TWELFTH AIR NAVIGATION CONFERENCE

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Agenda Item 1: Strategic issues that address the challenge of integration, interoperability and harmonization of systems in support of the concept of "One Sky" for international civil aviation
1.1: Global Air Navigation Plan (GANP) – framework for global planning
c) Navigation roadmap

ECAC NAVIGATION ROADMAP

(Presented by the Presidency of the European Union on behalf of the European Union and its Member States[1]; by the other Member States of the European Civil Aviation Conference[2]; and by the Member States of EUROCONTROL)

1. INTRODUCTION: THE GLOBAL CONTEXT

1.1 The *Global Air Traffic Management Operational Concept* (Doc 9854) presents the ICAO vision of an integrated, harmonized and globally interoperable ATM system. The ultimate goal of this system is to support airspace users' requirements to follow preferred trajectories on each flight, resulting in fuel savings and reduced emissions. This requires the ATM system to manage each flight in four dimensions (4D), the fourth being time. The system must also support approaches with the lowest possible minima and vertical guidance to all qualifying runways. Meeting these goals requires the implementation of the global navigation satellite system (GNSS) and performance-based navigation (PBN).

1.2 The sought-after global ATM system will be achieved through the implementation of many initiatives over several years on an evolutionary basis. Initiative GPI-21 is related to PBN, a cornerstone of current and future navigation developments. Its declared scope is to: "Enable the introduction and evolution of performance-based navigation supported by a robust navigation infrastructure providing an accurate, reliable and seamless global positioning capability." To meet those needs, the progressive introduction of performance-based navigation must be supported by an appropriate navigation infrastructure consisting of a combination of GNSS, self-contained navigation systems (inertial navigation system) and conventional ground-based navigation aids.

1.3 ICAO's PBN concept was introduced through publication of the updated ICAO *Performance-based Navigation (PBN) Manual* (Doc 9613) in 2008. The PBN concept specifies that aircraft navigation system performance requirements be defined in terms of accuracy, integrity, continuity

[1] Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom. All these 27 States are also Members of ECAC.

[2] Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Croatia, Georgia, Iceland, Moldova, Monaco, Montenegro, Norway, San Marino, Serbia, Switzerland, The former Yugoslav Republic of Macedonia, Turkey and Ukraine.

and functionality required for the proposed operations in the context of a particular airspace concept, when supported by the appropriate navigation infrastructure. PBN enables airspace design to cater to operational requirements without being constrained by the location of navigation facilities. GNSS-centred performance-based navigation enables a seamless, harmonized and cost-effective navigational service from departure to final approach that provides benefits in safety, efficiency and capacity.

1.4 ICAO is presenting to AN-Conf/12 the global navigation roadmap as part of the Global Air Navigation Plan (AN-Conf/12-WP/3) based on the material prepared by the Navigation Systems Panel (NSP) (AN-Conf/12-IP/3). This paper explains the customization of this global roadmap to the needs of the European Region.

2. EUROPEAN CONTEXT

2.1 Air traffic in the ECAC area is forecast to increase substantially over the next decades. This will require increases in the organization and efficiency of the European ATM network. Additional capacity will need to be delivered, using new concepts, to respond to higher traffic levels and to accommodate all categories of airspace users. Flight efficiency will also need to be improved and environmental impact reduced, while maintaining or improving safety of operations.

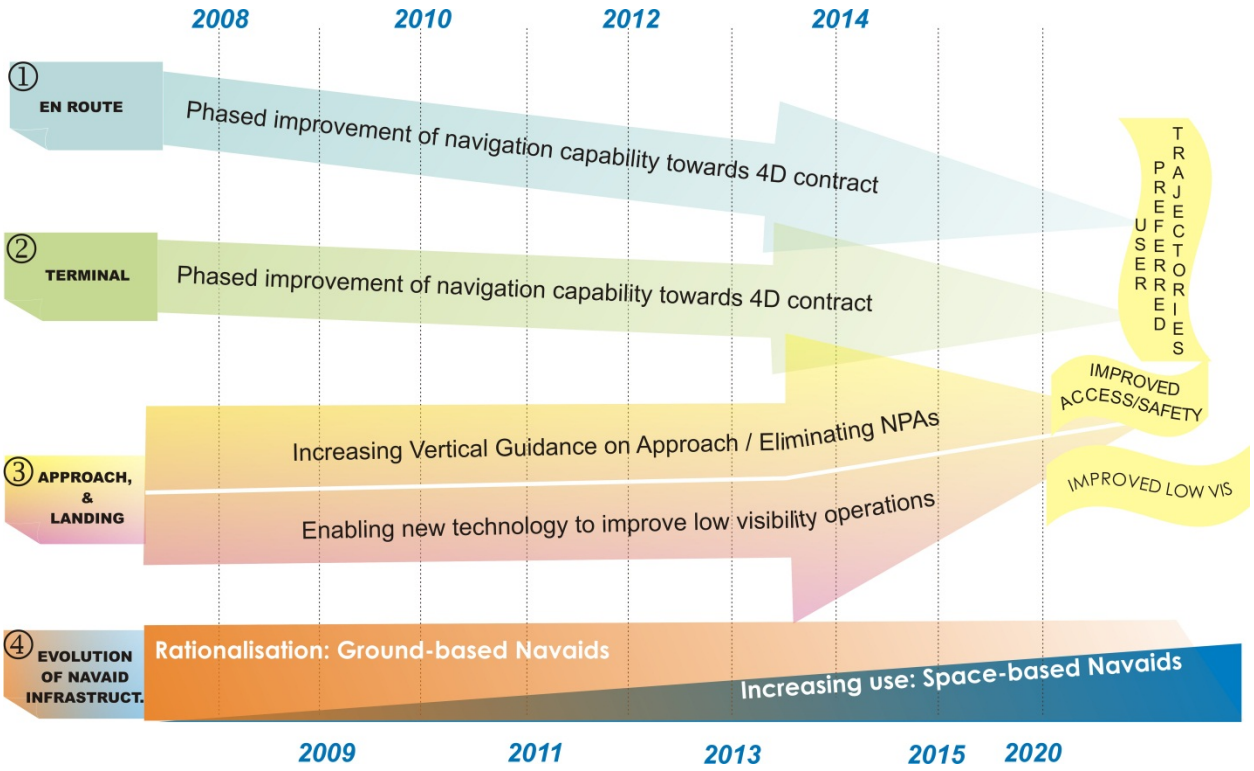
2.2 Up to 2011, shorter-term airspace developments in ECAC were coordinated within the Dynamic Management of European ATM Network (DMEAN) Framework Programme, which has now been transitioned into the Single European Sky (SES) Network Manager functions. The implementation of the European ATM Master Plan will progressively allow realising the SES ATM Research (SESAR) ATM Target Concept. In airspace terms, this means a striking conceptual evolution. The SESAR programme is developing technical and operational enablers for 4D navigation to support user preferred trajectories. There are several on-going projects defining the SESAR navigation baseline and associated roadmap.

2.3 Given the considerable differences between the envisaged operating environments of today and SESAR, it was considered appropriate to have an intermediate step based on the introduction of a new PBN specification, A-RNP (Advanced-required navigation performance). The need for uniform aircraft capability has been demanded by ATC, the reason, confirmed repeatedly by real time simulation, being the difficulty of managing a mixed fleet capability. EUROCONTROL is supporting the European Union on a regulatory scenario under the Single European Sky legal framework in order to achieve a PBN implementing rule based on the A-RNP specification. This mandate, applicable to the European airspace, would enable the realization of the required increase in capacity by reducing route spacing, whilst enhancing safety and flight efficiency and reducing environmental impact.

3. THE NAVIGATION ROADMAP

3.1 The following figure depicts the ECAC navigation roadmap, giving a navigation perspective to the European ATM Master Plan, mirroring the role of the CNS roadmaps in the GANP. It shows a good alignment with the GANP material, and connects on-going work to the main envisaged evolution steps.

3.2 The roadmap is composed of five streams that are developed hereafter (note arrow number 3 is broken up into two streams):



3.3 **Stream 1 - En Route Operations**

3.3.1 The existing B-RNAV (RNAV 5) applications in en route airspace that were introduced in 1998, will be maintained until the navaid infrastructure and aircraft capabilities can enable implementation of A-RNP applications (circa 2018). This is an interim step towards the 4D navigation environment to be implemented for the long term as defined in the European ATM Master Plan.

3.4 **Stream 2 - Terminal Operations**

3.4.1 P-RNAV (RNAV 1 equivalent) applications will be further implemented in TMAs for arrival and departure procedures, to replace existing conventional and B-RNAV procedures, until the navigation infrastructure and aircraft capabilities can enable implementation of A-RNP applications (circa 2018). This is an interim step towards a 4D navigation environment to be implemented for the long term as defined in the European ATM Master Plan.

3.5 **Stream 3A - Approach Operations**

3.5.1 RNAV approaches based on the use of GNSS are being implemented to replace existing conventional non-precision approaches (NPA) or provide IFR approach procedures at airports where the ground infrastructure doesn't support conventional NPA procedures. In 2011, EGNOS (SBAS) was declared operational. This is an important enabler for aviation to achieve the aims of ICAO Assembly Resolution A37/11 regarding implementation of approach procedures with vertical guidance everywhere. Approaches with vertical guidance supported by EGNOS/SBAS or Baro-VNAV will provide improved accessibility and safety of operations.

3.6 Stream 3B - Precision Approach and Landing Operations

3.6.1 The instrument landing system (ILS) is presently used globally as the standard precision approach navaid and all IFR-approved aircraft are equipped with ILS receivers. Ground-based augmentation system (GBAS) stations have the capability to support more advanced operations to all nearby runways, and overcome some ILS limitations.

3.6.2 The first GBAS Cat I station has been certified in Germany and is available for operational use whilst a second station, installed in Spain, is currently undergoing the certification process. GBAS CAT I is considered to be an interim step towards the development of GBAS Cat II/III. Current developments within the SESAR programme are aimed at achieving Cat II/III capabilities based on GPS with only one frequency (L1) as well as GPS/Galileo multi- frequency augmentation.

3.6.3 The implementation of GBAS will not see a rapid replacement of ILS but can be economically viable and operationally desirable for an increasing number of airports and airspace users over time.

3.7 Stream 4 – Navigation Infrastructure

3.7.1 The navigation infrastructure evolution in ECAC is based on a transition to support a complete PBN environment. This requires a gradual increase in reliance on GNSS for positioning and timing. Precision approach capabilities are also evolving towards GNSS. The final goal being a satellite-based primary navigation service, with a ground-based fall back solution based mainly on DME and ILS to cater for remaining GNSS vulnerabilities. The implementation of A-RNP and the progressive reduction of conventional routes and procedures will enable a gradual removal of NDB in the mid-term and of VOR systems in the long term. The network of DME stations will be gradually optimized to provide contingency for RNAV operations to equipped users in areas of high density operations.

3.7.2 GPS is supporting multiple CNS systems and operations since 1993. GNSS (which includes the core GPS signal as well as its augmentations to ensure aviation suitability) is the basis for PBN and future 4D navigation services. When A-RNP will be implemented in Europe, some GNSS outages could imply a reversion to conventional systems and procedures that would provide reduced navigation services and potentially a decrease in airspace capacity.

3.7.3 Multi-constellation GNSS has clear technical advantages that will reduce the risk of navigation service degradation and support the provision of other operational benefits, including the expansion of approach service coverage to practically all airports. Galileo is the European contribution to multi-constellation GNSS. ICAO SARPS for Galileo are under development.

3.7.4 To realize these benefits, ICAO, States, ANSPs, standards bodies, manufacturers and aircraft operators need to coordinate activities to address and resolve related economic, technical and institutional issues identified in AN-Conf/12-WP/21 addressing multi-constellation GNSS. This is of particular importance for Europe to be able to ensure the acceptance and implementation of robust GNSS-based CNS services.

3.7.5 It is recognized that for the foreseeable future, a terrestrial infrastructure must be retained to sustain operations, both to ensure safe recovery of aircraft subject to a wide-area GNSS outage as well as minimize the operational impact of an outage. Only once sufficient operational experience with a robust GNSS infrastructure and an appropriately equipped user base is gained, could this principle be re-

evaluated. For the short and medium term, this terrestrial infrastructure will be based on a rationalized and optimized network of conventional navaids, as well as other CNS elements, in line with the European ATM Master Plan. It will need to be studied further in the years to come whether this combination of elements is sufficient in the very long term or if the standardization and implementation of a new capability (tentatively termed alternate positioning, navigation and time system (APNT)) is cost effective and operationally required in Europe, in particular in light of the higher levels of ATM system performance to be enabled by SESAR (see also WP/21).

3.7.6 While such studies should be supported, it needs to be emphasized that this should be done in a CNS context, taking into account all the various levels of redundancy offered and required. While traditionally, COM, NAV and SUR have been kept separate on purpose, the interdependencies introduced by GNSS will require interdisciplinary ways of working to ensure that available synergies can be exploited to create a future CNS system that meets evolving operational needs. Any new technology proposed will need to bring significant incremental benefits with respect to the current solution based on conventional navaids and offset the related costs. Additionally, any new technology will need to meet requirements for spectrum efficiency without creating undue technological complexities.

4. CONCLUSIONS

4.1 The navigation roadmap summarizes navigation developments particularly in the area of PBN. These developments aim to implement operational benefits in all phases of flight while balancing infrastructure and avionics requirements. However, it is recognized that the use of GNSS in other areas of CNS, such as surveillance, introduces additional complexities. While currently, navigation (as well as communications and surveillance) stands on its own in using GNSS alongside a developed conventional navigation environment supporting both conventional procedures and PBN, this may be more difficult for some of the advanced applications envisaged by SESAR. Studies are on-going to address these issues, which may lead to updates especially in the area of infrastructure. While the current conventional navigation infrastructure is expected to provide adequate GNSS reversion capabilities for navigation for many years to come, it is also considered essential that CNS developments are coordinated to ensure that technological and operational synergies are exploited.

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