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English, French, Russian and Spanish only[*]

ELEVENTH AIR NAVIGATION CONFERENCE

Montreal, 22 September to 3 October 2003

Agenda Item 6: Aeronautical navigation issues
6.2 : Navigation policy issues in the light of present and envisaged GNSS services and architectures, integration and back-up options

NAVIGATION INFRASTRUCTURE

(Presented by the European Organisation for the Safety of Air Navigation — EUROCONTROL, on behalf of its Member States and those of ECAC[1])

SUMMARY

The EUROCONTROL Navigation Strategy for the area of the ECAC Member States identifies a transition to an area navigation (RNAV) environment supported by global navigation by satellite system (GNSS). Consideration of the costs of the transition to such an environment together with the need to ensure failure survival indicates that there will, for the foreseeable future, remain a need for ground-based navigation aids and the consequent requirement to ensure continued spectrum protection for these aids.

With increased competition for spectrum, many services are looking to the navigation bands as a potential source of bandwidth. However, in view of the uncertainty as to the ability to rely solely upon GNSS, it is essential that the long-term viability of the existing ground navigation infrastructure as well as the ability to provide microwave landing system (MLS) as a future precision landing aid, need to be given due priority over any other new systems/services proposed for the navigation bands.

Action by the conference is in paragraph 7.

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[*] French, Russian and Spanish versions provided by EUROCONTROL.

[1] The ECAC Member States are: **Albania**, Armenia, **Austria**, Azerbaijan, **Belgium**, Bosnia and Herzegovina, **Bulgaria**, **Croatia**, **Cyprus**, **the Czech Republic**, **Denmark**, Estonia, **Finland**, **France**, **Germany**, **Greece**, **Hungary**, Iceland, **Ireland**, **Italy**, Latvia, Lithuania, **Luxembourg**, **Malta**, **Moldova**, **Monaco**, **the Netherlands**, **Norway**, Poland, **Portugal**, **Romania**, Serbia and Montenegro, **the Slovak Republic**, **Slovenia**, **Spain**, **Sweden**, **Switzerland**, **The former Yugoslav Republic of Macedonia**, **Turkey**, Ukraine and **the United Kingdom**).

The 31 Member States of EUROCONTROL appear in **bold**.

1. BACKGROUND

1.1 With the development of the ICAO communications, navigation, surveillance/air traffic management (CNS/ATM) concept, aviation started a major transition period towards an environment envisaged to be based mainly on global navigation satellite system (GNSS), aimed at increasing the efficiency and cost-effectiveness of flight operations world-wide, and supporting the expected increases in traffic over the following decades. A typical aviation project life cycle from concept development and spectrum allocation to global standardisation, certification and carriage by concerned aircraft exceeds 15 years. During the transition period, the ability to accommodate both existing and new CNS/ATM technologies is vital to continued safe operations. This requires, inter-alia, the availability of adequate radio spectrum capacity.

1.2 However, radio spectrum is a scarce resource with finite capacity limits for which demand has been increasing constantly in recent years. Commercially oriented and dynamic sectors, able to achieve faster implementation than the historical users of radio spectrum, have triggered a major change in the International Telecommunications Union (ITU) practices. These have moved gradually away from allocating radio bands for exclusive use by designated services and/or user domains/sectors, to share use of the same band by different services and/or user groups.

1.3 With increased competition for spectrum, and in view of the planned transition to GNSS, many new aeronautical systems and/or services are looking to the Navigation bands as a potential source of spectrum. Examples include ground-based augmentation systems (GBAS) and VHF data link Mode 4 (VDL 4)[2] in the instrument landing system (ILS)/VHF omnidirectional radio range (VOR) band and new GNSS signals in the distance measuring equipment (DME) band.

1.4 Not all the contenders for radio spectrum will present a restriction to the use of these bands by the existing navigation services, at least initially. However, in highly populated regions, such as Europe, the high density of navaids results in frequency bands becoming congested. Therefore, there is an increasing risk that expansion of the existing navigation service whilst accommodating a new service in the band could generate conflicts, which can only be solved by vacating some or all of the available frequencies to allow their use by the new systems.

2. NAVIGATION APPLICATIONS

2.1 The EUROCONTROL Navigation Strategy for the ECAC Member States area envisages a shift towards a total area navigation (RNAV) environment en-route and in terminal area (TMA) with defined minimum required navigation performance (RNP) levels post-2010. The main driver for this evolution derives from the RNAV ability to support improvements in airspace capacity whilst enabling increased economy of operation and reducing environmental impact. For precision approach and landing operations, the strategy envisages a continued support to all weather operations, to at least the existing level of capability.

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[2] VDL 4 applications for non-aviation use are not expected to use the aviation VHF navigation band.

2.2 The infrastructure to support such operations requires significant developments both of airborne systems as well as suitable ground- and space-based components. The overall requirement is for a safe, fault-tolerant and cost-effective navigation operation supported by an appropriate infrastructure.

2.3 The goal in the period to 2015 is for RNAV supported by GNSS with DME and, where appropriate, inertial reference systems (IRS) or inertial sensor systems (ISS). For precision approach and landing, a gradual move away from ILS is expected, as it becomes increasingly difficult to provide Cat III operations due to multipath and interference, and an increased use of GNSS with, where necessary, the use of MLS. However, with the pressure to keep ILS for as long as possible, it is evident that there will be an extended period in which GNSS, ILS and MLS will co-exist.

2.4 The cost of meeting the aircraft requirements predominates in the overall cost of implementing the navigation element of the CNS/ATM concept. Nevertheless, the operational gains could warrant the expenditure on airborne system developments. However, in considering the costs and benefits to be derived, a major problem in all the implementations undertaken or planned in the ECAC area has been the difficulty of supporting existing capabilities whilst providing a cost effective transition to the future system.

3. ROLE OF GNSS

3.1 For reasons of global coverage, GNSS will be one of the main means of meeting the ECAC navigation infrastructure requirement. However, the relative roles of ground- and space-based navigation infrastructure in a high-density ATM environment such as that in the ECAC Member States area remain to be validated.

3.2 Positioning accuracy based on GNSS is no longer the limiting factor for the majority of operations, although GNSS performance for precision approach, in particular for Cat II/III operations remains to be validated. The remaining uncertainty in respect to the GNSS potential to become the “sole navigation service” stems from its potential failure modes (whether due to intentional or unintentional causes), their corresponding impact on the ATM operations of the ECAC Member States, and the identification of mitigation possibilities.

3.3 The global positioning system (GPS) without any external augmentation has already been accepted as a means of providing a basic RNAV capability en-route throughout ECAC. This has been possible because the ability to revert to conventional navigation using ground navigation aids (VOR/NDB) was retained, thus ensuring that the risk of total loss of navigation remains “extremely remote”. The availability of Galileo as a second satellite system complementing GPS, as well as additional navigation signals, were expected to allow further reliance upon GNSS, thereby enabling VOR/NDB decommissioning. This would result in navigation relying upon RNAV based upon GNSS and DME.

3.4 However, whilst the GPS plus Galileo might provide the basis upon which a total RNAV environment might be predicated, it has still to be proven that such a solution would be cost effective. The basis of this concern is that safety studies related to a total RNAV environment implementation have highlighted the potential need for carrying dual RNAV systems to meet the requirement that the risk of loss of total navigation capability on the aircraft must be “extremely remote”. Today this is met on Transport Category aircraft by the provision of dual VOR installations on the aircraft. Since many new aircraft continue to be equipped with only single RNAV or flight management system (FMS) equipment, the timescale by

which a cost-effective transition to a total RNAV environment could therefore be considerably extended. This would generate a delay to when VOR/NDB decommissioning will be possible; such considerations being largely independent of any decision in respect of the relative roles of GNSS and DME in the future navigation infrastructure.

3.5 Even with dual on-board systems, meeting the requirement for the risk of total loss of navigation capability to be "extremely remote" may still require two different sensor inputs, e.g. GNSS aided by INS or DME. If this is required DME coverage will need to be improved with an overall increase in DMEs required in the ECAC area over the next 10-20 years.

3.6 Studies have identified that, in the 2010-2015 time-scale, it might be more cost-effective to ensure the required level of continuity of service by retaining the current VOR environment to support reversionary navigation than it would be to require dual RNAV/FMS equipment with dual sensor input. Such VOR reversionary operation was the basis of the safety case for the use of GPS for basic RNAV (B-RNAV) implementation in 1998 in ECAC States. If these initial results are confirmed, the expected decommissioning of VOR in that period might not be possible. However, the requirements in respect to reversionary operation remain under review at the present time.

3.7 SBAS based on GPS/L1, like the European Geostationary Navigation Overlay Service (EGNOS) or the wide area augmentation system (WAAS), will enhance GPS performance with respect to accuracy, availability and integrity, and is capable of supporting navigation down to approach with vertical Guidance II (APV-II), but is unlikely to support Cat I performance.

3.8 As a result GBAS remains today the only confirmed GNSS means with potential to allow Cat I precision approaches. In the future, with dual frequency GPS- IIR, and Galileo, the SBAS systems could support Cat I precision approaches. GBAS should be capable of attaining the stringent performance requirements for Cat II and III landing, once dual-frequency GNSS is operational, but this remains to be proven. Continued operation of ILS or the introduction of MLS remain operationally viable options. In view of the uncertainties concerning the feasibility and time-scales for a GBAS Cat II/III, the future direction of development of the precision approach environment is still unresolved.

4. STAKEHOLDER POSITION ON GNSS

4.1 A "Common Aviation Position" on GNSS has been developed in co-ordination with airspace users, air traffic service providers and States, and is the subject of a separate paper. That position represents a clear recommendation to proceed with a stepwise implementation of GNSS services to the degree that this can be achieved in a **safe and cost-efficient manner**. Nevertheless whilst this is the goal, the ability of GNSS to meet these requirements has still to be verified.

4.2 The evaluation of these requirements require, inter alia:

a) review of the cost of implementing the required infrastructure and on-board navigation systems, as well as the cost of managing the transition; and

b) evaluation of the impediments to GNSS becoming a "sole service"[3] and the mitigations available for the ECAC environment.

4.3 Until these questions have been resolved, it will not be possible to state whether GNSS can meet the requirements set out in the "Common Aviation Position". Therefore, from both an operational and a technical standpoint, it is not yet possible to identify the overall navigation infrastructure mix needed in the ECAC Member States area in the period to 2020 and beyond.

5. IMPACT ON PLANNING FOR ECAC NAVIGATION INFRASTRUCTURE

5.1 The implications of the above considerations lead to the following conclusions:

5.1.1 Decommissioning of all point source ground navaids (VOR and NDB) and reliance upon RNAV as the sole means of navigation is unlikely to be cost-beneficial in the short to medium term in the ECAC environment.

5.1.2 There will remain an operational need to continue to provide DME as an input to RNAV. In addition, there may be a need, for an extended period, to continue to provide VOR as a backup to cater for single on-board RNAV system failure.

5.1.3 For approach and landing, aircraft operators wish to continue to operate with ILS for as long as possible. However, the long-term viability of ILS is more and more under pressure due to interference from commercial radio and multipath due to airport building development.

5.1.4 The application of GNSS for low visibility procedures remains a target. However, some of the potential failure modes for GNSS landing systems can have a significantly different impact to ILS failures. The potential for simultaneous loss of guidance on multiple runways might necessitate the need for backups.

5.1.5 As a result of the issues raised in 5.1.3 and 5.1.4, there is an increasing expectation of MLS being needed, either as the primary means of providing a precision approach facility, or as a backup to a GNSS-based approach and landing.

5.2 It is therefore imperative that the radio spectrum required to support the existing terrestrial systems is adequately protected, at least until it is assured that GNSS can provide a safe and cost effective service envisaged as the target of the "Common Aviation Position" paper.

5.3 In addition, it is increasingly important that false expectation is not raised as to the speed of being able to vacate the navigation bands in the planning of new services. Proposals for shared use of spectrum at present exclusively assigned to navigation services will need to take account of the substantially unchanged demand in the case of VOR and ILS in the short to medium term and the potential increase in DME and MLS service requirements.

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[3] The term "Sole Service" GNSS identifies that GNSS is the sole radio navigation service available. This does not exclude that other self-contained navigation systems such as iInertial reference systems (IRS) or inertial navigation systems (INS) are available.

6. CONCLUSIONS

6.1 From the above considerations it is concluded that:

a) the goal of the EUROCONTROL Navigation Strategy for the ECAC Member States is a total RNAV environment, and that GNSS will be an important enabler for future navigation applications;

b) for en-route and, to a limited extent, TMA operations, GPS is already used today by many operators as the only input to an RNAV system;

c) it is expected that the availability of Galileo, will provide an important complementary capability to GPS (enhancing redundancy and integrity) that could enable greater reliance to be placed on GNSS;

d) it is expected that there are no technical constraints to GNSS being able to be used for all phases of flight. Nevertheless, the potential failure modes, their effect on the ECAC ATM system and the cost of transition to the future Navigation environment together present a considerable challenge to GNSS being able to provide a "sole service" future navigation infrastructure;

e) until it can be demonstrated to what degree reliance can be placed upon GNSS to provide the navigation infrastructure in a safe and cost-efficient manner, the radio-spectrum required to ensure long-term viability of the VOR, ILS and DME infrastructure as well as the ability to provide MLS as a long-term replacement to ILS, all need to be given due priority over any other new systems/services of the corresponding navigation bands.

7. ACTION BY THE CONFERENCE

7.1 The conference is invited to:

a) recognize that, whilst future developments are expected to considerably reduce the risks associated with a sole service GNSS environment, there is a risk that there will remain failure modes which could prevent a total reliance upon GNSS;

b) note that whilst, in the context of operations within the ECAC Member States area, there is work on-going to identify means and associated mitigation strategy by which a gradual move towards sole service might become possible, the ability to reach that end point and the time-scale by which this could be achieved both remain uncertain; and

c) recommend the development of a coordinated plan for the shared use of the navigation radio bands by new systems/services, giving due priority to the existing systems (ILS/VOR/DME/MLS), ensuring sufficient radio spectrum capacity for their continued use for as long as operationally required and economically feasible.

— END —