM Onboard Aircraft
IFE	In-flight entertainment
ISM	Industrial, scientific and medical applications
ITS	Intelligent Transport Systems
ITS-G5	5 GHz wireless communication
MS	Mobile Service
MSS	Mobile Satellite-Service
PT	Project Team
R&TTE	Radio and Telecommunications Terminal Equipment
RFID	Radio Frequency Identification Device
RFIDs	Radio frequency identification devices
RIM	Research In Motion
RLAN	Radio Local Area Network
RLS	RadioLocation Service
RTTT	Road Transport and Traffic Telematics
SAP/SAB	Services Ancillary to Programme making / Services Ancillary to Broadcasting
SIG	Special Interest Group
SRD	Short Range Device
TC	Technical Committee
TDD	Time Division Duplex
TDMA	Time Division Multiple Access

4 Comments on the System Reference Document

The statements in clauses 4.1 to 4.3 have been recorded.

4.1 Statement by Cisco Systems Belgium, CSR, Broadcom Corporation, Research in Motion UK Limited, Qualcomm UK Ltd and BIPT

WiFi® and Bluetooth® (BT) usage in the 2,4 GHz band has a huge economic and social value. 1 billion WiFi® chipsets and 2 billion BT chipsets have been shipped in 2011 alone. The forecasts, *Cisco White Paper [*i.17*]*, demonstrate that mobile data traffic will double in 2012 and will have an 18-fold growth in 2016, where Europe accounts for a considerable amount of this growth. As a result, WiFi® networks in Europe will play a crucial role as a complement to cellular networks in responding to this tremendous need for mobile data traffic. Currently, there is a trend towards offloading mobile data in urban hotspots from cellular networks to smaller cells, WiFi-based and femtos. This trend will be accelerated in the future and a considerable amount of Smartphone traffic will be routed over WiFi® networks. The role of WiFi® for data traffic over fixed networks is even much more important. In this sector, WiFi® networks carry in Europe more than 20 times as much Internet data as carried over cellular networks. Global sales of WiFi® based equipment is expected to reach 3,5 billion euro in 2014, see [i.19].

With increasing penetration of Bluetooth® in the automotive, consumer electronics and mobile phone markets as well as emerging markets such as health and fitness, smart home and industrial the technology is expected to continue to evolve and expand, taking advantage of the small-form factor radio, low power, low cost, built-in security, robustness, ease-of-use, and ad-hoc networking abilities. By 2016 it is expected that the number of Bluetooth® chipsets shipped in that year alone will have increased to 7 billion.

Until now radio equipment in the 2 400 MHz to 2 483,5 MHz band has been used on the ground (terrestrial). This has enabled public operators as well as private (commercial and non-commercial) owners of larger properties (e.g. university campus, airports, train stations, city centers, hospitals, shopping malls, industrial production areas, supply chain areas, forestry, agriculture and research areas) to plan their local area wireless networks (e.g. based on Wi-Fi, Bluetooth®, ZigBee®, active and passive RFID etc.) without uncontrolled interference from outside of their property. DA2GC deployment operating in this band would act as an uncontrollable interferer (from the base stations as well as from the planes) to these wireless networks and would limit the currently existing freedom of network configuration and arrangement in these areas, which are very important and more significant to the economy than DA2GC. This potentially introduces requirements for more robust planning of wireless networks in these areas and would result in unpredictably higher costs for these sectors.

In 1993, ETSI published the very first edition of EN 300 328 [i.2]. No one could at that moment predict that this technology would enable the development of such an important business that has changed the way we work, live and communicate. We trust that CEPT administrations will make the right decision and will ensure the future of the spectrum currently in use by WiFi® and Bluetooth® will remain available to support further growth of WiFi® and Bluetooth® business. The economic value and growth potential that WiFi® and Bluetooth® represents today, and will represent in the future, should not be put at risk by allowing an outdoor DA2GC network of high power base stations operating in license exempt spectrum such as the 2,4 GHz band and covering the whole European territory. Compared to what is put at risk, the economic value of such application is very low.

Therefore Cisco Systems Belgium, CSR, Broadcom Corporation, Research in Motion UK Limited, BIPT and Qualcomm UK Ltd. do not support the consideration of the 2,4 GHz band for DA2GC.

ETSI members Cisco Systems Belgium, CSR, Broadcom Corporation, Research in Motion UK Limited and Qualcomm UK Ltd. propose the below power density mask to apply on the ground stations for both the 2,4 GHz and the 5,8 GHz bands (or any other license exempt band being proposed for DA2GC usage). However, this mask does not fully address interference concerns in the 2,4 GHz band and therefore even with the addition of the mask we still do not support the consideration of the 2,4 GHz band for DA2GC.

The -3 dBm/MHz is based on a 10 dBm signal using a 20 MHz channel bandwidth being transmitted in the horizontal plane.

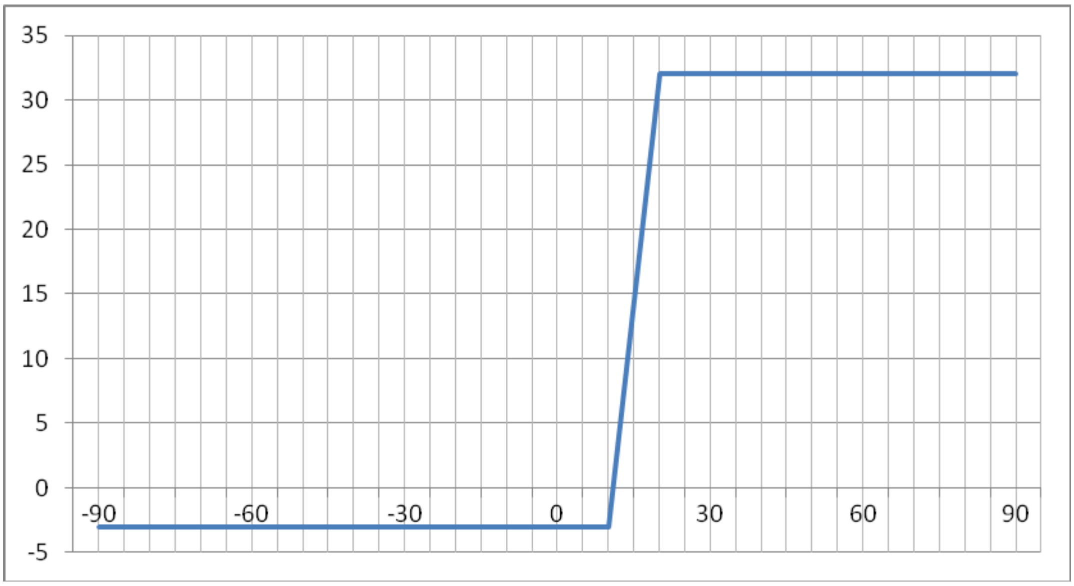


Figure 0: Max. e.i.r.p. density (dBm/MHz) versus Elevation angle (deg)

4.2 Statement by Bluetooth® SIG

Background on the Bluetooth® **SIG** (www.bluetooth.org)

The Bluetooth® Special Interest Group (SIG) is a not-for-profit trade association serving over 15 000 member companies including the leaders in the telecommunications, computing, consumer electronics, automotive, industrial automation, and network industries. Representing very diverse devices and market segments the SIG members are devoted to drive the development of *Bluetooth*® wireless technology, and implement and market the technology in their products.

Bluetooth® wireless technology is the global short-range wireless standard enabling connectivity for a broad range of electronic devices. The technology continues to evolve, building on its inherent strengths - small-form factor radio, low power, low cost, built-in security, robustness, ease-of-use, and ad hoc networking abilities. *Bluetooth*® v4.0 unifies these evolutionary advancements and provides manufacturers and consumers with low energy and high speed features for connecting devices wirelessly. Manufacturers and consumers can choose to activate one or all of these features in *Bluetooth*® enabled devices, depending on device functionality.

The Bluetooth® SIG members are committed to enable interoperability in the market place. This is achieved via extensive testing during prototyping of the specifications, verification of product prototypes during recurring verification testing events (named Bluetooth® Unplugfests) and finally through certification testing within the Bluetooth® Qualification program. Via the Bluetooth® Qualification program, the Bluetooth® SIG has to this date completed over 25 000 product certifications, encouraging the expanded use of Bluetooth® products and services in new and established markets. Bluetooth® SIG estimates that more than two billion Bluetooth® products were shipped in 2011. By 2016 it is expected that the number of Bluetooth® chipsets shipped in that single year will have increased to 7 billion.

Bluetooth® SIG response on the SRdoc

Since the first edition of EN 300 328 [i.2] in 1993 we have seen tremendous pickup of wireless technology in the license exempt spectrum. Due to the imposed politeness rules different technologies such as Bluetooth® and WiFi®, for example, coexist in the spectrum. Despite high device density and high volume of data transferred the end user has good quality of service. Although the personal wireless applications still are in their adolescence years there were more than 2 billion Bluetooth® devices and 1 billion WiFi® devices shipped in 2011.

The SRdoc discusses that there is an increasing expectation amongst airline passengers to be able to access the Internet from their mobile devices during flight, provided that the pricing of the services was sufficiently attractive. This is a conclusion that is consistent with our experience that people expect wireless to be accessible in all environments. We welcome the initiative from the flight industry to provide WiFi® access in that environment and acknowledge that to accomplish this there is need for a broadband link to ground. In order to achieve the anticipated quality of service we would expect that such a link should be possible to maintain wherever in the world a plane may fly and not only in Europe or whilst flying over land. As presented we do not see that the Direct-Air-to-Ground Communications system discussed in the SRdoc has the capabilities to fulfil that requirement.

Our reading of the SRdoc implies additionally that if accepted, there would potentially be multiple DA2GC systems in operation on any given flight route in order to service different airlines or airline alliances. We therefore think that the sharing studies also need to consider scenarios where there are multiple operating DA2GC systems side by side, and that given the competition, the systems would have no coordination between themselves.

In order to achieve the experience that wireless works in the 2,4 GHz band the industry has invested heavily in enabling interoperability between different Bluetooth® platforms as well as coexisting with other technologies in the 2,4 GHz band such as WiFi®. We are very concerned about the imbalance DA2GC would introduce in the now heavily used 2,4 GHz band. To maintain the balance in the intensively used 2,4 GHz band, the requirements such as maximum output power and the need for a polite sharing mechanism must be identical for all license exempt users of this band. No single license exempt application should be allowed to transmit at a higher power than others. Although the proponents are planning to use directional antenna systems, the high Tx power of the ground stations makes it extremely unlikely that there will not be cases in which the e.i.r.p. on the ground or in buildings will exceed the allowed levels. DA2GC as presented in the present document cannot be considered a short range technology and therefore it simply does not belong together with Bluetooth®, WiFi® and other short range technologies using the 2,4 GHz licensed exempt spectrum.

Market estimates indicate a growth potential for Bluetooth® technology to realize annual shipments in 2016 in the range of 7 to 10 billion units. The expected growth will partly happen within already established markets such as automotive, consumer electronics and mobile phone but will also expand Bluetooth® technology into emerging markets such as health and fitness, smart home, industrial and machine to machine. The economic value and growth potential that this represents, and will represent in the future, should not be put at risk by allowing an outdoor DA2GC network of high power base stations operating in license exempt spectrum such as the 2,4 GHz band and covering the whole European territory. Compared to what is put at risk, the economic value of DA2GC is very low.

Unless DA2GC can comply with existing regulations including complying with the current transmission power limits (e.i.r.p.), medium utilization limits and the requirement to implement a sharing mechanism, the DA2GC systems shall not be accommodated in the 2,4 GHz band.

4.3 Statement by Federal Ministry for Transport, Innovation and Technology (AUSTRIA)

The Federal Ministry for Transport, Innovation and Technology is of the opinion, that the description of the parameters for Broadband Direct-Air-to-Ground Communications System in the present document is too imprecise for a serious compatibility study. Severe impairments to other systems are expected. Therefore, an unlicensed operation in this band, as for Short Range Devices (SRD) with less than 25 mW e.i.r.p. is impossible.

TC BRAN is requested to consider additionally the following arguments in the further treatment of the the present document.

The description of the transmit parameters for DA2G in the present document is too imprecise for a serious compatibility study, severe threads to other systems like:

- DSRC road tolling, as described in [i.14] and [i.15];
- ITS safety and non-safety communication as described in [i.13]; and
- radio location

are expected.

From the compatibility point of view the elevation antenna diagram as shown in the present document for the ground station is not acceptable. The maximum e.i.r.p. and spectrum mask must be significantly lower in the horizontal plane to reduce risk for interfering to other radio services. Lower limits of maximum e.i.r.p. and spectrum mask must be defined for elevation angles -90° (down) and up to +20° elevation.

5 Presentation of the system or technology

The described broadband DA2G system is intended to provide broadband connectivity between an aircraft and the ground, to enable provision of services to passengers on board (e.g. e-mail, web browsing, infotainment, etc.). The overall system connectivity also enables the facility to provide non-safety relevant airline information services whilst maintaining complete isolation between such data and the various internet and infotainment services available to passengers in the aircraft cabin.

The system is designed to enable consideration of the option for licence-exempt or lightly licensed operation in the 2,4 GHz and/or 5,8 GHz bands. From a frequency sharing perspective, an important feature of the described system is the use of four sectors at the ground station, with each sector having at least eight phased array beamforming antennas (i.e. eight elements per quadrant) and an array of digitally controlled antenna elements connected to the aircraft radio, which are mounted on the underside of the airframe in order to constitute an adaptive array.

The use of beamforming permits the production of shaped and dynamically steerable beams in both the forward link (ground-to-air) and reverse link (air-to-ground) directions, thereby enabling the desired system performance objectives to be maintained as the aircraft traverses its route whilst, at the same time, minimising interference into other co-frequency systems. This is achieved through the benefits of tailored radiation patterns which can be optimised to reduce interference and allow operation at lower transmit powers (on the ground and in the air) than would otherwise be necessary if more conventional fixed antennas were deployed.

In respect of the underlying modulation and coding schemes used, etc., the system has much in common with other existing and proposed mobile broadband backhaul technologies, as described more fully in clause 7.

6 Market information

The potential market for air passenger communications was examined when developing a previous System Reference Document Broadband DA2G Communications. This showed that there was an increasing expectation amongst airline passengers to be able to access the internet from their own mobile devices during flight, provided that the pricing of the services was sufficiently attractive. A Direct Air-to-Ground system would enable lower transmission costs per megabyte per aircraft than existing satellite-based backhaul alternatives. Furthermore, European air traffic densities (and hence addressable passenger numbers per year) were forecast to continue to increase in coming years, leading to ever higher numbers of potential customers for in-flight broadband services.

Subsequently, the ECC has determined the necessary spectrum bandwidth for such systems based, in part, on additional and updated market information as presented in [i.6]. This document includes an illustration of the rapid growth in mobile data traffic across a range of mobile applications, taken from the well publicised Cisco Visual Networking Index, which is updated on an annual basis. In the referenced 2011 Cisco report, cumulative annual traffic growth rates of 92 % were forecast for the five year period from 2010 to 2015. The document [i.6] also refers to information about customers and data rates published by the different aircraft connectivity operators which demonstrate the increasing utilisation of their respective GSMOBA and/or WiFi® services during recent years.

For the DA2G communications system described in the present document the addressable markets for the intended services are broadly similar.

7 Technical information

7.1 Detailed technical description

The broadband DA2G system is designed to provide bi-directional ground-to-aircraft connectivity as part of an overall broadband communications system which will offer a variety of IP-based applications for the use of passengers as well as airline information (non-safety) data.

Figure 1 gives a high-level overview of how the DA2G system fits within the end-to-end system architecture. The elements which are the subject of this SRDoc are those elements which provide connectivity between the Air Network and the Ground Network, including the Air Station and Wireless Base Station shown in the top left hand corner of the figure.

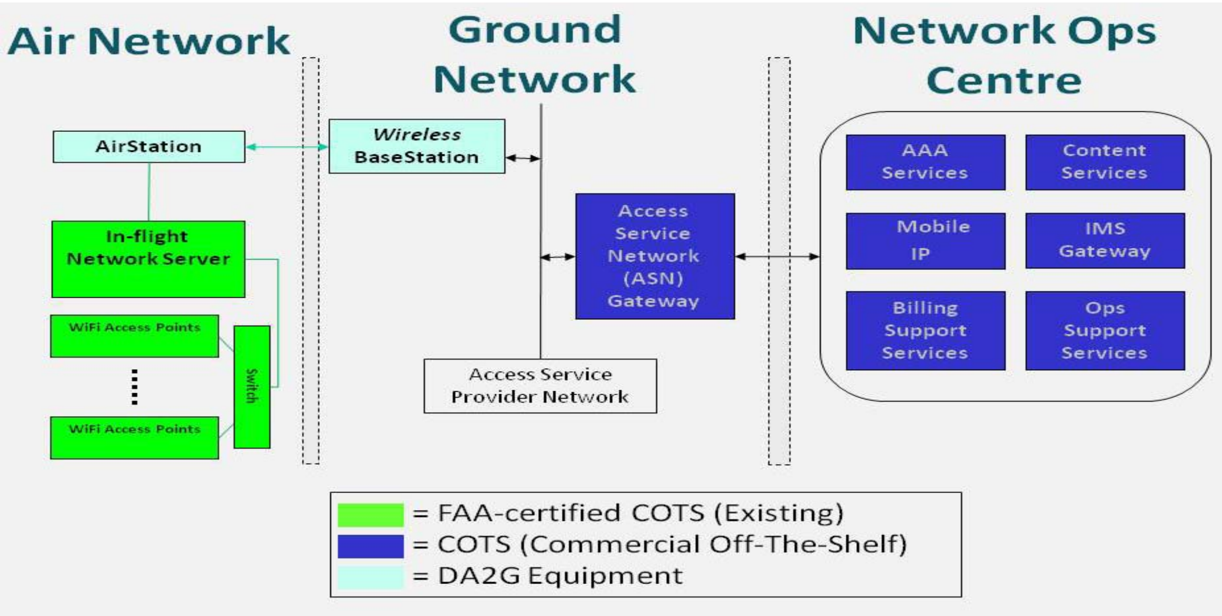


Figure 1: DA2G system, as part of overall end-to-end architecture

7.1.1 Airborne equipment

The in-flight entertainment (IFE) distribution system makes use of wireless networking technology to enable passengers to use their personal devices such as laptops during the flight to access the internet, watch videos, communicate via e-mail and take advantage of the multitude of web-based applications which are already available via terrestrial fixed and mobile broadband networks. The system also allows for airlines to make these services available via in-seat displays.

The IFE element of this system has been installed and successfully tested on commercial airliners. Tests inside the aircraft proved the usability of the wireless IFE solution under full load conditions and with other communication channels in use.

Figure 2 illustrates the basic concept of the IFE system, together with the connection to the air-to-ground radio equipment and, in this example, the use of four aircraft mounted 'fin antennas'.

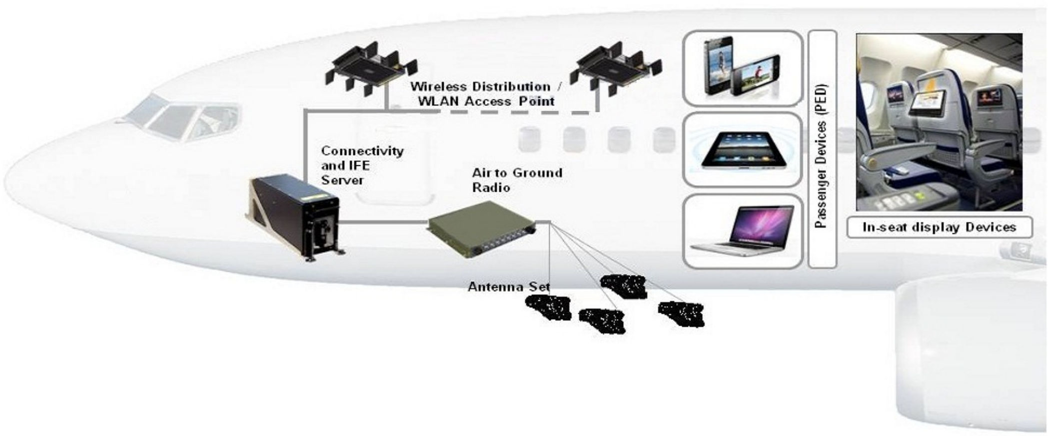


Figure 2: In-flight Entertainment System and airborne DA2G equipment connectivity

Specifically tailored passenger information services could also be provided, such as arrival-, transfer-, customs- and airport- related information, Moving Map flight information, In-flight Shopping, travel advice, destination tourist information, weather forecasts, etc.

Airline information data (non-safety relevant) could include localized real-time weather information to better inform the pilot of immediate weather conditions and well as the ability to relay real-time flight systems data from the aircraft to the ground to assist in diagnostics and other flight-related requirements.

The system has been designed to keep the airline information and passenger data completely separate by means of the physical hardware layout as well as through the use of secure encryption and data routing software, as illustrated in Figure 3.

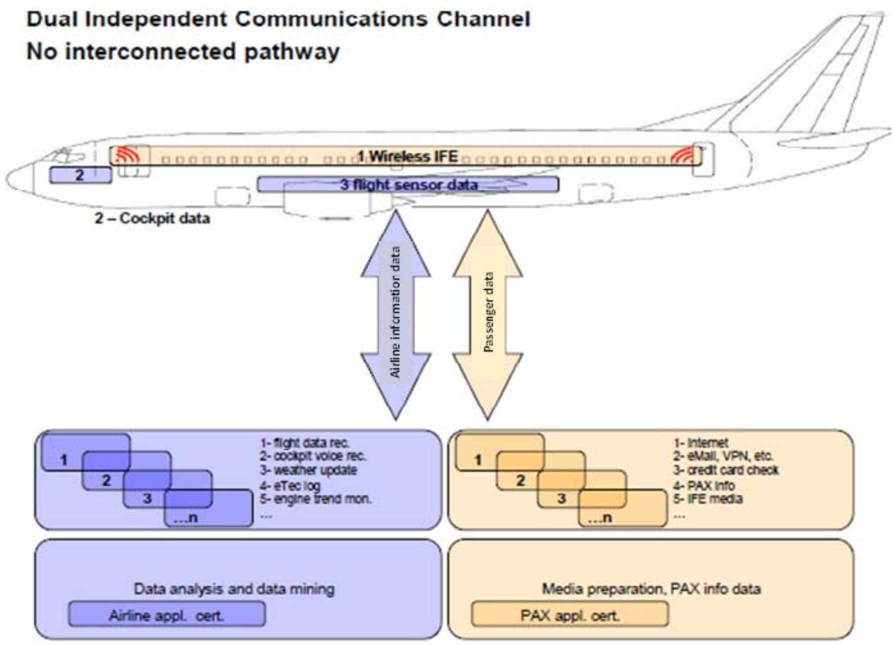


Figure 3: Independent channels for airline information and passenger data

7.1.2 Ground station equipment

Another important feature of this DA2G system is the simultaneous use of four separate integrated radio transceivers/phased array antenna assemblies at the ground station. Such an arrangement enables each ground station to cover the entire visible air space, from horizon to horizon, at all azimuths. Each integrated antenna array is capable of simultaneously producing at least two co-frequency shaped beams which are spatially separated, thereby allowing for a minimum of two beams per sector (or quadrant), or eight beams per ground station. This is shown diagrammatically in Figure 4.

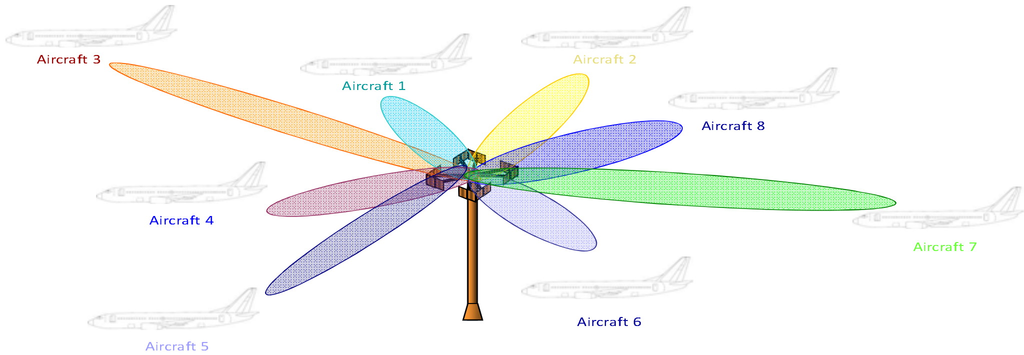


Figure 4: Typical Ground Station antenna arrangement producing multiple beams

Although the illustration in Figure 4 shows a total of 8 aircraft being served per ground station, this assumes that each sector is served by a 4-element beamforming antenna array. The number of beams can be increased to 4 beams per quadrant or 16 per ground station in the case where 8-element antenna arrays are used. In addition, the use of TDMA and FDMA can further increase the number of individual data paths established (and hence number of aircraft served) to much higher numbers, albeit at the cost of reduced data rate per aircraft. Potential problems of cross-talk between the transmit and receive paths of the various aircraft links at a given ground station antenna are eliminated due to the use of TDD, together with synchronisation of signals such that all paths are in transmit or receive mode at the same time when each beamforming array is generating multiple beams.

7.2 Technical parameters and implications on spectrum

7.2.1 Status of technical parameters

7.2.1.1 Current ITU and European Common Allocations

As previously indicated, the system has currently been optimised for operation in the ISM frequency bands around 2,4 GHz and 5,8 GHz. These two bands are included in the list of candidate bands under consideration in CEPT [i.8].

Current allocation of the candidate bands in the ITU Radio Regulations [i.7] is included in Table 2, along with actual usage within the CEPT.

Table 2: ITU Allocations & actual usage within CEPT

Frequency band	ITU allocations in Region 1	Actual usage of the band national level within CEPT	Actual usage of adjacent bands national level within CEPT
2 400 MHz to 2 483,5 MHz	FIXED MOBILE Amateur (*2 400 MHz to 2 450 MHz only*) Radiolocation	RLANs, SRDs/RFIDs, ISM	Aeronautical Telemetry, Amateur, Mobile applications, SAP/SAB (cordless cameras), MSS, ISM
5 855 MHz to 5 875 MHz	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE	BFWA, ITS, SRDs, FSS (uplink), military systems (on a national level), ISM	RLS, RTTT, BFWA, SRDs, ITS

Current common allocation of the above bands in Europe is given in ERC Report 25 [i.1].

7.2.1.2 Sharing and compatibility studies already available

At the time of drafting the present document, the sharing and compatibility studies between DA2G links and other systems are in the early stages within the CEPT/ECC Spectrum Engineering Working Group. A number of bands have been identified for initial study, including the 2,4 GHz and 5,8 GHz bands for which this system has presently been optimised. An initial study examining sharing between the currently described system and RLANs in the 2,4 GHz band has been presented to the Working Group, but no final conclusions have yet been drawn. Some initial studies have also been presented on the sharing of DA2GC systems with other systems in the 5,8 GHz band.

Studies [i.9] on co-channel operation of the DA2GC system described in the present document and outdoor RLAN devices in the band 2 400 MHz to 2 483,5 MHz - by considering aircraft altitudes of 3 000 m and 10 000 m - concluded that interference into the AS receiver for the forward link (ground-to-air) as well as into the RLAN receivers for the reverse link (air-to-ground) would occur.

Statement by Federal Ministry for Transport, Innovation and Technology (AUSTRIA):

*The CEPT/ECC FM48(11)038 [*i.18*] uses obviously different transmit parameters than* the present document *and therefore the interference to other systems is strongly underestimated. Either FM48(11)038 or* the present document *has to be updated.*

7.2.1.3 Sharing and compatibility issues still to be considered

A number of different sharing scenarios will need to be studied for each of the bands under consideration. This will entail sharing/compatibility between DA2G communications and a range of other services in the same and in adjacent frequency bands. These studies will need to include sharing/compatibility with both air-to-ground and ground-to-air links, depending on the choice of FDD or TDD operation.

The parameters to be used for the victim systems will be based on agreed parameters contained within existing ECC and ETSI deliverables, supplemented by the most up-to-date information where available from the expert Project Teams concerned.

It has been recognised that, in CEPT countries, the 2,4 GHz band is densely populated with equipment operating on a licence-exempt basis (e.g. RLANs, Bluetooth® and other SRDs), which is likely to place challenging constraints on the practical deployment of broadband DA2G Ground Stations, even when employing beamforming antennas.

The uniform density of radio equipment currently in usage in the band 2 400 MHz to 2 484,5 MHz is show in Table 3 (see also [i.10]).

Table 3: Densities of currently deployed equipment in 2 400 MHz to 2 484,5 MHz band

	RLAN/ Wi-Fi - Outdoor (including p2p, p2mp, mesh ...)	RLAN/ Wi-Fi - indoor	Bluetooth®	Bluetooth® (class 1)	ZigBee® - 802.15.4	RFID
Uniform Density per km^2	50	5 000 (e.g. Monaco)	10 000 (e.g. Monaco)	1 000	100	100
Percentage indoor	0 %	99 %	75 %	98 %	99 %	75 %

Consequently, although studies began with an initial analysis on the compatibility of the system described in the present document with RLANs in the 2,4 GHz band, it is anticipated that future studies will focus more on the 5,8 GHz band.

The band 5 755 MHz to 5875 MHz is assigned to BFWA [i.11] and [i.12], ITS, SRDs, FSS (uplink), military systems (on a national level) and ISM. Adjacent band usage encompasses RLS, RTTT, BFWA, SRDs, ITS.

Statement by Volkswagen AG:

According to the present document, the DA2GC-System is intended to work in the frequency range of: 5 855 MHz to 5 875 MHz.

This portion of frequency spectrum is reserved for non-safety ITS- applications in Europe. (see frequency- allocation and spectral emission mask below).

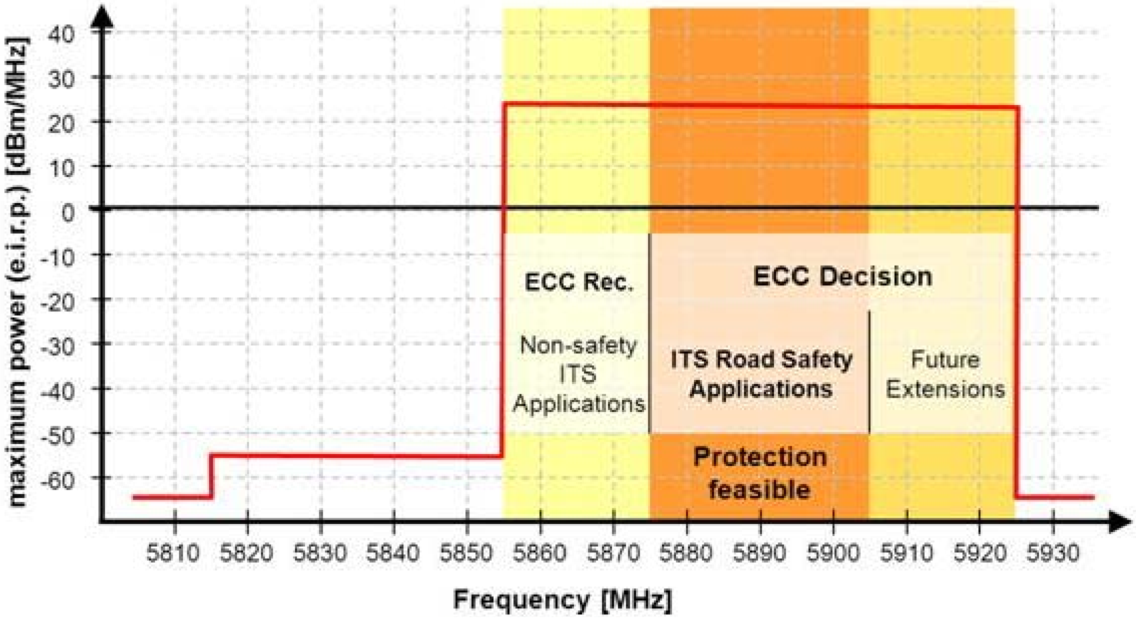


Figure 4a: Frequency allocation in Europe

Apart of inter-operability issues of the two systems regarding mutual interference, spurious emission masks, co-channel suppression, system-blocking, the question is which service will be the "primary" service, and which the "secondary" service. Usually the secondary service has to deal with distortions from the primary service.

According to our opinion, and based to the focus of introduction of ITS- services in the near future to improve car safety and driver-assistance, at least the following topics have to be discussed in ETSI and frequency- allocation boards:

System-Interoperability with ITS-G5:

- *Spurious emission must be compatible with ITS-G5 (in band, and out of band), (see spectral emission mask above).*
- *Adjacent channel rejection regarding ITS-G5 channels*
- *System blocking for the two systems*
- *Mutual interference for ITS- System in case of simultaneously operation with surrounding DA2CG-System, proof of fully tolerable interoperability*
- *Degradation in quality of Service regarding packet- and bit error-rate*
- *...to be continued...*
- *....*

Frequency - allocation:

- *5 855 MHz to 5 875 MHz is intended to use for ITS-G5 non- safety applications in Europe, and used in USA as 20MHz spectrum for the so called service- Channels*
- *Band is not ISM, but reserved for Car2Car and Car2Infrastructure wireless applications.*
- *In case of system co-existence: Definition of primary and secondary service is mandatory.*
- *International harmonisation of frequency- allocation and applied services.*

Radiation - Pattern of Ground-Stations:

- *Definition of horizontal and elevation antenna pattern for the foreseen antenna-array configurations of the ground-stations.*
- *According to ETSI draft document, the max. Peak Ant. Gain is up to 23 dB, leading to a e.i.r.p. in main beam direction of 45 dBm. The antenna-radiation beams of the ground station must not hit any road or infrastructure equipment in near vicinity to avoid mal functions of the ITS- G5 System. (commitment on the technical parameters listed above)*

System operational issues of DA2GC-System:

- *The use-case of the DA2GCS is not specified at all. E.g. is it allowed to use infotainment services of the DA2GC system during take-off and landing phase?*
- *Which services are foreseen for in band data and control issues (e.g. telematics & data-services and flight safety and control?, are this services then intended to be active during take-off and landing (at low beam-elevation)?*

7.2.2 Transmitter parameters

7.2.2.1 Transmitter Output Power / Radiated Power

Table 4

	Tx-output	**e.i.r.p.**
Maximum transmit power (ground station) (dBm) for a single beam, see note 1	25	45
Maximum aircraft station power (dBm), see note 2	28	45
ATPC used?	Yes	
Maximum operational ATPC range (dB)	30	
Maximum number of antenna arrays per Ground Station (See clause 7.1.2)	4	
Maximum number of beams per antenna array (See clause 7.1.2)	4	
NOTE 1: The quoted Tx-output power level is the total transmit power delivered to all antennas and antenna elements of a single ground station antenna array when the transmitter is operating at its maximum power control level. This power level applies when using a 4-antenna array with a maximum antenna gain of 20 dBi. This power level will be reduced when using higher gain antenna arrays (e.g. an 8-antenna array) to maintain a maximum e.i.r.p. of +45 dBm. NOTE 2: The quoted power level is the total transmit power delivered to all antennas and antenna elements of the aircraft station when the transmitter is operating at its maximum power control level.		

NOTE: The e.i.r.p. levels in table 4 represent the maximum operational levels at all times for a single beam, including link acquisition, since the periodic beacon signal transmitted from the ground station radiates lower transmit powers than the signals used to carry data once the aircraft links are established.

7.2.2.2 Antenna Characteristics

Table 5

Ground station peak gain using 4 antenna array (dBi)	20
Ground station peak gain using 8 antenna array (dBi)	23
Aircraft peak gain using 4 antenna array (dBi)	10
Maximum Aircraft peak gain using > 4 antenna array (dBi)	17
NOTE: The Ground Station peak gains given above are for a single antenna array.	

Use of phased array antennas and beamforming results in beam shapes which can be optimised for the intended operational frequency bands and co-existence scenarios. The beamforming algorithms used at the ground station and on the aircraft station permit highly accurate beam pointing, i.e. with an accuracy of 0,1 degrees, and the pointing is refreshed at a rate of at least 200 times per second. This is achieved by means of a 5 ms TDD frame, which includes signaling, control data, and payload data. The beamforming is updated using this signaling every frame in receive and then reciprocity is used and these weights are utilised for transmit. This enables accurate control to be maintained during all phases of a flight, including the ability to maintain pointing direction to within 0,5 degrees or less even during periods of flight turbulence or extreme manoeuvres.

7.2.2.2.1 Antenna masks

The ground station and aircraft antennas can be characterised by the following generalised gain masks, which the proponents have provided for use in compatibility studies with other services and applications.

The ground station antenna masks (as represented by Figures 5 and 6) are suitable for single entry ground path interference compatibility analyses. Figure 5 is also appropriate for determining the transmit power control behaviour on the DA2GC air-to-ground path which is needed for compatibility analyses addressing interference from aircraft.

The aircraft antenna masks (as represented by Figures 7 and 8) are suitable for statistical (i.e. multiple entry interference) compatibility analyses relating to the DA2GC air-to-ground path. They average the side-lobe peaks and nulls to provide appropriate envelopes. Figure 7 also takes into account the variation of aircraft antenna elevation patterns with pointing angle.

Cisco Systems Belgium, CSR, Broadcom Corporation, RIM, Kapsch and Qualcomm UK Ltd *request the sharing studies to be performed using realistic, simplified antenna masks to prevent a technology specific approach being taken (>< technology neutral) which cannot be verified and enforced by market surveillance authorities and which in addition, would be anti-competitive.*

Therefore, at least for the elevation range in which victims are potentially located, simplified antenna mask have to be proposed for both the ground and aircraft stations.

- *which will ensure a technology neutral regulation to be developed (and not linked to one particular proposal from one vendor and containing complex radiation patterns)*
- *which will ensure protection of other services*
- *which is verifiable and therefore can be enforced by market surveillance authorities*
- *which shall form the basis to calculate the actual e.i.r.p. levels for the DA2GC system to be used in the sharing study*

which will also be included in the regulation and the ETSI harmonized standard so as to prevent higher e.i.r.p. values, as those assumed in the sharing studies, being used in the actual deployment.

Lufthansa Systems *concurs, in principle, with the above points. However, as explained in the opening paragraphs of this Clause, the simplified masks presented for the aircraft antenna represent averaged patterns, for use in statistical multiple entry interference analyses. Although a compliance mask will need to be developed in the final regulation and in the harmonized standard, Lufthansa Systems believes that the exact formulation of any such mask can only be derived once the sharing studies are completed.*

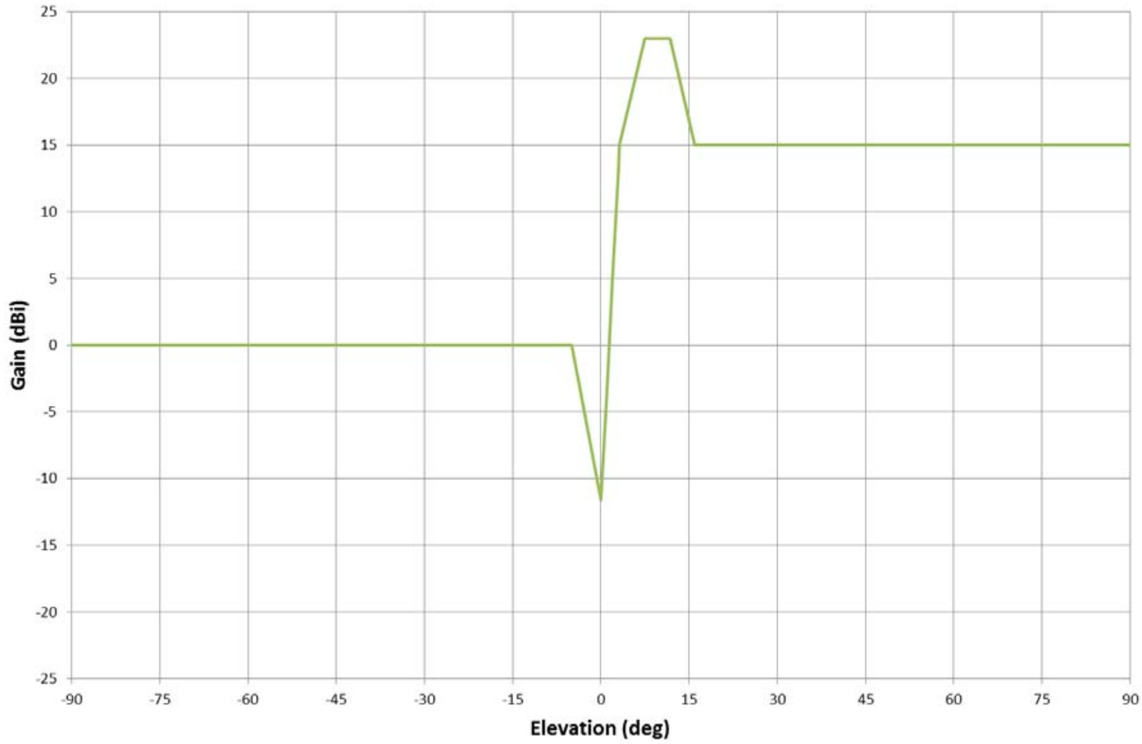


Figure 5: Ground Station antenna gain versus elevation

The mask shown in Figure 5 is characterised as follows:

Region A

For -90 deg < Θ ≤ -4 deg the gain is constant:

- $G_A = 0$

Region B

For -4 deg < Θ ≤ 0 deg the gain varies linearly from 0 dBi to -11,58 dBi:

- $G_B(\Theta) = G_A + (G_{BC} - G_A) (\Theta + 4) / 4$

Region C

For 0 deg < Θ ≤ 3,2 deg the gain varies linearly from -11,58 dBi to 15,0 dBi:

- $G_{BC} = -11,58$
- $G_C(\Theta) = G_{BC} + (G_G - G_{BC}) \Theta / 3,2$

Region D

For 3,2 deg < Θ ≤ 7,47 deg the gain varies linearly from the high-elevation plateau value to the peak value (i.e. 15,0 dBi to 23,0 dBi):

- $G_D(\Theta) = G_G + (G_E - G_G) (\Theta - 3,2) / 4,27$

Region E

For 7,47 deg < Θ ≤ 11,73 deg the gain is constant at the peak value:

- $G_E = 23$

Region F

For 11,73 deg < Θ ≤ 16 deg the gain varies linearly from the peak value to the high-elevation plateau value (i.e. 23,0 dBi to 15,0 dBi):

- $G_F(\Theta) = G_E + (G_G - G_E)(\Theta - 11,73) / 4,27$

Region G

For 16 deg < Θ ≤ 90 deg the gain is constant at the high-elevation plateau value:

- $G_G = 15$

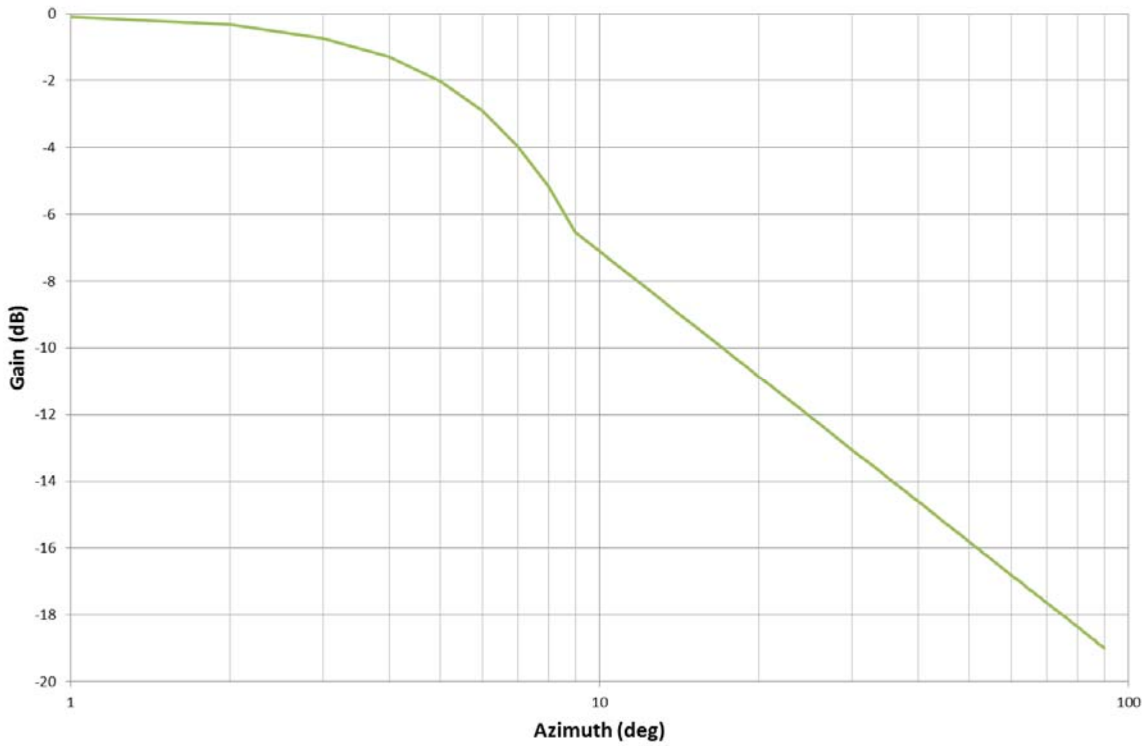


Figure 6: Ground Station antenna gain versus azimuth (relative to pointing direction)

The symmetric mask shown in Figure 6 is characterised as follows:

Region A

For 0 deg ≤ Θ ≤ 9 deg, the main lobe is represented by the curve:

- $G(\Theta) = -0,08067\ \Theta^2$

Region B

For 9 deg ≤ Θ ≤ 90 deg the gain decays linearly in log(Θ) from the gain at the Region A boundary to the value at the Region C boundary (i.e. -6,53 dBi to -19 dBi):

- $G_{AB} = G_B(9)$
- $G_B(\Theta) = G_C + (G_{AB} - G_C) \log(\Theta/90) / \log(11/90)$

Region C

For Θ > 90 deg, the gain is constant:

- $G_C = -19$

NOTE: The beam produced by the ground station tracks the associated aircraft in azimuth. In order to compute the overall ground station antenna gain in any given direction, the gain derived from the mask in Figure 6 is applied as an additional loss to the gain derived from the elevation pattern shown in Figure 5.

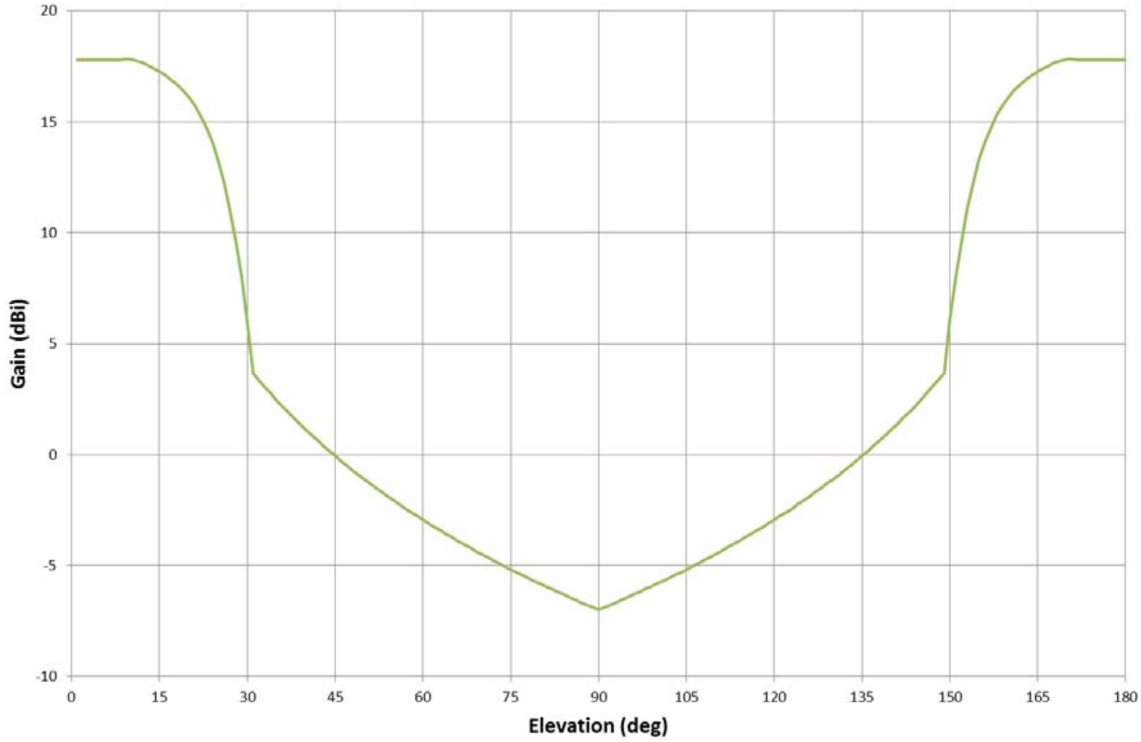


Figure 7: Aircraft Station antenna gain versus elevation

The symmetric mask shown in Figure 7 is characterised as follows:

Region A

For 0 deg $\leq \Theta \leq$ 8 deg the gain is constant. Note that the beam tracks the associated ground station, so that the aircraft station antenna gain on the DA2GC link is always the maximum value, 17,8 dBi:

- G_A = -17,8

Region B

For 8 deg < $\Theta \leq$ 31 deg, the main lobe is represented by the curve:

- $G_B(\Theta)$ = -1,10119E-04 Θ^4 + 6,26370E-03 Θ^3 - 1,42524E-01 Θ^2 + 1,37212E+00 Θ + 1,31874E+01

Region C

For 31 deg < $\Theta \leq$ 90 deg the gain decays linearly in log(Θ) from the gain at the Region B boundary to the limiting value (i.e. -3,66 dBi to -7 dBi):

- $G_{BC} = G_B(31)$
- G_D = -7
- $G_C(\Theta) = G_D + (G_{BC} - G_D) \log(\Theta/90) / \log(31/90)$

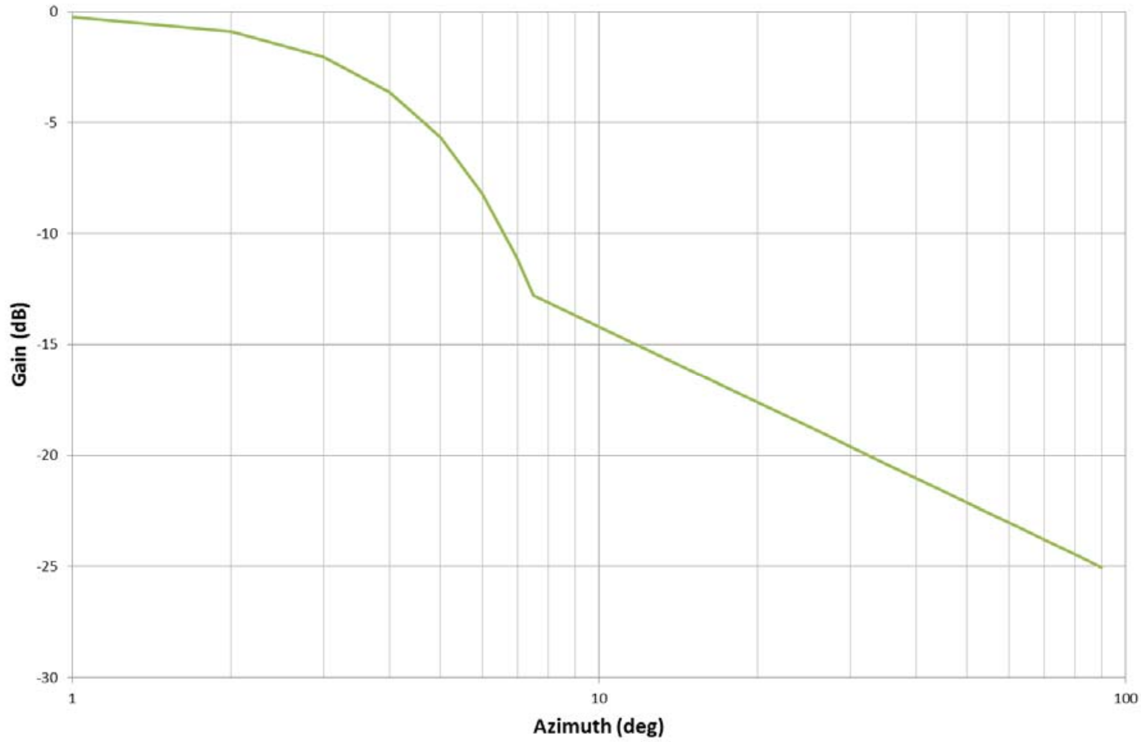


Figure 8: Aircraft Station antenna gain versus azimuth (relative to pointing direction)

The symmetric mask shown in Figure 8 is characterised as follows:

Region A

For 0 deg $\leq \Theta \leq$ 7,5 deg, the main lobe is represented by the curve:

- $G_A(\Theta) = -0{,}227039646\ \Theta^2$

Region B

For $\Theta \leq$ 90 deg the gain decays linearly in log(Θ) from the gain at the Region A boundary to the value at the Region C boundary (i.e. -12,77 dBi to -25,03 dBi):

- $G_{AB}(\Theta) = G_A(7{,}5)$
- $G_B(\Theta) = G_C + (G_{AB} - G_C) \log(\Theta/90) / \log(7{,}5/90)$

Region C

For $\Theta >$ 90 deg, the gain is constant:

- G_C = -25,03 dBi

NOTE: The beam produced by the aircraft station tracks the associated ground station in azimuth as well as elevation. In order to compute the overall aircraft antenna gain in any given direction, the gain derived from the mask in Figure 8 is applied as an additional loss to the gain derived from the elevation pattern shown in Figure 7.

7.2.2.2.2 Example radiation patterns

Example radiation patterns are shown in Figures 9 and 10, for the ground station and aircraft station antennas respectively, when operating in the 2,4 GHz band. These are based on the current first-generation product using 4-antenna arrays at the ground station and on the aircraft. At the time of writing (February 2012), an 8-antenna version of the ground station product is in the final stages of production and is due to be submitted for certification under the United States FCC process within the next few months. Figures 10 and 11 show the elevation and azimuth patterns respectively for this 8-antenna array. This 2nd generation product can operate in the 2,4 GHz and/or the 5,8 GHz bands, but the plots shown in Figures 10 and 11 are based on measurements performed at 5,8 GHz. Further development work is also underway on the aircraft antenna, to increase the number of elements to eight or more, which will allow more flexibility to tailor the radiation patterns and further optimise the potential for sharing with other co-frequency services on the ground. Figures 12 and 13 show examples of the elevation and azimuth patterns for a 16-element aircraft antenna.

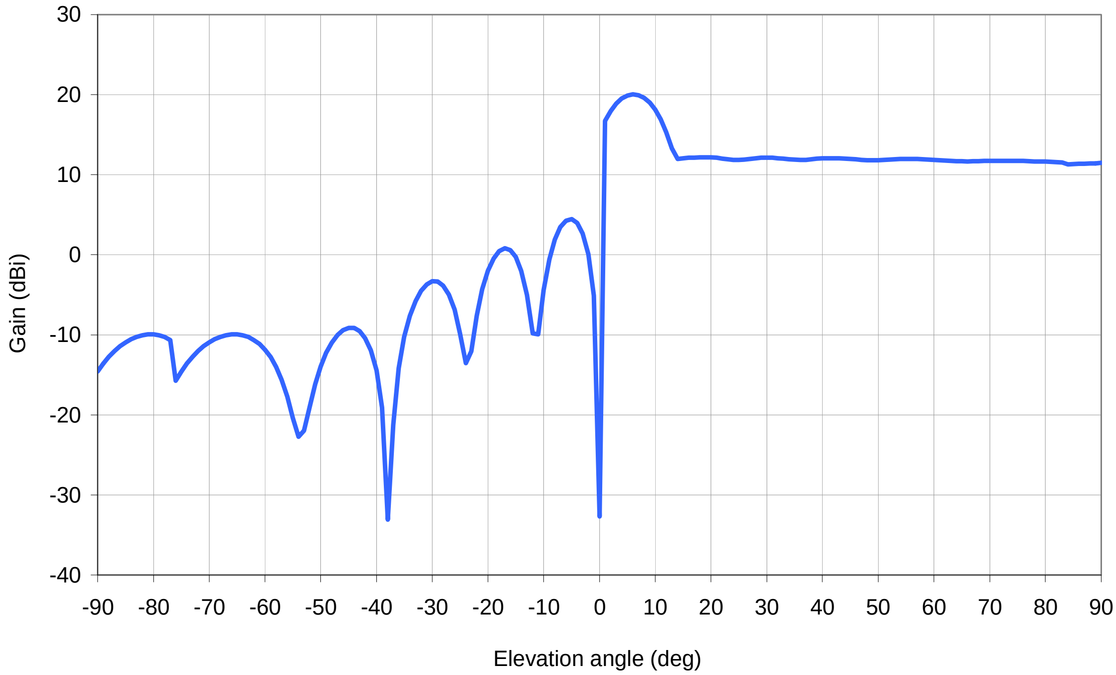


Figure 9: Ground Station Antenna Elevation Pattern (1st generation 4-antenna array)

The Ground Station antenna array has a fixed pattern in the vertical plane, but is designed to use beamforming in azimuth so that one or more aircraft can be tracked during flight. Although, in practise, the radiation pattern will vary as the beam is scanned, the pattern given in Figure 9 can be assumed to be the worst case for all azimuths. i.e. the gain at any azimuth pointing direction will be less than or equal to the values shown, for any given elevation angle.

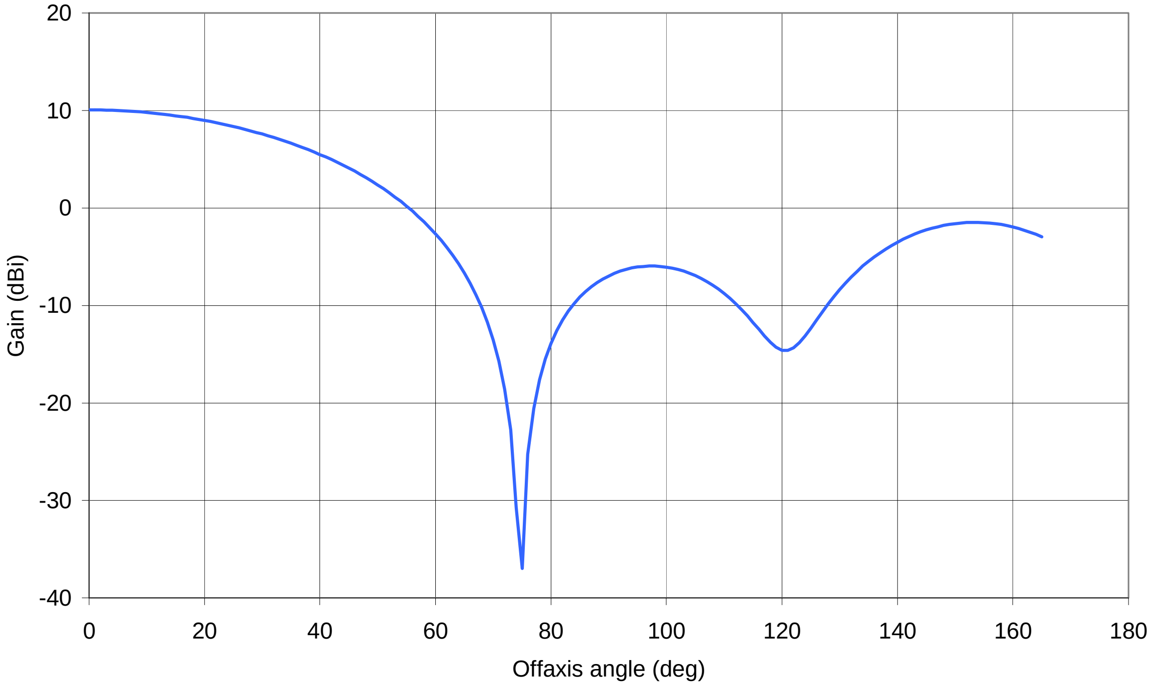


Figure 10: Aircraft Station Antenna Pattern (1st generation 4-antenna array)

The beam produced by the aircraft antenna array is steered in both azimuth and elevation so that the main lobe tracks the ground station as the aircraft traverses its flight path. The off-axis radiation pattern shown in Figure 10 can be assumed to be the worst case for all main lobe pointing directions.

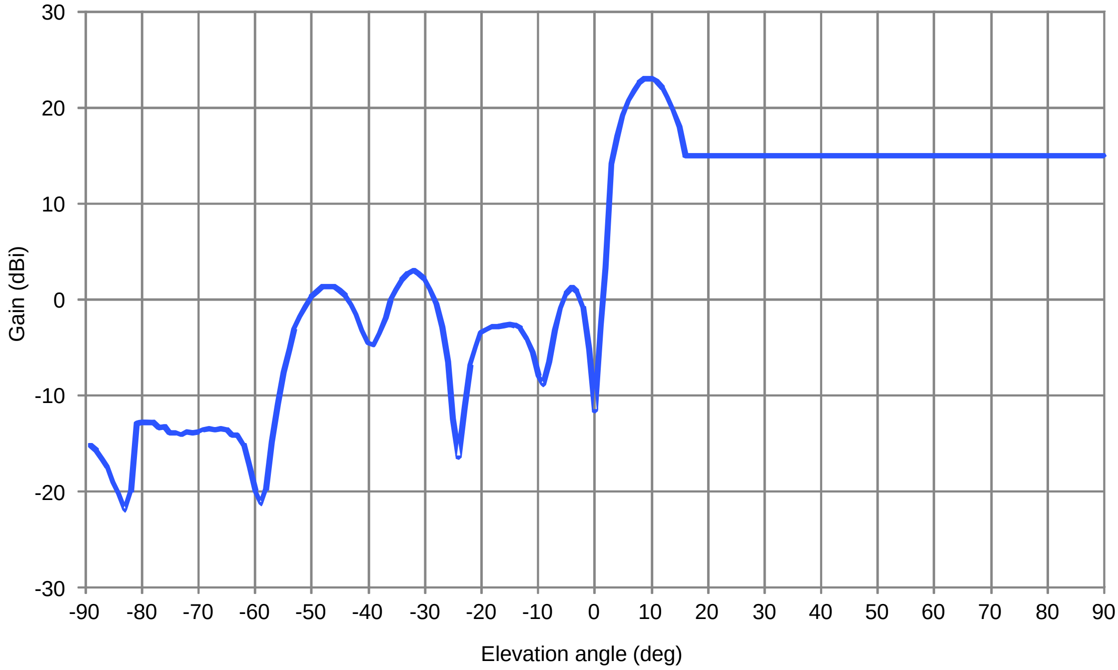


Figure 11: Ground Station Antenna Elevation Pattern (2nd generation 8-antenna array)

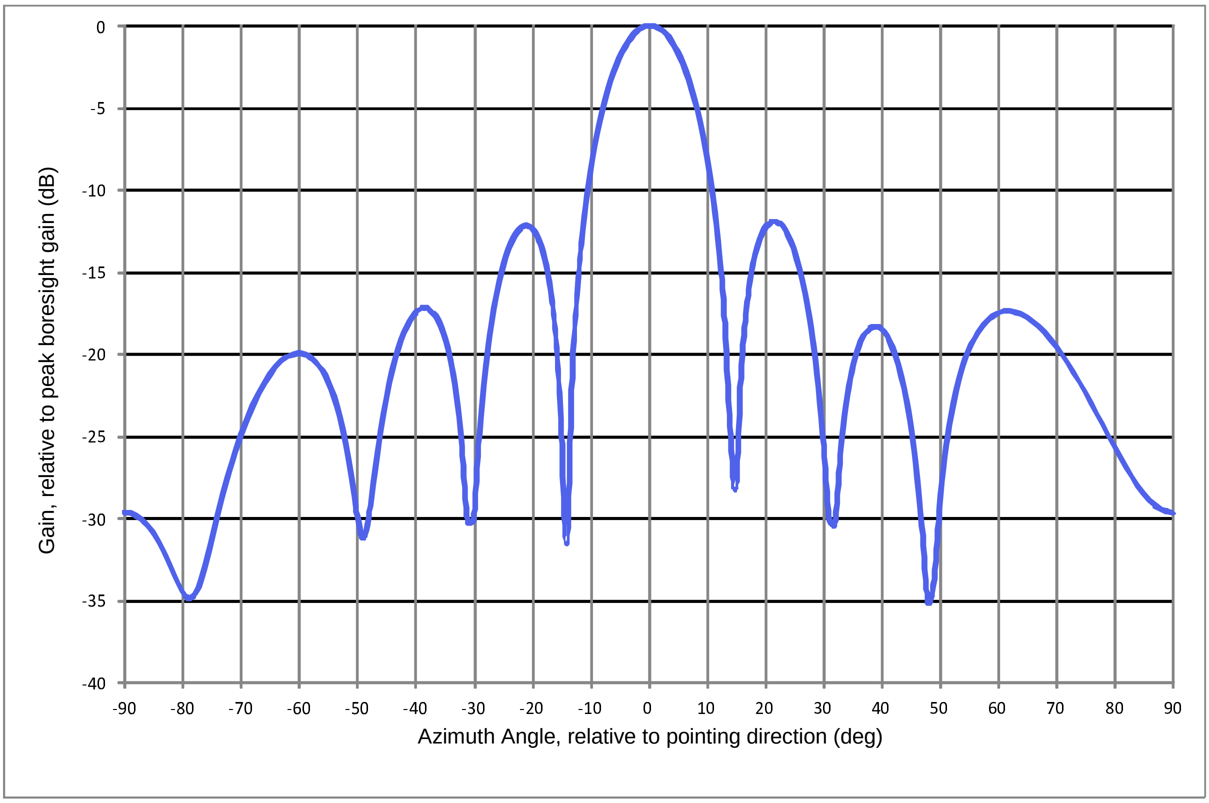


Figure 12: Ground Station Antenna Azimuth Pattern (2nd generation 8-antenna array)

Note that, for three dimensional computations, the resulting ground station antenna gain in any given pointing direction is the sum of the relevant elevation and azimuth gains shown in Figures 11 and 12 respectively.

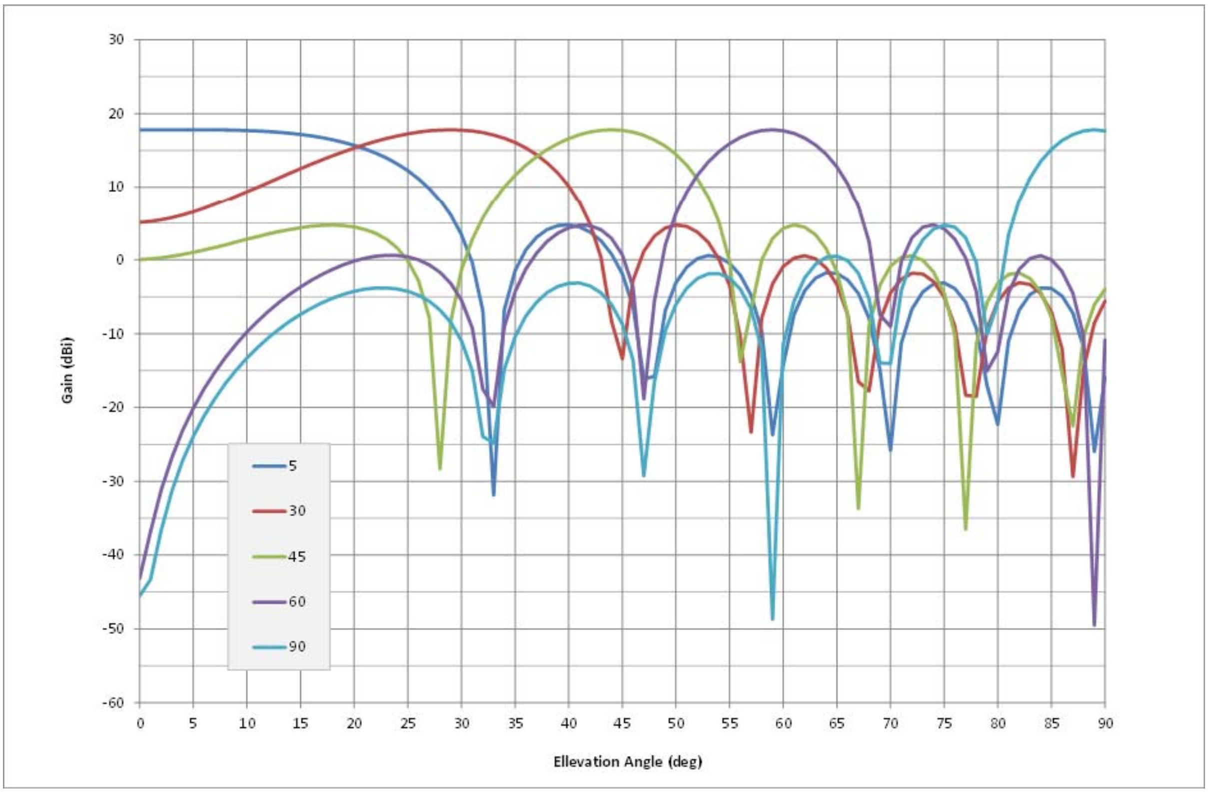


Figure 13: Aircraft Station Antenna Elevation Patterns (2nd generation 16-antenna array)

Note that, in the above sample plots, an elevation angle of 0 degrees represents the horizon pointing direction and 90 degrees is straight down.

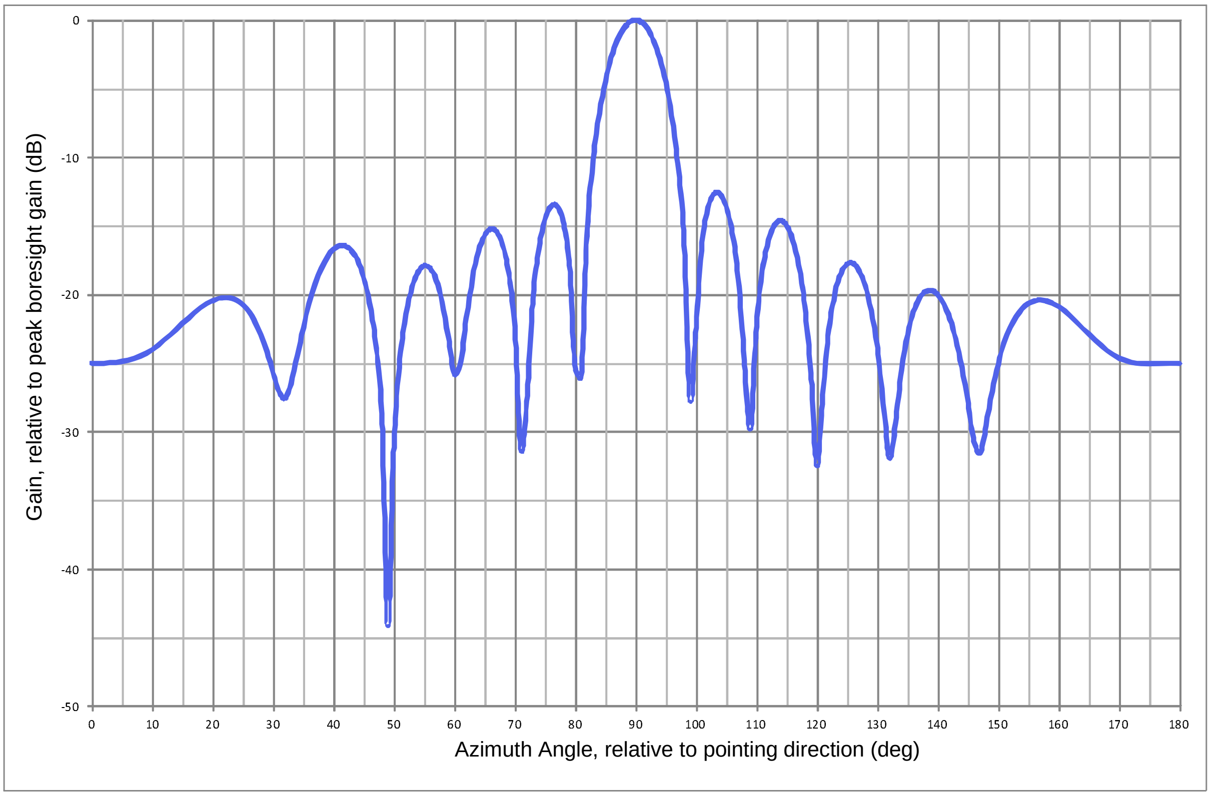


Figure 14: Aircraft Station Antenna Azimuth Pattern (2nd generation 16-antenna array)

Note that, for three dimensional computations, the resulting aircraft station antenna gain for any given pointing direction is the sum of the relevant elevation and azimuth gains shown in Figures 13 and 14 respectively.

7.2.2.3 Operating Frequency

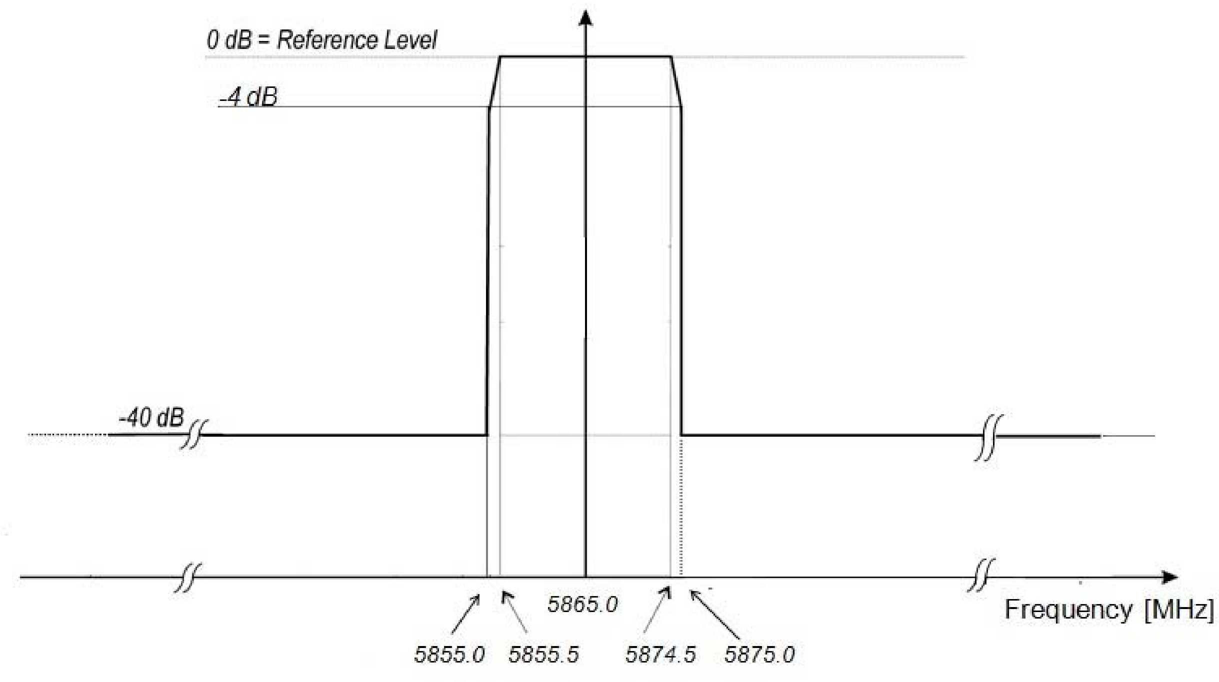
The scope of the present document is restricted to operation within the 2 400 MHz to 2 483,5 MHz band and/or the 5 855 MHz to 5 875 MHz band. However, the technology is capable of operating in any frequency band within the range from 790 MHz to 6 GHz.

7.2.2.4 Bandwidth

The necessary bandwidth (as defined by Articles 1.152 and 1.153 of the ITU Radio Regulations [i.7]) is 20 MHz and the occupied bandwidth complies with Clause 4.3.2.6 of EN 300 328 V1.8.1 [i.2] for operation in the 2 400 MHz to 2 483,5 MHz band and falls within the emission mask specified in Clause 4.3.2.2 of EN 302 502 V1.2.1 [i.3] for operation in the 5 855 MHz to 5 875 MHz band.

7.2.2.5 Unwanted emissions

The unwanted emissions, including spurious emissions and out-of-band emissions (as defined by Article 1.146 of the ITU Radio Regulations [i.7]) fall within the limits specified in Clauses 4.3.2.7 and 4.3.2.8 of EN 300 328 V1.8.1 [i.2] for operation in the 2 400 MHz to 2 483,5 MHz band. The ground station emissions when operating in the 5 855 MHz to 5 875 MHz band fall within the limits given in Figure 15 when operating under highest output power conditions.



NOTE: 0 dB Reference Level represents the maximum spectral power density of the transmitted signal.

Figure 15: Emission Mask

7.2.3 Receiver parameters

The sensitivity is better than or equal to -87 dBm in a 20 MHz bandwidth on both the ground station and aircraft station receivers. Adjacent channel selectivity is 43,5 dB for the ground station and 27 dB for the aircraft station, as specified in TS 136 104 [i.4] and TS 136 101 [i.5] respectively. Other relevant receiver parameters comply with the corresponding requirements within these 3GPP specifications.

7.2.4 Channel access parameters

The operational channel access parameters such as frame duration, resource grouping and allocation in time and frequency, random access procedures, are fully configurable. Typically, the system employs 5 ms frames with 80 % forward/20 % return link (4 ms to ground to air, 1ms air to ground). The frequencies are broken into 12 to 24 channels, depending on the scheduler. The access is fully scheduled using MAC messaging inside the 5 ms frame.

7.3 Information on relevant standard(s)

See under clause 2.2 Informative references. Broadband DA2G communication systems are to be covered in a Harmonized European Standard under the R&TTE Directive [i.16].

8 Radio spectrum request and justification

The described broadband DA2G communications system is unlikely to require any dedicated spectrum to be made available, since the features of the technology permit co-frequency sharing with other radio applications with the minimum of constraints (e.g. careful siting of ground stations with workable exclusion zones around each site). This is particularly the case when considering the potential for operation in the ISM spectrum bands from 2 400 MHz to 2 483,5 MHz and/or 5 725 MHz to 5 875 MHz, which are used for various licence-exempt radio applications.

Whatever frequency band is ultimately chosen, the system can operate with variable bandwidths in any sub-band within the relevant frequency range. For optimum performance, in TDD mode, the system would require a contiguous block of spectrum of 20 MHz. Alternatively, 2 × 10 MHz contiguous blocks would be needed if operated in FDD mode (although the forward and return links need not necessarily be within the same frequency band). These spectrum requirements are driven by the need to supply sufficient capacity to serve passengers and crew onboard the aircraft with the desired range of broadband services and have been noted by the ECC at its 30th meeting in December 2011, based on the information given in [i.6].

9 Regulations

9.1 Current regulations

In Europe, there are currently no frequency bands which are designated for DA2G use and no specific regulations to facilitate introduction of such services.

9.2 Proposed regulation and justification

It is proposed, after the finalisation of the required sharing and compatibility studies, that an ECC Decision is developed for the designation of spectrum (2 × 10 MHz or 20 MHz) within the frequency bands 2 400 MHz to 2 483,5 MHz and/or 5 855 MHz to 5 875 MHz for the Broadband DA2GC system using beamforming antennas as described in the present document. Access to the spectrum should be as easy as possible, e.g. based on a light licensing procedure. An ECC Decision would appear to be the most appropriate regulatory instrument, since this would give the highest degree of harmonisation across the CEPT region.

Assuming that the conclusion from the sharing studies confirms the feasibility to operate the described system co-frequency with other applications within the frequency bands 2 400 MHz to 2 483,5 MHz and/or 5 855 MHz to 5 875 MHz, there would be a need for a relaxation of the current e.i.r.p. limits which apply in Europe in these bands. Such a relaxation could be limited to broadband DA2G communications systems employing beamforming antennas and could be coupled with a requirement for consultation with the local regulator on the precise location of the ground stations.

The current FCC rules applying to licence-exempt technologies in the 2,4 GHz band in the United States already permit an e.i.r.p., when using beamforming antennas, which can be at least 25 dB higher than the current 100 mW limit in Europe (depending on the antenna gain being used). Although the precise figure for tolerable power in Europe will need to be confirmed by the CEPT, an increase to an e.i.r.p. (per beam) of at least +45 dBm (in either the 2,4 GHz or 5,8 GHz band) would be the objective. This would enable an efficient deployment of the described system across Europe at the desired level of performance.

Annex A: Bibliography

- Commission Decision 2008/294/EC of 7 April 2008 on harmonised conditions of spectrum use for the operation of mobile communication services on aircraft (MCA services) in the Community.
- ERC Recommendation 70-03 (Tromso 1997 and subsequent amendments): "Relating to the use of Short Range Devices (SRD)".

History

Document history		
V1.1.1	July 2012	Publication (Withdrawn)
V1.1.2	August 2012	Publication (Withdrawn)
V1.1.3	September 2012	Publication