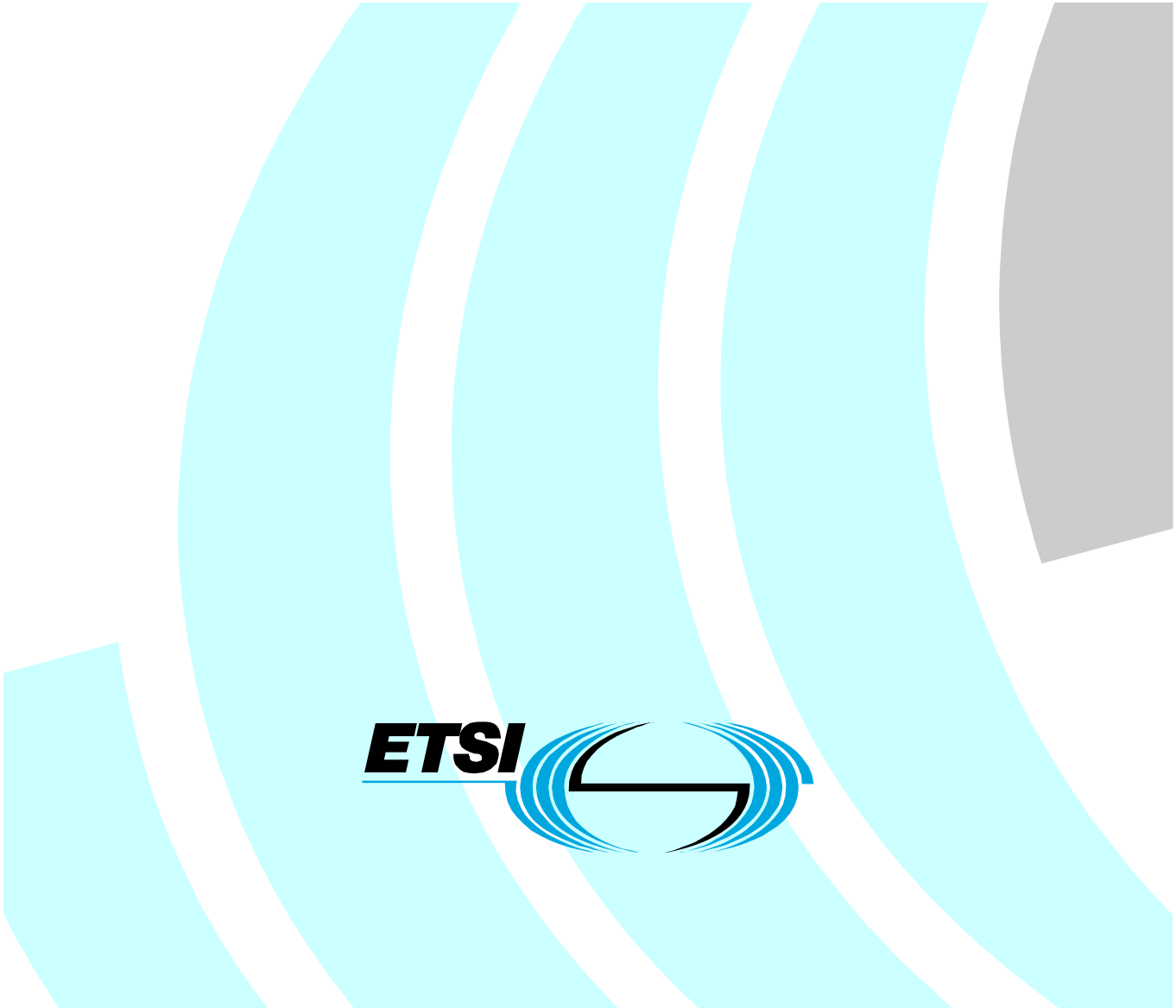
ETSI TR 103 054 V1.1.1 (2010-07)

Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference Document; Broadband Direct-Air-to-Ground Communications operating in part of the frequency range from 790 MHz to 5 150 MHz



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Contents

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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

Ubiquitous internet access is an increasing demand in private and business environments. This includes broadband connectivity to aircraft to be used by passengers on board (e.g. e-mail, web browsing, messaging, infotainment, voice communications) or to be used by airlines and/or aircraft manufacturers for various process optimization purposes.

Existing satellite-based connectivity solutions suffer from high operational cost and from significant weight and effort to install aircraft equipment (especially satellite antennas). Depending on the degree of usage and growth of the market the L-Band solutions may run into capacity limitations in the mid term, especially for high density air traffic over continental areas such as Europe.

An interesting alternative bringing broadband data to continental aircraft fleets is Direct Air-to-Ground (DA2G) connectivity, because most of the European air traffic is concentrated over mainland. Modern broadband wireless access technologies as specified for next generation mobile networks (NGMN) could be a sound technological basis for a DA2G communication solution. The present document describes this new alternative.

A comparable system using CDMA2000 EVDO Rev A technology, namely the GOGO service operated by Aircell, has been successfully introduced in the USA in the 800 MHz band.

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 Postal and Telecommunications Administrations (CEPT).

The present document is intended to help to find an appropriate frequency range by describing the system and providing an estimation of the radio spectrum demand for broadband Direct Air-to-Ground (DA2G) communications between a terrestrial ground network and aircraft. It thus intends to lay the foundation for industry to quickly implement an innovative and useful system within Europe while avoiding harmful interference with other services and systems.

Status of the pre-approval draft system reference document

The present document has been created and agreed by TC ERM TG DMR. It went through ETSI internal consultation and was, in parallel, send it to the ECC working groups (WGFM and WGSE) for advanced information as preliminary draft SRDoc "stage 1". Is now requested for final approval at ERM#41 after successful resolution of all comments received during ETSI internal consultation.

Table 1: Document status

Target version	Pre-approval date version				
V1.1.1	**a**	**s**	**m**	**Date**	**Description**
V1.1.1	0.0.1			2rd March 2010	Submitted to TG DMR#33bis
V1.1.1	0.0.2			3rd March 2010	Created in TG DMR#33bis
V1.1.1	0.0.3			5th March 2010	Submitted to TC ERM for submission to ETSI internal consultation process and submission to ECC WGs as SRdoc "stage 1"
V1.1.1	0.0.4			24th March 2010	Partial restructuring to bring in line with new EG on creation of SRDocs
V1.1.1	0.0.5			15th May 2010	New version from rapporteur taking into account comments received from EuroControl and ETSI internal consultation
V1.1.1	0.0.6			21st May 2010	Agreed version at ERM TG DMR extraordinary meeting on DA2G on comments resolution
V1.1.1	0.0.7			25th May 2010	Revision of C.3 according changes in WG FM#69 minutes and correction of AOC

1 Scope

The present document describes broadband DA2G communications. Network elements providing coverage onboard aircraft (WiFi and GSMOBA) as well as service platforms (e.g. for passengers, airline internal, aircraft manufacturer) already exist [i.1] and [i.11]. Hence, the presented system concept focuses on the Direct Air-to-Ground (DA2G) connection only, i.e. mainly on DA2G communication infrastructure onboard the aircraft (external antenna, modem, cabling, interface to onboard network) and on the terrestrial radio access network for DA2G communication with broadband backhaul links, preferably to be based on existing infrastructure, but with modifications (e.g. with regard to antenna types and base station implementation) to establish high-performance radio links to aircraft.

The present document does not cover equipment compliance with relevant civil aviation regulations. In this respect, the onboard unit of the DA2G communication system is subject to additional national or international civil aviation airworthiness certification, for example to EUROCAE ED-14E [i.6].

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] Commission Decision of 7 April 2008 on harmonised conditions of spectrum use for the operation of mobile communication services on aircraft (MCA services) in the Community.

[i.2] ETSI TS 136 104: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (3GPP TS 36.104)".

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

[i.4] ERC Report 25: "The European Table of frequency allocations and utilisations in the frequency range 9 khz to 3000 GHz".

[i.5] ETSI TS 136 201: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Long Term Evolution (LTE) physical layer; General description (3GPP TS 36.201)".

[i.6] EUROCAE ED-14E (2005) (Equivalent to RTCA DO-160E): "Environmental Conditions and Test Procedures for Airborne Equipment".

[i.7] Airbus (2009): "Global Market Forecast 2009-2028".

[i.8] Boeing (2009): "Current Market Outlook 2009-2028".

[i.9] Eurocontrol (2009): "Long-Term Forecast Flight Movements 2008 - 2030".

[i.10] ETSI TS 136 300: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (3GPP TS 36.300)".

[i.11] ECC Decision (06)07 of 1 December 2006 on the harmonised use of airborne GSM systems in the frequency bands 1710-1785 and 1805-1880 MHz, amended in March 2009.

[i.12] Report ITU-R Recommendation M.2118 (2007): "Compatibility between proposed systems in the aeronautical mobile service and the existing fixed-satellite service in the 5091 - 5250 MHz band".

[i.13] ITU-R Recommendation M.1827 (2007): "Technical and operational requirements for stations of the aeronautical mobile (R) service (AM(R)S) limited to surface application at airports and for stations of the aeronautical mobile service (AMS) limited to aeronautical security (AS) applications in the band 5091-5150 MHz".

[i.14] Resolution [COM4/8] (WRC-07): "Considerations for use of the band 5 091-5 150 MHz by the aeronautical mobile service for certain aeronautical applications (note "security")".

[i.15] Final Technical Report 203 EU 1603: "Enhanced Air Traffic Management For Europe's Single Sky Using Third Generation Mobile Telephone Technology (EAS-3G)".

[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).

3 Definitions, symbols 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

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

3.2 Symbols

For the purposes of the present document, the following symbol applies:

ΔF_{OOB} Δ Frequency of Out Of Band emission

3.3 Abbreviations

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

3G Third Generation
AAC Airline Administrative Communications
AOC Aeronautical Operational Control
APC Air Passenger Communications
AS Aircraft Station

ATC	Air Traffic Services Communications
ATM	Air Traffic Management
BS	Base Station
CDMA	Code Division Multiple Access
CEPT	Conference Europeenne des Administrations des Postes et des Telecommunications
DA2G	Direct Air-to-Ground
eNB	evolved NodeB (LTE/E-UTRA base station)
ECC	Electronic Communications Committee
ERM	Electromagnetic compatibility and Radio spectrum Matters
EVDO	Evolution Data Only
E-UTRA	Evolved UMTS Terrestrial Radio Access
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
FDD	Frequency Division Duplex
FL	Forward Link
GS	Ground Station
GSM	Global System for Mobile communications
GSMOBA	GSM On-Board Aircraft
HSPA	High Speed Packed Access
ICT	Information and Communication Technology
IFR	Instrument Flight Rules
IMS	Internet Protocol Multimedia Subsystem
ITU	International Telecommunication Union
LTE	Long Term Evolution
NB	NodeB (UMTS base station)
NGMN	Next Generation Mobile Network
O&M	Operation and Maintenance
RF	Radio Frequency
RL	Reverse Link
SNR	Signal-to-Noise Ratio
TDD	Time Division Duplex
TFTS	Terrestrial Flight Telecommunications System
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
US	United States
USB	Universal Serial Bus
VPN	Virtual Private Network
WiFi	Wireless Fidelity
WLAN	Wireless Local Area Network

4 Comments on the System Reference Document

During the ETSI internal enquiry the following comments were received.

4.1 DFS (Deutsche Flugsicherung GmbH) and « Le Gouvernement du Grand-Duché du Luxembourg - Administration de la Navigation Aérienne »

ETSI TR 103 054 titled "Broadband Direct-Air-to-Ground Communications operating in part of the frequency range from 790 MHz to 5150 MHz" intends to provide support on identification of appropriate frequency bands for broadband Direct Air-to-Ground (DA2G) communications between a terrestrial ground network and aircraft. In order to avoid harmful interference with aeronautical safety services, such a system should not be operated in bands allocated to aeronautical safety services as listed in Table 2.

4.2 NATS (UK Air Navigation Services Provider) on clause 6.2.2.4, first paragraph, last sentence

This paragraph seems to claim that a frequency re-use factor of one is achievable, or necessary. Technically this is not feasible, any cellular system cannot use the same frequency in adjacent cells (to avoid interference). A frequency re-use factor of 7 is more likely.

Detail changes not proposed because, if the value of frequency re-use factor assumed in clause B.2.1.4 were to increase from one to seven, say, the spectrum requirement would increase proportionally, with possible ramifications throughout the document.

NOTE: Clause B.2.1.4 is changed into clause 6.2.2.4 in the present version.

ERM TG DMRs'response on frequency re-use factor:
The Long Term Evolution (LTE) mobile broadband system uses Orthogonal Frequency Division Multiple Access (OFDMA) as combined transmission and multiple access technique in the downlink. With OFDMA, the system bandwidth is split into a number of sub-carriers, each featuring a bandwidth smaller than the system's coherence bandwidth, on which data of different users is transmitted in parallel. Regarding frequency reuse, there are three major alternatives in cellular OFDMA systems: hard frequency reuse (HFR), fractional frequency reuse (FFR), and soft frequency reuse (SFR). With soft frequency reuse, the overall bandwidth is shared by all base stations (i. e., a reuse factor of one is applied).

It was also noted in ERM TG DMR that ETSI recently selected the same frequency reuse factor of 1 in another ETSI SRDoc on the spectrum need for future broadband PPDR systems as in the present document.

4.3 DSNA (Direction des Services de la Navigation Aérienne)

The proposed internet access or broadband connectivity to aircraft to be used for air passenger communications corresponds to a commercial usage of frequency band. At present, no dedicated frequency band for broadband DA2G communication is available in Europe. Especially, the current aeronautical frequency bands support systems are dedicated to the safety and regularity of flights and therefore, in order to avoid harmful interference with these aeronautical safety services, such a DA2G system shall operate in frequency band that are not already allocated to aeronautical safety services.

In particular, clause 8.1 recalls that *"WRC'07 decided on modified allocations for aeronautical frequency bands - in particular in the 1 GHz and 5 GHz ranges - with focus on systems supporting safety and regularity of flights, i.e. on ATC (Air Traffic Services Communications) and AAC/AOC (Airline Administrative / Operations Communications), but not on APC (Air Passenger Communications)."* Therefore, these modified allocations are not appropriate to support APC communications.

It should be noted that in the US, two nationwide DA2G communication spectrum licenses where given in the 800 MHz band in 2006, and therefore in a frequency band that is not allocated to aeronautical safety services. The DSNA only support that kind of possible allocation.

In order to avoid harmful interference with aeronautical safety services, DA2G system shall operated in other bands than those listed in the table below. Moreover, if DA2G systems are proposed in a frequency band adjacent to one frequency band listed in Table 2, appropriate measures will have to be taken to protect the safety services in the adjacent band.

Table 2: Frequency bands allocated to aeronautical safety services

Band	Service	Aviation use
*960 MHz to1 215 MHz	ARNS RNSS AM(R)S	DME/UAT GNSS
1 030 and 1 090 MHz	ARNS	SSR/ACAS/1090ES
*1 215 MHz to 1 400 MHz	RLS/RNSS ARNS	GNSS Primary surveillance radar
*1 525 MHz to 1 559 MHz	MSS (s-E)	Satellite communications
*1 610 MHz to 1 626,5 MHz	AMS(R)S (s-E, E-s)	Satellite communications
*1 626,5 MHz to 1 660,5 MHz	MSS (E-s)	Satellite communications
*1 559 MHz to 1 626,5 MHz	ARNS/RNSS/ MSS	GNSS
*2 700 MHz to 3 300 MHz	ARNS/RNS/RLS	Primary surveillance radar
*4 200 MHz to 4 400 MHz	ARNS	Radio altimeter
*5 000 MHz to 5 150 MHz	ARNS AM(R)S RNSS	GNSS, MLS
AM(R)S: Aeronautical mobile (route) service AMS(R)S: Aeronautical mobile-satellite (route) service ARNS: Aeronautical radionavigation service MSS: Mobile-satellite service RDSS: Radiodetermination-satellite service RLS: Radiolocation service RNS: Radionavigation serviceRNSS: Radionavigation-satellite service		

5 Presentation of the system

An interesting alternative bringing broadband data to continental aircraft fleets is Direct Air-to-Ground (DA2G) connectivity, because most of the European air traffic is concentrated over mainland. Modern broadband wireless access technologies as specified for next generation mobile networks (NGMN) could be a sound technological basis for a DA2G communication solution. The present document describes this new alternative.

A comparable system using CDMA2000 EVDO Rev A technology, namely the GOGO service operated by Aircell, has been successfully introduced in the USA in the 800 MHz band.

Network elements providing coverage onboard aircraft (WiFi and GSMOBA) as well as service platforms (e.g. for passengers, airline internal, aircraft manufacturer) already exist [i.1] and [i.11]. Hence, the presented system concept focuses on the Direct Air-to-Ground (DA2G) connection only, i.e. mainly on DA2G communication infrastructure onboard the aircraft (external antenna, modem, cabling, interface to onboard network) and on the terrestrial radio access network for DA2G communication with broadband backhaul links, preferably to be based on existing infrastructure, but with modifications (e.g. with regard to antenna types and base station implementation) to establish high-performance radio links to aircraft.

Ubiquitous internet access is an increasing demand in private and business environments. This includes broadband connectivity to aircraft to be used by passengers on board (e.g. e-mail, web browsing, messaging, infotainment, voice communications, etc.) or to be used by airlines and/or aircraft manufacturers for various process optimization purposes.

6 Technical information

6.1 Detailed technical description

The overall end-to-end system architecture of the broadband DA2G communication system is illustrated in Figure 1.

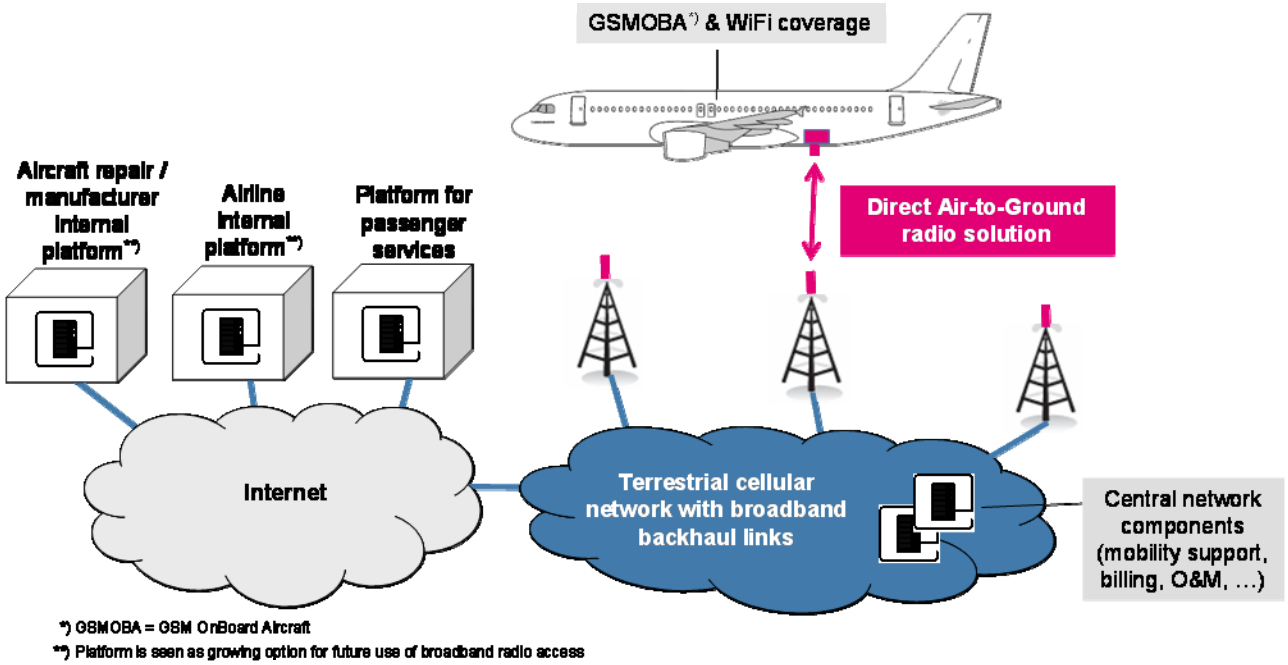

Figure 1: System architecture for broadband DA2G communication

The major building blocks of the end-to-end system architecture are:

1) service related network infrastructure onboard the aircraft, e.g. WiFi coverage and GSMOBA (GSM OnBoard Aircraft is already standardized);

2) DA2G communication infrastructure onboard the aircraft (external antenna, modem, cabling, interface to on-board network);

3) terrestrial radio access network for DA2G communication with broadband backhaul links, which would preferably be based on existing infrastructure, but with modifications (e.g. with regard to antenna types and base station implementation) to establish high-performance radio links to aircraft in DA2G environment;

4) mobile core network for session, mobility, subscriber and security management providing IP connectivity to external packet data networks (e.g. intranet, internet, IMS);

5) central network components required for O&M, billing, etc. in the DA2G communication network;

6) various IP-based service delivery platforms e.g. for passenger services or for airline or aircraft repair / manufacturer internal applications.

Modern broadband wireless access technologies as specified for next generation mobile networks (NGMN), could be a sound technological basis for a DA2G communication solution, capturing mainly items 2) and 3) in the list above.

It is envisaged to use NGMN standardised equipment (e.g. LTE/E-UTRAN) for the DA2G connections. The user equipment (UE) would refer to the DA2G aircraft station (AS), and the base station (BS) would refer to the DA2G ground station (GS). An overview as well as an overall description of E-UTRAN is given in [i.10].

6.2 Technical parameters and implications on spectrum

6.2.1 Status of technical parameters

6.2.1.1 Current ITU and European Common Allocations

Due to the broad range of possible frequencies covered, an excerpt of the ECA table is not reproduced here. Please see [i.4] for further details. Generally, bands allocated to the Aeronautical Service or to the Mobile Service might be most suitable for DA2G communication.

6.2.1.2 Sharing and compatibility studies (if any) already available

So far, no compatibility studies have been conducted.

6.2.1.3 Sharing and compatibility issues still to be considered

Due to the character of DA2G communication, coexistence with other radio services and applications within the same frequency bands might not be feasible. Thus, compatibility with services and applications in bands adjacent to the DA2G candidate bands need to be considered. Studies are requested to be performed for both directions, i.e. also possible interference into the DA2G system.

6.2.2 Transmitter parameters

6.2.2.1 Transmitter Output Power

In case of using E-UTRAN, for the Ground Station the maximum transmitter output power values as specified in clause 6.2 in [i.2] would apply. As an example, the maximum transmitter output power in 10 MHz bandwidth for an E-UTRAN BS (eNB) is 40 W. In order to compensate for high path loss due to large cell sizes, potentially slightly increased maximum transmit power values may be required. This is currently being studied.

For the Aircraft Station, the maximum transmitter output power values as specified in clause 6.2 in [i.3], would apply. However, it is anticipated that the transmitter output power would need to be slightly increased to compensate for high path loss due to large cell sizes. The required increase is currently being studied and depends on a variety of parameters such as cell size, operating frequency, antenna gain at the GS and at the AS, number of receive antennas at the GS, etc.

The different phases of a typical flight profile are shown in Figure 2. Adoption to lower transmit power during take-off, climb, descent and landing is possible. Below altitudes of 3 000 m, only AAC services would be supported.

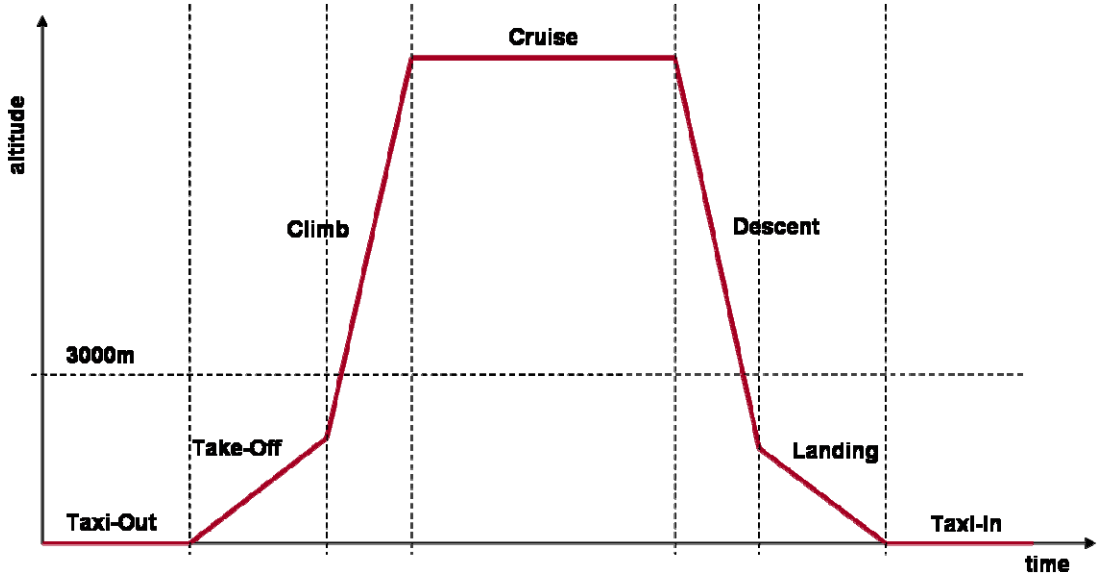

Figure 2: Phases of a typical flight profile

6.2.2.2 Antenna Characteristics

The GS antenna characteristics are similar to those of a BS in terrestrial mobile networks. However, instead of an antenna downtilt, an antenna uptilt is used, i.e. the antennas are pointed into the sky rather than towards the ground. The exact antenna characteristics depend on a variety of parameters such as cell size, degree of sectorisation, AS distribution, etc.

The AS antennas will have more or less hemispherical properties.

6.2.2.3 Operating Frequency

The target operating frequency is in the range below 6 GHz. In this range, atmospheric impacts even for large cell sizes are still tolerable. However, the lower the operating frequency, the lower the path loss and thus the better the link-budget (achievable signal-to-noise ratio, SNR). This translates to either higher data throughput values (with fixed transmit power) or less transmit power (with fixed data throughput value). On the contrary, a higher operating frequency would lead to smaller structures for e.g. the GS and AS antennas. Due to the high velocities involved, the Doppler shift will increase to unacceptable values above 6 GHz.

6.2.2.4 Bandwidth

Typical spectral efficiency values for NGMN technologies is between 1 and 2 bit/s/Hz. Taking into account actual and future demands for broadband data access in standard terrestrial mobile networks, together with the fact that air passengers will expect similar user experience regardless of whether they are on the ground or in the air, the DA2G communication system will need a minimum of 10 MHz of spectrum for both, the forward link and the reverse link. The frequency reuse factor is assumed to be 1.

In case of using E-UTRAN the channel bandwidths listed in clause 5.6 in [i.2] and [i.3], respectively, would apply.

6.2.2.5 Unwanted emissions

In case of using E-UTRAN the emissions specified in clause 6.6 in [i.2] and [i.3], respectively, would apply.

Unwanted emissions comprising the out-of-band and spurious emissions are illustrated for E-UTRA in Figure 3.

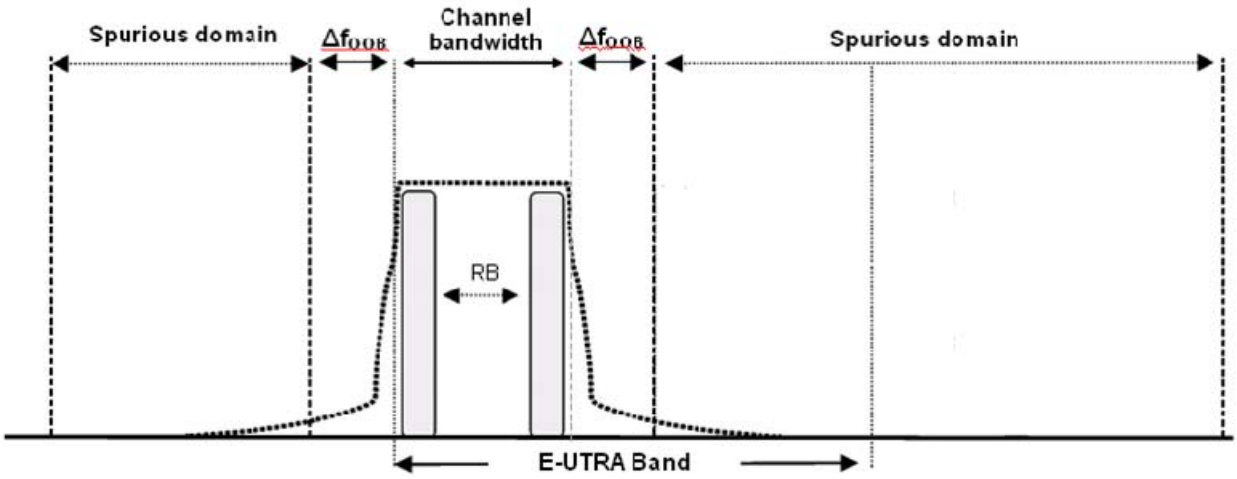

Figure 3: Transmitter RF spectrum

6.2.3 Receiver parameters

In case of using E-UTRAN the receiver characteristics as defined in clause 7 in [i.2] and [i.3], respectively, would apply.

6.2.4 Channel access parameters

In case of using E-UTRAN, the used channel access parameters such as frame duration, resource grouping and allocation in time and frequency, random access procedures, are within the parameter ranges defined in [i.5].

6.3 Information on relevant standard(s)

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

7 Market information

Connectivity to ICT services while travelling has become an expectation of the flying public, and a competitive advantage among airlines attempting to gain or protect market share. Existing satellite-based connectivity solutions for aircraft in L-Band and Ku-Band suffer from high operational cost and from significant weight and effort to install aircraft equipment (especially satellite antennas). Depending on the degree of usage and growing of the market the L-Band solutions may run into capacity limitations in the mid term, especially for high density air traffic over continental areas such as Europe.

An interesting alternative bringing broadband data to continental aircraft fleets is Direct Air-to-Ground (DA2G) connectivity. Modern broadband wireless access technologies as specified for next generation mobile networks (NGMN) could be a sound technological basis for a DA2G communication solution due to their inherent high spectral efficiency and distinctly reduced infrastructure cost onboard the aircraft compared to satellite systems.

The introduction of broadband DA2G communication is focused on:

- scheduled aviation;
- business aviation.

The main application field will be Air Passenger Communications (APC), e.g. internet/company intranet access and voice communication (via fixed or WLAN-based onboard connectivity network and/or via GSMOBA), but in addition the system may also support Airline Administrative Communications (AAC).

The envisaged broadband DA2G communication system is not intended to be used for safety-relevant communications such as Air Traffic Management (ATM) and related services.

For detailed market information see annex A.

8 Regulations

8.1 Current regulations

No dedicated frequency band for broadband DA2G communication is available in Europe. A designation of frequency bands (1 670 MHz to 1 675 MHz / 1 800 MHz to 1 805 MHz) to Terrestrial Flight Telephone System (TFTS) was withdrawn in 2003.

In the USA, two nationwide DA2G communication spectrum licenses in the 800 MHz band were awarded in 2006, but with a bandwidth of only 2 x 1,5 MHz. Aircell is the main market driver with the so-called "GOGO" service. The system is based on 3G CDMA EVDO technology.

WRC-07 decided on modified allocations for aeronautical frequency bands, in particular in the 1 GHz and 5 GHz ranges, with focus on systems supporting safety and regularity of flights, i.e. on ATC (Air Traffic Services Communications) and AAC/AOC (Airline Administrative Communications / Aeronautical Operational Control), but not on APC (Air Passenger Communications).

8.2 Radio spectrum request and justification

It is proposed to designate frequency spectrum to "Broadband DA2G Communication Systems" in the frequency range 790 MHz to 5 150 MHz. Spectrum above 6 GHz is not appropriate for such an application, due to wave propagation aspects (e.g. increased path loss, Doppler shift).

The signal bandwidth required depends on system characteristics (e.g. operating frequency, frequency reuse, spectrum efficiency) and service data rate required per aircraft and per cell/sector. According to the evaluation of current air traffic density, there is an average number of more than 26 aircraft simultaneously within one cell with coverage radius of 100 km in high air traffic areas. This number is expected to increase by about 4 % to 5 % per year (see Figures A.3 and A.5).

2 x 10 MHz paired spectrum (FDD) is seen as necessary to cope with short- to medium-term demand.

Unpaired spectrum for TDD operation might be seen as a secondary option only, because system performance would suffer due to guard time intervals required for large cell sizes. Furthermore, it might be more complicated to identify a contiguous block of 20 MHz for TDD operation.

The spectrum identified should be at least harmonized on a European-wide basis. A globally harmonized identification could be envisaged if considered possible. An individual authorisation is deemed appropriate.

It is requested to support the deployment of a broadband DA2G communication system within Europe in order to enable European citizens getting comparable services onboard aircraft like in other regions, e.g. in the US market. Thus, a corresponding Commission Decision will be requested in the future.

Generally, bands allocated to the Aeronautical Service or to the Mobile Service might be best suitable.

No enforcement issues are expected.

Annex A:
Market information

In recent years the market for mobile access to Internet services (including intra-company VPN data communication) is drastically increasing mainly caused by improved coverage and capacity provided by evolved radio network infrastructures like 3G HSPA, but also due to availability of smartphones like Apple's iPhone and netbooks with integrated or USB-based modems. In addition most user equipment supports access to public WiFi networks (hot spots). This market will further increase in the future.

People will be more and more accustomed to use their equipment everywher, i.e. at home, at work and while travelling. So the demand for internet access and voice communication onboard aircraft, denoted as Air Passenger Communications (APC), will grow. In Figure A.1 the results of a market research with US air passengers published in 2009 is presented which demonstrates the increasing interest in APC. Especially business travellers will benefit from installation of connectivity infrastructure in aircraft by using more efficiently the flight time, but also private travellers will participate e.g. in getting online information for their trip planning in case of any delays. One of the requirements for user acceptance is the price to be paid for the service, which is directly related to the connectivity solution used.

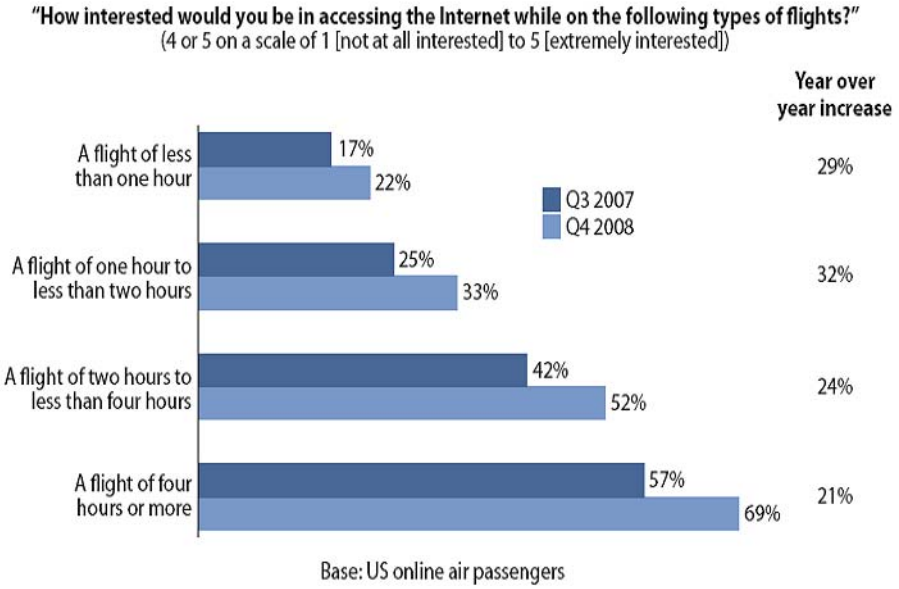

Figure A.1: Interest of passengers in Internet access during flight (source: Forrester Research, Inc. / 2009)

Up to now mainly satellite-based connectivity is provided to aircraft for APC, via L-Band (e.g. Inmarsat's Swift Broadband service) and Ku-Band (service providers such as Panasonic, ViaSat and Row44). These solutions suffer from high operational costs and from significant weight and effort to install aircraft equipment (especially satellite antennas). Depending on the degree of usage and market growth, the L-Band solutions may run into capacity limitations in the midterm, especially for high density air traffic over continental areas such as Europe. Nevertheless, they will remain the only access medium for intercontinental flights across ocean areas.

For continental areas, Direct Air-to-Ground (DA2G) connectivity tends to be an interesting alternative due to distinctly reduced infrastructure cost onboard aircraft compared to satellite systems. In the US, Aircell is currently providing their GOGO APC service via a terrestrial radio network based on 3G CDMA2000 EVDO Rev A technology in the 800 MHz band. This spectrum was made available by the FCC by awarding two nationwide licenses in 2006, but with a bandwidth limited to 2 x 1,5 MHz which will cause capacity shortages with service take-up of additional airlines in 2009/2010. Now, all major airlines (American Airlines, Delta Airlines, United Airlines, Air Canada, Virgin America, AirTran Airways, Continental Airlines (from 2nd quarter 2010)) offer this service.

Due to their inherent high spectral efficiency, more sophisticated broadband wireless access technologies as specified for next generation mobile networks (NGMN) are seen as the technological basis for DA2G communication to satisfy the future high market demand:

- In addition to APC, i.e. Internet/company Intranet access and voice communication via fixed or WLAN-based onboard connectivity networks and/or via GSMOBA, a commercial DA2G communication network may also support non-safety relevant Airline Administrative Communications (AAC). In principle also safety-relevant Air Traffic Management (ATM) services could be supported, but due to the required high availability for such services the network costs would be drastically increased.
- Provisioning of onboard connectivity will be a competitive factor among airlines attempting to gain or protect their market share in the future, but in contrast to the USA, the European APC market suffers currently from missing frequency bands for introduction of broadband DA2G communication after release of former TFTS bands in 2003.

The introduction of broadband DA2G communication is mainly focused on:

- scheduled aviation; and
- business aviation.

In Figure A.2 an overview about European air traffic market segments is given based on the year 2006. It is not expected that there will be any significant change in the market fractions given on the left side. The scheduled aviation as mentioned before includes both the traditional scheduled market segment as well as the low cost airline market.

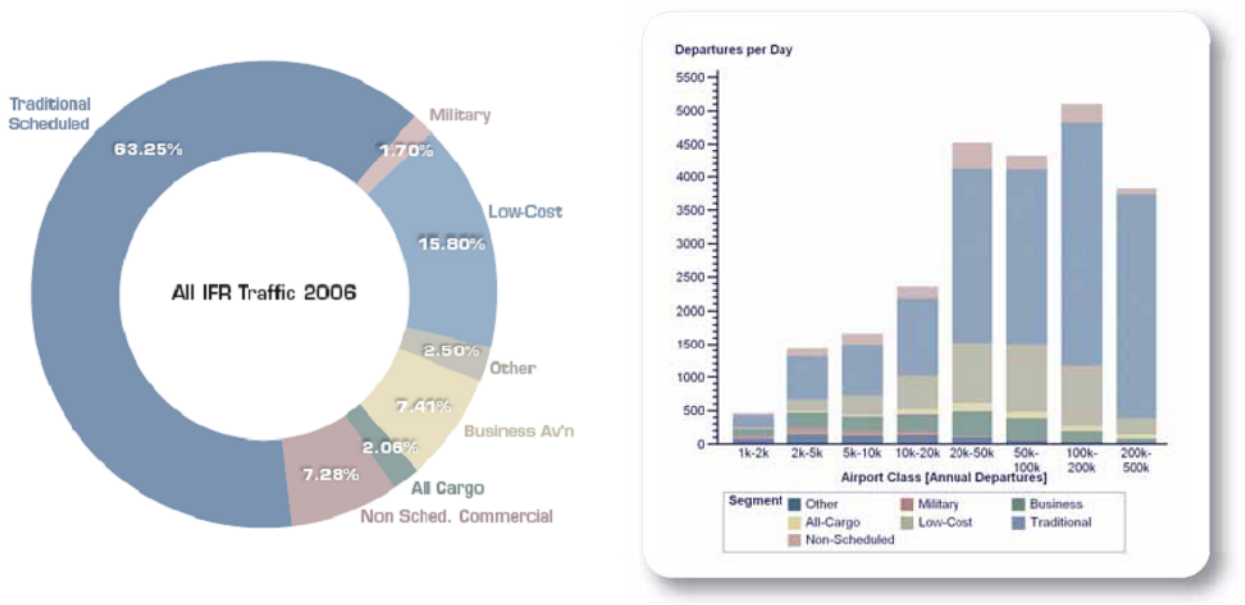

Figure A.2: Flight market segments in Europe (left side) and traffic by market segment and airport size (right side) for the year 2006 (source: Eurocontrol / 2007)

The air traffic within European area until 2014 is estimated to increase as shown in Figure A.3. In general the annual growth rate is in the range of about 4 % to 5 % on average during the last decades except of years with economic crises arising as in 2008/2009.

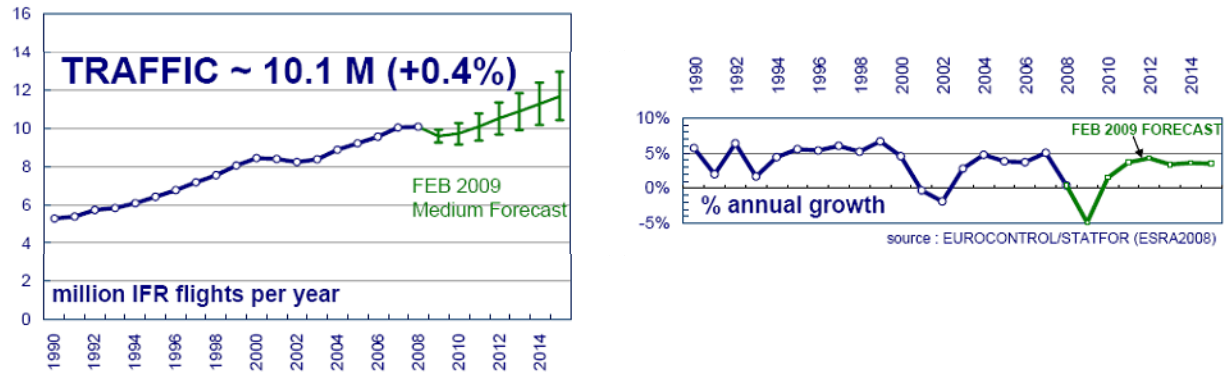

Figure A.3: Forecast of European air traffic (source: Eurocontrol / 2008)

About 66 % of those flights are national or continental flights, i.e. the main part of the airline business. The addressable market in Europe for DA2G communication is currently consisting of about 160 airlines with more than 4 500 aircraft expected in 2014 (without business aviation). Further information about the air traffic market trends in next years can be found e.g. in [i.7], [i.8] and [i.9].

In general a strong increase in percentage of aircraft fleet equipped with Internet connectivity solutions is expected during next years as exemplarily displayed in Figure A.4. As a result of that market research more than 40 % of aircraft will allow APC services to their passengers up to 2016.

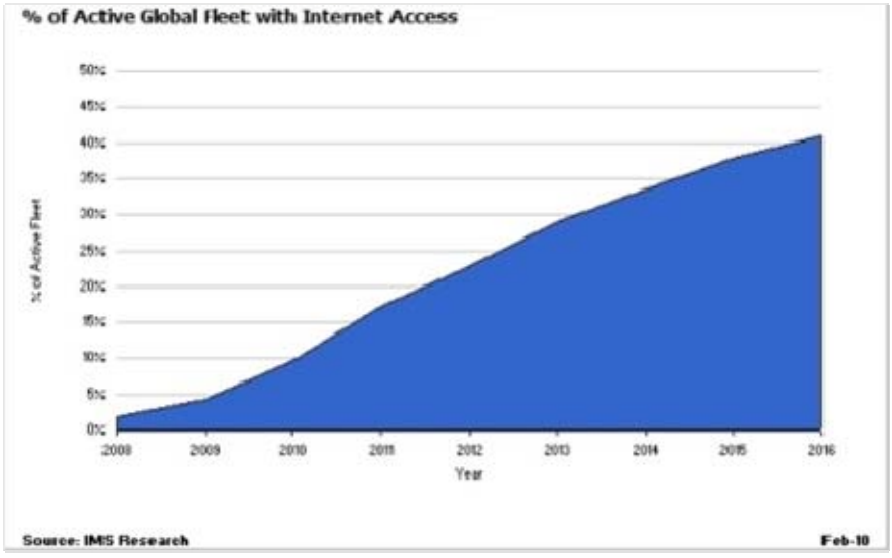

Figure A.4: Expected percentage of aircraft (source: IMS Research / 2010)

The flight density across European area for 2006 is presented on the left side of Figure A.5. This figure also includes a long-term forecast for the year 2025.

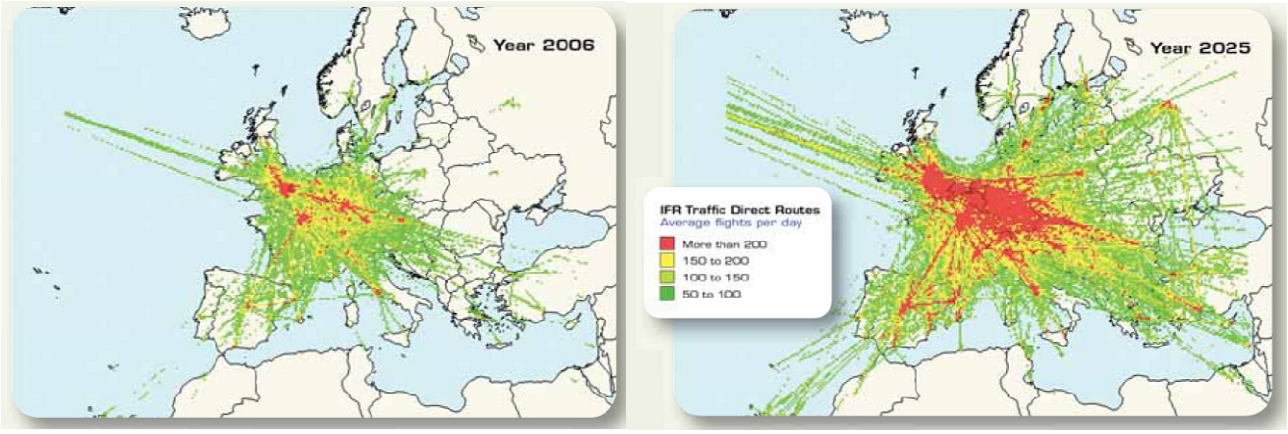

Figure A.5: Growth of European flight density (source: Eurocontrol / 2007)

The density patterns in Figure A.5 can be used to define basic rollout coverage scenarios for the terrestrial DA2G communication network, which can be extended during the following years to cover main flight routes and areas in Europe and neighbouring countries according to increasing air traffic demand.

Annex B:
Coexistence issues

In the context of agenda items 1.5 and 1.6 of WRC-07, compatibility beetween proposed systems in the aeronautical mobile service and the existing fixed-satellite service in the band 5 091 MHz to 5 150 MHz was considerd. The corresponding ITU-R Report [i.12] proposes a methodology for compatibility analyses.

Annex 3 of this ITU-R Report deals with "Civil aeronautical security requirement". The European Commission and Eurocontrol were co-funding a project [i.15] to support the Eurocontrol strategic initiative to validate a high capacity air-ground communications capability for the transmission of encrypted cockpit voice, flight data and on-board video information. The objective of this project work was to demonstrate the feasibility for enhancing ATM security by making available key security related information in encrypted form via a secure radio link between the ground and the aircraft. The technology used was an adaptation of the IMT-2000 CDMA air interface standard. Successful flight trials at C-band were conducted to a range of greater than 100 km. These demonstrated that the adapted CDMA standard can be used for aeronautical security applications in the band 5 091 MHz to 5 150 MHz.

Technical and operational requirements and considerations for use of the band 5 091 MHz to 5 150 MHz by the aeronautical mobile service for certain aeronautical applications are available in RECOMMENDATION ITU-R Recommendation M.1827 [i.13] and RESOLUTION [COM4/8] (WRC-07) [i.14], repectively.

Annex C:
Related discussions in CEPT ECC fora

C.1 Working Group Spectrum Engineering 56th Meeting, Tromsø, Norway, 10 - 14 May 2010

Meeting Report extract:

"ERM has adopted a new work item for an ETSI System Reference document on Broadband Direct-Air-to-Ground (DA2G) communications. The draft of the document has been agreed in ERM TG DMR but has not yet undergone ETSI internal consultation (ETSI draft SRdoc "stage 1"). The ETSI Liaison Officer presented the preliminary draft system reference document in InfoSE(10)016annex1. ETSI asks CEPT / ECC to perform the relevant spectrum investigations and compatibility studies necessary to designate appropriate frequency bands for the forward link (FL) and the reverse link (RL) for the introduction of a broadband DA2G communication service covering the whole of Europe. An ECC Decision, designating the bands, is requested by ETSI to be available by mid 2012. Mr. Weber also informed that Eurocontrol has been participating in the ETSI internal consultation on the document. WG SE also noted an input document from Eurocontrol to WG RA and the WG SE Chairman informed the WG RA Chairman about the ETSI documentation in order to ensure alignment of the activities on Broadband Direct-Air-to-Ground (DA2G) communications."

C.2 20th Meeting of WG RA, Gdynia, Poland, 11 - 14 May 2010

Meeting Minutes extract:

"Mr Geoffrey Bailey, Eurocontrol, introduced info doc 3 concerning the need for an ECC Decision covering the regulatory aspects of air/ground broadband connectivity, to enable onboard fixed and mobile devices that support security applications and/or the full range of applications normally available though an Internet Service Provider, a service for which there is great demand. An ECC Decision would promote a harmonized deployment of the service in Europe. The system is proposed to operate in the frequency band 5091 - 5150 MHz, which already has an allocation for the aeronautical mobile service limited to security applications AMS(AS). The proposed ECC Decision will not cover any aeronautical safety aspects, as such issues are outside the scope of radio regulation and remain the responsibility of the relevant aviation authorities.

The meeting evaluated the proposal by Eurocontrol and approved an evaluation report as shown in Annex 11."

Extract from Annex 11 to doc RA(10)065:

"From the perspective of WGRA it appears from the evidence presented by Eurocontrol Agency that if their assumptions regarding the technical limitations are correct then the issue would appear to be a regulatory issue that would need to be resolved in order for ECC to agree to this request and not a technical one. It also appears that there is merit in ECC exploring further this request to liberalise the current allocation. In addition it was argued if we were to allocate this spectrum as requested it would help reduce costs for the aviation industry in addition to increasing the efficient use of the spectrum. In any case as some of the evidence presented may not be within our competencies to verify we agreed to prepare this information document to be added the WGRA chairman's report to the next ECC meeting."

C.3 59th Meeting of WG FM, St. Petersburg, Russia, 17 - 21 May 2010

Meeting Minutes extract:

"The ETSI liaison officer introduced document FM(10)044 containing a draft System Reference document on Broadband Direct-Air-to-Ground (DA2G) communications. This version was used for the internal consultation which had ended. The resolution meeting still has to take place. It is expected that ERM will receive the final version for consideration and approval during their June meeting.

A comparable system using CDMA technology has been successfully introduced in US in the 800 MHz band where several airline carriers are now implementing this technology in their planes.

In the draft System Reference document, ETSI asks CEPT/ECC to perform the relevant spectrum investigations and compatibility studies necessary to designate appropriate frequency bands for the forward link (FL) and the reverse link (RL) for the introduction of a broadband DA2G communication service covering the whole of Europe. An ECC Decision, designating the bands, is requested to be available by mid 2012.

The question was raised whether exclusive spectrum is intended as it is unlikely that coexistence can be achieved with existing services. Germany confirmed that the preferred solution would be to have exclusive spectrum but would not like to preclude other solutions at this point in time.

Based on a question raised by Eurocontrol, it was clarified that the envisaged broadband DA2G communication system is not intended to be used for safety-relevant communications such as Air Traffic Management (ATM) and related services. Eurocontrol also suggested to remove Aeronautical Operational Control (AOC) as this is also a safety critical communication.

A question was raised by UK about a possible overlap between a system proposed by Eurocontrol and the technology described in the draft System Reference document. It was confirmed that Eurocontrol participated in the ETSI internal consultation. Therefore, it is expected that a possible overlap between both systems would be clearly described.

France appreciated the work done by ETSI and suggests that WG FM should start work on the proposal contained in the System Reference document.

Germany introduced document FM(10)079 which contains a proposal to create a new WG FM project team for broadband DA2G communications which should deal with the spectrum aspects of these systems. Such a new PT could also consider issues on Wireless Avionics Intra-Communications (WAIC) for which no appropriate PT has been available so far.

The contribution also includes a proposal for the ToR for the new PT. The German administration could also provide a candidate for the chairmanship for such a PT.

The UK and Norway stated that it is too premature to decide on a project team and therefore suggested to wait until the situation with potential overlap with Eurocontrol activities has been clarified. Norway reminded the meeting that, in relation with agenda item 1.3 of WRC-12, Eurocontrol had made a presentation during a CPG PT C meeting describing a similar system.

The meeting finally agreed to create a new project team. A correspondence group, chaired by Mr. Thomas Weilacher (Germany, email: thomas.weilacher@bnetza.de), will further develop the ToR for adoption at the next WG FM meeting in September, and will clarify the issues raised above. The actual work of the PT should start after the September meeting of WG FM."

History

Document history		
V1.1.1	July 2010	Publication