International Civil Aviation Organization

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Agenda Item 7: Navigation (7.4 Other navigation-related matters)

ESTABLISHMENT AND VALIDATION OF AUSTRALIA'S BACKUP NAVIGATION NETWORK

(Presented by Australia)

SUMMARY

Australia has established a Backup Navigation Network (BNN) which is intended to support the safe completion of flight in the event Global Navigation Satellite System (GNSS) is unavailable. This paper presents information on Australia's approach for establishing the BNN, the Navigation Aids that form part of the BNN and safety assessment undertaken to validate the suitability of the BNN.

1 INTRODUCTION

1.1 In February 2016, Australia mandated the use of the Global Navigation Satellite System (GNSS) as the primary means of Instrument Flight Rules (IFR) navigation in Australia. This mandate was in line with a commitment from Australia to invest in modern air navigation infrastructure, including satellite technology, to further enhance safety and efficiency.

1.2 With the transition to GNSS as the primary means of Navigation, Australia undertook a comprehensive safety assessment and determined that a Backup Navigation Network (BNN), independent of GNSS was required to support the safe completion of flight, in the event GNSS is unavailable to a pilot[1]. The safety assessment took into consideration the unique operating context of Australia, different user scenarios, the risks associated with a loss of GNSS in different phases of flight and involved extensive consultation with key aviation stakeholders that is further elaborated in this paper.

[1] This could be due to a localised or widespread outage of GNSS or a specific issue with the GNSS avionics.

2 DISCUSSION

Methodology for Establishing the BNN

2.1 The BNN sites were selected to assure Australia's regulatory requirements for navigation capability continued to be met for all users. In particular, there are requirements for IFR aircraft to plan for a suitable destination alternate aerodrome in a range of circumstances, including requirements on the level of navigation capability fitted to the aircraft. These regulatory requirements identify users who require a ground-based Navigation Aid to be available at the alternate aerodrome[2], as well as the necessary infrastructure at the aerodrome.

2.2 Taking into consideration these regulatory requirements, the following key criteria were used to identify candidate sites that could form part of the BNN:

a) determine which aerodromes were commonly serviced by the air transport and or regional / charter segment of the aviation industry;

b) assess the capability of nearby aerodromes to adequately serve as an alternate considering factors including:
i. whether the aerodrome is certified;
ii. distance from the primary destination;
iii. aerodrome infrastructure, lighting, runway length, pavement strength; and

2.3 The candidate sites for inclusion in the BNN were extensively reviewed and agreed through a series of workshops over a period of approximately 10 years with stakeholders across the industry including, but not limited to, aircraft operators, the civilian Air Navigation Service Provider, aerodrome operators, the civil aviation Regulator and Australian government departments.

2.4 The following key assumptions, specific to the Australian aviation environment (circa 2005 to 2015), were used when establishing the BNN:

a) that Australian civil aviation regulatory rules will allow the use of TSO C145/C146 receivers as a sole means of navigation (for at least General Aviation private operation). Note, Australia has permitted aircraft fitted with TSO-C145/146 receivers to use GNSS as the sole means of IFR navigation (with conditions2) since 2006;

b) that aircraft operating in regional areas primarily nominate NDB serviced aerodromes as alternates; and

c) Regular Public Transport Jet (RPT) aircraft do not use NDBs other than as a last resort and the area of operations make the VOR the most appropriate alternative for these aircraft.

[2] These requirements are identified in the Australian Civil Aviation Manual of Standards relevant to the operation (e.g. Part 91, Part 121 and Part 135).

2.5 The following factors, specific to the Australian aviation environment (circa 2005 to 2015), influenced the composition of the BNN:

a) Out of a total of 394 Navigation Aids, 294 were NDBs and this made up the highest proportion of Navigation Aids particularly in regional areas. Given the relatively large size of Australia, NDBs were the most economically viable solution to provide navigation services to as many locations as possible when the Navigation Aid network was first developed;

b) prior to the introduction of GNSS, Australia required RPT and large charter aircraft to be fitted with VOR navigation capability;

c) Australia did not have a sufficiently dense network of DMEs to make DME/DME navigation viable. Therefore, when establishing the BNN, the use of DME/DME was not considered a feasible GNSS contingency arrangement to support area navigation; and

d) if the aerodrome is controlled, VOR and/or NDB would be retained plus ILS where presently installed.

Composition of the BNN

2.6 Table 1[3] summarises the number of Navigation Aids prior to and post the establishment of the BNN. Since the BNN was established in 2016, a further four ground-based Navigation Aids have been decommissioned based on consultation with the aviation community and an extensive safety assessment.

2.7 The navigation aids selected in the BNN were situated at or near aerodromes and have associated instrument approach procedures. Navigation aids used primarily for enroute navigation and locators were generally decommissioned.

Table 1 - Number of Navigation Aids pre and post establishment of the BNN

Type of Navigation Aid	**Number of Navigation Aids**		
	Pre-BNN	**BNN**	**Current (1 April 2025)**
NDB	245	111	109
VOR	84	48	47
DME (excluding ILS DME)	65	54	53
Total	**394**	**213**	**209**

Validating the Design of the BNN

2.8 The transition to the BNN was predicated on the safety argument that a reduction from the existing number of ground-based Navigation Aids to the BNN, in the GNSS environment, has a negligible effect on operational safety and that Australia's National Airways System continues to remain acceptably safe.

2.9 This safety argument was validated through the use of fault tree analyses with the top-level events of Mid-Air Collision (MAC) and Controlled Flight Into Terrain (CFIT) over a number of scenarios in the GNSS environment including:

[3] There are still some Navigation Aids in operation that do not form part of the BNN. These Navigation Aids have been retained based on industry feedback and have been excluded from Table 1.

a) GNSS with existing ground-based Navigation Aid network;
b) GNSS with BNN; and
c) GNSS only.

2.10 Table 2 and Table 3 summarise the results from the MAC and CFIT analysis respectively. The analysis was based on 50% of aircraft being equipped with an Inertial Navigation System (INS), a 35% probability that an aircraft is operating outside of nominal radar coverage at altitude 10,000 feet[4], a Navigation Aid in the BNN is available 98% of the time, and a 77% probability that an aircraft is both outside nominal radar coverage at 10,000 feet and there is no Navigation Aid in range[5].

Table 2 - Probability of MAC for different scenarios

Scenario	MAC per million flights
GNSS with existing ground-based navigation aid network	0.04
GNSS with BNN	0.04
GNSS only	0.04

Table 3 - Probability of CFIT for different scenarios

Scenario	CFIT per million flights
GNSS with existing ground-based navigation aid network	0.02
GNSS with BNN	0.03
GNSS only	0.05

2.11 As evident from Table 2 and Table 3, the analysis demonstrated that there is a negligible difference in the probability of a MAC or CFIT between the scenarios. Therefore, the analysis concluded that in the GNSS environment, the difference between the current and backup navigation networks has a negligible effect on operational safety and the National Airways System remains acceptably safe.

Future Review

2.12 Australia continues to review the composition of the BNN to assure it remains fit for purpose. Australia is considering the following factors in the future composition of the BNN:

a) the increasing number of instances of GNSS interference and spoofing being observed at other locations in the world;
b) the need for the state to consider economic resilience and mitigation to the potential for mid and long term GNSS disruptions or corruption;
c) instances of GNSS interference observed and reported locally;
d) instances of GNSS unavailability to pilots due to avionics failure or malfunction;
e) evolution of aircraft capabilities that will improve GNSS resilience; and

[4] This figure represents the proportion of all flight hours over Australia, including airspace out to 50 NM from the coastline, which are outside nominal radar coverage at altitude 10,000 feet. This figure was derived based on an analysis of IFR flight data. Note, ADS-B surveillance coverage was not considered in the analysis as a loss of GNSS additionally results in a loss of ADS-B capability.

[5] This figure indicates the probability that an aircraft is both outside nominal radar coverage at altitude 10,000 feet and not within 50 NM from a conventional Navigation Aid in the BNN. This is a conservative value as the rated coverage of a Navigation Aid is nominally significantly greater than 50 NM.

f) evolution of regulatory requirements for PBN including the requirements for flight planning and avionics fitment.

3 ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note Australia's approach to establishing the composition of the BNN and the safety assessment to validate the suitability of the BNN; and

b) discuss any relevant matters as appropriate.

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