NSS System Assessment Report

new southern sky

Version 1.0

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Abbreviations

AC	Advisory Circular
ASSC	Aviation System Safety Criteria
ADS-B	Automatic Dependent Surveillance – Broadcast
COI	Critical Operational Issue
CONOPS	Concept of Operations
CME	Coronal Mass Ejection
DME	Distance Measuring Equipment
EMP	Electro-Magnetic Pulse
FOM	Figure of Merit
GBNA	Ground Based Navigation Aid
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HEMS	Helicopter Emergency Medical Services
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
IRU	Inertial Reference Unit
MOE	Measure of Effectiveness
MON	Minimum Operating Network
MOS	Measure of Suitability
NAANP	National Airspace and Air Navigation Plan
NSS	New Southern Sky
OT&E	Operational Test and Evaluation
SOPs	Standard Operating Practices
VFR	Visual Flight Rules
VOR	Very High Frequency Omnidirectional Range
VOR/DME	Co-located VOR and DME

Definitions used in Operational Test & Evaluation

Critical Operational Issues (COI)	COIs operational effectiveness or operational suitability issues (not parameters, objectives, or thresholds) that must be examined during operational testing to determine a system's capability to perform its intended mission. COIs are framed as questions to be answered by operational testers when evaluating a system's overall operational effectiveness, suitability and operational capabilities.
Measure of Effectiveness (MOE)	The measure of the degree to which a component, system, concept or approach is able to accomplish its mission when used by qualified and representative personnel in the environment planned or expected for employment. Employment considers a wide variety of factors to include organisation, doctrine, tactics, survivability, vulnerability, and threat.
Measures of Suitability (MOS)	The measure of the degree to which a component, system, concept or approach can be satisfactorily placed in field/flight use when operated and maintained by typical operational personnel in expected numbers, at the expected level of competency, to be reliable, compatible, maintainable, interoperable, available, logistically supportable, ergonomic, and safe.

Executive Summary

The NSS System Assessment has completed 20 simulation exercises, incorporating 488 planned IFR flights over 278 IFR flight hours, analysed the observed results, and reached the following conclusions:

a) The proposed Ground Based Navigation Aid (GBNA) network and cooperative contingency surveillance network can enable the safe recovery of IFR flights that have been affected by a disruption to GNSS/GPS services within the domestic airspace of New Zealand, provided the recommended GBNA and contingency surveillance changes are implemented prior to the operational transition of the NSS System.

b) The application of the proposed changes to the PBN Rules framework can enable the safe extraction and recovery of IFR flights that have been affected by a disruption to GNSS/GPS services.

c) The ATS workload generated by GNSS/GPS disruption or equipment failure events can be managed effectively within the current configuration of ATS areas of responsibility provided the recommendations of this report are implemented before the transition to the proposed Navigation and Surveillance environment (circa 2023). Any significant changes made to the current sector configuration may affect the capacity of ATS to manage future disruption events and therefore should be considered in the change process.

Introduction

The New Southern Sky (NSS) Programme is a New Zealand government endorsed plan to modernise the national airspace system of New Zealand and to deliver measurable improvements to safety, efficiency, resilience and cost effectiveness. The plan implements major components of the ICAO Global Air Navigation Plan commonly referred to as Aviation System Block Upgrades (ASBU's) that are tailored to the needs of the New Zealand aviation environment and its stakeholders.

The modernisation plan includes a range of separate projects overseen by a Governance Group of key industry stakeholders and managed by the stakeholder organisations. The integration of these work streams is managed by the NSS Working Group; a forum of industry organisation representatives chaired by the Director of NSS.

Two of the major changes being implemented are Performance Based Navigation (PBN) and Automatic Dependent Surveillance – Broadcast (ADS-B). Both changes involve the aviation system placing an increasing level of dependence on the Global Navigation Satellite System (GNSS) and, specifically on the Global Positioning System (GPS).

The National Airspace and Air Navigation Plan (NAANP) recognised the criticality of this common point of dependence for both navigation and surveillance of aircraft within the aviation system and recommended mitigations that were endorsed in the 2016 Aviation System Safety Criteria (ASSC) (updated in 2018).

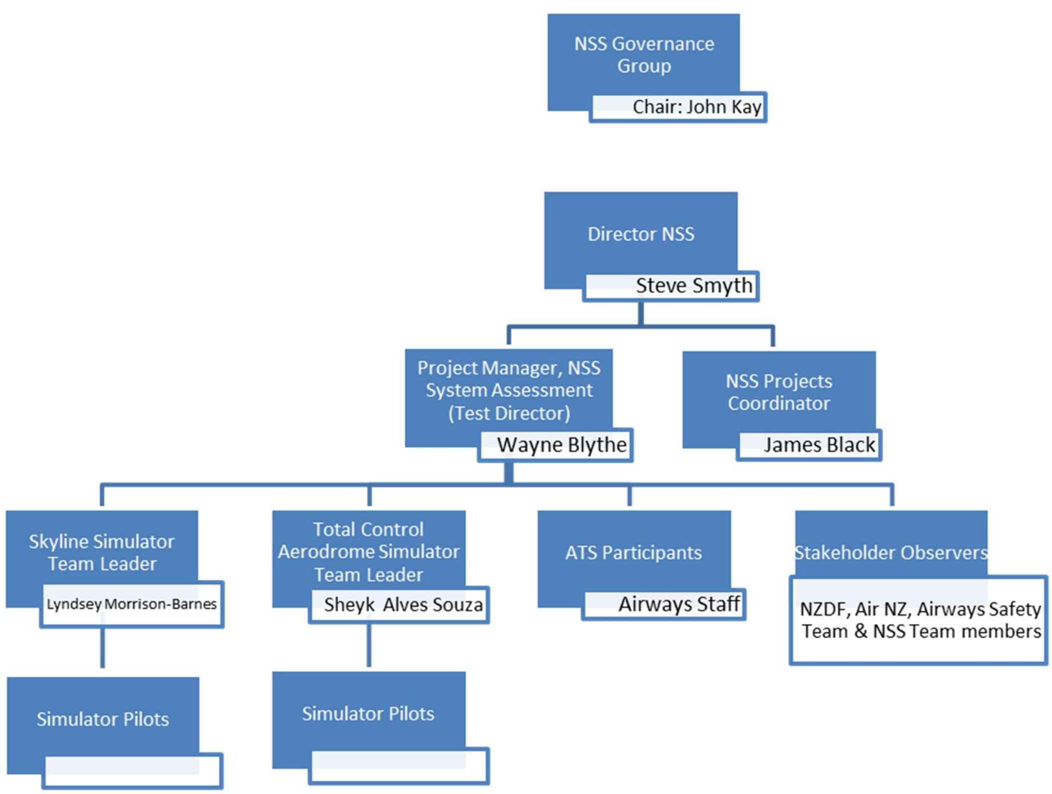
The NSS Ground Based Navigation Aid (GBNA) Infrastructure Strategy (November 2016) recommended a GBNA network and associated approach procedures be retained to allow reversion to conventional VOR/DME navigation when one or more aircraft encountered a disruption to GPS/GNSS service.

The ASSC recommended a contingency surveillance network be retained for the main trunk airspace around and between Auckland, Wellington and Christchurch airports. This mitigation would allow air traffic controllers to provide a surveillance-based separation service whenever one of more aircraft encountered a disruption to GPS/GNSS service while within the contingency surveillance system coverage area.

The objective of these mitigations is to ensure that any aircraft operating under instrument flight rules (IFR) that encounters a disruption to GPS/GNSS service can be recovered safely to a suitable aerodrome and in the event of a widespread disruption, that the Air Traffic Management system was capable of safely managing a future large scale disruption event with the proposed mitigations.

This report is intended to provide assurance to NSS Governance Group that the proposed navigation and surveillance systems can provide the mitigation intended by the ASSC.

Organisational Structure



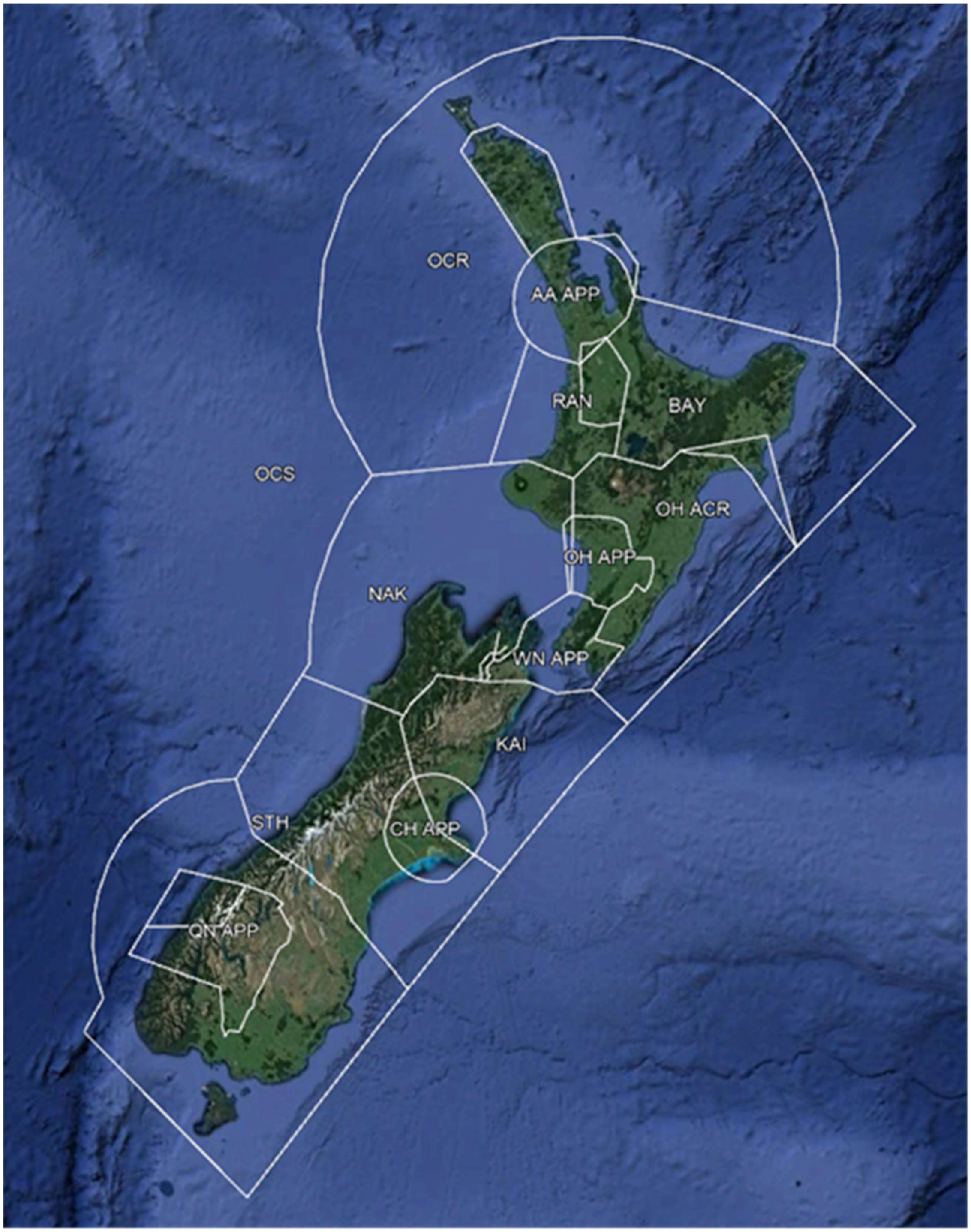
Assessment Methodology

1. A test environment was designed to enable a realistic simulation of the NSS CONOPs that will apply after 2023, including locations and coverage of ground-based navigation aids, the associated approach procedures and the coverage of planned contingency and non-cooperative surveillance systems.
2. Air traffic and weather scenarios were developed to enable a credible test of the proposed contingency navigation and surveillance environment post 2023.
3. The simulation exercises were tested prior to the assessment stage to ensure accurate representation of contingency capability and traffic flows.
4. Operating companies were asked to provide aircrew standard operating practices (SOPs) to ensure the simulations reflected best practice in the test scenarios.
5. Proposed Rule changes and ACs were also considered in the development of the test environment.
6. An agreed range of threats were incorporated in the test scenarios (i.e. threats that could disrupt GNSS/GPS services to NZ airspace users and ATS providers), the characteristics of each threat and known or expected mitigations that will or could be introduced to reduce the safety consequences from these threats.
7. A series of evaluation exercises (i.e. three for each representative sector(s) and two options for restoration of the main trunk services) were conducted.
8. Suitably qualified participants were used in the exercises and qualified observers assessed each exercise.
9. Safety data from observations and records of flight simulator exercises were collected and analysed by the Test Director. These records related to the performance of aircrew and the air traffic services responsible for managing the associated airspace sector(s).
10. The entire process was subject of a peer review by NZDF personnel experienced in Operational Test and Evaluation.
11. Video records of the assessment exercises and data from the exercises have been retained on the CAA InfoHub.
12. The Test Director produced a report for the NSS Governance Group that reflects the assumptions, findings and conclusions from the System Assessment and presented this report to the forums specified by CAA together with any recommendations and lessons learned for the respective NSS Partners.

Assumptions

The conclusions of the NSS System Assessment report are based on the following set of assumptions:

1. The VOR/DME network in 2023 will be configured as described in Appendix A.
2. The Contingency surveillance network will provide non-GNSS dependent cooperative surveillance coverage as described in Appendix B.
3. Non-cooperative surveillance coverage will be provided as described in Appendix C (unless a safety case supports an alternative coverage / capability).
4. CA Rule Part 91.21 and AC91.XX will provide the regulatory framework for PBN operations, airworthiness and operating approvals.
5. Airspace Sectorisation is closely aligned to the following graphic.


OCR
AA APP
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CH APP
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Constraints

The average experience level of participating Air Traffic Controllers exceeded that of the sector under test, the exceptions being the Nelson Tower and AA TMR/ OCA assessments. It is acknowledged that the current balance of the Airways workforce means that experience levels are higher than pre-COVID. The experience levels of the controllers who participated in the test scenarios provides important context to this report as in most test events the controllers under test had a wide range of experience, including practical experience delivering ATS prior to the advent of RNAV.

Sources of Hazards to GNSS/ GPS Services

GPS is a reliable system used by many global industries to enable improvements to safety and efficiency. However, like any technology and the services that rely on it, there are vulnerabilities that need to be understood and managed effectively. The following is a summary of the known sources of hazards to GPS and the aviation applications (i.e. PBN & ADS-B) considered in the NSS System Assessment.

Ref	Threat Source	Alert Time	Extent of disruption to navigation	Extent of disruption to surveillance	Potential Mitigations
01	Single or Dual GNSS/ GPS receiver failure on a single IFR aircraft.	No advance warning	Impacts PBN navigation of a single aircraft until aircraft lands.	Single aircraft is no longer tracked by ADS-B and alternative separation is required	1. Aircrew apply extraction procedures based on AC 91.XX 2. ATC apply alternate separation procedures based on contingency radar coverage or non-surveillance ATC procedures
02	Loss of a few GNSS/GPS satellites due to a SW fault or external interference	No advance warning	Impacts the performance of GNSS/GPS for <u>some aircraft</u> until standby satellites are repositioned to restore full service	ADS-B coverage may become erratic with coverage gaps appearing for brief periods. A reduction in FOM for affected aircraft may prevent use of surveillance separation in some areas.	1. Aircrew with IRU's / FMS may be capable of maintaining ANP within RNP specification for remaining segments of SID/STAR procedures or revert to VOR/DME or ILS approach. 2. ATC apply separation procedures based on contingency radar/ WAM coverage or non-surveillance separation.
03	Corruption of GPS signal-in-space caused by electromagnetic storm	Possibly no warning (maybe 15 – 60 mins advance warning if SWC detection occurs)	Loss of satellite lock occurs intermittently resulting in Nav system alerts or erroneous position data being presented	Low FOM indications or complete loss of track data from ADS-B.	1. Aircrew with IRU's / FMS may be capable of maintaining ANP within RNP specification for remaining segments of SID/STAR procedures or revert to VOR/DME or ILS approach. 2. ATC apply separation procedures based on contingency radar/ WAM coverage or non-surveillance separation.
04	Loss of several GNSS/ GPS satellites following a Eruptive Solar Storm (i.e. Coronal Mass Ejection)	15 – 60 mins advance warning of a CME caused disruption (i.e. Notice from ICAO Space Weather Centres)	Impacts all PBN services to IFR aircraft. Potential for disruption to aircraft avionics (computer reboots) and unreliable indications.	Impacts all ADS-B services to all aircraft. A large-scale loss of GNSS/ GPS satellites would result in prolonged outage. (The duration could be measured in months or years.)	1. ICAO Space Weather Service will provide notice to contracting states of impending SWX event and forecast impact area and duration. 2. NZ Government (CAA?) issue notice to Aviation industry and convene Crisis Management Group? 3. Decision made to suspend all air operations for EMP affected period and to conduct a controlled shut down of the aviation system to protect aircraft and infrastructure electronics. 4. A large-scale loss of GNSS/ GPS satellites would result in a prolonged outage.

Test Environment

The Airways Skyline and Total Control Aerodrome Simulator environments were used for the assessments. These environments were chosen because they were the most suitable for a high-level assessment of the aviation system. However, these environments had a few limitations For example, the Skyline simulator did not display all the information that was available in the operational Skyline platform for both controller workstations and the workstations used by observers. A full list of limitations is provided in Appendix F.

The current Skyline environment was updated with the location and coverage of contingency surveillance and navigation facilities that are expected to be operational by 2023 (or any subsequent transition date). The flights within the assessment exercises have been developed from a baseline of actual Skyline traffic (i.e. pre-COVID19 levels) with weather conditions that reflect common weather patterns experienced in NZ, and updated Part91 Rules /AC and operator SOPs were applied within the simulation and assessment process.

The NSS System Assessment was a high-level assessment of the performance of the aviation system not an assessment of individual performance. ATS and Pilots accurately represented the human element of the system under test, therefore, any errors they made is considered indicative of a typical error any other participant will make in the same circumstances. Participants assumed that observed errors were system induced (i.e. the error was not due to personal competence).

Post exercise debriefing and observer questioning was used to determine if errors observed were an unrelated slip or lapse, or if the error was induced by the system. All participants were invited to provide feedback to the NSS team of Observers following the assessment exercises.

One of the benefits of conducting the assessment before the infrastructure changes occurred was the opportunity to identify potential enhancements to both Pilot and ATC training that would ensure they are equipped to handle the challenges of managing the future operating environment.

Assessment Framework

The assessment framework adopted for this assessment is based on the principles outlined in NZDF Aviation Systems Trial and Operational Test and Evaluation Manual (New Zealand Air Publication (NZAP) 102) and CAA wish to acknowledge the valuable assistance of the NZDF’s Director of Evaluation & Airworthiness (Operating) in the development of this assessment and peer review.

The assessment plan involved 20 discrete exercises. Three different scenarios were assessed for each of the 6 sector locations and two exercises for the Main Trunk Contingency operations. The exercises assessed airspace sectors or combinations of airspace sectors that share common boundaries. The selection of sectors was designed to focus the assessment on representative environments that share common infrastructure design features. This enabled an effective assessment process that balanced stakeholder costs and effort while maintaining the integrity of the assessment.

A selection of qualified specialists from diverse aviation disciplines participated in the NSS System Assessment. They were provided with relevant briefing material and guidance. A copy of the Observer Briefing Pack is available (on request) as a supplement to this report.

The Observers were asked to provide answers to the Critical Operational Issue questions based on their observations during each assessment exercise.

Critical Operating Issue #1	The adequacy of the GBNA MON to enable effective extraction and recovery to a suitable aerodrome
MOE Statement	The GBNA MON provides an effective means of extraction and recovery to a suitable aerodrome for IFR aircraft

Measure of Effectiveness	Strongly Agree	Moderately Agree	Agree	Disagree	Moderately Disagree	Strongly Disagree
Indicate scoring (X)						
	The GBNA MON provides a suitable means of extraction and recovery to a suitable aerodrome for IFR aircraft					
Measure of Suitability	Strongly Agree	Moderately Agree	Agree	Disagree	Moderately Disagree	Strongly Disagree
Indicate Scoring (X)						

Critical Operating Issue #2	The adequacy of the Contingency Surveillance System to support effective recovery of IFR flights to a suitable aerodrome.					
MOE Statement	The Contingency Surveillance System provides an effective means of supporting the safe recovery of IFR aircraft to a suitable aerodrome.					
Measure of Effectiveness	Strongly Agree	Moderately Agree	Agree	Disagree	Moderately Disagree	Strongly Disagree
Indicate scoring (X)						
MOS Statement	The Contingency Surveillance System provides a suitable means of supporting recovery of IFR aircraft to a suitable aerodrome.					
Measure of Suitability	Strongly Agree	Moderately Agree	Agree	Disagree	Moderately Disagree	Strongly Disagree
Indicate Scoring (X)						

Critical Operating Issue #3	The adequacy of ATS to support effective recovery of IFR flights to a suitable aerodrome.					
MOE Statement	The Air Traffic Service provides an effective means of supporting the safe recovery of IFR aircraft to a suitable aerodrome.					
Measure of Effectiveness	Strongly Agree	Moderately Agree	Agree	Disagree	Moderately Disagree	Strongly Disagree
Indicate scoring (X)						
MOS Statement	The Air Traffic Service provides a suitable means of supporting recovery of IFR aircraft to a suitable aerodrome.					
Measure of Suitability	Strongly Agree	Moderately Agree	Agree	Disagree	Moderately Disagree	Strongly Disagree
Indicate Scoring (X)						

The observers were asked to record details of their observations, both positive and negative aspects of the system performance with regard to achieving the operational objectives (i.e. any shortcomings of contingency navigation or surveillance facilities, whether ATS priorities were applied appropriately, key decisions communicated clearly and in a timely manner). Any operational safety concerns (i.e. loss of separation with terrain or other flights in the simulation exercise), potential regulatory non-compliance, or other safety concerns. An assessment of workload changes during the recovery phase will be based on the Bedford Workload Scale[1] and suitability of procedures employed based on the Modified Cooper Harper Scale[2].

[1] The Bedford Scale is a uni-dimensional workload rating scale designed to identify operator's spare mental capacity while completing a task. The single dimension is assessed using a hierarchical decision tree that guides the operator through a ten point rating scale, each point of which is accompanied by a descriptor of the associated level of workload. It is simple, quick and easy to use to assess task load in high workload environments, but it does not have a diagnostic capability. The scale ranges from 1 to 10, with 1 indicating insignificant workload and 10 unmanageable workload.

[2] The modified Cooper Harper Scale is designed to quantify the effectiveness of processes and procedures which include a variety of perceptual, cognitive, and communications tasks, Like the Bedford scale, it is a hierarchal ten point rating scale, with each point being accompanied by a descriptor. The scale ranges from 1 to 10, with 1 indicating an enhancing process without deficiencies, through to 10 indicating n unacceptable process with critical deficiencies and/or safety compromises.

Results

1. The NSS System Assessment included 20 separate simulations, covering a total of 488 planned aircraft operations, 278 IFR flight hours conducted during 14 hours of simulation time.
2. The assessment was conducted on representative sectors of the national airspace system to ensure that sectors with similar contingency characteristics were considered separately. Duplication of effort was minimised with this approach (details are provided in Appendix E).
3. The recovery of representative traffic, in representative weather conditions without loss of separation was assessed and the lessons learned during this process were captured for future application.
4. There were no losses of separation observed (i.e. between aircraft or between aircraft and terrain) during the assessments.
5. The following types of flight delays were observed:
    a. Departing flights that were airborne returned to point of departure following the failure condition occurring.
    b. Planned departures were held at the point of departure.
    c. Airborne flights were held to sequence arrivals.
    d. Airborne flights held to dump fuel prior to returning to point of departure.
    e. Airborne flights diverted to alternate aerodromes.
6. The extent of disruption impacts varied significantly for each of the three exercises. Details of flights disruptions have been recorded for further analysis if required.
7. All airborne flights reached their destination or nominated alternate without exceeding their regulatory minimum fuel reserve allowances.

Findings

1. <u>The GBNA network is assessed as effective and suitable enabler of extraction and recovery for IFR flights</u>. This assessment is made on the basis that all qualified observers either Agree or Strongly Agree with this statement.
2. <u>The contingency surveillance network is assessed as an effective and suitable enabler of extraction and recovery for IFR flights</u> This assessment is made on the basis that the majority of qualified observers either Agree or Strongly Agree with this statement
    a. Note: A minority of qualified observers Disagreed with statements regarding the effectiveness and suitability of the contingency surveillance solution available within the Bay and Ohakea TMA Sectors. The reasons given to support this view include the limitations of contingency surveillance coverage, ATC not being able to provide a surveillance separation service to some flights, loss of interpolated tracks following loss of surveillance tracks and the lack of lateral separations to

resolve conflictions for unidentified flights. When considered in the context of the quantitative results of testing, these observations highlight issues which if addressed would further improve the effectiveness and suitability of the system.

b. Note: The reservations highlighted above are limited to the Bay and Ohakea TMA/ MAN sectors.

3. The capacity of ATS to manage disruptions is assessed as an effective and suitable enabler of recovery for IFR flights This assessment is made on the basis that the majority of qualified observers either Agree or Strongly Agree with this statement.

    a. Note: A minority of qualified observers Disagreed with the statements regarding the capacity of ATS to manage disruptions in the Bay and Ohakea TMA/MAN sectors. The reasons given to support this view include ATC not being able to provide a surveillance separation service for some aircraft, the loss of interpolated tracks following loss of surveillance tracks when the flight was still airborne, the lack of lateral separations to resolve conflictions for unidentified flights, lack of clear communication protocols and operational guidance related to the management of large scale GNSS disruption events. When considered in the context of the quantitative results of testing, these observations highlight issues which if addressed would further improve the effectiveness and suitability of the system.

4. ATS workload was observed to rise only slightly when dealing with single aircraft technical failures (i.e. loss of a Mode S transponder or GNSS/GPS services). However, the unalerted widespread disruption to GNSS/GPS event caused a sudden peak in workload that remained high for several minutes before returning to higher than normal but sustainable levels during the recovery. The sectors with planner roles were able to distribute workload more equitably during the disruption events and prevented excessive workloads for individual roles.

5. All observers agreed that the education of accountable managers, operational ATC and aircrew needed to achieve a greater awareness of the impact of space weather on Navigation and Surveillance systems, and agreed that a coordinated stakeholder response to sudden loss of GNSS/ GPS services would reduce ambiguity, and a need to proactively implement a transition from PBN (GNSS/GPS) based navigation to conventional navigation when disruption events occur or are forecast to occur, was a more effective and suitable response.

6. All observers and participants agreed that the Space Weather Advisory notice was difficult to interpret and needs to incorporate plain language terminology to reduce the potential for confusion.

7. The restoration of Main Trunk services following any widespread disruption event such as a solar storm should be the subject of a comprehensive multi-stakeholder safety case. The project team have simulated two route structures and traffic flows for consideration during the development of the recommended safety case. The details are included in a separate presentation.

A summary record of Observer responses to the COI questions is Provided in Appendix H. A comprehensive record of the Observer responses has been retained on the CAAs InfoHub.

Conclusions

1. All IFR flights affected by disruption to GNSS/ GPS in the assessment exercises were able to complete extraction and recovery procedures to reach a safe landing surface using the relevant GBNA and comply with Rule Part 91 & AC 91 guidance.

2. The cooperative contingency surveillance systems available to controllers in the following sectors enabled an effective and suitable means of managing the recovery of IFR flights affected by disruption to GNSS/ GPS in the assessment exercises (Ref Appendix H):

    a. Auckland TMA and Oceanic Radar Sectors

    b. Queenstown Approach and South Sectors

3. The cooperative contingency surveillance systems available to controllers in the following sectors enabled an effective means of managing the recovery of IFR flights but some Observers expressed concern about the effectiveness and suitability of the contingency coverage, documented ATC guidance, training, and procedures available to deal with a large-scale GNSS/ GPS disruption event (Ref Appendix H):

    a. Bay Sector

    b. Ohakea TMA and Manawatu Sectors

4. The suitability of Air Traffic Services to manage large scale GNSS/GPS disruptions would be significantly improved by establishing clear lines of responsibility for a national response to any widespread actual or forecast loss of GNSS/GPS. A nationally coordinated response to such disruptions should include suspension of the use of PBN / ADS-B and reversion to conventional navigation.

5. Aircrew and ATC procedures should be published to outline standard practices used in any widespread GNSS/GPS disruption event. These should form the basis for operational training (including refresher training) for aviation license holders and accountable managers.

6. The restoration of main trunk services following any widespread GNSS/GPS disruption event should be supported by a comprehensive multi-stakeholder safety case. This should be developed prior to the transition in 2023 and become the basis for a planned response to these events.

Recommendations

1. The NSS Governance Group is invited to note this report and be assured that the proposed NSS Systems for Navigation and Surveillance in the New Zealand FIR, can meet the ASSC criteria and stakeholder expectations for flight safety and resilience.

2. The CAA considers seeking guidance from appropriate scientific sources on the space weather phenomenon and its impact on aviation activity and systems. This information should inform the training curriculum for aviators, ATC and related roles in the aviation system.

3. The CAA considers developing an agreement with key aviation stakeholders on the best practice response for management of a widespread GNSS/GPS disruption. This agreement should form the basis for specific communication protocols and procedures to be followed by key stakeholders (i.e. CAA, Met Service, Airways NZ and Airline Operating Companies).

4. The CAA considers preparing and publishing guidance in the AIP (or other suitable document) for aircrew and ATC to use when responding to GNSS/GPS disruption events including:

    a. Use of plain language when verbally relaying Space Weather Advisories

    b. Considering introducing airport specific safe climb sectors that could be used during periods of GNSS disruption.

5. Airways NZ considers initiating a multi-stakeholder safety case to determine the appropriate design of a contingency route structure between Auckland, Wellington and Christchurch airports, and associated ATS procedures that could be implemented following a widespread and prolonged GNSS/GPS disruption event.

6. The NSS partners consider initiating a future NSS System Assessment following the implementation of all the recommendations of this report to verify that the changes made achieve the desired outcomes.

Acknowledgements

The NSS team acknowledge the significant contribution made to the success of this project by Airways NZ (providing Air Traffic Simulation facilities, operational ATS and training staff), Air New Zealand (providing aircrew for qualified observers), New Zealand Defence Force (providing aircrew for qualified observers, OT&E guidance, and Peer Review) and CAA staff from the Flight Ops Inspection and NSS teams (providing qualified observers). The nimble collaboration of the partners has enabled the project to achieve its objectives in the context of challenging circumstances including disruptions due to changes in COVID-19 alert levels and severe constraints on each organisation’s resources.

A detailed list of participants and support personnel is included in Appendix G. Please direct any questions about the report to the Test Director or Chair of the NSS Work Group. Please do not approach these individuals for comment on the report.

Records of the Assessment Exercises

1. Screen recordings of the following exercises in Airways NZ Skyline or Total Control Aerodrome Simulator have been stored on the CAA InfoHub:

Sector	Ex01	Ex02	Ex03	Date
Auckland TMA/ OCR	√	√	√	22 Feb 2021
Ohakea TMA / MAN	√	√	√	30 Mar 2021
North Sector	√	√	√	31 Mar 2021
Bay Sector	√	√	√	20 Apr 2021
Queenstown TMA / South Sector	√	√	√	23 Apr 2021
Nelson Tower	√	√	√	08 May 2021
	RNAV2	MON		
Main Trunk Contingency	√	√		16 April 2021

2. Extraction and Recovery Procedures Recorded during Simulation Exercises

Extraction Procedures Assessment

Location	ATS Team	Aerodrome	Aircraft Type / Ops Rule	Aircraft Operator	Phase of Flight
North Sector	ATSS	NZGB	C208/ Part 135	Barrier Airlines	Departure
		NZJR	AW169 / Part135	ARHT	Approach
		NZKK	DHC8-Q300/ Part 121	Air NZ	Approach
Bay Sector	Bay Team	NZTO	DA42/ Part 135?	AR Flying School?	Approach
		NZTO	PA46 / Part 91	PVT	Departure
OH TMA/ MAN	Ohakea Team	NZMS	JS32/ Part 135	Originair (OGN)	Approach
		NZWU	S8/ Part 135	Sounds Air	Departure
NS Approach	NS TWR Team	NZTK	PA34/3 / Part135	Golden Bay Air	Departure
QN Approach/ South Sector	Bay / QN & Area Teams	NZDU	BK117 / Part 135	HeliOtago	Approach
		NZLX	Saab340 / Part125?	Air Chathams	Departure
		NZWF	S8 / Part 135	Sounds Air	Approach

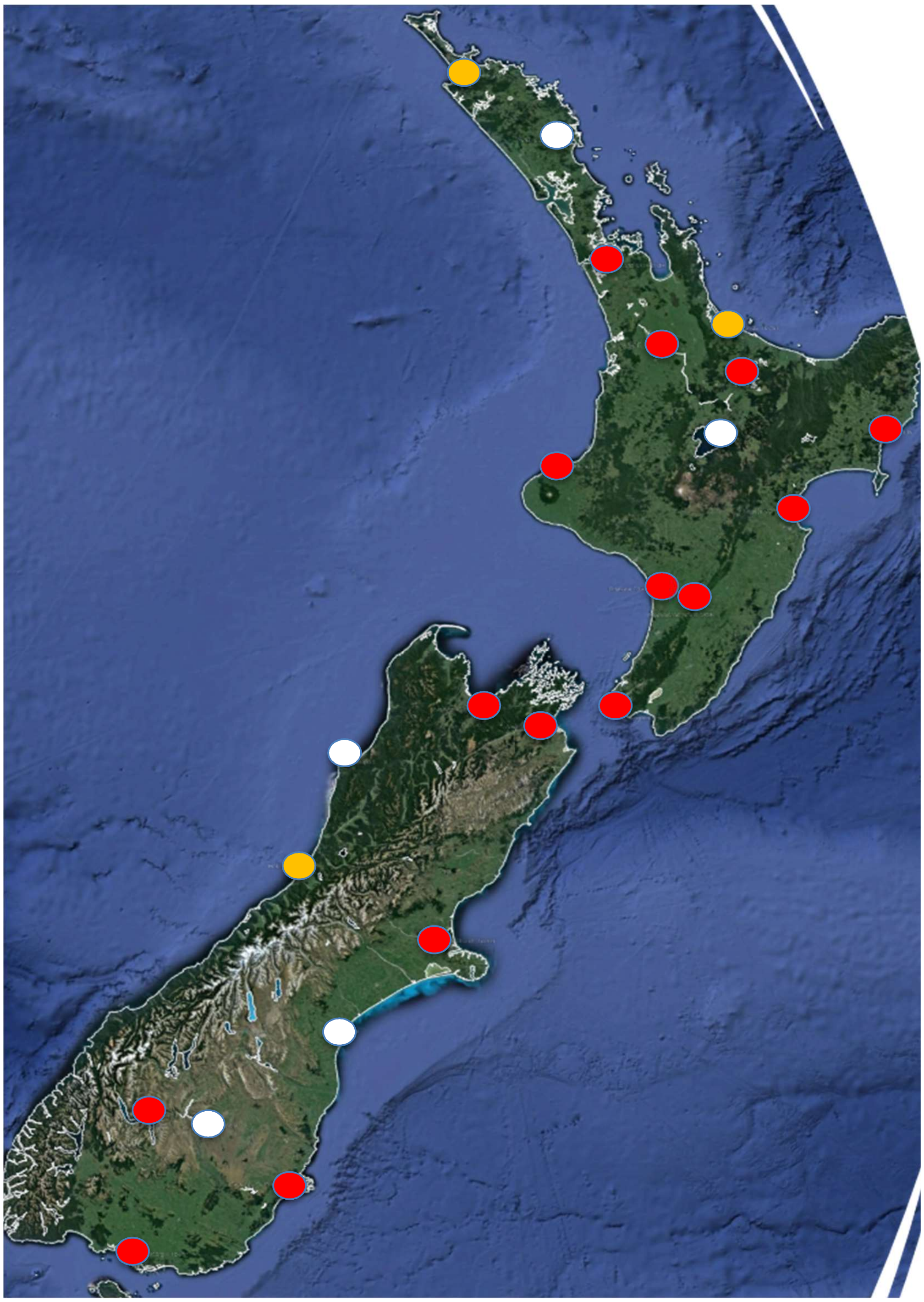
Examples of Operator Extraction and Recovery procedures have been supplied by Air New Zealand and Auckland Rescue Helicopter Trust for the following aircraft types.

- A320, ATR76 and DHC8/Q300
- AW169

Appendix A: VOR/DME Network (GBNA/MON)

- Red symbols indicate existing VOR/DME sites
- Yellow symbols indicate VOR/DME sites proposed by the GBNA Review Panel of NSS in 2019 and White symbols indicate VOR/DME sites proposed by the GBNA Technical Panel in Feb 2021.
- ILS/DME Approaches will be retained at AKL, WLG, CHC and DUD

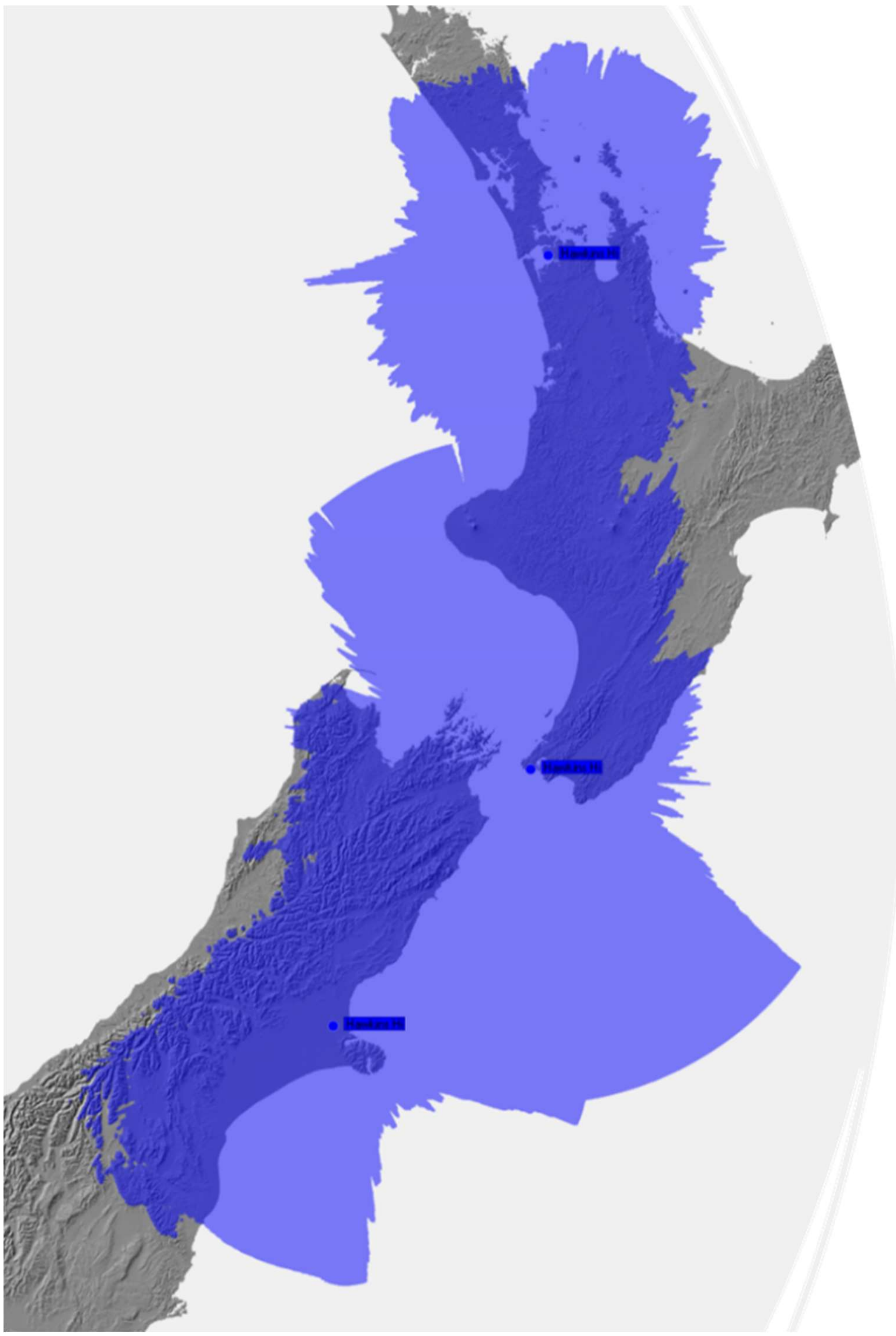
Refer ASSC Criteria 1.5, 2.1, 3TI.3, 3.AE.1, 3.AE.2, 3.AE.3, 3.AN.11, 12, 13 & 14



Appendix B: Non-GNSS Dependent Contingency Surveillance Coverage

- The graphic highlights contingency secondary surveillance radar coverage @ 10,000ft
- The WLG – CHC routes have extensive overlapping MSSR coverage.
- Most of the remaining coverage area is supported by a single MSSR
- Use of the 3nm separation standard within Terminal Areas is still available but a risk assessment is needed to determine if this standard is appropriate in the operational context (i.e. an extended period of disruption to GNSS/GPS).

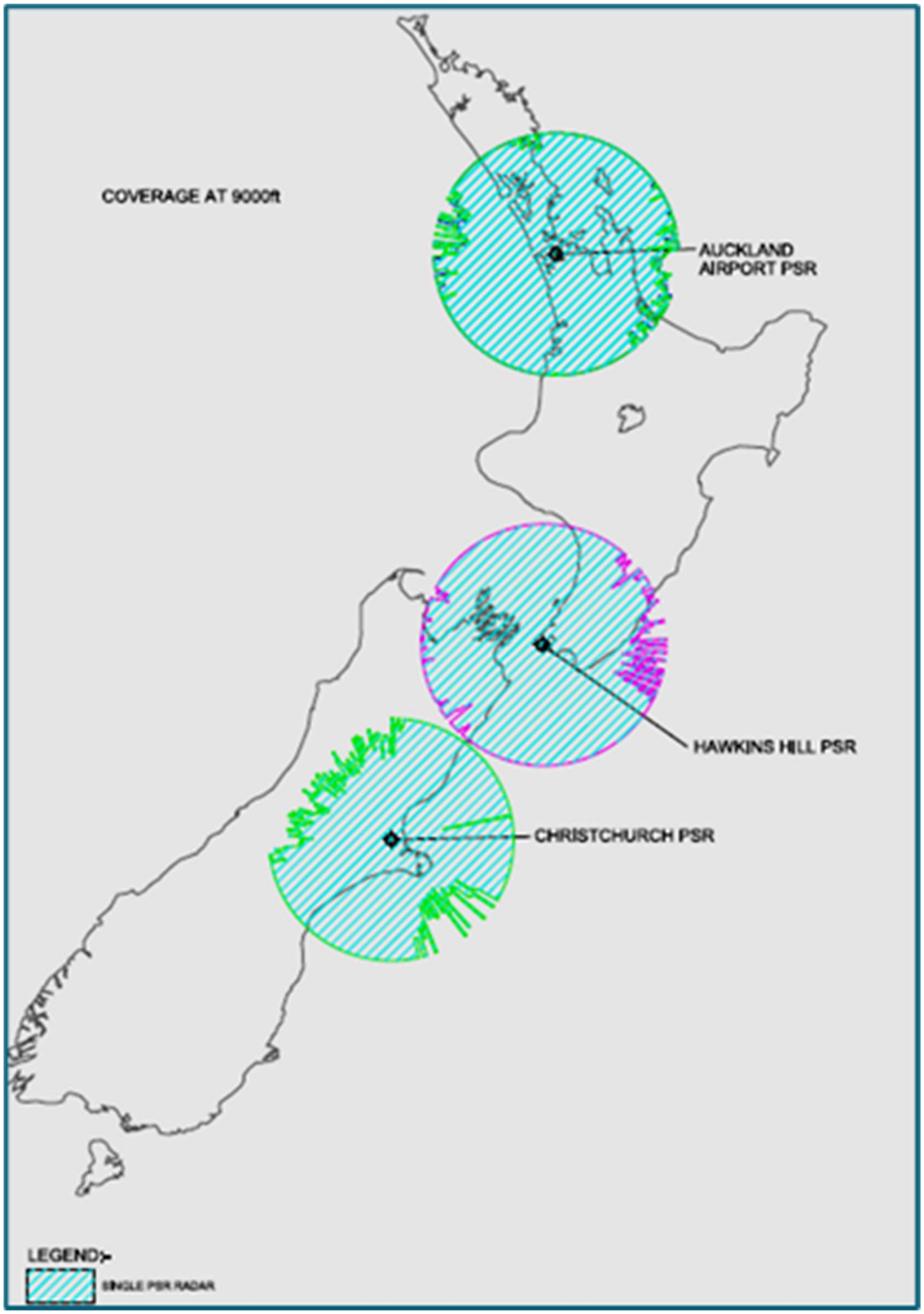
Refer ASSC criteria: 3.AN.10



Appendix C: Non-cooperative Surveillance coverage

- PSR coverage was assumed to be unchanged from present state (i.e. approximately 80nm range from AKL, WLG & CHC). A safety case should support any proposal to change this assumption.

Refer ASSC 3.AN.9



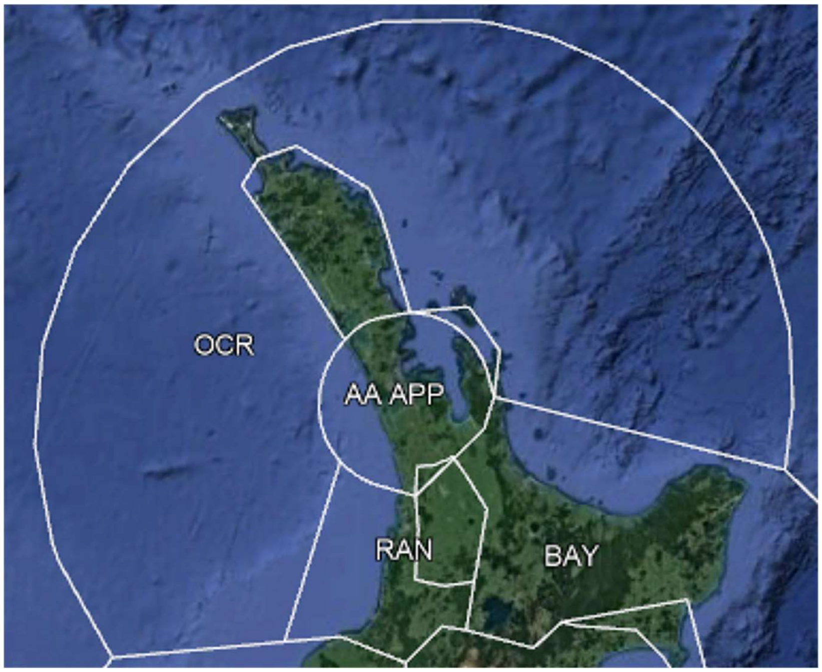
Appendix D: CA Regulatory Guidance

https://www.aviation.govt.nz/assets/rules/nprms-and-summaries/PBN-regulatory-framework/AC91.XX-Rev.0-Extraction-and-Recovery-Guidance-Material-Pre-Technical-Consultation.pdf

Appendix E: Operational Sectors Selected for Assessment

The following sectors were selected to ensure a representative sample of ATC & FIS sectors were included in the NSS System Assessment.

Auckland TMA in conjunction with Oceanic Radar



Auckland TMA shares common contingency infrastructure characteristics to Wellington and Christchurch TMA Sectors and similar traffic types although traffic volumes vary significantly between them:

- VOR/DME and ILS navigation facilities to support extraction and recovery of IFR flights.
- Comprehensive cooperative contingency surveillance coverage (i.e. SSR).
- Extensive non-cooperative surveillance coverage within the AA TMA sector (i.e. PSR).

Bay Sector

The Bay Sector has unique characteristics and challenges including managing three regional approach services simultaneously, highly variable traffic types and volumes:

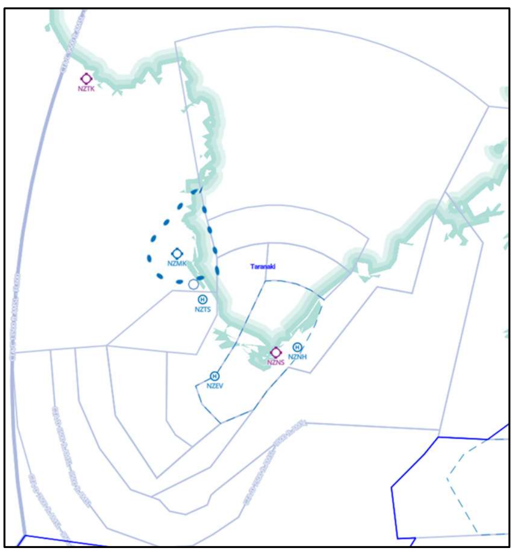
- VOR/DME navigation facilities at key regional aerodromes to support extraction and recovery of IFR flights.
- Limited cooperative contingency surveillance coverage (i.e. SSR from AKL airport/ Rua-o-te-whenua).
- Very limited non-cooperative surveillance coverage (i.e. PSR).

Ohakea Approach and Area Sector (Manawatu)

The Ohakea and Manawatu Sectors have unique characteristics and challenges including managing two regional approach services simultaneously, highly variable traffic types and volumes:

- VOR/DME or ILS navigation facilities at key regional/ military aerodromes to support extraction and recovery of IFR flights.
- Limited cooperative contingency surveillance coverage (i.e. SSR from Hawkins Hill / near WLG airport).
- Very limited non-cooperative surveillance coverage (i.e. PSR located at Hawkins Hill).

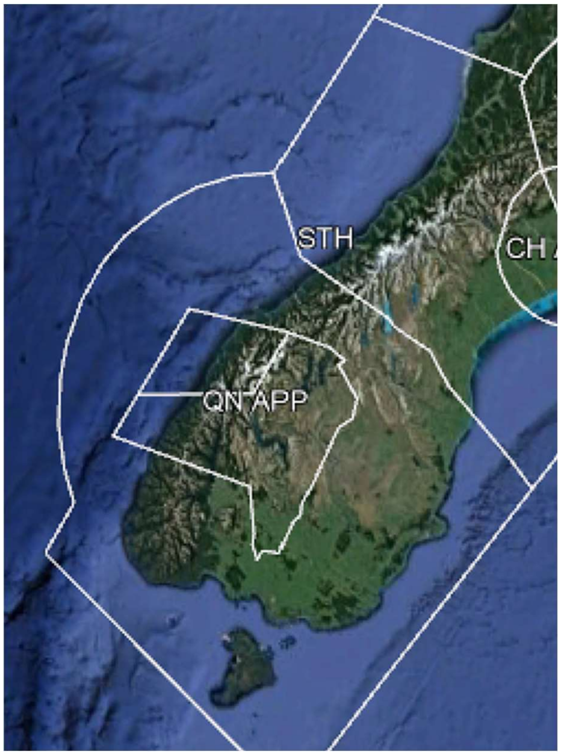
Nelson Tower



Nelson Tower has unique characteristics and challenges including providing a non-surveillance-based approach service to a busy regional airport.

- VOR/DME navigation facilities located on the airport at Nelson to support extraction and recovery of IFR flights.
- Limited cooperative contingency surveillance coverage (i.e. SSR from Hawkins Hill / near WLG airport).
- Very limited non-cooperative surveillance coverage (i.e. PSR located at Hawkins Hill).

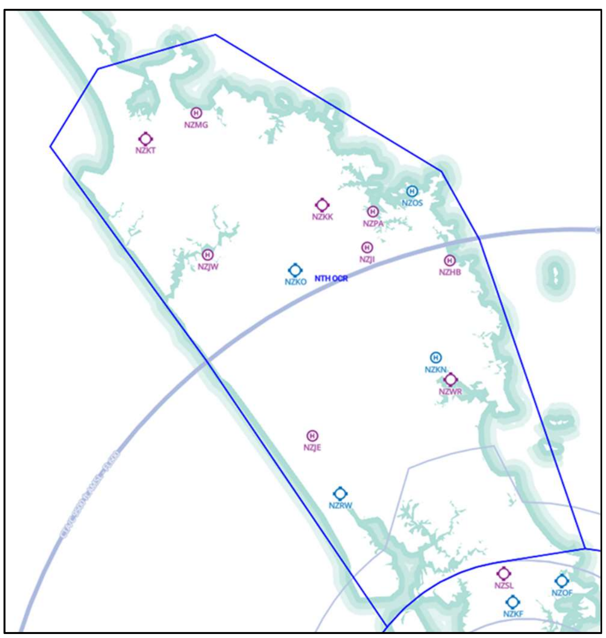
Queenstown Approach and South Sector



Queenstown Approach and South Sectors have unique characteristics and challenges including managing a mix of domestic and international traffic, inflexible RNP AR approaches into a technically challenging airport:

- VOR/DME or ILS navigation facilities at key regional aerodromes to support extraction and recovery of IFR flights.
- Extensive cooperative contingency surveillance coverage (i.e. Wide Area Multi-lateration around Queenstown and SSR from either Cass Peak / or CHC airport).
- South Sector has very limited non-cooperative surveillance coverage (i.e. PSR located at CHC airport) and Queenstown Approach has no non-cooperative surveillance coverage.

North Sector FIS



North FIS has unique characteristics and challenges including providing a flight information service rather than an ATC service, managing a mix of traffic types and volumes at diverse locations.

- VOR/DME navigation facilities will be located at key regional aerodromes to support extraction and recovery of IFR flights.
- Limited cooperative contingency surveillance coverage (i.e. SSR from either RUA or AKL airport).
- Very limited non-cooperative surveillance coverage (i.e. PSR located at AKL airport).

Note: The Taranaki Sector(NAK), Kaikoura Sector(KAI) and Raglan Sector(RAN) were excluded from the NSS assessment process. These sectors share common characteristics which include extensive contingency surveillance coverage and predominantly IFR traffic that operates above 10,000ft that is equipped with advanced navigation capabilities.

Appendix F: Limitations of the Test Environment

The Airways Skyline and Total Control Aerodrome simulation environments were used for the assessments. Although these environments were suitable, there were some limitations in displayed information for both ATC controller workstations and the CWPs used by observers. A reminder of these limitations was included in the initial exercise briefing and listed below for reference:

1) The Track Labels on the ATC CWPs <u>will not show</u> an ADS-B Alert message (normally yellow text at the top of label for each affected track) when ADS-B track messages are not available to Skyline. However, the Test Director will notify the ATC at their CWPs when the Alert would be expected to appear.
2) The Observer CWPs <u>will not show</u> all the detail reflected on the ATC CWP displays. The following information will not be displayed;
    a) The symbols for tracks that qualify for 3nm Separation (Green Triangles)
    b) The symbols for tracks that qualify for 5nm Separation (Green Hexagons)
    c) The hand off / hand in indications will not be evident to Observers. Flights entering the controllers sector will be coloured blue prior to hand in and will flash approaching the boundary on the ATC CWP. The flashing will continue until the controller accepts control of the flight plan. Flights exiting a controllers sector will flash when hand off is initiated (manually or automatically approaching the boundary) and continue to flash until accepted by the adjacent sector controller.
    d) Any ATC initiated actions (e.g. moving a label to avoid clutter or initiating hand out or acceptance of inbound flights)
3) Other than these exceptions the Observer displays will provide an accurate situational picture and when combined with the audio feed supported the assessment function.

Appendix G: Participants and Support Team

Stakeholder Organisation	Team	Participant
Airways NZ	Head of Policy and Standards	Mark Blanchard
	Airways Training: Simulator Teams	Lyndsey Morrison-Barnes, Team Leader Sheyk Alves Souza, Team Leader
	Safety Team	Sarah Druce
	Auckland Approach Team	Karl Taylor, Team Leader Glenn Sampson Ben Longworth
	Auckland Oceanic Team	Allan London, Team Leader Lydia Hann
	Ohakea Approach and Area Team	Darren Meyers, Team Leader Matthew Plunket Andrew Leadley Tim Brazier
	Air Traffic Services Support Team	Owen Pritchard Nico Kozomara
	Bay & Queenstown Approach Team	Lucy Taylor, Team Leader John Anthony Mike Bishop Rob Buhler
	Area Team	Stu Balchin, Team Leader Ryan Hall Jeff Smith
	Nelson Tower Team	Adam Arnold-Kelly, Chief Controller Mark Stokell
	Management Team Support	Dean Urquhart, Manager Planning and Performance Phil Rakena, Operations Development Specialist
Air New Zealand	A320 Fleet	Operations Manager
	Q300 Fleet	Technical Pilots
Civil Aviation Authority	Certification, Air Transport and Flight Training Team	Hamish Kim, FOI Flight Ops Inspector

	New Southern Sky Team	Steve Smyth, Director NSS Scott Griffith, Aviation Examiner and Standards Emerging Technology James Black, Projects Coordinator NSS Wayne Blythe, Project Manager and Test Director
New Zealand Defence Force	Directorate of Evaluation and Airworthiness (Operating)	WGCDR L.G. Wilson, Director of Evaluation & Airworthiness (Operating) SQNLDR Charlie Matthews, Executive Officer, Directorate of Evaluation & Airworthiness (Operating)

Appendix H: Summary of Assessment Results

The NSS System Assessment observers used the following criteria to score the system performance in each of the exercises with respect to the Critical Operational Issues:

- Measure of Effectiveness (MOE)
- Measure of Suitability (MOS)
- Bedford Workload Scale (BWS)
- Modified Cooper Harper Scale (MCH)

Definitions of these scales are contained in the Observer Briefing Pack along with general guidance on the assessment process.

2021 02 26 System Assessment Observer

Each exercise focused on a single failure condition described below:

Exercise #01 – Single Aircraft Transponder Failure and or Unable RNAV

Exercise #02 – Unalerted large scale disruption to GNSS

Exercise #03 – Alerted large scale disruption to GNSS (Space Weather Advisory / Solar Storm)

AA TMA/ OCR Assessment Results Range:

Critical Operational Issues	MOE			MOS		
	EX01	EX02	EX03	EX01	EX02	EX03
Adequacy of GBNA	Not Tested	Strongly or Moderately agree	Strongly or Moderately agree	Not Tested	Strongly or Moderately agree	Strongly or Moderately agree
Adequacy of Contingency SUR	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree
Adequacy of ATS Capacity	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree
ATS Workload/ Procedures	AA TMA			OCR Sector		
Bedford Workload Scale	4	4	4	2	5-7	5-7
Modified Cooper Harper Scale	5	5	5	2	5	5

Ohakea TMA/ Manawatu Sector Assessment Results Range:

Critical Operational Issues	MOE			MOS		
	EX01	EX02	EX03	EX01	EX02	EX03
Adequacy of GBNA	Not Tested	Strongly or Moderately agree	Strongly or Moderately agree	Not Tested	Moderately Agree to Agree	Strongly Agree to Agree
Adequacy of Contingency SUR	Strongly or Moderately agree to Disagree	Strongly or Moderately agree	Strongly or Moderately agree	Moderately Agree to Moderately Disagree	Moderately Agree to Agree	Strongly Agree to Agree
Adequacy of ATS Capacity	Strongly or Moderately agree to Moderately Disagree	Strongly or Moderately agree	Strongly or Moderately agree	Moderately Agree to Moderately Disagree	Strongly or Moderately agree	Strongly Agree to Agree
ATS Workload/ Procedures	OH TMA			Manawatu Sector		
Bedford Workload Scale	5	5	5	5	5	5
Modified Cooper Harper Scale	5	5	4	5	4	4

North Sector FIS Results Range:

Critical Operational Issues	MOE			MOS		
	EX01	EX02	EX03	EX01	EX02	EX03
Adequacy of GBNA	Not Tested	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree
Adequacy of Contingency SUR	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree
Adequacy of ATS Capacity	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree	Strongly or Moderately agree
ATS Workload/ Procedures	North Sector FIS					
Bedford Workload Scale	5	4-6	3-4			
Modified Cooper Harper Scale	4	5-7	5-6			

Bay Sector Assessment Results Range:

Critical Operational Issues	MOE			MOS		
	EX01	EX02	EX03	EX01	EX02	EX03
Adequacy of GBNA	Strongly agree to agree	Strongly agree to agree	Strongly agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree
Adequacy of Contingency SUR	Strongly Agree to Agree	Strongly agree to disagree	Strongly agree to Disagree	Strongly agree to agree	Strongly Agree to Disagree	Strongly Agree to Disagree
Adequacy of ATS Capacity	Strongly agree to Disagree	Strongly agree to Agree	Strongly agree to Disagree	Strongly Agree to Disagree	Strongly Agree to Agree	Strongly agree to Disagree
ATS Workload/ Procedures	Bay Sector					
Bedford Workload Scale	6	4	5-6			
Modified Cooper Harper Scale	5	5-6	6-7			

Queenstown Approach / South Sector Assessment Results Range:

Critical Operational Issues	MOE			MOS		
	EX01	EX02	EX03	EX01	EX02	EX03
Adequacy of GBNA	Not Tested	Strongly Agree to Agree	Strongly Agree to Agree	Not Tested	Strongly Agree to Agree	Strongly Agree to Agree
Adequacy of Contingency SUR	Strongly or Moderately agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree
Adequacy of ATS Capacity	Strongly agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree
ATS Workload/ Procedures	QN Approach			South Sector		
Bedford Workload Scale	2	4	2-3	3	4	2-3
Modified Cooper Harper Scale	2	4	3	3	4	4

Nelson Tower Assessment Results Range:

Critical Operational Issues	MOE			MOS		
	EX01	EX02	EX03	EX01	EX02	EX03
Adequacy of GBNA	Not Tested	Strongly Agree to Agree	Strongly Agree to Agree	Not Tested	Strongly Agree to Agree	Strongly Agree to Agree
Adequacy of Contingency SUR	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree
Adequacy of ATS Capacity	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree	Strongly Agree to Agree
ATS Workload/ Procedures	Nelson Tower					
Bedford Workload Scale	3	Peaked briefly @ (7- 8) then reduced to 3	Peaked briefly @ (3-4) then reduced to 2			
Modified Cooper Harper Scale	3	3	3			

Appendix I: Aviation System Safety Criteria (2018)

2018 ASSC Report
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