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NAVIGATING THROUGH PNT LOSS: DEFINING A MINIMUM OPERATING NETWORK OF GROUND-BASED NAVIGATION AIDS

(Presented by New Zealand)

EXECUTIVE SUMMARY

In the mid-2010s New Zealand modernised its air navigation system infrastructure. Maximising the benefits of performance-based navigation, minimising the costs of maintaining legacy infrastructure, and delivering operating efficiencies were key outcomes; however, all rely on the availability, continuity, and integrity of GNSS inputs. GNSS is a single point of vulnerability. That prompted in-depth analysis of the minimum ground-based navigation infrastructure needed to:

1. Safely recover airborne aircraft in the event of GNSS signal loss; and
2. Maintain of ATS between New Zealand's main cities in a prolonged outage.

Subsequent work ensured that both the infrastructure and regulatory framework provided for these outcomes and backup for lower performance aircraft and helicopter emergency medical services and similar 'non-normal' operations.

New Zealand shares its approach as a resource for other States considering a minimum operating network.

<i>Strategic Goals:</i>	This working paper relates to Strategic Goal <i>Every flight is safe and secure.</i>
<i>Financial implications:</i>	Activities to be undertaken within existing budgetary allocations.
<i>References:</i>	A42-WP/335-TE/135, GNSS Radio Frequency Interference (RFI) A42-WP/237-TE/95, Regional CNS Minimal Operating Networks A42-WP/210-TE/75, Implementation of a Minimum Operational Network (MON) A42-WP/204-TE/70, Global Navigation Satellite System (GNSS) Resilience in a Radio Frequency Interference (RFI) Environment Doc 9750, <i>Global Air Navigation Plan</i>

1. INTRODUCTION

1.1 New Zealand notes several papers discussing minimum operating networks (MON) of non GNSS dependent ground-based navigation aids (GBNA) to manage the threat to GNSS-based systems from radio frequency interference (RFI) and other sources.

1.2 In the mid-2010s, New Zealand's surveillance radar infrastructure was approaching end-of-life and was replaced with automatic dependent surveillance — broadcast (ADS-B). That, together with the drive to fully enable performance-based navigation (PBN) drove a ten year, three stage programme to modernise the air navigation system, an initiative known as New Southern Sky.

1.3 Like many other States, New Zealand considered the potential operational and financial benefits of reducing the number of GBNA and optimising investment in replacement infrastructure. At the same time Airways, New Zealand's air navigation service provider (ANSP) and owner of many of the navigation aids, had proposed consolidation of the GBNA as part of system modernisation.

1.4 New Southern Sky considered the vulnerability of GNSS as part of system modernisation, including the potential consequences of and mitigations of signal loss due to on-board equipment failure, or widespread loss or degradation of the GNSS signal.

1.5 In that context, CAA New Zealand convened a sector-led panel to recommend a minimum operating network MON based on the New Zealand's operating context that would provide for two critical outcomes in the event of GNSS outage or degradation:

- a) safely recover all airborne aircraft flying IFR in the New Zealand FIR, and international incoming flights with no viable alternative; and
- b) maintain air transport services between New Zealand's major city airports in the event of a longer outage.

2. RATIONALE FOR A MINIMUM OPERATING NETWORK

2.1 The move to predominantly satellite-based navigation offers improved safety and efficiency and reduced environmental impact. It also offers the potential to rationalise GBNA, which can be costly to maintain. Some are aging and increasingly out of step with modern aircraft equipage and instrument flight procedures (the lack of Automatic Direction Finding equipment in most modern aircraft is one example.)

2.2 However, the GNSS signal is vulnerable. Threats include natural phenomena like space weather, and inadvertent disruption such as radio interference from adjacent frequency use¹. 'Spillover' effects from GPS location jammers, for example, have been widely reported². Spoofing, jamming, and deliberate radio frequency interference were and continue to be well documented risks to GNSS signal continuity, integrity and availability³.

¹ This topic has been widely covered at recent fora. For example, see recommendations from the [ICAO APAC Radio Navigation Symposium item 7.2 GNSS interference and mitigating measures](#) June 2025

² For example, see <https://rntfnd.org/2017/09/15/gps-jammer-delays-flights-in-france/>

³ For example, see [GNSS Interference: Impacts to airline operations](#) Eurocontrol March 2021.

2.3 New Zealand's *National Airspace and Air Navigation Plan* (2014) recommended that removal of all GBNA and adoption of GNSS-based procedures as the sole means of instrument navigation was not appropriate. To maximise the economic benefits of the move to performance-based navigation while maintaining redundancy in the system, GBNAs should be rationalised to provide a MON.

3. **DEFINING THE MINIMUM OPERATING NETWORK**

3.1 CAA New Zealand established a GBNA Review Panel comprising sector experts and representatives of key user groups. The scope covered assessment of the current and proposed future GBNA network to deliver the two objectives. The group was tasked with recommending retention, removal, or replacement of GBNAs to create a minimum operating network. The group explicitly did not consider cost as part of its work.

3.2 **How the Review Panel conducted its work**

3.2.1 The Panel developed a series of questions and issues for consideration when defining the MON. Given the diverse nature of New Zealand's aviation fleet, range of aviation operations and operating conditions, the Panel assessed regions separately, then built a national picture. The factors were:

- a) location and use patterns of current GBNAs;
- b) weather, specifically GBNAs enabling weather alternates;
- c) terrain, including effects on GBNA coverage and resulting constraints on aircraft with varying performance levels;
- d) actual operators in each region, including performance of aircraft used or the type of operations. This included services operations related to essential services such as hospitals, and specific needs of air ambulance services; and
- e) aerodrome infrastructure.

3.2.2 The group included specific assumptions in its analysis:

- a) to provide for the primary goal of recovering aircraft, MON GBNA should be located at aerodromes;
- b) all MON GBNA will have at least one approach for each instrument approach runway end;
- c) GBNA procedures will be replaced by performance-based navigation (PBN) procedures for aerodromes or routes from which GBNA are removed; and
- d) new rules for GNSS will permit GNSS primary means navigation outside the navigation cover of GBNA.

3.2.3 Surveillance was not in the Review Panel's scope, however, GNSS dependency was considered under New Southern Sky as part of surveillance modernisation. New Zealand moved to ADS-B

as the primary surveillance system, and retained primary radar capability to manage on-board equipment failures and short or persistent GNSS signal loss⁴.

3.3 Results

3.3.1 The Panel recommended a MON comprising GBNA at all controlled aerodromes. In addition, it called for three additional GBNA to provide coverage into the Oceanic FIR, and to areas that do not have controlled aerodromes and would therefore not have adequate coverage for aircraft recovery.

3.3.2 While the MON would not provide complete coverage, aircraft could readily fly into areas with coverage by climbing or lateral re-positioning.

3.3.3 Analysis of the MON determined that the network required to safely recover all IFR aircraft would support ATS between the main centres, albeit at a reduced traffic rate. No additional GBNA were required for service continuity.

3.3.4 The Panel recommended that all GBNA should be VHF omnidirectional radio range (VOR) with co-located distance measuring equipment (DME), meaning replacement of non-direction radio beacons (NDB) at some locations.

3.4 A regulatory framework to support the minimum operating network

3.4.1 The MON was a key consideration in the implementation of New Zealand's PBN environment, including consideration of how the rationalised GBNA network would support scheduled ATS on PBN routes, requirements for lower performance IFR aircraft, and 'non-normal' operations, such as helicopter emergency medical services (HEMS).

3.4.2 HEMS operators noted that removal of some GBNA would reduce access to some areas at night or in poor weather. An example would be a HEMS operation in a remote area with icing conditions at higher altitudes, mountainous terrain and no low-level GBNA coverage. In the event of GNSS system failure in this scenario, the aircraft could not safely climb to achieve GBNA coverage so would be unable to navigate or recover safely. As a result of these discussions, the New Zealand Government agreed to fund several GBNA in addition to the original MON to provide coverage in critical areas of the country.

3.4.3 The PBN rollout was effectively completed in 2023. New Zealand's PBN regulations take a flexible, performance-based approach to safe navigation procedures for HEMS and other non-normal operations, enabling flight crews to plan safe operations based on the individual capabilities of their aircraft and the environment they are operating in.

3.4.4 The discussions prompted by the MON helped shape the regulatory framework by providing the baseline GBNA requirements, and building on those to ensure the network provided for PBN operations beyond the primary MON objectives of aircraft recovery and main centre connectivity.

⁴ See [New radar for air traffic control | aviation.govt.nz](https://aviation.govt.nz/new-radar-for-air-traffic-control/)

4. CONCLUSION

4.1 The New Zealand experience highlights the importance of developing a baseline MON with clear outcomes in mind. In this case, the recovery of aircraft and the continuity of critical links provided invaluable focus to the initial MON description.

4.2 The one certainty about the operating environment is change. In New Zealand, revisions of the MON were necessary in response to HEMS operational requirements, and the rollout of PBN. Maintaining a GNBA network for backup in the case of GNSS outage, while not eroding the cost benefits of PBN and system modernisation, is a difficult line to walk. Key to striking the right balance was considering the MON and the regulatory framework together as a system, recognising that the settings for each component are critical to maximising benefits of the other.

4.3 Involving a wide range of sector interests and perspectives, and engaging in depth with the most affected operators was key to this programme. In the decade since this work began, technological and geopolitical changes, and the growing focus on GNSS RFI have heightened the focus on protection of, and providing backup for, GNSS. We encourage States to consider GNSS in the wider context of national and regional interests, maintaining critical infrastructure and essential services, including those provided or enabled by the air navigation system.

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