MARSHALL DAY Acoustics

EPBC ACT 2010/5747
F-35A NOISE AND FLIGHT PATH ACTIVITY
DECEMBER 2018 – DECEMBER 2020

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F-35A Noise and Flight Path Activity: December 2018 – December 2020

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EXECUTIVE SUMMARY

The Department of Environment's approval decision, EPBC Act project Approval (EPBC 2010/5747), for the flying operations of the F-35A aircraft in Australia outlines requirements for the management of environmental aircraft noise.

This report addresses Condition 1, Condition 3.e.ii. and Condition 3.e.ii.i. of the approval decision. Specifically, F-35A aircraft flight activity and noise level predictions presented in the Environmental Impact Statement (EIS) have been compared with actual data measured during the transition from F/A-18A/B Hornet to F-35A aircraft operations at RAAF Base Williamtown and Salt Ash Air Weapons Range (SAAWR). The comparison is based on an analysis of data collected by Defence's Noise and Flight Path Monitoring System (NFPMS) over the period from December 2018 to December 2020, including flight tracks and measured noise levels in the surrounding area.

The data for this period demonstrated that the number of flying days, typical operating hours, and general flight tracks of the F-35A aircraft are similar to F/A-18A/B Hornet operations. Importantly, the EIS predictions for F-35A aircraft operations were based on a forecast for the year 2025 when all aircraft would have been delivered and at Full Operating Capability. As all F-35A aircraft have not yet been delivered to date, and the aircraft is not at Full Operating Capability, there were fewer F-35A aircraft operations and therefore actual aircraft noise events than presented in the EIS.

Aircraft noise levels are prone to high degrees of variability when comparing individual, day-to-day and month-to-month operations. This is evident in the wide variation in measured aircraft noise levels for both F-35A aircraft and F/A-18A/B Hornet. This variability contributed to differences between measured and predicted noise levels. In particular, measured noise levels above and below the predicted noise levels were identified for both aircraft, depending on the type of aircraft operation and the location being considered. However, while differences were evident between the measurements and predictions, the range of the measured noise levels at most noise sensitive locations were similar for both aircraft. Further, while measured average maximum noise levels of the F-35A were marginally higher than the F/A-18A/B Hornet at some locations, this occurred in areas where there were a low number of aircraft events. These outcomes are consistent with expectations, as the EIS noise predictions were determined using modelling that was primarily configured for the assessment of aircraft noise level changes rather than forecasting absolute noise levels of individual operations. At the locations where the difference between the measured and EIS predicted noise levels were greatest, the differences were evident for both aircraft.

The measured F-35A aircraft and F/A-18A/B Hornet arrival noise levels in areas east of RAAF Base Williamtown and SAAWR were considerably higher than indicated by the EIS predictions. However, the number of aircraft events in these areas were relatively low. Further, the differences between the actual measured noise levels and the EIS predictions were comparable for both aircraft; this indicates for both aircraft a systematic difference between the way arrivals occur in practice and the way that these procedures were modelled in the EIS.

At locations around Raymond Terrace, both F-35A aircraft and F/A-18A/B Hornet departure noise levels were considerably higher than the EIS predictions. The difference for both aircraft can be attributed to runway 30 departure flight tracks being closer to Raymond Terrace than considered in the EIS. In addition to the flight track differences, and shortly after commencement of the first F-35A aircraft operations at RAAF Base Williamtown, Air Combat Group (ACG) identified that the F-35A aircraft could not safely depart the base using the reduced thrust setting that formed the basis of the EIS predictions. ACG has advised that for the safety of the public and pilots, higher thrust is required during departures for the aircraft to meet minimum altitude and air speed targets so that, in the event of engine failure, the F-35A aircraft is able to manoeuvre away from built-up areas, and ideally make an emergency landing back at the base. The higher than expected F-35A aircraft thrust settings and associated noise levels therefore also need to be considered in the context of public and RAAF personnel safety.

The findings of the analysis for the period between December 2018 and December 2020 indicate that flying operations and noise level changes associated with the F-35A aircraft are generally consistent with the findings of the EIS. However, as a result of the higher departure thrust settings required for safety reasons, the higher than predicted noise levels associated with these operations warrant the development of corrective measures in accordance with Condition 1 of the approval decision.

Accordingly, ACG has been trialling alternative departure procedures at RAAF Base Williamtown from the middle of 2019. The aim of the trials, conducted in accordance with the RAAF Base Williamtown Aircraft Noise Management Plan F-35A Noise and Flight Activity Verification Program, is to identify procedures that do not compromise the safe operation of the F-35A aircraft, the safety of the public and RAAF pilots, and minimise noise at sensitive receivers, while still achieving training and operational requirements. The program was designed to be carried out from the first flying operations of the F-35A aircraft in Australia as from January 2019 through to December 2022.

In 2021, Air Combat Group will commence Phase 4 of the verification program, which involves continued monitoring and comparison at RAAF Base Williamtown and SAAWR, as well at other bases where the F-35A will operate. The results will be addressed in future reports.

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1.0 INTRODUCTION

The Royal Australian Air Force (RAAF) has commenced operation of the F-35A Lighting II (F-35A) aircraft. Noise from the proposed flying operations of the F-35A aircraft was previously assessed under the requirements of Commonwealth Legislation, specifically the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Full details of the noise assessment were documented in the Environmental Impact Statement, Volume 10, Appendix F (Marshall Day Acoustics, 2014), subsequently referred to as the EIS herein.

In July 2015, the Department of the Environment (now Department of Agriculture, Water and the Environment (DAWE)) published the approval decision, EPBC Act project Approval (EPBC 2010/5747), for the flying operations of the F-35A aircraft in Australia. The approval decision outlines a suite of conditions including requirements for the management of environmental noise. Condition 1 of the approval decision defines requirements concerning the level of environmental noise by F-35A aircraft operations during the transition period, and Condition 3 defines a range of ongoing management and reporting requirements.

The Department of Defence (Defence) has engaged Marshall Day Acoustics Pty Ltd (MDA) to provide input to the biennial compliance reporting requirements of the approval decision, and to address the environmental noise information requirements outlined in Condition 1 and Condition 3.e.ii. of the approval decision.

Specifically, this report represents the first biennial noise report which compares the F-35A aircraft flight activity and noise level predictions presented in the EIS, with actual data during the transition period. The transition period assessed in this report extends from December 2018, when the first two (2) F-35A aircraft were delivered to RAAF Base Williamtown, to December 2020.

The approval decision conditions apply to F-35A aircraft operations at all RAAF bases where it will eventually operate. However, all F-35A aircraft delivered to date are based at RAAF Base Williamtown, where almost all F-35A aircraft operations occurred during the transition period. There were a small number of F-35A aircraft operations at RAAF Base Amberley associated with either:

- Poor weather diversion during the delivery of the aircraft to RAAF Base Williamtown; and
- The provision of small scale support for a training activity in 2020, though most of the F-35A aircraft operations for this were conducted from RAAF Base Williamtown.

This report therefore considers F-35A aircraft operations and noise levels at RAAF Base Williamtown and Salt Ash Air Weapons Range (SAAWR) only.

In accordance with the Aircraft Noise Management Strategy, and to address Condition 3 of the approval decision, the RAAF Base Williamtown Base Aircraft Noise Management Plan (BANMP) was produced in 2018. As well as addressing the specific requirement of Condition 3 for an aircraft noise management plan for RAAF Base Williamtown, enclosure 1 of the BANMP set out a proposed framework to address the overall requirements of Condition 3 with respect to F-35A aircraft operations from the base, and designed to inform operations across Australia. This document was subsequently endorsed by a DAWE delegate in December 2018, with minor amendments in December 2019 and December 2020.

The report has been prepared in accordance with the Technical Method Document (Marshall Day Acoustics, 2020) that outlines the methods to address the condition requirements relating to the preparation of this biennial report. The biennial review of Defence's F-35A aircraft noise management and reporting programmes required as part of Condition 3, is documented in the separate Marshall Day Acoustics report (2021), which is referenced where appropriate in this report.

A glossary of terminology and abbreviations used throughout this report is provided in Appendix A.

A list of documents referenced in this report is provided in Appendix B.

2.0 APPROVAL DECISION

The approval decision (DAWE, 2015) for the flying operations of the F-35A aircraft in Australia, EPBC Act project Approval 2010/5747 outlines a suite of conditions including a requirement to report biennially on actual F-35A aircraft operations, compared with that presented in the EIS.

This biennial report addresses the following conditions from the approval decision which relate to the comparison of F-35A flying activity and measured noise levels to those predicted in the EIS:

1. *Ensure, during the transition period, aircraft noise levels at sensitive receptors at RAAF Base(s) do not exceed the F-35A Lightning II aircraft noise levels predicted in the Environmental Impact Statement. During the transition period monitoring must be undertaken, reported biennially to the Department, and, if noise levels exceed the F-35A Lightning II aircraft noise levels predicted in the Environmental Impact Statement, then corrective measures must be developed and implemented, until agreed in writing by the Minister.*

3. *Prepare and implement Aircraft Noise Management Plan(s), as described in the Aircraft Noise Management Strategy, at RAAF Base(s) to minimise noise disturbance at sensitive receptors from the flying operations of the F-35A Lightning II aircraft. The plan(s) must include, but not be limited to, the following measures:*

   …

   e) *Reporting, to ensure clear and timely public access to noise levels and flight activity monitoring data. This must include, but not be limited to:*

      ii. *biennial publication on the Defence Aircraft Noise website of:*

         i. *noise levels and flight activity monitoring data of the F-35A Lightning II aircraft; and*

         ii. *a comparison of actual noise levels and flight activity of the F-35A Lightning II with those predicted in the Environmental Impact Statement. This must include, but not be limited to:*

            a) *noise management measures;*

            b) *days and hours of operation;*

            c) *flight paths used to reduce noise; and*

            d) *frequency and type of activities that occur at Salt Ash Weapons Range.*

In relation to Condition 3, the overarching requirement to prepare an Aircraft Noise Management Plan (BANMP) for RAAF Base Williamtown was addressed by Defence's publication in 2018, which was subsequently endorsed by a DAWE delegate on 3 December 2018 with minor amendments in December 2019 and December 2020. The assessment presented herein is therefore primarily concerned with addressing Condition 1 and with respect to Condition 3, the information requirements of subclause 3.e.ii.

A cross reference table that identifies where each of the above condition requirements is addressed in this report is provided in Appendix C.

3.0 ASSESSMENT METHOD

Condition 1 and Condition 3.e.ii. require the comparison of the F-35A aircraft flight activity and predicted noise levels presented in EIS, with actual data during the transition period.

A key point of context to the assessment presented herein is that RAAF Base Williamtown has been a permanent fighter aircraft base since its construction in 1941 and is the Headquarters of Air Combat Group (ACG). Military aircraft noise has therefore been a long term feature of the environment around RAAF Base Williamtown and SAAWR. The change in military aircraft noise associated with the introduction of F-35A aircraft operations was therefore the primary consideration in the EIS assessment. The assessment of change therefore carried through as the primary consideration in the development of the assessment procedures outlined in the Technical Method Document and the assessment presented herein.

Recognising that RAAF Base Williamtown is a long-established military airfield, the EIS was primarily based on an assessment of the change introduced by the replacement of F/A-18A/B Hornet operations with planned future F-35A aircraft operations. To enable a meaningful assessment of the change, and to address noise levels over a wide range of areas around the base, the EIS was based on a simplified representation of complex operations to inform the development of comparable noise models for the two (2) aircraft. This comprised a model to represent baseline F/A-18A/B Hornet operations (i.e. operations prior to introduction of F-35A aircraft, as represented in the EIS by flying activity from 2012 onwards) and a model to represent F-35A aircraft operations (i.e. operations for the year 2025, when it was envisaged that all 56 aircraft would be based at RAAF Base Williamtown and at Full Operating Capability (FOC)). The EIS then presented a large quantity of predicted noise level data for different noise metrics and operating scenarios based on these models. This data therefore necessarily included predicted noise level data specific to F-35A aircraft operations, primarily for the purpose of assessing noise level changes.

The prediction of noise levels from military aircraft operations is complex and subject to several uncertainties. These uncertainties relate to the accuracy of the simplified representations used to model aircraft operations, and the accuracy of the calculation's representation of actual sound emission and propagation in the environment. However, as well as providing a way of quantifying noise levels from an operation that is yet to commence, a key benefit of predictive modelling is that it enables a much wider range of time periods and locations to be considered than is practically possible with measurements alone. Importantly, for the purposes of the EIS, predictive modelling provided a practical way of enabling a controlled like-for-like comparison of situations; a particularly important element of the EIS given that the F-35A aircraft was being introduced to replace fast jet operations of the F/A-18A/B Hornet aircraft.

Further, aircraft noise levels are highly variable when comparing individual, day-to-day and month-to-month operations. This variability arises from a range of factors related to changes in aircraft operating patterns, procedures (flight profiles and paths), and atmospheric conditions that influence sound propagation. To quantify any change, the F-35A aircraft predictions were accompanied by equivalent predictions of baseline F/A-18A/B Hornet operations. The predicted range of noise levels for the two (2) aircraft were then compared to provide a basis for assessing the noise impacts associated with the introduction of the F-35A aircraft.

Accordingly, to address the approval decision for this biennial report and provide consistency with the EIS assessment that the approval decision was based on, it is necessary to differentiate the noise level changes that primarily relate to the introduction of the F-35A aircraft from the following:

- Inherent variations in military aircraft noise;
- Inherent differences between predicted and measured noise levels (particularly when referring to noise modelling data primarily configured to assess relative noise changes rather than absolute noise levels); and

- Noise level changes arising from broader operational variations and changes that apply to all military fast jet aircraft operations at the base (i.e. changes in military aircraft operating patterns which may affect, but are not specific to, F-35A aircraft operations).

Given the nature of the EIS assessment, the quantity of noise data produced, and the complexities noted above, it was necessary to develop a technical assessment method which would address the information requirements of the approval conditions. The two key elements to the development of the assessment method were:

- RAAF Base Williamtown Base Aircraft Noise Management Plan (BANMP) (RAAF, 2018), specifically Enclosure 1 outlines Defence's approach to compare the EIS predictions and actual F-35A aircraft noise and flight activity over a five (5) phase verification program; and
- Preparation of a Technical Method Document (Marshall Day Acoustics, 2020) for consultation with DAWE, to define a framework for addressing the conditions and inform the preparation of this report.

The following sections provide:

- A description of the five (5) phase verification program outlined in the BANMP to address elements of the conditions;
- Details of the data sources for F-35A aircraft flying activity and noise levels during the period December 2018 - December 2020 that have been referenced in this assessment; and
- A summary of the method detailed in the Technical Method Document to analyse and compare F-35A aircraft flying activity and noise level measurement data with the EIS information.

3.1 RAAF Base Williamtown Aircraft Noise Management Plan – F-35A Noise and Flight Activity Verification Program

Enclosure 1 to the BANMP outlines a five (5) phase F-35A aircraft Noise and Flight Activity Verification Program, as the aircraft are progressively delivered to RAAF Base Williamtown and RAAF Base Tindal. The five (5) phases are:

- Phase 1 Baseline: period up to end of 2018, prior to delivery of the first RAAF F-35A aircraft;
- Phase 2 Initial: early 2019, at a time when two (2) - eight (8) F-35A aircraft have been delivered;
- Phase 3 Detailed: a Verification and Validation program (V&V program) throughout 2019 and 2020, as more F-35A aircraft are delivered and operations increase;
- Phase 4 Conclusions: 2021, when up to two-thirds of all F-35A aircraft have been delivered and are at Initial Operating Capability; and
- Phase 5 Ongoing: 2022, when most F-35A aircraft would have been delivered, including aircraft at RAAF Base Tindal.

This report represents the first biennial noise report, aligning with Phase 3. Specifically, this phase involves the collation of actual F-35A aircraft data obtained from the Noise and Flight Path Monitoring System (NFPMS) during the period December 2018 - December 2020 to develop a dataset which can be used to compare actual F-35A aircraft noise levels and activity with the EIS predictions, as required by the conditions. This period incorporates the verification program and therefore includes trialling of alternative F-35A aircraft procedures and departure profiles as discussed in Section 4.7.2.

3.2 Data sources

3.2.1 EIS information

Flying activity

Table 1 summarises the sections of the EIS (Marshall Day Acoustics, 2014) which detailed the F-35A aircraft flying activity at RAAF Base Williamtown and SAAWR. This data forms the basis for comparison with actual F-35A aircraft flight activity data in this report.

Table 1: F-35A aircraft flying activity information presented in the EIS

F-35A aircraft flying activity	EIS section (Volume 10, Appendix F)
Number of movements, based on 56 aircraft at FOC in the year 2025	Section 7.1.3, Table 8
Days of operation	Section 6.1.2
Hours of operation	Section 6.1.3 and Section 7.1.4
Runway use, presented as percentage use of runway 12 and runway 30	Section 7.1.3
Flight tracks	Section 7.1.1, Figures 33 to 37 Section 8.1, Figures 48 to 51
Flight profiles, presented as percentage use for arrival, departure and circuit training flight profiles	Section 7.1.2, Table 6
SAAWR activity, including number of days and number of F-35A aircraft passes in 2025	Section 7.1.3, Table 8, and Section 8.2.2

Aircraft noise levels

The EIS presented aircraft noise level information in a range of formats to provide a comprehensive description of environmental noise from Base operations. Predicted noise level contours were primarily used to provide information over a wide area. More detailed noise level predictions and analyses were also provided at discreet locations to represent residential areas, schools, places of worship, community facilities and on-base locations.

Importantly though, the EIS documents did not present summary noise level information at existing Noise Monitoring Terminal (NMT) locations. The noise metrics and information needed for comparison with actual measured data have therefore been calculated using the EIS noise model(s) at these locations to provide a basis for comparison. Specifically, the following information has been calculated for each aircraft using the EIS noise model:

- F/A-18A/B Hornet: predicted noise levels at each NMT for baseline operations, represented by movements in the year 2012, accounting for the updated flight procedures in ACG's Fly Neighbourly Policy in place at the time; and
- F-35A aircraft: predicted noise levels at each NMT for the year 2025, corresponding to the period in the EIS when it was envisaged that all 72 aircraft would have been delivered (the majority of which would be based at RAAF Base Williamtown) and at FOC. The predictions for 2025 accounted for the extended runway, Defence's forecast of typical flying operations, and the mitigation strategies that were planned to be implemented.

To predict noise levels at the NMTs, the only changes to the noise model were the inclusion of calculation points for each of the NMTs. The input information, calculation configurations and calculation software were therefore identical to that of the noise modelling data presented in the EIS.

3.2.2 Transition period information

Information about actual F-35A aircraft operations and noise levels for the period December 2018 – December 2020 has been obtained from the following:

- ACG records, including:
  - Details of actual days and times of F-35A aircraft operations at RAAF Base Williamtown and SAAWR;
  - Flight profile used during departure operations at RAAF Base Williamtown.
- Defence's Noise and Flight Path Monitoring System (NFPMS) for RAAF Base Williamtown and SAAWR. The data collated by the NFPMS includes the following:
  - Aircraft position data collected from the Defence radar network primarily from Secondary Surveillance Radar (SSR). Additional data is sourced from Primary Surveillance Radar to provide supplementary coverage to assist with the tracking of fast-moving and/or low flying military fast jets;
  - Noise data collected from a network of Noise Monitoring Terminals (NMT) deployed in the vicinity of the base and frequent flight corridors to measure aircraft and ambient noise levels; and
  - Flight data from additional data sources to assist with the identification of aircraft operations including RAAF aircraft operations logs, RAAF SSR code allocations and Airservices Australia Radar and Air Traffic Control data.

The NFPMS correlates aircraft position data with the noise data measured at each NMT to enable measured levels that are primarily attributable to aircraft overflights to be catalogued as 'aircraft noise events' for each NMT.

The NFPMS represents a sophisticated modern system for the measurement of noise and flight path measurement data. However, the measurement and detection of aircraft noise levels is complex and subject to practical challenges which are compounded by the specific characteristics of military aircraft operations, when compared to civilian aircraft operations. These include limited radar coverage at low altitudes, military aircraft formation flying, limited operational data provided by military data feeds, training circuit movements and aircraft operating without active transponders. The NFPMS data is therefore subject to a reduced level of operational detail. For example, in some instances, the specific military fast jet type associated with an event may not be identifiable, resulting in the broad classification of the operation as a 'military fast jet' instead of a specific aircraft type.

The information sources were compared and indicated F-35A aircraft operation numbers recorded by the NFPMS aligned with ACG records and provided support for the accuracy of the data retained by ACG. The ACG data did however record slightly higher numbers and has therefore been adopted as the primary reference with respect to F-35A aircraft movement numbers. The ACG data is also the primary reference with respect to the departure profile, including those trialled by F-35A aircraft.

The NFPMS data is the primary reference for flight track and noise level information.

Further information with respect to the NFPMS and associated data limitations are detailed in Appendix D, while the Marshall Day Acoustics report (2021) provides a review of the NFPMS.

3.3 Technical Method Document

The Technical Method Document was prepared to provide a framework for addressing the conditions and inform the preparation of this report.

The following summarises the steps in the assessment process to address both Condition 1 and Condition 3.e.ii. of the approval decision:

1. Collate flight record data from ACG and the NFPMS for the period December 2018 – December 2020, including:
   - Total numbers of F/A-18A/B Hornet and F-35A aircraft movements;
   - Dates and times of F/A-18A/B Hornet and F-35A aircraft movements;
   - Details of operation types for each aircraft (where available e.g. runway use and type of departure procedure);
   - Details of F/A-18A/B Hornet and F-35A aircraft use of SAAWR; and
   - Recorded flight tracks for both F/A-18A/B Hornet and F-35A aircraft.
2. Compare F-35A aircraft flying activity with corresponding flying activity forecast in the EIS to address Condition 3.e.ii., accounting for:
   - Aircraft numbers;
   - Movement numbers;
   - Days of operation;
   - Hours of operation;
   - Runway use;
   - Flight paths;
   - Flight profile use; and
   - Noise management measures.
3. Collate actual measured F/A-18A/B Hornet and F-35A aircraft noise levels and EIS noise modelling outputs at the NMT locations. Summarise the measured and modelled noise levels in a similar format to the information presented in the EIS. The noise level information to be compared is summarised in Table 2;
4. Compare the measured change in aircraft noise levels, based on differences between measured F/A-18A/B Hornet and F-35A aircraft noise levels as it relates to the early phases of operations;
5. Investigate instances where the measured difference between F/A-18A/B Hornet and F-35A aircraft noise levels are higher than the differences predicted in the EIS;
6. Assess whether corrective measures as referenced in Condition 1 need to be developed and implemented, having regard to the measured aircraft noise levels, the BANMP and the five (5) phase program.

Table 2: Aircraft noise level information

Noise level information presented in EIS	Analysis for biennial reporting
F/A-18A/B Hornet and F-35A aircraft single event maximum noise levels, presented as single event contours.	A summary of the maximum noise levels determined by calculating the average and typical highest values from the dataset derived from the EIS predictions and the measurement data. These summary values were not presented in the EIS and are not commonly included in a package of aircraft noise information. These values are therefore only presented for informative purposes as a practical way addressing the volume of data relating to the maximum noise levels of individual events, enabling a simplified comparison of F/A-18A/B Hornet and F-35A aircraft maximum noise levels at the NMT locations.
F/A-18A/B Hornet and F-35A aircraft single event maximum noise levels, presented as event level histograms.	Histograms of the average number of daily measured maximum noise levels, grouped by noise level range, are generated for each of the NMT locations. The charts are produced for both the F/A-18A/B Hornet and F-35A aircraft, and compare actual measurement data with the EIS noise model predictions.
F/A-18A/B Hornet and F-35A aircraft single event maximum noise levels, presented as Number Above contours.	Number Above statistics (including N70 and N85) are calculated at the NMT locations from actual measurement data and compared to EIS noise model predictions.
Australian Noise Exposure (ANE) metrics	The ANE metric is used to describe total noise levels from all aircraft operations. However, to provide a comparison based on this metric, the ANE contribution of both F/A-18A/B Hornet and F-35A aircraft operations to the total noise level from all aircraft operations, is calculated at NMT locations from actual measurement data and compared with equivalent EIS noise model predictions.
Community hearing protection thresholds	This metric is additional to the information described in the Technical Method Document. Consistent with the assessment presented in the EIS, measured noise level data is compared with relevant hearing protection criteria and guidelines.

4.0 F-35A AIRCRAFT FLYING ACTIVITY

This section presents a comparison of the F-35A flying activity presented in the EIS with the actual flying activity of the aircraft during the period December 2018 - December 2020. This comparison addresses Condition 3.e.ii. of the approval decision.

4.1 Number of aircraft

The EIS noise predictions referenced in the approval decision were based on theoretical projections for the year 2025 to represent the time when all F-35A aircraft that are proposed to be based at RAAF Base Williamtown will have been acquired and when all F/A-18A/B Hornets have been withdrawn from service.

At December 2020, there were 30 F-35A aircraft based at RAAF Base Williamtown, distributed between No. 2 Operational Conversion Unit (2OCU) and No. 3 Squadron (3SQN).

4.2 Number of movements

4.2.1 Number of movements – EIS information

Table 3 summarises the annual F-35A aircraft movement numbers presented in the EIS.

Table 3: F-35A aircraft annual movements at RAAF Base Williamtown – year 2025

Period	Departures	Arrivals	Touch and Go*
EIS for 2025	6,964	6,964	3,118

*The touch and go numbers separately count the arrival and departure of a single Touch and Go circuit i.e. one Touch and Go circuit equates to two movements

4.2.2 Number of movements – Actual for period December 2018 – December 2020

Table 4 summarises the number of F-35A aircraft movements at RAAF Base Williamtown.

Table 4: F-35A aircraft annual movements at RAAF Base Williamtown – December 2018 – December 2020

Period	Departures	Arrivals (1)	Touch and Go (2)
December 2018 – December 2019	408	408	63
January 2020 – December 2020	1,612	1,612	184

Note: (1) ACG records include dates and times of departure operations only. The number of arrivals will inherently be the same as the number of the departures. The 30 arrival movements for the delivery of the 30 new aircraft are not included in the figures but are noted to constitute less than 2 % of all arrivals during the period December 2018 – December 2020.
(2) Data based on information from the contractors responsible for the NFPMS.

The information above indicates considerably fewer F-35A aircraft movements in 2019 and 2020 than presented in the EIS. This is expected given there were fewer F-35A aircraft operating at the base than was considered in the EIS, which was based on a forecast year 2025 when all F-35A aircraft would have been delivered and at FOC.

Additionally, ACG have advised there was a reduced number of military aircraft operations in 2020 due to COVID-19 pandemic related restrictions.

4.3 Days of operation

4.3.1 Days of operation – EIS information

The EIS states that military operations at RAAF Base Williamtown and SAAWR are generally limited to weekdays for 48 weeks of the year. The EIS noise modelling therefore considered F-35A aircraft operations occurring five (5) days per week on average across 240 days of the year.

4.3.2 Days of operation – Actual for period December 2018 – December 2020

Table 5 presents a summary of the number of days of F-35A aircraft flying activity at RAAF Base Williamtown.

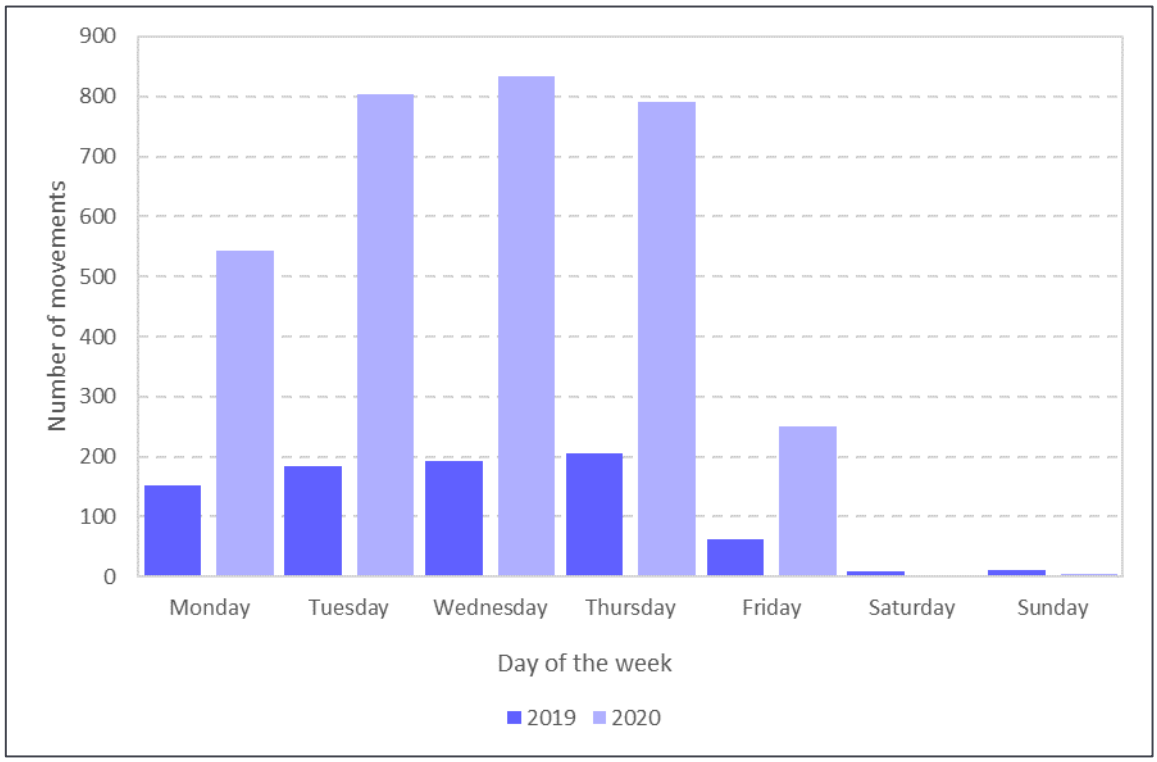
Table 5: Days of F-35A aircraft flying activity at RAAF Base Williamtown

Period	Days of F-35A aircraft flying activity
December 2018	1 (delivery of first two (2) aircraft)
January 2019 – December 2019	116
January 2020 – December 2020	163

There were considerably fewer days of F-35A aircraft flying activity at RAAF Base Williamtown during this period than presented in the EIS, which is to be expected due to the gradual delivery of F-35A aircraft over the two (2) year period and the low number of aircraft, as well as reduced military aircraft operations in 2020 due to COVID-19 pandemic related restrictions.

Figure 1 presents a summary of the distribution of days of F-35A aircraft flying activity at the base during the period December 2018 – December 2020.

Figure 1: Number of F-35A aircraft movements at RAAF Base Williamtown per day: December 2018 – December 2020



The majority (more than 99 %) of F-35A aircraft movements occurred on weekdays, consistent with the EIS. There was a total of 26 F-35A aircraft movements on weekends during the period December 2018 - December 2020, representing less than 1 % of the total number of movements.

4.4 Hours of operation

4.4.1 Hours of operation – EIS information

The EIS indicated that the times of F-35A aircraft operations were expected to be consistent with existing military fast jet operations at RAAF Base Williamtown and SAAWR, almost all which were noted to occur between 7 am and 10 pm, with very limited movements outside of these hours.

Further, 20 % of F-35A aircraft movements at RAAF Base Williamtown were anticipated to occur between 7 pm and 11 pm, noting that arrivals occurring up to 11 pm are due to extended daylight hours during summer.

4.4.2 Hours of operation – Actual for period December 2018 – December 2020

The hours of F-35A aircraft operations at RAAF Base Williamtown are presented in Figure 2 and Figure 3 for December 2018 - December 2019 and January 2020 - December 2020, respectively.

The trends demonstrate:

- More than 80 % of F-35A aircraft operations occurring between 9 am and noon, and between 1 pm and 4 pm;
- Limited activity (<10 %) between 5 pm and 9 pm;
- 5 % of F-35A aircraft operations occurred between 7 pm and 11 pm; and
- Fewer than 1 % of F-35A aircraft movements occurred between 11 pm and 7 am.

The hours of operation for F-35A aircraft operations are therefore consistent with the EIS.

Figure 2: F-35A aircraft operation times at RAAF Base Williamtown: December 2018 – December 2019

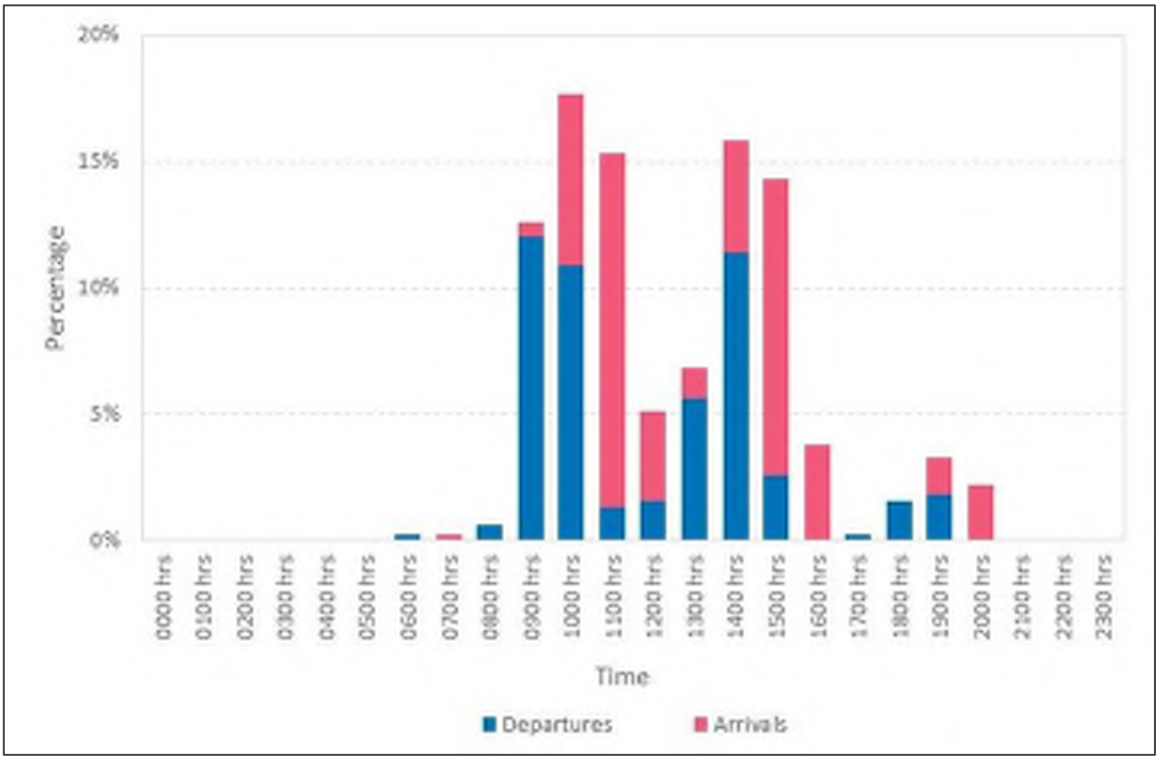
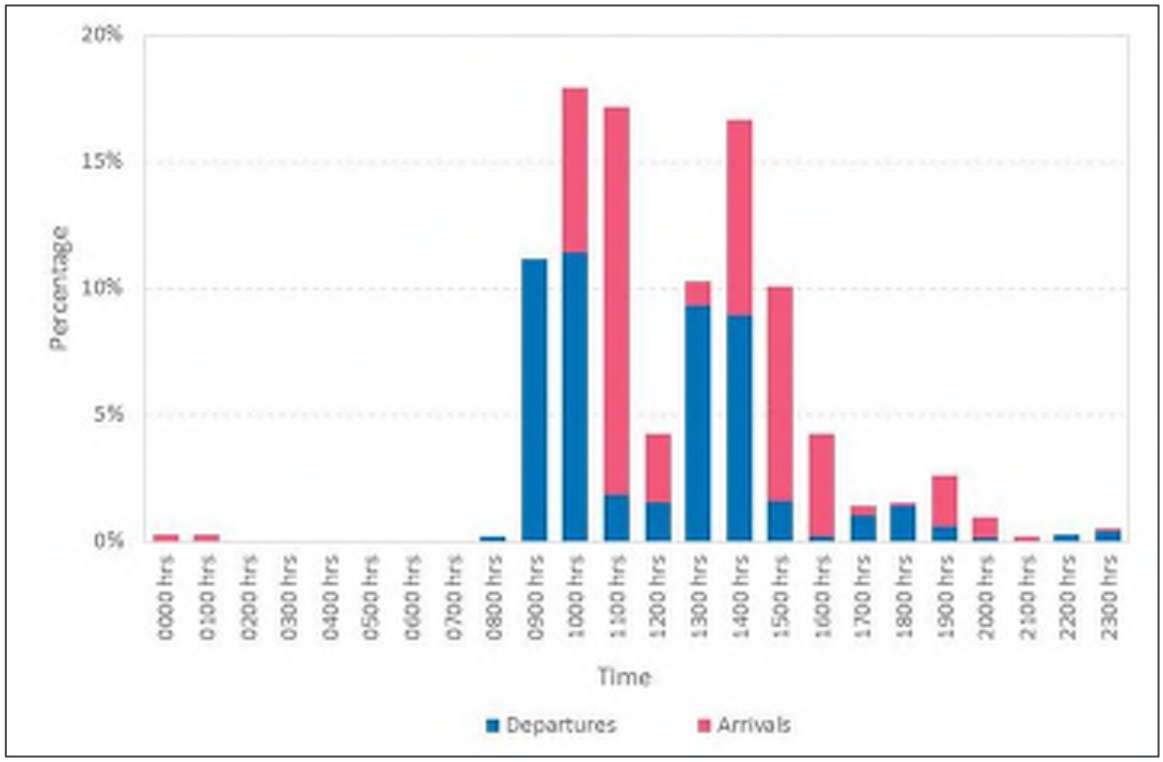


Figure 3: F-35A aircraft operation times at RAAF Base Williamtown: January 2020 – December 2020



4.5 Runway use

4.5.1 Runway use – EIS information

The runway use at RAAF Base Williamtown for F-35A aircraft operations was based on an annual average of 45 % on runway 12 and 55 % on runway 30, i.e. more than half of arrivals from the southeast, and more than half of departures to the northwest.

4.5.2 Runway use – Actual for period December 2018 – December 2020

Table 6 presents the F-35A aircraft annual average runway use at RAAF Base Williamtown for the period December 2018 – December 2020, obtained from the runway assigned to each NFPMS record.

Table 6: F-35A aircraft runway use at RAAF Base Williamtown

Period	Runway 12	Runway 30
December 2018 – December 2019	47 %	53 %
January 2020 – December 2020	47 %	53 %

The average runway use by F-35A aircraft during this period is consistent with the EIS.

4.6 Flight tracks

4.6.1 Flight tracks – EIS information

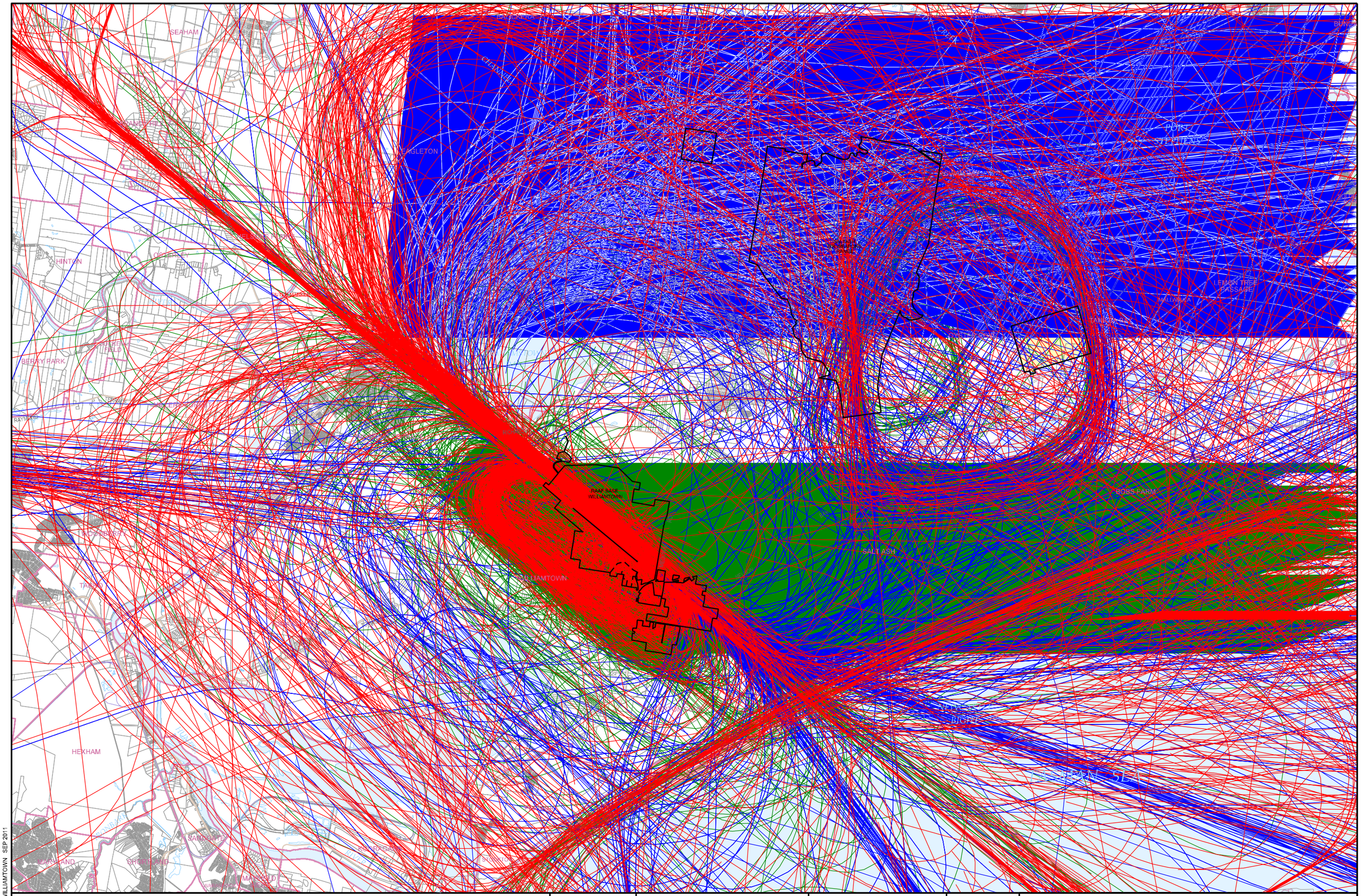
The flight tracks in the EIS were modelled with a central backbone track, accompanied by a set of sub-tracks used to represent variations in flight track caused by meteorological conditions, formation flying and pilot technique. These flight tracks were developed as a simplified representation of the majority of aircraft movements, and therefore do not account for every possible track which may be flown in practice. There will occasionally be instances where the aircraft exactly follow the EIS track, but in practice, aircraft will normally be within the corridors formed between the backbone track and associated sub-tracks. There will inevitably be instances in practice where aircraft flight tracks differ from the model, and this may occur for a range of reasons including operational, air traffic control and safety requirements.

The EIS F-35A aircraft flight tracks and forecast use were based on an analysis of flight tracks followed by military fast jets in 2011, supplemented by adjustments to account for flight path changes described in the Fly Neighbourly Policy (Air Combat Group, 2012). Defence advised at the time of the EIS, that this provided the best representation of the flight tracks that were expected to be followed by both F/A-18A/B Hornet operations (post 2012) and future operations of the F-35A aircraft.

To provide context to the flight path data used for noise modelling purposes, the figure on the following page reproduces the example NFPMS flight track data which was presented in the EIS for Quarter 3 of 2011. The subsequent figure then shows the EIS noise model flight tracks representing military fast jet aircraft departures on runway 30, included in the EIS noise model for 2011. Comparing the two figures, the noise model tracks are representative of the geometry and dispersion of the most common arrival and departure flight tracks (red and blue lines respectively) recorded by the NFPMS.

The flight tracks which were subsequently used to model both F/A-18A/B Hornet operations (post 2012) and future F-35A aircraft operations, accounting for the Fly Neighbourly Policy, are shown in Figure 7.

The annual percentage use of the flight tracks was also provided in the EIS.



LEGEND:

- Department of Defence Property
- Suburb Boundary
- Arrivals
- Departures
- Circuits

RUNWAY LAYOUT

NOTE:
CADASTRAL DATA DATED 2009
(SUPPLIED BY THE DEPARTMENT OF DEFENCE)

0 1 2 3
SCALE IN KILOMETRES

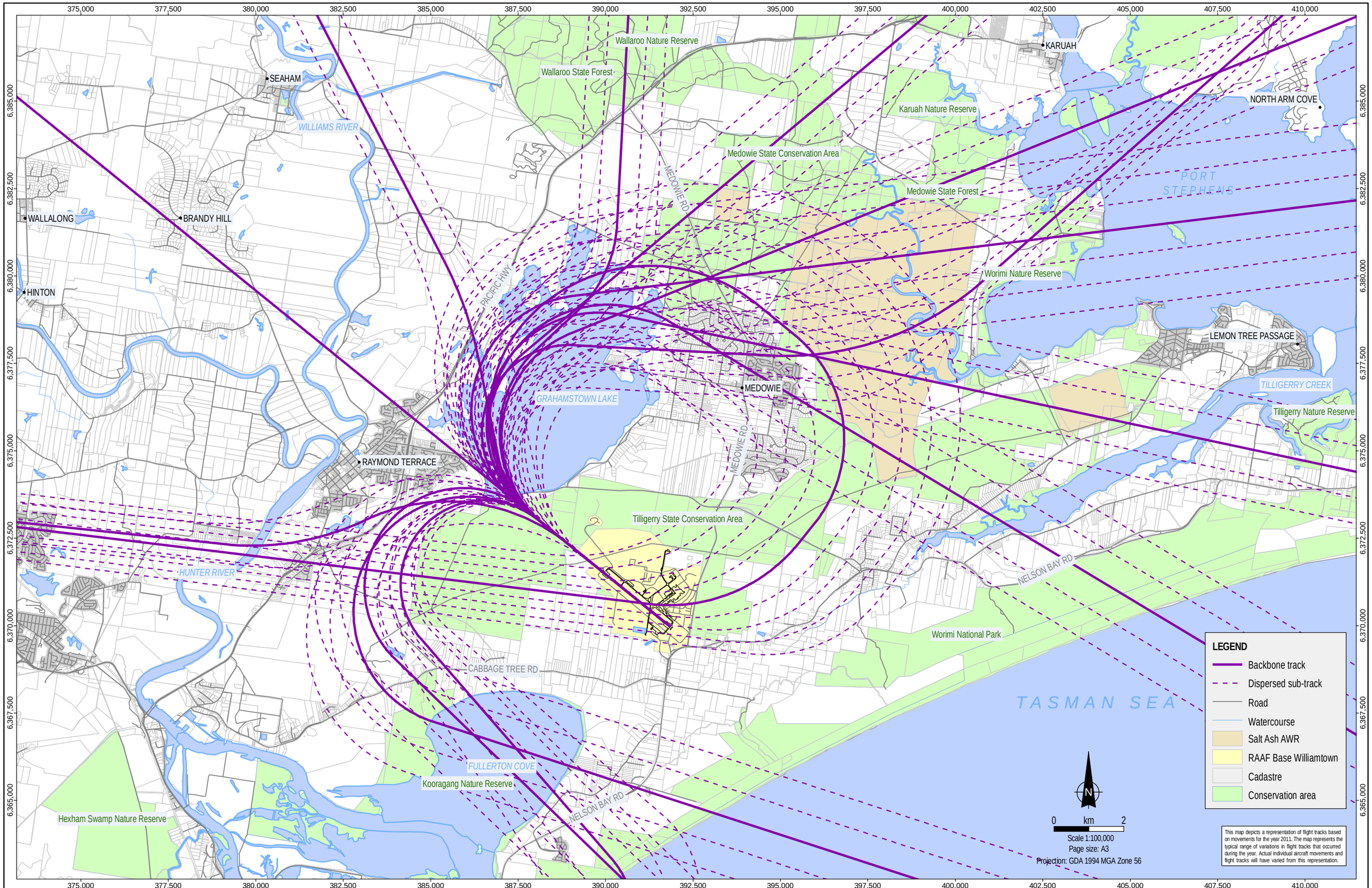
Australian Government
Department of Defence

RAAF BASE WILLIAMTOWN, NSW
2011 QTR 3, NFPMS REPORT

AIRCRAFT FLIGHT TRACKS
ALL MILITARY AIRCRAFT

Figure 9

G:\23\12899\CADD\DRAWINGS\WILLIAMTOWN SEP 2011



Source:
Departure tracks on runway 30 from 2011 ANEI, prepared by MDA (in consultation with Department of Defence), 2013.
Base boundaries, cadastre, roads and watercourses from Department of Defence, 2012.
Place names, reserves and coastline from GEODATA250K (Optimum scale 1:250,000).
Additional managed area reserves from NSW DECCW (Office of Environment & Heritage), 2009.
Spatial data management and map production by Coffey, 2013.

MARSHALL DAY Acoustics

Date: 13.01.2014
MXD: 1446_MDA_WLM_GIS007_v0_5
File Name: WLM_B-3

Department of Defence

F-35A Lightning II Aircraft EIS

2011 military fast jet departure paths - runway 30

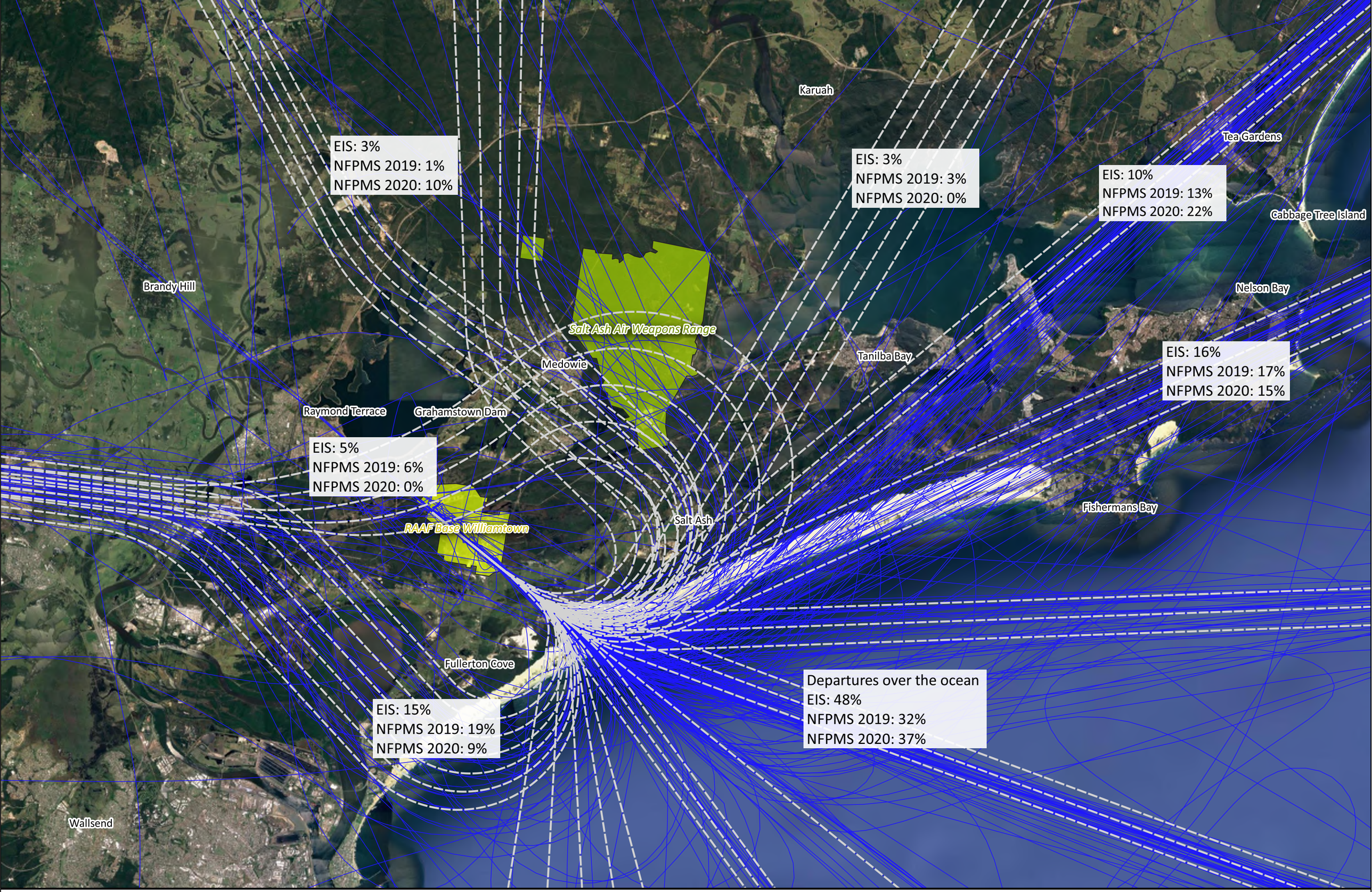
Figure No:

4.6.2 Flight tracks – Actual for period December 2018 – December 2020

Figure 6 to Figure 9 present the NFPMS records of F-35A aircraft flight tracks for departures and arrivals on runway 12 and runway 30. The figures also show the EIS noise model flight tracks, which have been annotated to compare the EIS forecast and actual use between December 2018 and December 2020.

To determine the number of movements per flying area (i.e. the usage data annotated on these figures), the actual flight tracks were categorised by assigning them to the corresponding EIS noise model flight track. The categorisations were based on the proximity of each actual flight track and operation to the EIS noise model flight tracks. There were a considerable number of arrival and departure flight tracks recorded by the NFPMS that could not be assigned to a particular EIS flight track due to limited geospatial information, meaning the radar track was "short" and hence a direction to or from could not be determined. The percentage of movements that could not be assigned to one of the EIS flight tracks are noted in each figure.

Additional data from the NFPMS would therefore need to be analysed to provide further information for passes of SAAWR, which were not available due to practical limitations of the radar system, as discussed in Appendix D.



Percentage split of F-35A aircraft flight track use – departures runway 12

Figure number: 6

NFPMS flight tracks not correlated to EIS flight tracks
2019: 9%
2020: 7%

Percentages are rounded and may not add up to 100%

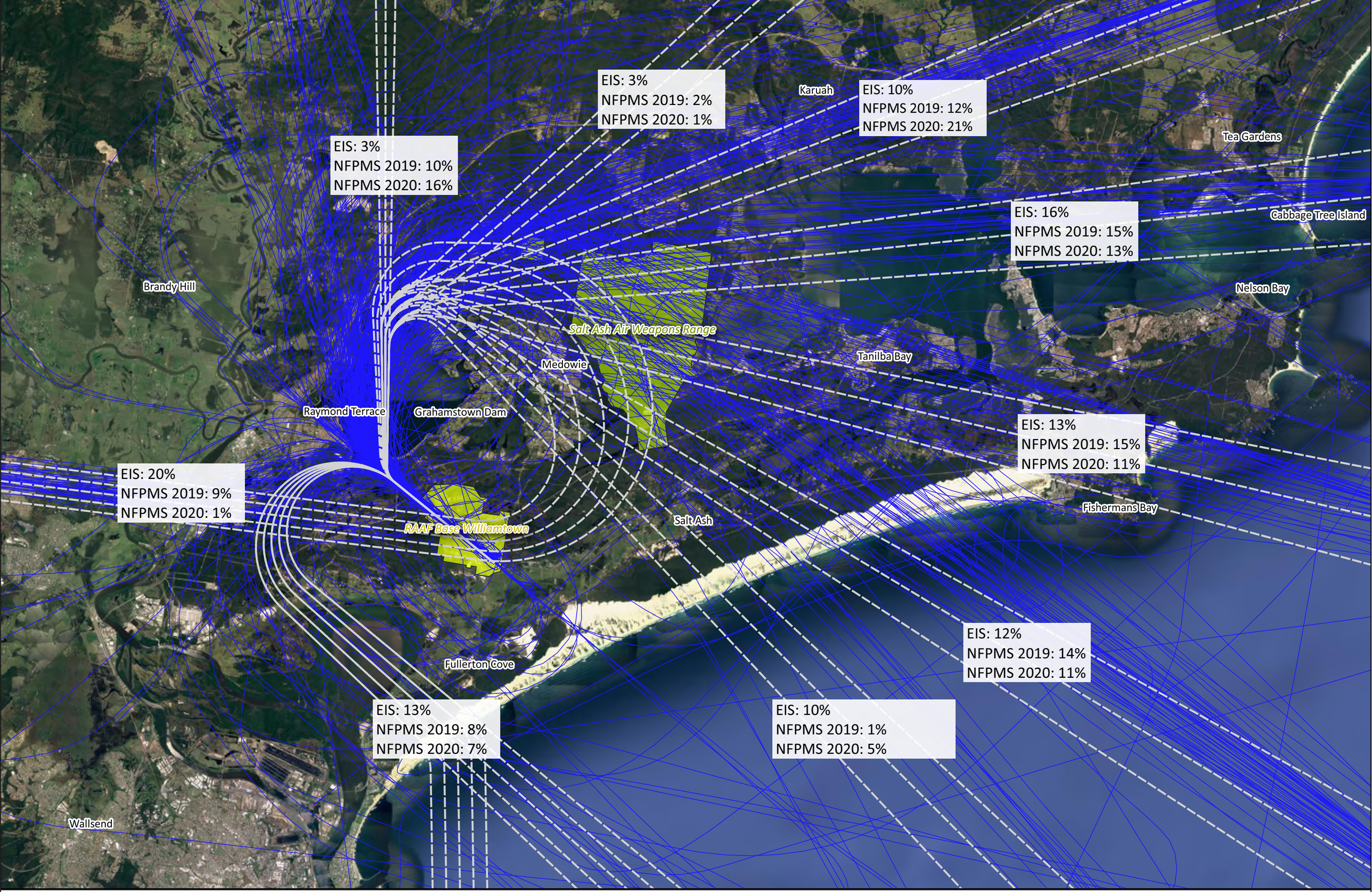
Legend
EIS noise model flight track
NFPMS flight track

Report number: Rp 002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 2 4 km

N



Percentage split of F-35A aircraft flight track use – departures runway 30

Figure number:7

NFPMS flight tracks not correlated to EIS flight tracks
2019: 14%
2020: 15%

Percentages are rounded and may not add up to 100%

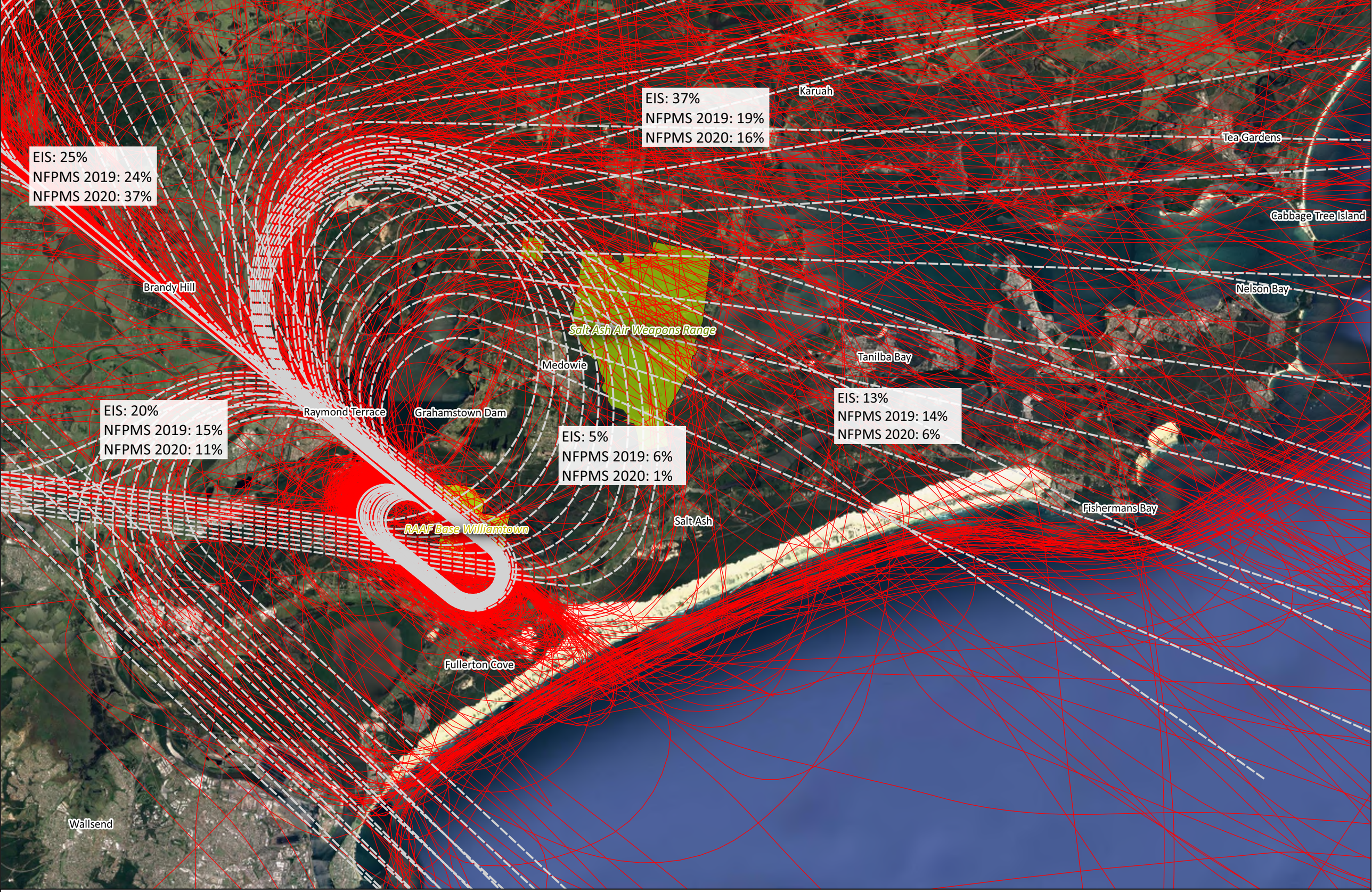
Legend
EIS noise model flight track
NFPMS flight track

Report number: Rp 002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 2 4 km

N



Percentage split of F-35A aircraft flight track use – arrivals runway 12

Figure number: 8

NFPMS flight tracks not correlated to EIS flight tracks
2019: 22%
2020: 29%

Percentages are rounded and may not add up to 100%

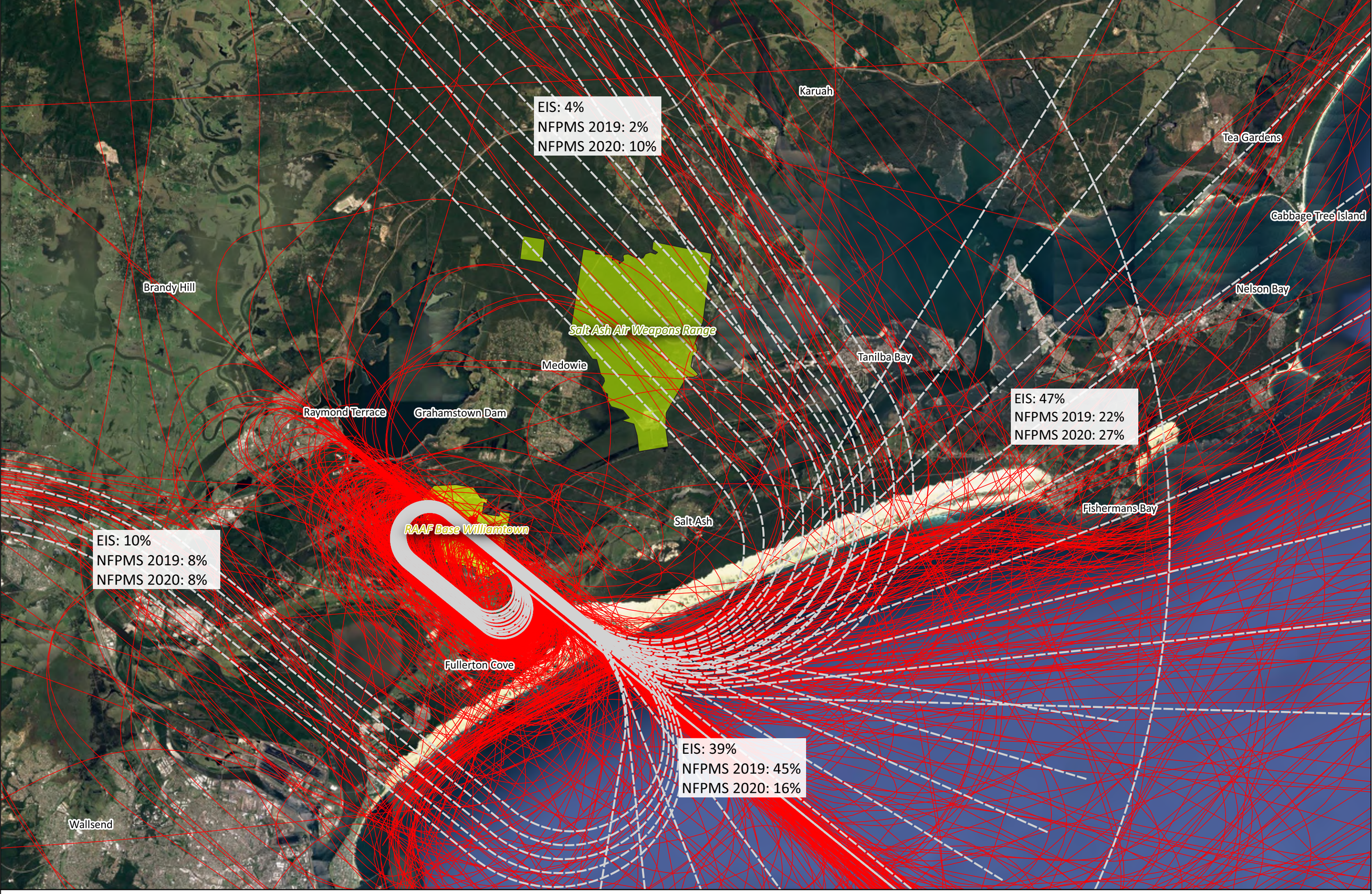
Legend
EIS noise model flight track
NFPMS flight track

Report number: Rp 002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 2 4 km

N



Percentage split of F-35A aircraft flight track use – arrivals runway 30

Figure number: 9

NFPMS flight tracks not correlated to EIS flight tracks
2019: 22%
2020: 39%

Percentages are rounded and may not add up to 100%

Legend
EIS noise model flight track
NFPMS flight track

Report number: Rp 002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 2 4 km

N

The figures above show that the F-35A aircraft flight track percentage use in the EIS differs from the actual flight track use for the period December 2018 – December 2020. This is to be expected given that the EIS flight tracks were a simplified representation of typical flight tracks. This is evident from the complex pattern of recorded flight tracks from the NFPMS, which illustrate a wide variation in flight tracks relative to the simplified EIS noise model flight tracks. While the percentages may be higher in some instances, it is noted that the total number of movements associated with each corridor are well below the numbers represented in the EIS modelling. This is expected given the F-35A aircraft flying activity during the transition period is unlikely to be representative of the longer-term flying activity when the aircraft has reached FOC, as considered in the EIS.

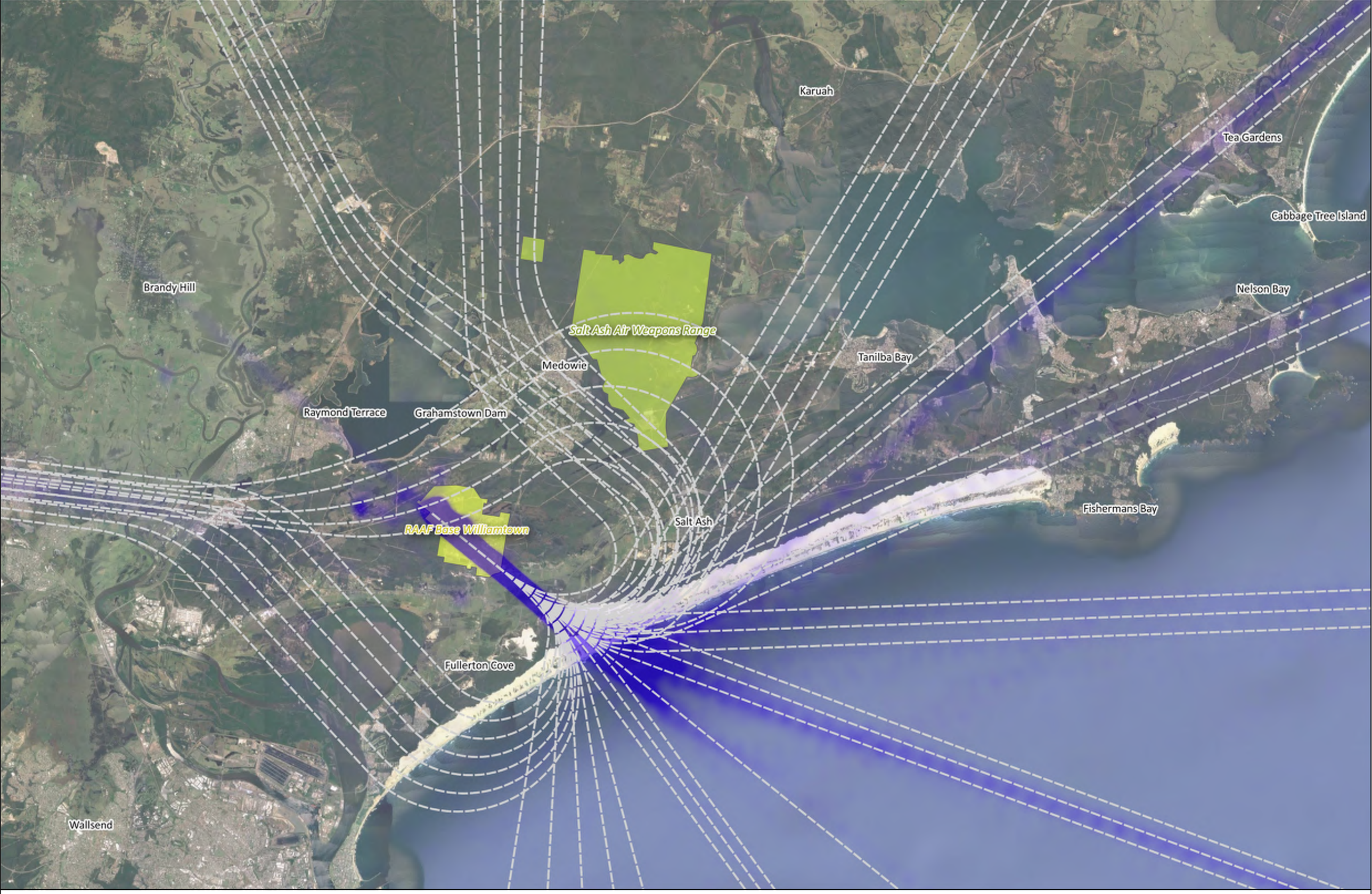
In broad terms the flight track use in 2019 followed similar trends to that presented in the EIS. For example, the flight tracks that were forecast to be used most frequently are consistent with the tracks most frequently flown in practice.

The EIS noise model flight tracks are representative of the trend or pattern of actual flight tracks in the vicinity of populated areas and points of interest during the period December 2018 – December 2020. The figures above show that there were flight tracks that did not correlate to an EIS model flight track, particularly those that include flying activities near the base between a departure and an arrival.

However, the comparison also indicates differences. For example, the figures above show:

- The dispersion of runway 30 departure flight tracks that turn north over Grahamstown Dam was greater than presented in the EIS, meaning the aircraft are generally not following a turn as tight as was accounted for in the modelling and are therefore nearer to the northeast extent of Raymond Terrace. This was specifically recognised in Section 8.4.2 of the EIS, where inspection of the available albeit limited records following the introduction of this runway 30 departure procedure in the Fly Neighbourly Policy, showed that aircraft avoid passing over Raymond Terrace, but the actual flight path flown tended to comprise a wider right turn, and hence greater dispersion of movements;
- There were a number of runway 30 departure flight tracks that turn to the west and pass to the south of Raymond Terrace that were not represented in the EIS; and
- The dispersion of initial and pitch arrival tracks around the base was greater than presented in the EIS.

Flight track density plots are presented in Figure 10 to Figure 13 as an alternative method to display the relative frequency of F-35A aircraft flying activity in flight corridors. The figures also show the EIS noise model flight tracks.



Flight track density plot F-35A aircraft - departures runway 12

Figure number: 10

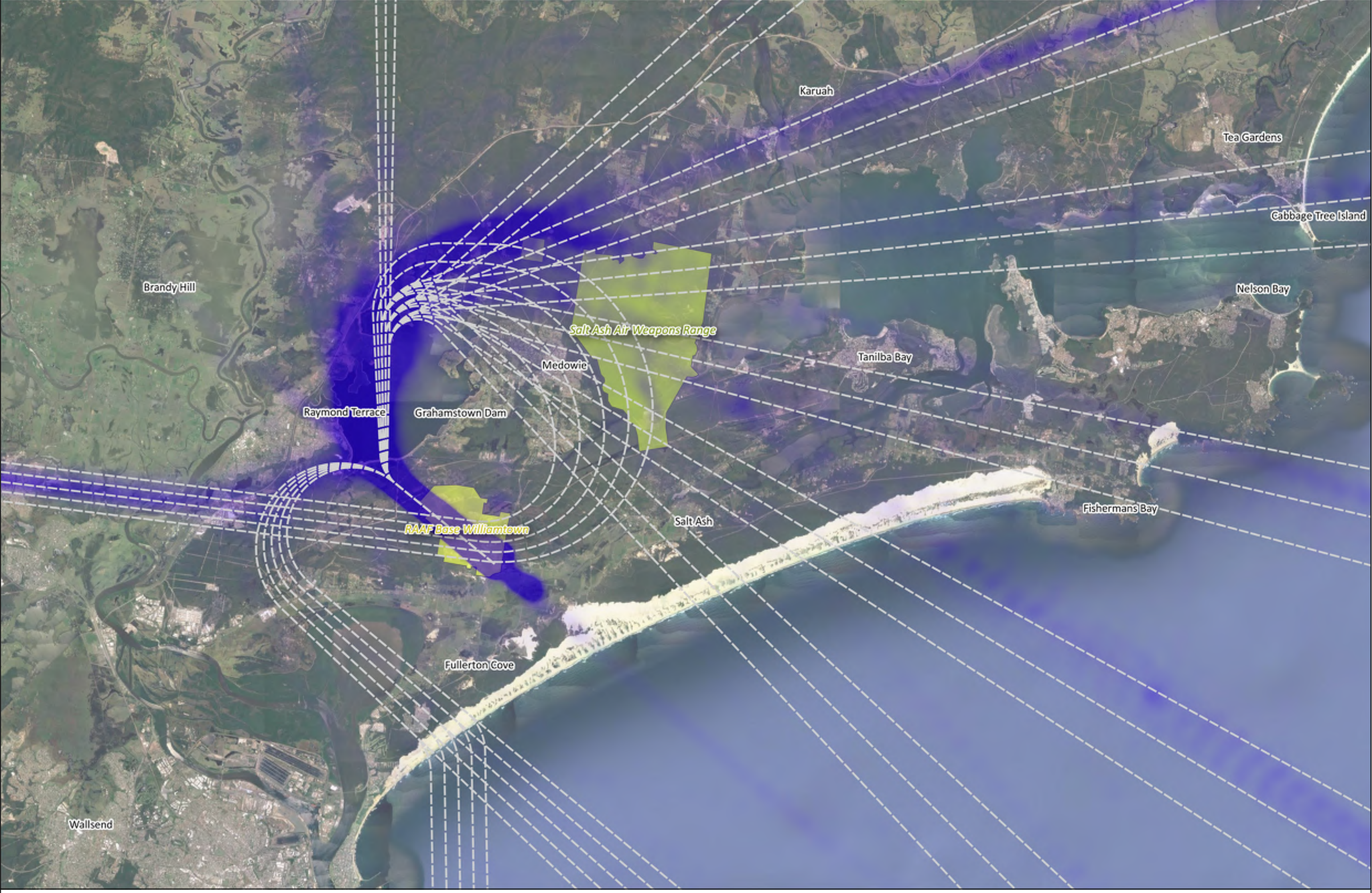
Legend
EIS noise model flight track
NFPMS flight track density

Report number: Rp 002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 2 4 km

N



Flight track density plot F-35A aircraft - departures runway 30

Figure number: 11

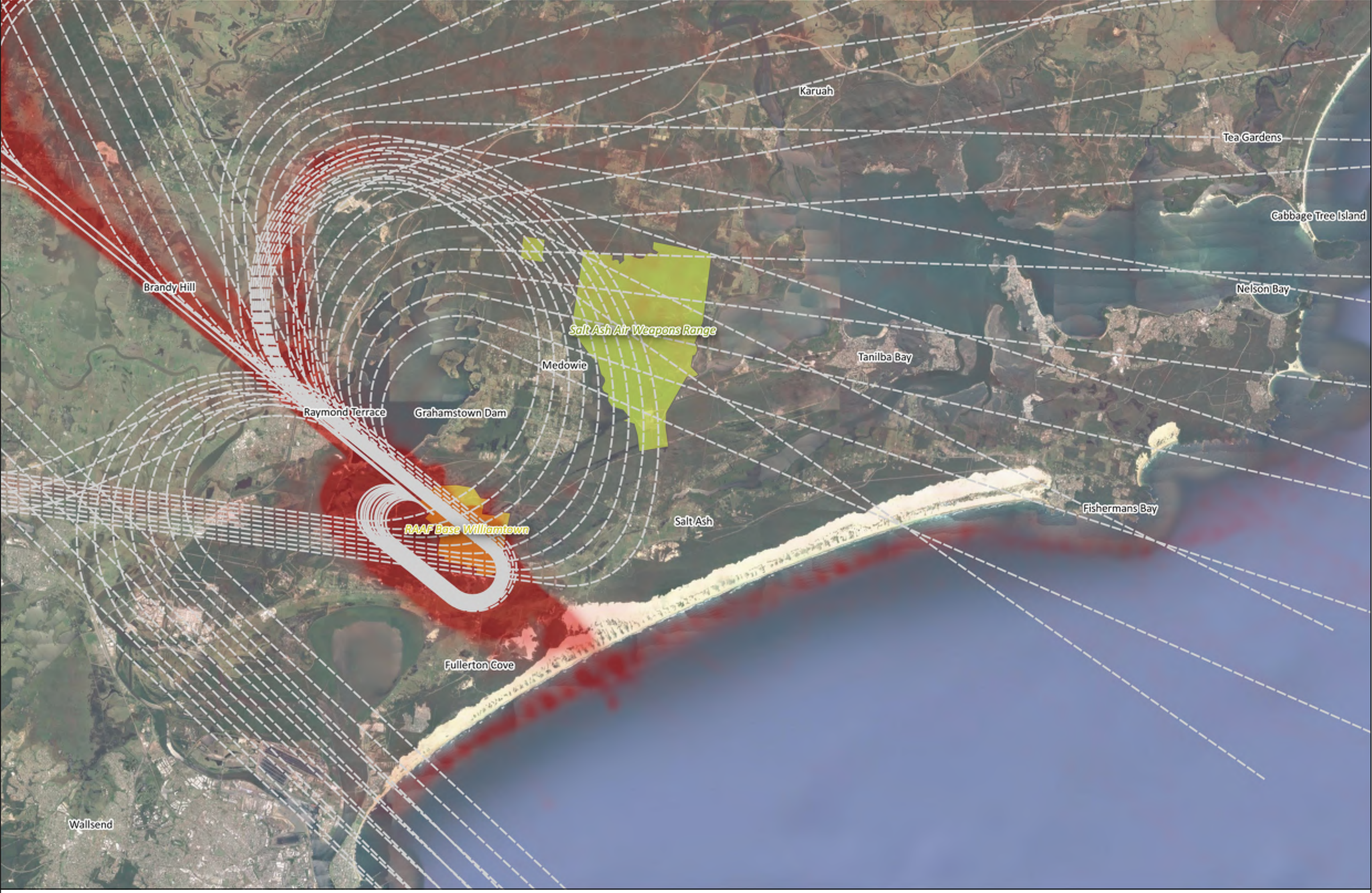
Legend
EIS noise model flight track
NFPMS flight track density

Report number: Rp 002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 2 4 km

N



Flight track density plot F-35A aircraft - arrivals runway 12

Figure number: 12

Legend
EIS noise model flight track
NFPMS flight track density

Report number: Rp 002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 2 4 km

N

Flight track density plot F-35A aircraft - arrivals runway 30

Figure number: 13

Legend
EIS noise model flight track
NFPMS flight track density

Report number: Rp 002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 2 4 km

N

4.6.3 Fly Neighbourly Policy flight tracks

The ACG Fly Neighbourly Policy advises that military fast jet departures on runway 30 are to avoid directly passing over Raymond Terrace when possible. Specifically, aircraft are to turn right to fly north over Grahamstown Dam and then follow other path and height guidance before turning right over Medowie (when required).

The EIS model flight tracks for runway 30 departures reflected the intent of the Fly Neighbourly Policy in place at the time, with a right turn at the south end of Grahamstown Dam shortly after take-off, followed by the aircraft flying north through the middle of the dam. At the time of preparation of the EIS, there was limited actual flight track data for these to verify the suitability of the EIS model flight tracks.

The EIS noise model flight track along with the actual F-35A aircraft flight tracks during the period December 2018 – December 2020 for this departure procedure is shown in Figure 14.

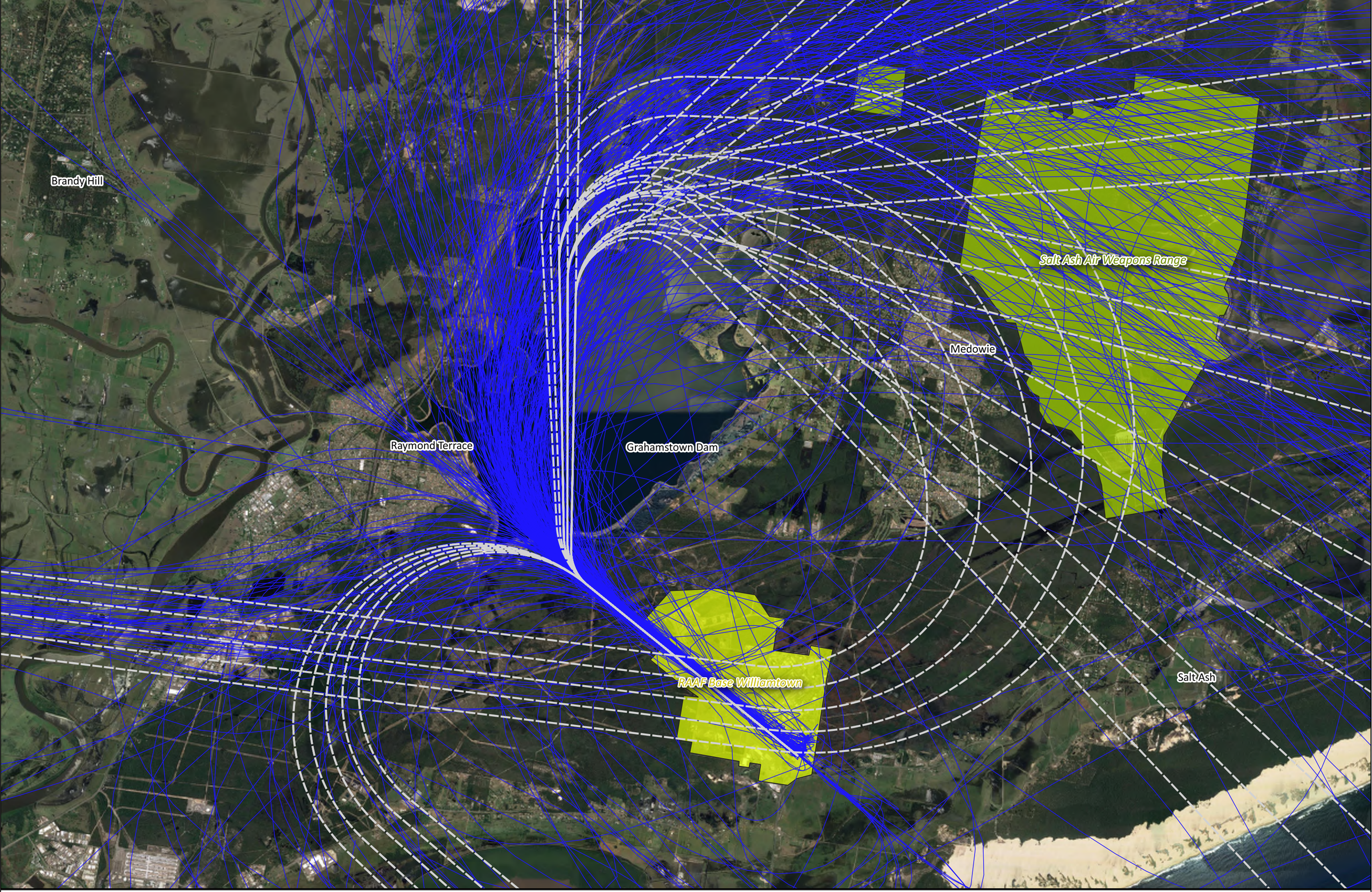
This comparison illustrates that the actual F-35A aircraft departure flight tracks on runway 30 avoid passing over Raymond Terrace, and fly north of built-up areas over Medowie. However, the tracks flown are characterised by a wider right turn, and a greater dispersion of movements than represented in the EIS. As a result, the actual flight tracks overlap the western extent of the Grahamstown Dam, and are therefore nearer to the northeast extent of Raymond Terrace than the EIS model flight tracks.

The effect of these differences is that the noise of F-35A departures on runway 30 is likely to have been higher than if the actual flight tracks aligned more closely with the flight tracks in the EIS noise modelling. It is however noted that the departure described by the Fly Neighbourly Policy is a military fast jet measure and is therefore applicable to F/A-18A/B Hornet operations. A review of F/A-18A/B Hornet departure 30 flight tracks during the period December 2018 – December 2020 showed similar trends to those by the F-35A aircraft. Accordingly, the observed differences in flight tracks, and the expected effect in terms of noise levels, applies generally to military fast jet operations and is not specific to the F-35A aircraft.

In September 2020, ACG began trials of earlier turns to the north when departing on runway 30 to move departure flight tracks over the middle of Grahamstown Dam, further east of Raymond Terrace.

Figure 15 shows the flight tracks where an earlier turn over the dam was trialled (yellow) compared with other departure tracks (blue). The earlier turn generally results in flight tracks that are further from Raymond Terrace. However, this also results in flight tracks that are closer to residential areas to the east of the dam.

ACG are continuing to evaluate and trial alternative departure flight tracks in accordance with the BANMP F-35A Aircraft Noise Flight Activity Verification Program.



F-35A aircraft runway 30 departure flight tracks: EIS noise model and actual tracks

Figure number: 14

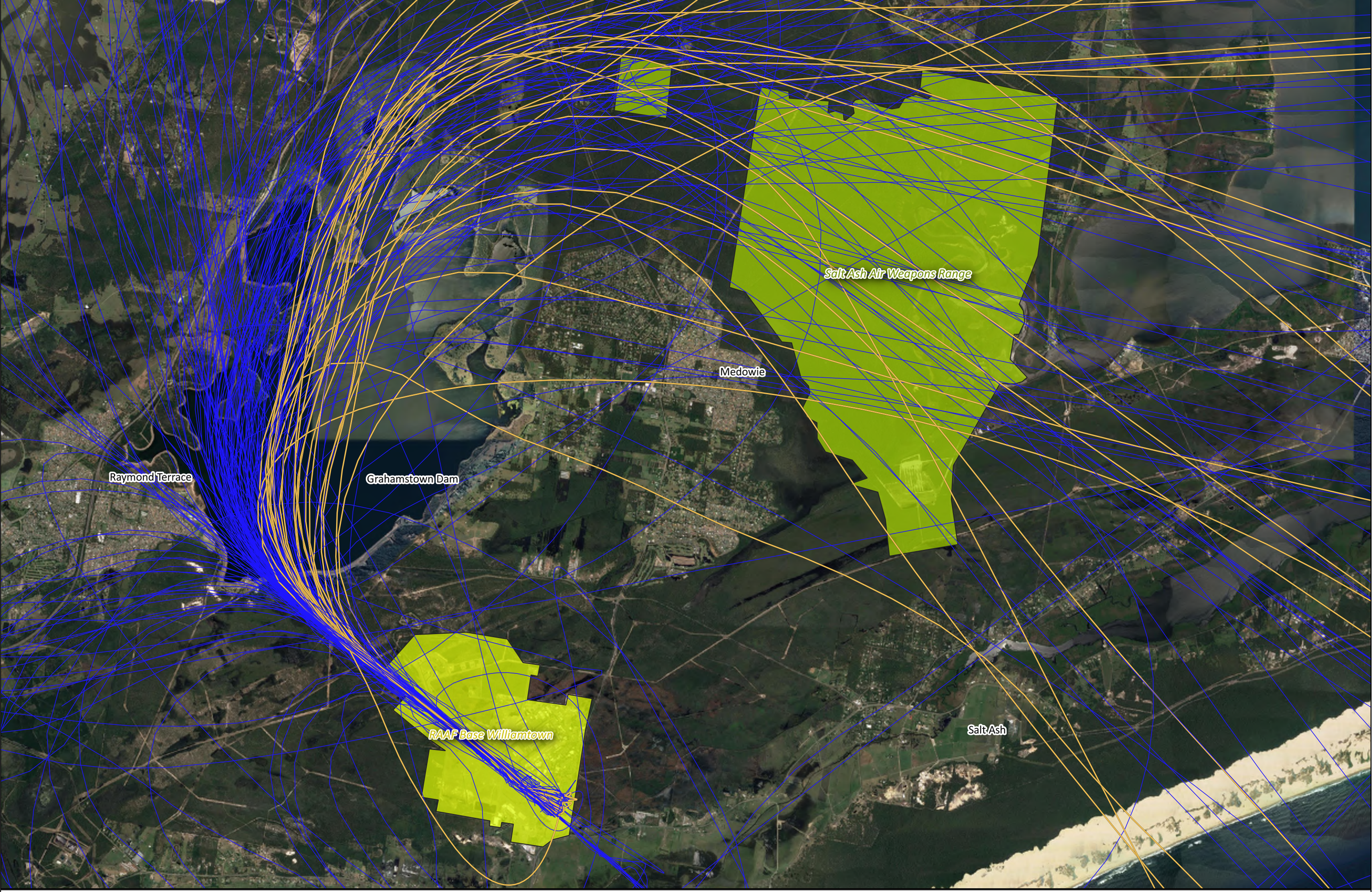
Legend
- EIS noise model flight track
- NFPMS flight track

Report number: Rp 002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 1 2 km

N



F-35A aircraft departure 30 flight tracks over Grahamstown Dam - ACG trials

Figure number: 15

Legend
Trial of early turn
Other

Report number: Rp 002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 1 2 km N

4.7 Flight profile use

Aircraft flight profiles describe the different procedures that are performed by aircraft and are used to characterise the operating state of the aircraft at different points along a flight track.

The aircraft flight profiles used for the purpose of the EIS noise modelling are defined by a set of points that characterise the geometrical and physical characteristics of an aircraft's flight operation. The flight profile relates the aircraft's ground distance with its altitude, true airspeed, and engine thrust setting. For the purpose of the EIS noise modelling, the engine thrust setting was the operational characteristic used to define the noise emission of the aircraft at any given point along the aircraft's flight track. The noise emission value is then used to calculate the noise level at ground locations. Thrust setting is therefore an important point of comparison when considering predicted and actual flight profile use. For the F-35A aircraft, the thrust setting is defined in terms of the Engine Thrust Request (ETR), where 100 % ETR represents full 'military power,' without afterburner.

4.7.1 Flight profile use – EIS information

The EIS presented the forecast annual percent use of various F-35A aircraft arrival, departure and circuit flight profiles. This information is shown in Table 7.

Table 7: EIS F-35A aircraft arrival, departure and circuit profile percent use at RAAF Base Williamtown

Operation	Profile type	Percent use
Departures	Military power take-off with reduced thrust (60 % ETR) on climb	80 %
	Military power take-off with military power on climb	0 %
	Afterburner take-off with reduced thrust (60 % ETR) on climb	19.8 %
	Afterburner take-off with military power on climb	0.2 %
Arrivals	Initial and pitch	80 %
	Tactical Air Navigation System (TACAN) arrival	6 %
	Instrument Landing System (ILS) arrival	10 %
	Straight in visual arrival	4 %
Circuits	Normal touch and go	87 %
	Low level touch and go	13 %

The key assumptions for flight profile use described in Table 7 with respect to noise were:

- The use of reduced thrust (60 % ETR) during climb for almost all F-35A aircraft departure movements;
- Afterburner would be used for approximately 20 % of F-35A aircraft departures during take-off, when required for operational or safety reasons, such as maintenance test flights, heavy-weight operations, or adverse weather (e.g. wet runway); and
- The majority (80 %) of F-35A aircraft arrivals to be visual, using initial and pitch, where the aircraft turns into a circuit pattern around the base while decelerating, prior to landing.

4.7.2 Flight profile use – Actual for period December 2018 - December 2020

Departure operations

ACG departure records were analysed for F-35A aircraft departure profile use, including the use of afterburner.

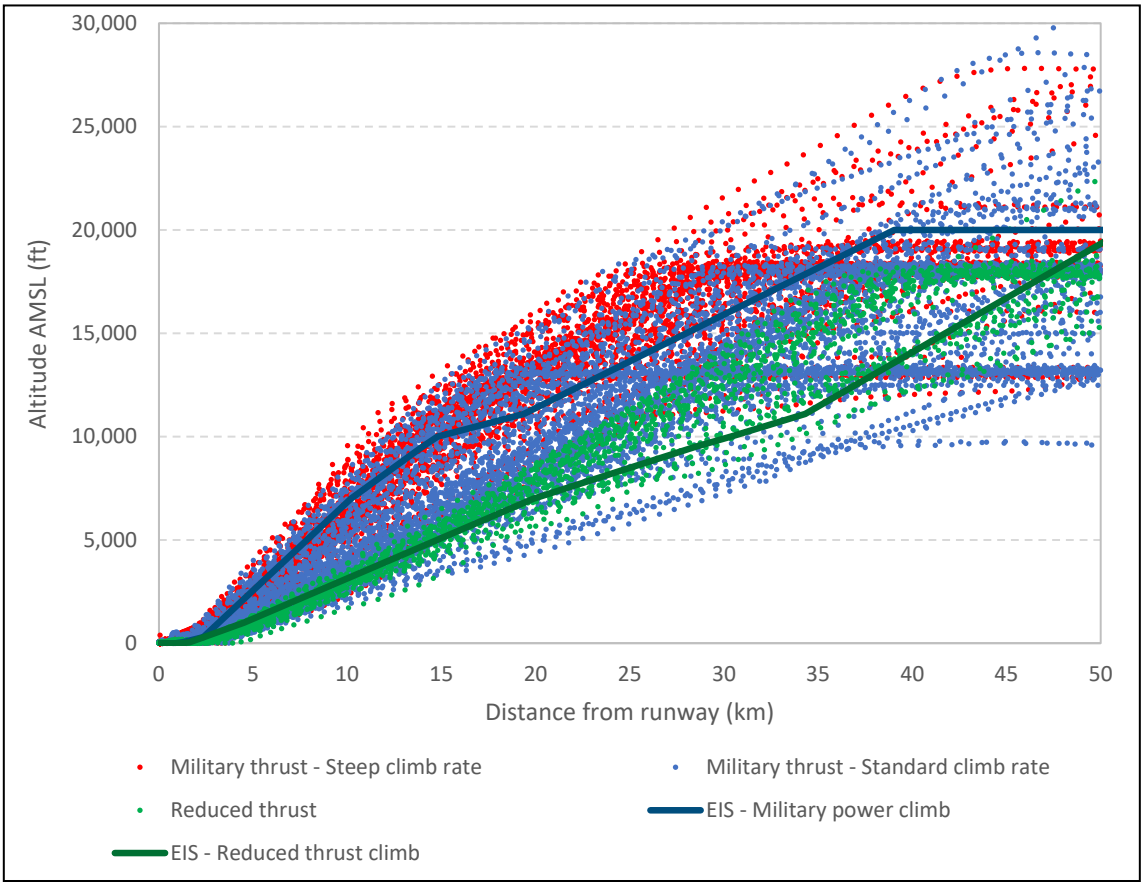
In mid-2019, ACG trialled the reduced thrust climb departure described in the EIS, i.e. using a thrust setting of 60 % ETR during the climb segment. It was quickly identified that the aircraft could not safely depart the base at this reduced thrust setting. It was therefore necessary to adopt thrust settings that were higher than those assumed in the EIS. The higher thrust settings were required to enable the F-35A aircraft to reach optimal airspeeds and satisfactory climb rates to meet minimum safety requirements, should the aircraft need to manoeuvre away from built up areas and ultimately turn back to the base and make an emergency landing in the event of engine failure.

In October 2019, ACG began trials of alternative departure profiles not considered by the EIS, which included the aircraft using military power thrust setting and a steep angle of climb to increase the altitude of the aircraft. The increase in altitude is intended to offset higher noise emissions due to the use of higher thrust settings by increasing the separating distance between the aircraft and sensitive receivers. In September 2020, ACG also began trials of an additional alternative noise mitigation departure profile from runway 30 (to the northwest), where the aircraft uses afterburner during take-off, followed by military power for the climb. The aircraft turn due north to pass over Grahamstown Dam earlier and hence further east of Raymond Terrace. The intent of this alternative profile is based on the same underlying objective of offsetting increased noise emissions with increased separation by enabling the aircraft to reach higher altitudes sooner after takeoff.

All activities are in accordance with the BANMP F-35A Aircraft Noise Flight Activity Verification Program, whereby alternative departure procedures at RAAF Base Williamtown are being investigated with the aim of identifying procedures that do not compromise the safe operation of the F-35A aircraft, and minimise noise at sensitive receivers, while still achieving training and operational requirements.

Figure 16 presents the F-35A aircraft actual climb profiles during departure operations, overlaid with the climb profiles included in the EIS.

Figure 16: F-35A aircraft climb profile at RAAF Base Williamtown



Arrival and circuit operations

NFPMS arrival flight tracks have been classified as either an initial and pitch or a straight in.

The straight in arrivals are either visual or use an instrument landing system (no information available to distinguish if an instrument landing system was used). ACG has advised that the flight profiles for visual and instrument straight-in arrivals are the same.

The NFPMS system includes touch-and-go circuit training segments of a flight track as part of an arrival. Additional data from the NFPMS would need to be analysed to provide further information, including a break-down of normal and low level circuits (limitations of the radar system resolving flight tracks of low altitude or close to the base).

Actual profile use

Table 8 presents a percentage break-down of F-35A aircraft departure (based on the ACG data) and arrival profiles (derived from analysis of the NFPMS data) being conducted as part of the F-35A Aircraft Noise Flight Activity Verification Program.

Table 8: F-35A aircraft flight profile use at RAAF Base Williamtown

Operation	Flight profile	December 2018 – December 2019	January 2020 – December 2020
Departure	Military power take-off with reduced thrust on climb	30 %	11 %
	Military power take-off with military power on climb	52 %	41 %
	Military power take-off with military power steep climb (alternative trialled noise-mitigation departure profile)	6.5 %	0 %
	Afterburner take-off with reduced thrust on climb	1.5 %	-
	Afterburner take-off with military power on climb	3 %	7 %
	Afterburner take-off with military power steep climb (alternative trialled noise-mitigation departure profile)	1.5 %	28 %
	Afterburner take-off with military power steep climb and an early turn over Grahamstown Dam (alternative trialled noise-mitigation departure profile)	-	11 %
	Other	5.5 %	2 %
Arrival	Initial and pitch	56 %	57 %
	Straight in (visual or instrument landing system)	44 %	43 %
Circuit	No information available	-	-

The following key points are noted from a comparison of the EIS and actual F-35A aircraft flight profile use:

- The departure procedures trialled employed a range of different strategies, including alternative reduced thrust settings which could be safely maintained, though higher than in the EIS;
- In 2019, the reduced thrust climb profile only comprised approximately one third of all departure operations, whereas the EIS was based on almost all (>99 %) departure operations adopting a reduced thrust climb using a 60 % ETR setting;
- In 2020, 50 % of departures adopted a profile to reduce noise, either using reduced thrust or adopting a steep climb angle;
- The 6 % use of afterburner in 2019 was below the 20 % presented in the EIS. Conversely, afterburner use increased in 2020 (46 %), primarily due to the trial of alternative departure profiles; and
- More than half (57 %) of arrivals were initial and pitch, below the EIS value of 80 %. However, given that not all aircraft activate their NFPMS transponder during formation flying (including during initial and pitch arrivals), the percentage of actual initial and pitch arrival profiles flown is likely to be higher than indicated and the percentage of straight in arrivals are therefore likely to be lower than indicated.

4.8 Salt Ash Air Weapons Range activities

4.8.1 SAAWR activities – EIS information

The EIS was based on 1,200 passes at SAAWR by the F-35A aircraft, occurring over 52 of the 115 permitted days of use of the range per year. This results in an average of 23 passes per day of use of SAAWR by the F-35A aircraft.

SAAWR operations are commonly scheduled to occur between 9 am and 4 pm. Night flying at SAAWR by any military fast jets is restricted to the minimum required to achieve operational and training targets, and generally there is no flying after 9 pm (10:30 pm during daylight saving).

4.8.2 SAAWR activities – Actual for period December 2018 - December 2020

Table 9 presents a summary of ACG records of F-35A aircraft passes at SAAWR.

Table 9: Number of F-35A aircraft passes at SAAWR

Date	Number of passes
7/05/2019	20
8/05/2019	19

Use of SAAWR by F-35A aircraft was considerably less than the EIS forecast for 2025, which is to be expected, as the EIS was based on FOC (all aircraft delivered). Additionally, ACG has advised that some F-35A aircraft training missions were conducted at Evans Head Air Weapons Range in lieu of SAAWR.

ACG records indicate that the 20 F-35A aircraft SAAWR passes on Thursday 7 May 2019 occurred in two (2) waves of two (2) aircraft; the first occurring after 9:30 am and the second after 2:30 pm. The 19 passes on Friday 20 May 2019 occurred in a single wave of two (2) aircraft after 9.30 am.

For context, there were three (3) days of SAAWR use by the F/A-18A/B Hornet in 2019 and three (3) days of use in 2020. The number of F/A-18A/B Hornet passes at SAAWR per day varied between 56 and 257.

4.9 Noise management measures

4.9.1 Noise management measures – EIS Information

Section 13 of the EIS included a summary of the noise management measures proposed by Defence for F-35A aircraft operations around RAAF Base Williamtown and SAAWR. At the time of preparing the EIS, these measures were expected to be practically achievable without compromising safety or operational requirements. The measures are summarised as follows:

- Departures on runway 30, and the majority of arrivals on runway 12, avoiding direct over flight of Raymond Terrace by adhering to flight paths over Grahamstown Dam;
- The majority of departure movements using military power during the ground roll, take-off and initial climb from the runway and then reduced (60 %) thrust settings for the departure climb to an altitude of 10,000 ft;
- Reducing the number of departure movements using afterburner during the ground roll, take-off and initial climb from the runway to 20 % of movements; this is compared to the F/A-18A/B Hornet which adopted afterburner for almost all of these procedures;

  This was considered achievable, as a result of the combination of the runway extension, and the enhanced capability of the F-35A aircraft;
- Departures on runway 30 avoiding over-flight of Medowie at altitude not less than 3,500 ft above mean sea level (AMSL);
- Reduction in the number of straight in arrivals on runway 12 which involve over flight of Raymond Terrace, by restriction of instrument arrivals to poor weather and greater use of simulator training for this type of procedure;
- Reduced annual F-35A operations at SAAWR, and a reduced number of flying days (52 days per year compared to the average annual allowance of 115 days applicable to Hawk 127 and F/A-18A/B Hornet operations); and
- Limiting F-35A aircraft operations at SAAWR to air to ground gunnery with modified procedures specifically developed for the management of aircraft noise. The F-35A aircraft was not proposed to engage in practice bombing at SAAWR as previously undertaken by the F/A-18A/B Hornet.

4.9.2 Noise management measures – Actual for period December 2018 – December 2020

Regarding the implementation of noise mitigation measures described in the EIS, Condition 2 of the approval decision states:

> *Implement the management and mitigation measures outlined at M01 to M36 of Appendix M of the Environmental Impact Statement and at SO1 to S08 of Annex A.*

Defence has published the first Annual Environmental Compliance Report (2020) to address Condition 7 of the approval decision. This requires publication of an annual report summarising the progress on addressing each condition.

Attachment A of the Annual Environmental Compliance Report (2020) lists the environmental management and mitigation measures referenced in Condition 2 and summarises the progress on addressing each measure.

The relevant F-35A aircraft management and mitigation measures that relate to flying activity and noise levels, and progress comments from the report are provided in Table 10. Additional comments are provided based on the findings of the preceding sections.

Table 10: F-35A aircraft noise management measures reproduced from Appendix M of the EIS

No.	Item	Defence comments from Annual Environmental Compliance Report	Additional comments
M01	Schedule operations on weekdays, where possible (training flights on weekends and public holiday will not generally occur).	*Condition met through application of RAAF Base Williamtown Aircraft Noise Management Plan (BANMP). Subsequent Base NMPs will be developed prior to arrival of F-35A at those locations.*	Section 4.3.2 demonstrated that more than 99 % of F-35A aircraft operations occurred on weekdays during the period December 2018 – December 2020.
M02	Schedule the majority of aircraft movements generally between 7 am and 10 pm (11 pm during daylight savings). (Applicable to RAAF Base Williamtown)	*Condition met through application of RAAF Base Williamtown Aircraft Noise Management Plan (BANMP). Subsequent Base NMPs will be developed prior to arrival of F-35A at those locations.*	Section 4.4.2 demonstrated that fewer than 1 % of F-35A aircraft movements at RAAF Base Williamtown occurred between 11 pm and 7 am during the period December 2018 – December 2020.
M03	Comply with flight path requirements as specified in the Defence policies.	*Condition met through application of RAAF Base Williamtown Aircraft Noise Management Plan (BANMP). Subsequent Base NMPs will be developed prior to arrival of F-35A at those locations.*	Section 4.6 reviews actual F-35A aircraft flight path in the context of Defence policies. A description of the requirements in Defence policies is discussed in Section 3.1.3 of the separate Marshall Day Acoustics report (2021).
M04	Follow the Air Combat Group Fly Neighbourly Policy guidelines where training and operational requirements and flight safety circumstances allow.	*Condition met through application of RAAF Base Williamtown Aircraft Noise Management Plan (BANMP). Subsequent Base NMPs will be developed prior to arrival of F-35A at those locations.*	The use of Fly Neighbourly Policy flight tracks is discussed in Section 4.6.3.
M05	Limit night flying at SAAWR to the minimum required to achieve operational and training targets.	*Condition met through application of RAAF Base Williamtown Aircraft Noise Management Plan (BANMP). Subsequent Base NMPs will be developed prior to arrival of F-35A at those locations.*	Section 4.8.2, details F-35A aircraft flying activity at SAAWR, which was limited to two (2) days during the period December 2018 – December 2020. This is expected given the low number of F-35A aircraft that have been delivered and operating. All F-35A aircraft SAAWR activity occurred during the day.

No.	Item	Defence comments from Annual Environmental Compliance Report	Additional comments
M07	Adopt a 60 % thrust setting during climb, as a standard procedure where training and operational requirements and flight safety circumstances allow	*In preparation for the commencement of F-35A operations at Williamtown, Air Force adopted a 60 % Engine thrust required (ETR) setting as a planned standard procedure, as documented in the approved RAAF Base Williamtown Base Aircraft Noise Management Plan of December 2018.* *In early 2019, shortly after commencement of the first F-35A operations at Williamtown, it became clear that the F-35A cannot safely depart the airfield in 60 % ETR setting. In late 2019, after 10 months of trialling various departure profiles, Air Force has concluded that flight safety is compromised and a safe departure profile cannot be achieved at 60 % ETR setting.* *Through the transition period, Air Force will continue to trial F35A departure profiles aiming to develop suitable profiles that minimise the impacts of aircraft noise, whilst ensuring training requirements, operational requirements and safe operations of the aircraft are achieved. The first biennial noise report due in early 2021 will assess the implications of the trials, including comparison with EIS predictions, and will inform any corrective measures developed and implemented in accordance with Condition 1 and Condition 3. Defence will continue to engage with local communities on these matters.*	ACG has been investigating alternative departure procedures at RAAF Base Williamtown as part of the F-35A Aircraft Noise Flight Activity Verification Program. The aim of the investigation is to identify departure procedures that do not compromise the safe operation of the F-35A aircraft while minimising noise at sensitive receivers. These include using either military or afterburner thrust during departure and different rates of climb to maximise altitude, thereby increasing the separation between the aircraft and sensitive receivers. ACG has continued to trial alternative departure procedures throughout 2019 and 2020. Further details are provided in Section 4.7.2.
M08	Limit afterburner take-offs to only those that are required for training, operational and safety reasons.	*Condition met through application of RAAF Base Williamtown Aircraft Noise Management Plan (BANMP) 2018. Subsequent Base NMPs will be developed prior to arrival of F-35A at those locations.*	Section 4.7.2 presents information on afterburner use during the period December 2018 – December 2020. ACG is currently evaluating alternative departure flight profiles including increased use of afterburner as part of the V&V program. Refer to comments for item M07.

No.	Item	Defence comments from Annual Environmental Compliance Report	Additional comments
M30	Abide by the no-fly zone over Cabbage Tree Island and Boondelbah Island during Gould's Petrel breeding season. Under the no-fly zone, F-35A aircraft will have altered flight paths to avoid flying close to, or above the islands.	*A Hazard and Noise Database provides "no fly" zones for Cabbage Tree Island and Boondelbah Island. The HAND informs aircraft navigation systems.*	Details are provided below.
S03	Introduce new noise abatement procedures for RAAF Base Williamtown in October 2014.	*Noise abatement procedures were implemented at RAAF Base Williamtown in October 2014.*	Refer to comments for item M07.

In addition to the implementation of noise mitigation measures described in the EIS, an evaluation of Defence's existing noise management programs, flight activity monitoring systems, and the communication of information on F-35A aircraft noise to the public has been addressed separately in the review of F-35A aircraft noise management and reporting (Marshall Day Acoustics, 2021). That report was specifically prepared to address specific subclauses of Condition 3 of the approval decision, with elements referenced in the additional comments in Table 10.

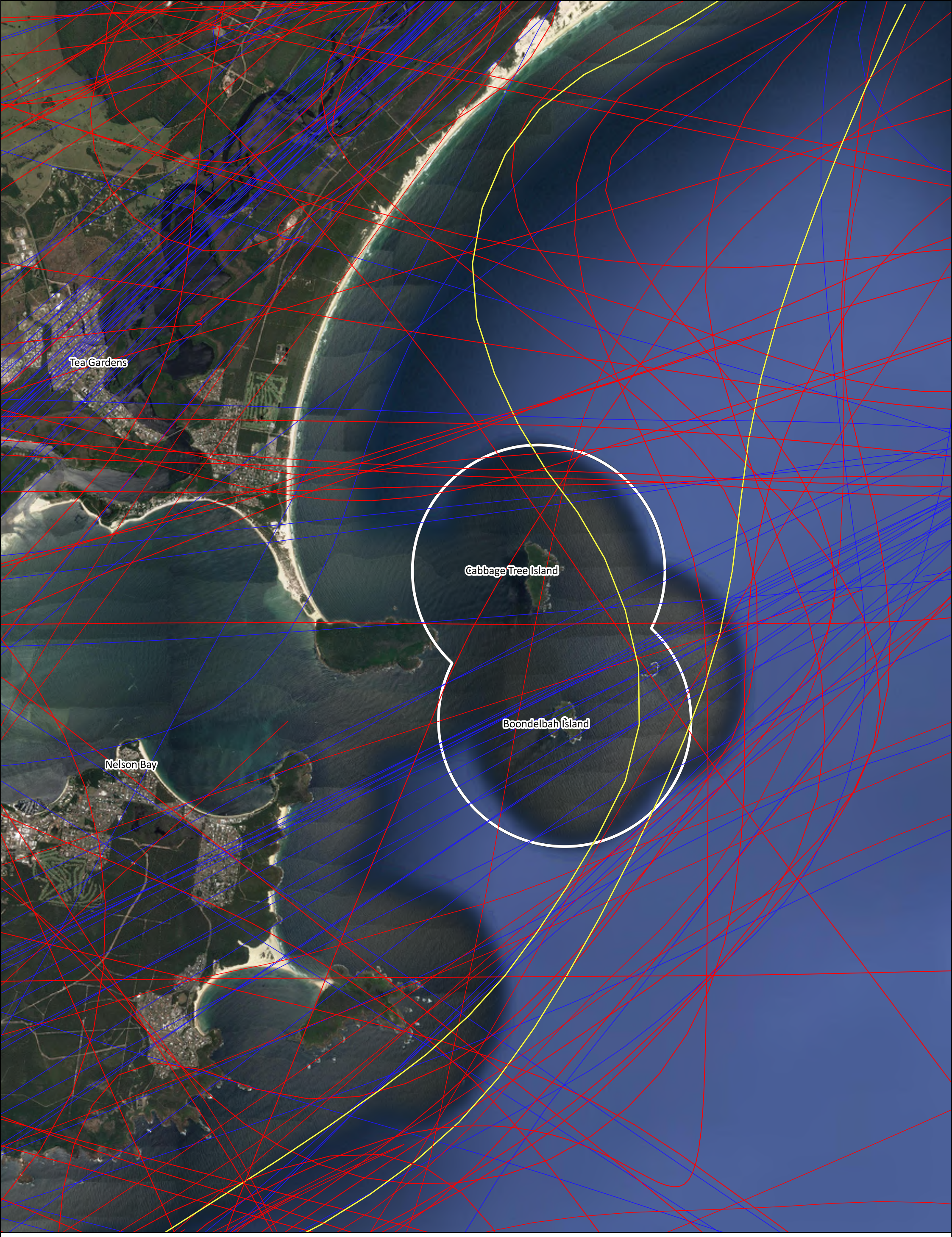
Flight tracks near Cabbage Tree Island and Boondelbah Island

The NFPMS radar data indicates civilian and military flights occurred in vicinity of the islands over the two year period.

Figure 17 presents F-35A aircraft flight tracks in the vicinity of Cabbage Tree Island and Boondelbah Island during the Gould's Petrel breeding season (nominally November – April).

Arrival flight tracks (shown in red) generally avoid overflight of the islands, with two (2) identified flights (shown in yellow) within the no-fly zone. An explanation for this could be for avoidance of weather or other aircraft traffic. Departure flight tracks (shown in blue) that passed directly over or near the island occur outside the no-fly zone (i.e. maintain minimum altitude).

Figure 18 shows the minimum altitude of F-35A aircraft flight tracks that passed within 1 nmi of Cabbage Tree Island and Boondelbah Island during the Gould's Petrel breeding season. The figure shows that all but the two (2) flights were well above the no-fly zone minimum altitude.



F-35A aircraft flight tracks in the vicinity of Cabbage Tree Island and Boondelbah Island during the Gould's Petrel breeding season

Figure number: 17

Legend
- No fly zone below 2,000 ft
- NFPMS flight track arrival
- NFPMS flight track departure
- Flight tracks within no-fly zone

Report number: Rp002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 1 2 km

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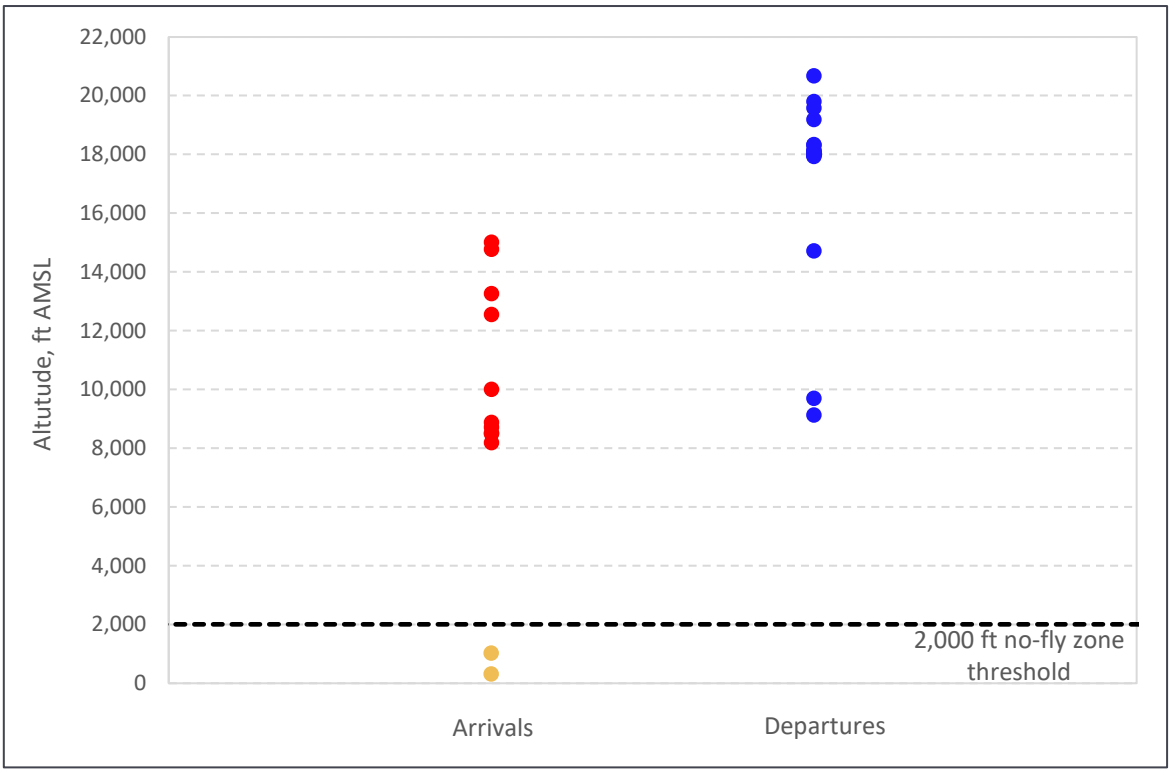
Figure 18: Minimum altitude of F-35A aircraft flight tracks within 1 nmi of Cabbage Tree Island and Boondelbah Island during the Gould's Petrel breeding season



4.10 Summary of F-35A aircraft flying activity

The key points from the comparison of the F-35A flying activity forecasts presented in the EIS with the actual flying activity of the aircraft during the period December 2018 – December 2020 are summarised in Table 11.

Importantly, the EIS predictions for F-35A aircraft operations were based on a forecast year 2025 when all aircraft would have been delivered and at FOC. Not all F-35A aircraft have been delivered to date and the aircraft is not at FOC. Accordingly, there were fewer F-35A aircraft movements and hence actual aircraft noise events than was presented in the EIS.

Table 11: F-35A aircraft flight activity comparison summary

Item	Comparison summary
Number of aircraft	There were fewer aircraft operating at the base compared to the operating scenario considered in the EIS.
Number of movements	F-35A aircraft movement numbers were considerably lower than presented in the EIS.
Days of operation	The days of operations were comparable with the information presented in the EIS. The total number of days of operation per year were less than presented in the EIS.
Hours of operation	The hours of daytime operations were consistent with the information presented in the EIS. There were considerably fewer movements occurring after 7 pm when compared to the EIS for night-time flying.
Runway use	The percentage runway use was comparable to the information presented in the EIS.
Flight tracks	While the EIS noise model flight tracks are generally representative of typical F-35A aircraft flight tracks near noise sensitive receivers, both F/A-18A/B Hornet and F-35A aircraft departures from runway 30 pass closer to populated areas than the tracks used in the EIS noise model. Notwithstanding this, a key part of the EIS assessment was the prediction of the change in noise levels associated with F-35A aircraft flying operations. F/A-18A/B Hornet and F-35A aircraft operations were modelled in the EIS using identical flight tracks. The actual measured departure flight tracks to the north showed that for both aircraft, the tracks cover the same area and exhibit similar dispersion. This finding is therefore not specific to F-35A operations. Percentage flight track use differed to the EIS noise model, however this is consistent with expectations given that the EIS flight tracks and their use were a simplified representation of typical flight tracks, and that the F-35A aircraft flying activity during the transition period is unlikely to be representative of FOC.
Flight profile use	The actual flight profile use differed to that presented in the EIS. The use of reduced thrust during departures was a noise mitigation included in the EIS and considered feasible by Defence. This has subsequently been identified as not satisfying ACG safety requirements and impractical to implement. Departure profile use has therefore differed to the EIS due to ACG assessing the capabilities of the aircraft and evaluating alternative and safer procedures. It is expected that departure noise mitigation measures will continue to evolve with alternative trial profiles that involves climbing at a higher rate to maximise altitude, thereby increasing the separation between the aircraft and sensitive receivers. There is an indication that initial and pitch arrivals may have been used less regularly than envisaged in the EIS. This is an aspect of operations which will likely change as the F-35A aircraft progresses to FOC.

Item	Comparison summary
Salt Ash Air Weapons Range (SAAWR) activity	The use of SAAWR was considerably lower than the presented in the EIS, which is consistent with expectations given the lower number of F-35A aircraft and hence flying operations during the transition period.
Noise management measures	Defence published the first Annual Environmental Compliance Report (2020) that includes discussion on the progress in implementation of the noise management measures detailed in the approval decision. The findings of this report are that EIS noise management measures have been implemented by Defence in all instances where both safety and operational requirements are able to be maintained. Defence has commenced investigations into trialling alternative procedures, where mitigation measures have not been implemented as a result of safety requirements.

5.0 AIRCRAFT NOISE LEVELS

This section presents a comparison of the EIS information with actual F-35A aircraft noise levels during the period December 2018 – December 2020, to address Condition 1 and Condition 3.e.ii.i. of the approval decision.

5.1 Noise information and metrics

The following subsections outline the F/A-18A/B Hornet and F-35A aircraft noise level metrics that have been generated to compare with information presented in the EIS.

Actual (measured) noise level information is only available at the permanent NMTs installed in the vicinity of RAAF Base Williamtown and SAAWR. Further, since the time of preparation of the EIS, additional NMTs have been deployed around the base. The noise models used for the EIS have therefore been recalculated for all NMT locations to provide the requisite data for the comparison (to confirm, the model inputs and calculation parameters are identical to the EIS – the only change was the inclusion of a geographic calculation point for each NMT).

The average noise level statistics were calculated as follows:

- Predicted data from EIS noise modelling: averaged over the potential number of days of flying activity (240 days per year); and
- Measured data during the period December 2018 – December 2020: averaged over the actual number of days of flying activity of each aircraft in 2019 and 2020. However, annual ANE values are averaged over 240 days as per the method for the calculation of the ANEF around RAAF Base Williamtown and SAAWR.

5.1.1 Number Above

Number Above values refer to the number of aircraft events that generate a noise level above a given maximum noise level threshold in a day; for example, the term *N70 20 events* means there were 20 or more daily aircraft noise events with a noise level 70 dB L_{Amax} or greater.

Number Above values for 70 dB L_{Amax} and 85 dB L_{Amax} noise level thresholds (i.e. the N70 and N85 respectively) have been calculated at each NMT location and compared with the EIS predictions. The Number Above values have been calculated based on the total number of aircraft events and the total number of flying days for each aircraft, and therefore represent the average number of events above these thresholds per day.

To review the change in daily Number Above events as more F-35A aircraft were delivered over the period December 2018 – December 2020, daily Number Above values are also provided for each quarter (3 month period).

5.1.2 Event level histograms

The approval decision infers the comparison of single figure noise levels for a given noise metric at a given location. However, irrespective of the noise metric considered, actual environmental noise levels in practice are inherently and highly variable. This variability arises from a range of factors related to changes in aircraft operating patterns (flight profiles and paths), aircraft procedures, and atmospheric conditions that influence sound propagation.

The effect of this variation is that step changes in single figure ratings of a noise environment cannot be simply interpreted as a corresponding step change in the perceived noise level which is experienced in practice. This is particularly the case when the change in noise levels or the number of aircraft noise events are comparable to, or considerably less than, the variation in levels and events that occur on a day-to-day basis.

To provide information that accounts for the range of variation that occurs in practice, the aircraft noise levels are presented in the form of histograms to compare measured aircraft noise levels with the EIS predictions.

5.1.3 Maximum noise levels

A simplified comparison of maximum noise levels for both arrival and departure operations is presented to review differences between F/A-18A/B Hornet and F-35A aircraft noise levels. Specifically, these operations relate to arrivals and departures to and from the Base.

The arithmetic average (mean) and highest (90th percentile) values of actual measured noise levels are compared with average (mean) and absolute highest predicted maximum noise level values presented in the EIS respectively.

These values are presented for informative purposes only as a practical way of addressing the volume of data relating to the maximum noise levels of individual events, enabling a simplified comparison of F/A-18A/B Hornet and F-35A aircraft maximum noise levels at each NMT.

5.1.4 Australian Noise Exposure (ANE)

The Australian Noise Exposure (ANE) rating is a noise metric predominantly used by local planning authorities for assessing new sensitive development and land use in the vicinity of an airfield. The ANE rating is a complex metric, based on noise exposure from all aircraft operations at an airport, using the concept of an average annual day. The ANE considers noise exposure for all aircraft operating at the base and is not limited to just a single aircraft type.

The contribution of F/A-18A/B Hornet and F-35A aircraft operations to the ANE at each NMT location has been derived from measurement data for 2019 and 2020 and compared to the EIS predictions.

The measured ANE contribution has been averaged over 240 days of flying activity per year, consistent with the EIS and the endorsed ANEF for RAAF Base Williamtown and SAAWR.

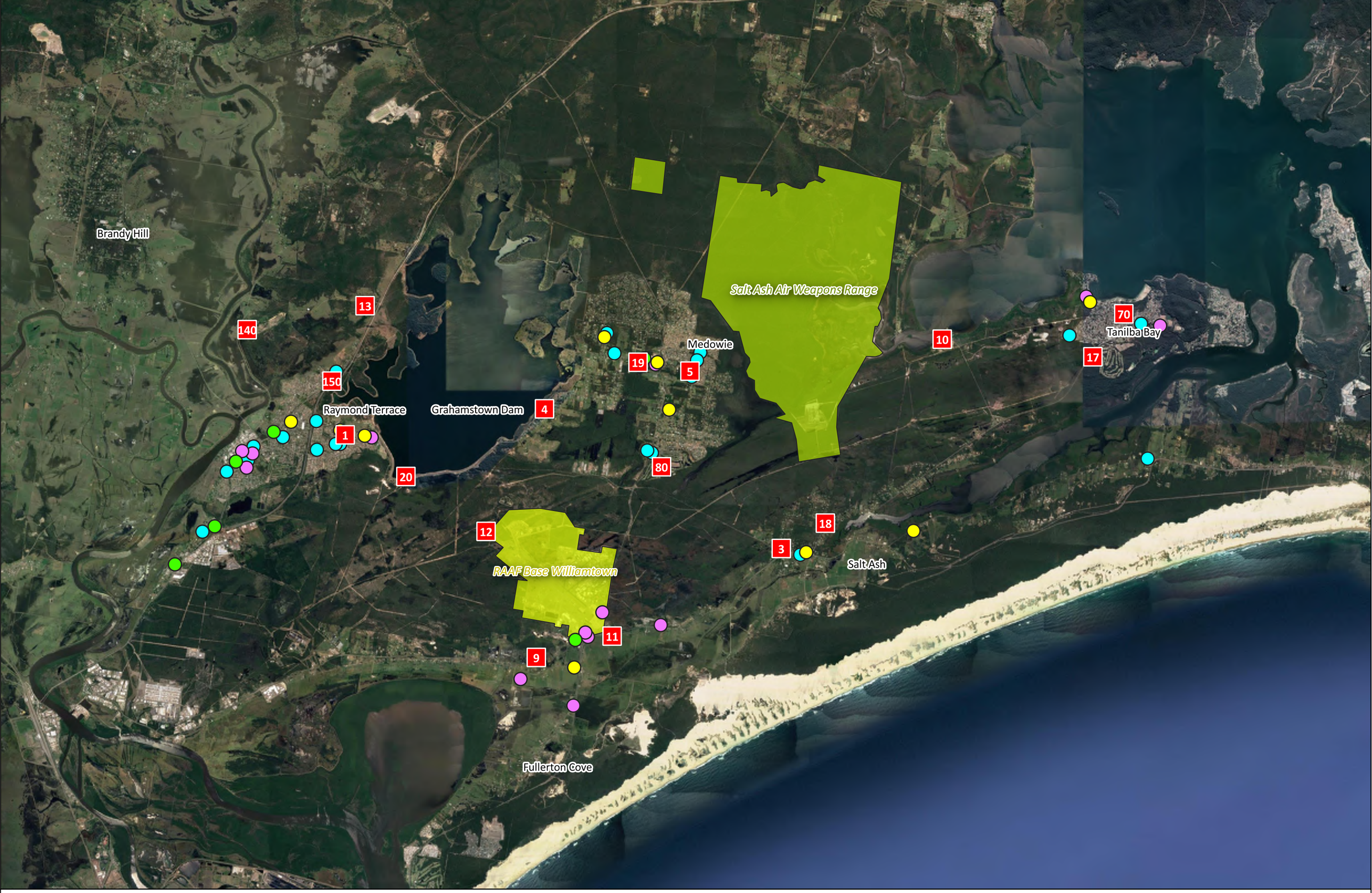
5.2 Comparison of aircraft noise level information

The comparison of the EIS predictions and measured aircraft noise levels at each NMT location are presented in Appendix E. Table 12 lists the relevant appendix for each NMT analysis.

Table 12: Noise level analysis

NMT	Name	Appendix reference for detailed aircraft noise levels
1	Grahamstown Public School	Appendix E1
3	Salt Ash Public School	Appendix E2
4	Lakeside Drive, Campvale	Appendix E3
5	Wirreanda Public School	Appendix E4
9	Cabbage Tree Road, Williamtown	Appendix E5
10	Frederick Drive, Oyster Cove	Appendix E6
11	Runway 30	Strategic NMT for aircraft counting purposes. The location is not representative of noise levels at Points of Interest or other sensitive receivers close to the base, therefore no analysis is presented at this location.
12	Runway 12	Strategic NMT for aircraft counting purposes. The location is not representative of noise levels at Points of Interest or other sensitive receivers close to the base, therefore no analysis is presented at this location.
13	Disabled Riding School	Appendix E7
17	Tanilba Golf Club	Appendix E8
18	Salt Ash Fire Station	Appendix E9. This is also a strategic NMT for aircraft counting purposes of SAAWR activity.
19	Ferodale Road, Sewerage Pump Station	Appendix E10
20	Water Pump Station, Ferodale	Appendix E11
70	Tanilba Primary School	Appendix E12
80	Pacific Dunes Golf Course	Appendix E13
140	Waste Transfer Station	Appendix E14 There are no Points of Interest or other sensitive receivers in vicinity of this NMT, therefore the analysis is presented for information only.
150	Rees James Road, Raymond Terrace	Appendix E15

A map showing the locations of each NMT in the vicinity of RAAF Base Williamtown and SAAWR, points of interest, and areas of relatively high residential density is provided in Figure 19.



NMT and Points of Interest in vicinity of RAAF Base Williamtown and SAAWR

Figure number: 19

Legend

- Accommodation
- Public Building
- School
- Place of Worship
- NMT

Report number: Rp 002 R01 20200162
Image source: Google Maps

MARSHALL DAY Acoustics

0 1 2 km

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The following key observations are noted in relation to aircraft noise levels around RAAF Base Williamtown and SAAWR:

- Number Above
  - There were considerably fewer F-35A aircraft N70 events during the period December 2018 – December 2020 when compared with the EIS. This is expected given there were fewer F-35A aircraft operating than considered in the EIS, which was based on a forecast year 2025, when all F-35A aircraft would have been delivered and at FOC; and
  - The trend in the quarterly values demonstrate an increase in average daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in average daily F/A-18A/B Hornet aircraft noise events in 2020.
- Event level histograms
  - The histograms illustrate similar ranges of noise levels for both aircraft, however the range for both aircraft was generally broader than the EIS predictions;
  - The measurements for both aircraft illustrate small numbers of events at noise levels above the range predicted in the EIS. In many cases, these variations will relate to atypical operations not represented in the EIS noise modelling; and
  - In some cases, the difference in range and distribution of noise levels compared with the EIS can be explained by the actual flying activity which occurred in practice (e.g. differences in the profiles flown and the departure tracks from runway 30).
- Maximum noise levels
  - Measured average maximum noise levels for the two aircraft are generally similar; and
  - The highest measured F-35A aircraft noise level are greater than the F/A-18A/B Hornet at some locations but lower at others, consistent with the findings and conclusions presented in the EIS.
- Australian Noise Exposure
  - The contribution to the measured noise exposure for each aircraft is generally lower than the EIS modelling. This is expected given the lower number of aircraft operating than considered in the EIS; and
  - The F-35A aircraft's contribution to the ANE is greater than expected at NMT locations near Raymond Terrace, even though there was a lower number of F-35A aircraft operations compared with the EIS. This is primarily due to the measured noise levels from departure operations on runway 30 being higher than the EIS. This is a result of the differences in the profiles flown and the departure tracks being flown closer to Raymond Terrace than what was considered in the EIS, coupled with the inability to safely fly the F-35A aircraft at 60 % ETR during climb out.

Table 13 summarises the maximum noise levels from aircraft operations near residential areas, based on the relevant NMT locations.

Table 13: Summary of aircraft noise levels at residential areas around RAAF Base Williamtown and SAAWR

Location	Discussion
Raymond Terrace (NMT ID 1, 13, 20, 150)	
Histograms	Approximately 50 % of measured F-35A aircraft events ranged between 80 and 95 dB L_{Amax}. This was greater than indicated by the EIS predictions (20 %). However, the measured percentage of occurrence of F-35A aircraft events in this noise level range was comparable to the measured occurrence of F/A-18A/B Hornet events. The difference for both aircraft is likely to relate to runway 30 departure flight tracks being flown closer to Raymond Terrace than considered in the EIS.
Maximum noise level statistics	Departures: Average measured F-35A aircraft departure noise levels were 7 – 15 dB higher than EIS predictions. Average measured F/A-18A/B Hornet departure noise levels were 6 dB higher than EIS predictions. The difference for both aircraft relates primarily to runway 30 departure flight tracks being flown closer to Raymond Terrace than considered in the EIS, as discussed in Section 4.6. The additional increase associated with F-35A aircraft can be attributed to the need for the aircraft to use higher thrust settings than was envisaged by Defence at the time of the EIS to satisfy ACG's minimum safe altitude and air speed targets (refer Section 4.7.2). Work is being conducted by ACG as part of the F-35A Noise Test and Flight Path Verification Program. Arrivals: Average measured maximum noise levels from F-35A aircraft arrivals were comparable to the EIS predictions.
Williamtown (NMT ID 9)	
Histograms	The EIS predicted maximum noise levels due to F-35A aircraft operations commonly ranged from 80 – 90 dB L_{Amax}, compared to 75 – 95 dB L_{Amax} for F/A-18A/B Hornet operations. The noise measurements indicated that there were comparable occurrences of events by both aircraft ranging between 70 and 85 dB $L_{Amax.}$
Maximum noise level statistics	Average measured aircraft noise levels from both arrival and departure operations were comparable to those presented in the EIS, although the predicted noise levels of F/A-18A/B Hornet departure operations were lower than indicated by the EIS predictions.
Medowie (central) (NMT ID 5, 19)	
Histograms	The measured percentage occurrence of F-35A aircraft events was generally comparable to the EIS predictions, albeit a lower number of events.
Maximum noise level statistics	Departures: Average measured aircraft noise levels from for both aircraft were comparable to those indicated by the EIS predictions. Arrivals: Average measured aircraft noise levels for both aircraft were lower than those indicated by the EIS predictions.

Location	Discussion
Medowie (south) (NMT ID 80)	
Histograms	The EIS predicted maximum noise levels due to F-35A aircraft operations commonly ranged between 70 and 75 dB L_{Amax}, compared to 65 – 75 dB L_{Amax} for F/A-18A/B Hornet operations. The noise measurements indicated that there were comparable occurrences of events by both aircraft ranging between 70 and 80 dB L_{Amax}
Maximum noise level statistics	Departures: Average measured F-35A aircraft departure noise levels were 4 dB higher than EIS predictions, though the highest measured events were lower than indicated by the EIS predictions. Arrivals: Average measured maximum noise levels of arrival operations by both aircraft were higher than EIS predictions (>10 dB). The number of aircraft events in these areas were however relatively low.
Salt Ash (NMT ID 3, 18)	
Histograms	The measured data for both arrival and departure operations (specifically, arrivals and departures to and from the base) showed comparable trends for the range and relative occurrence of noise events to those indicated by the EIS predictions, albeit at a much lower number of events. Importantly, the NMT measures noise events for all operation types including departure and arrival operations from the base as well as SAAWR activity, which was also the basis for the EIS predictions.
Maximum noise level statistics	Departures: The measured F-35A aircraft noise levels were comparable to those indicated by the EIS predictions. Absolute highest measured noise levels were lower than F/A-18A/B Hornet. Arrivals: Average measured maximum noise levels of arrival operations by both aircraft were higher than EIS predictions close to the base. The number of aircraft events in these areas were however relatively low.
Tanilba Bay (NMT ID 17, 70)	
Histograms	The measurement data showed comparable trends for the range and relative occurrence of noise events to EIS predictions for both aircraft.
Maximum noise level statistics	Departures Average measured F-35A aircraft noise levels were lower than indicated by the EIS predictions. F/A-18A/B Hornet noise levels were higher than the F-35A aircraft, which is consistent with the EIS. Arrivals: Average measured by both aircraft were much higher than indicated by the EIS predictions. The number of aircraft events in these areas were however relatively low.

Based on the comparison of measured F-35A aircraft noise levels with the EIS modelled predictions, corrective measures as referenced in Condition 1 of the approval decision may be considered warranted.

The primary reason for this finding is that the measured F-35A aircraft noise levels from departure operations on runway 30 are above those presented in the EIS in some areas east of Raymond Terrace. This is due in part to the need for the F-35A aircraft to climb out at power levels higher than 60 % ETR for safe flight. In accordance with the BANMP for RAAF Base Williamtown and F-35A Aircraft Noise Flight Activity Verification Program, ACG began investigating alternative procedures such as changed departure profiles from the middle of 2019. The aim of the trials is to identify procedures that do not compromise the safe operation of the F-35A aircraft, and minimise noise at sensitive receivers, while still achieving training and operational requirements.

The measured F-35A aircraft and F/A-18A/B Hornet arrival noise levels in areas east of RAAF Base Williamtown and SAAWR were higher than indicated by the EIS predictions. The number of aircraft noise events in these areas were however relatively low. Further, the differences between the actual measured noise levels and the EIS predictions were comparable for both aircraft; this indicates for both aircraft a systematic difference between the way arrivals occur in practice and the way that these procedures were modelled in the EIS.

Some locations featured marginally higher average maximum noise levels due to F-35A aircraft operations. These marginal differences are however comparable to the scale of variation associated with existing day to day and annual variation in noise levels and are therefore not expected to translate to perceptible differences.

5.3 Community hearing protection thresholds

5.3.1 Equivalent noise levels

The EIS indicated that average daily external aircraft noise exposure at all residential locations were expected to be below the 85 dB $L_{Aeq,8\,hr}$ level commonly referenced for the protection of hearing in occupational settings.

The measured noise level at all NMTs demonstrated that the average daily noise exposure from F/A-18A/B Hornet and F-35A aircraft operations at RAAF Base Williamtown and SAAWR was less than 75 dB $L_{Aeq,8hr}$ during the period December 2018 – December 2020.

The aircraft noise levels support that risk of hearing impairment in residential locations around RAAF Base Williamtown and SAAWR as a result of military aircraft operations remains very low risk following the introduction of the F-35A aircraft.

5.3.2 Short term noise levels

The EIS considered a threshold level of 125 dB L_{Amax} (Flindell, 1993, Flindell et al, 1998), the noise level above which the risk of instantaneous hearing damage begins to increase. However, as stated in the EIS, it is important to note that this precautionary value does not represent levels above which hearing damage is likely to occur. Instead, it represents a conservative lower bound below which it is not expected that adverse hearing effects would occur, even after a lifetime of exposure.

The measured maximum noise levels from F/A-18A/B Hornet and F-35A aircraft operations were below 120 dB L_{Amax} at all noise sensitive receiver NMT locations. At NMT 20 Water Pump Station and NMT 9 Cabbage Tree Road, Williamtown, F/A-18A/B Hornet and F-35A aircraft noise levels were measured between 110 and 120 dB L_{Amax}. Maximum aircraft noise levels at other community NMTs were below 110 dB L_{Amax}.

The two (2) NMTs at either end of the runway are used for aircraft counting purposes and therefore not representative of noise sensitive receiver locations. Maximum aircraft noise levels up to 126 dB L_{Amax} were measured for both F/A-18A/B Hornet and F-35A aircraft operations at these NMTs. There was a total of four (4) instances over the two (2) year period when maximum noise levels were above 125 dB L_{Amax} (by 1 dB) due to operations by either aircraft type.

Notwithstanding this, on base locations where maximum noise levels from aircraft operations are greatest, occupational health and safety procedures are in place to mitigate risk of hearing damage, e.g. through use of hearing protection.

The key point from is that the measured aircraft noise levels at NMT locations do not indicate there was an increased risk of hearing damage due to either F/A-18A/B Hornet or F-35A aircraft operations.

6.0 CONCLUSIONS

The Department of Environment published the approval decision, EPBC Act project Approval (EPBC 2010/5747), for the flying operations of the F-35A aircraft in Australia, that outlined a suite of conditions including requirements for the management of environmental noise.

This report has addressed Condition 1, Condition 3.e.ii. and Condition 3.e.ii.i. of the approval decision, for the transition period December 2018, when the first F-35A aircraft was delivered to RAAF Base Williamtown, to December 2020.

F-35A aircraft flight activity and noise levels presented in the Environmental Impact Statement (EIS) have been compared with actual data measured at RAAF Base Williamtown and SAAWR during the period December 2018 – December 2020.

The number of flying days, typical operating hours, and general flight tracks by the F-35A aircraft at are similar to F/A-18A/B Hornet operations. The number of F-35A aircraft operations are lower than presented in the EIS. The EIS predictions for F-35A aircraft operations were based on a forecast year 2025 when all aircraft would have been delivered and at FOC. As not all F-35A aircraft have been delivered to date and the aircraft is not at FOC, there were fewer actual aircraft noise events than presented in the EIS.

Aircraft noise levels are prone to high degrees of variability when comparing individual, day-to-day and month-to-month operations. This is evident in the wide variation in measured aircraft noise levels for both F-35A aircraft and F/A-18A/B Hornet. This variability contributed to differences between measured and the EIS predicted noise levels. In particular, measured noise levels above and below the predictions were identified for both aircraft, depending on the type of aircraft operation and the location being considered. However, while differences were evident between the measurements and predictions, the range of the measured noise levels at most noise sensitive locations were similar for both aircraft. Further, while measured average maximum noise levels of the F-35A were marginally higher than the F/A-18A/B Hornet at some locations, this occurred in areas where there were a low number of aircraft events. These outcomes are consistent with expectations, as the EIS predictions were determined using modelling that was primarily configured for the assessment of aircraft noise level changes rather than forecasting absolute noise levels of individual operations.

The measured F-35A aircraft noise levels for the period December 2018 – December 2020 indicate similar ranges of noise levels to F/A-18A/B Hornet operations at most noise sensitive locations around RAAF Base Williamtown and SAAWR.

The measured F-35A aircraft and F/A-18A/B Hornet arrival noise levels in areas east of RAAF Base Williamtown and SAAWR were higher than indicated by the EIS predictions. However, the number of aircraft events in these areas were relatively low. Further, the differences between the actual measured noise levels and the EIS predictions were comparable for both aircraft; this indicates for both aircraft a systematic difference between the way arrivals occur in practice and the way that these procedures were modelled in the EIS.

At locations around Raymond Terrace, aircraft noise levels for both F-35A aircraft and F/A-18A/B Hornet departure operations were higher than the EIS predictions. The difference for both aircraft is likely to relate to runway 30 departure flight tracks being flown closer to Raymond Terrace than considered in the EIS.

In addition to the flight track differences, and shortly after commencement of the first F-35A aircraft operations at RAAF Base Williamtown, ACG identified that the F-35A aircraft could not safely depart the Base using the reduced thrust setting that formed the basis of the EIS predictions.

ACG has advised that for the safety of the public and pilots, higher thrust is required during departures for the aircraft to meet minimum altitude and air speed targets so that, in the event of engine failure, the F-35A aircraft is able to manoeuvre away from built-up areas, and ideally make an emergency landing back at the base. The higher than expected F-35A aircraft thrust settings and associated noise levels therefore also need to be considered in the context of public and RAAF personnel safety.

The findings of the analysis for the period between December 2018 and December 2020, therefore, indicate that flying operations and noise level changes associated with the F-35A aircraft are generally consistent with the findings of the EIS. However, as a result of the higher departure thrust settings required for safety reasons, the higher than predicted noise levels associated with these operations warrant the development of corrective measures in accordance with Condition 1 of the approval decision.

Accordingly, ACG has been trialling alternative departure procedures at RAAF Base Williamtown, in accordance with the BANMP RAAF Base Williamtown F-35A Aircraft Noise Flight Activity Verification Program. The trials will investigate procedures that do not compromise the safe operation of the F-35A aircraft, the safety of the public and RAAF pilots, and minimise noise at sensitive receivers, while still achieving training and operational requirements.

APPENDIX A GLOSSARY OF TERMINOLOGY AND ABBREVIATIONS

ACG	Air Combat Group
AMSL	Above mean sea level
ANE	Australian Noise Exposure. A noise metric predominantly used to calculate noise exposure in areas around an airfield
ANEF	Australian Noise Exposure Forecast. A set of noise contours reviewed and endorsed by Airservices Australia or Department of Defence. It is the only contour map with status in land use planning decisions for aircraft noise exposure.
ANEI	Australian Noise Exposure Index. A set of noise contours based on historical data from a previous year, where the numbers and types of aircraft which used the aerodrome are known. ANEI are typically used as benchmarks or an indicator of change in aircraft noise exposure
ANO	Aircraft Noise Ombudsman
BANMP	Base Aircraft Noise Management Plan
DAWE	Department of Agriculture, Water and the Environment
dB	Decibels – the unit of sound pressure
EIS	Environmental Impact Statement, Volume 10, Appendix F
EPNL	Effective Perceived Noise Level is a measure of the relative noisiness of an aircraft noise event, measured in EPNdB. EPNL forms the basis of the ANEF metric.
ETR	Engine Thrust Request
Flight profile	A flight profile relates the aircraft's ground distance with its altitude, true airspeed, and engine thrust setting.
FOC	Full Operational Capability. It is declared when the entire capability can be deployed on operations. FOC considers the personnel, training, major systems, supplies, facilities and training areas, logistics, support, command and management required to deliver the full capability required.
Initial and pitch	An approach to the base from a(n) (initial) point approximately 10 km along the runway centreline to overhead the airfield, followed by a turn (pitch) into the circuit pattern while decelerating for landing
Instrument approach	An approach to the base using navigation aids such as ILS and TACAN, usually required in poor visibility conditions
$L_{Aeq\ (t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
L_{Amax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period
Movement	Refers to a departure or arrival by an aircraft
NMT	Noise Monitoring Terminal
nmi	Nautical mile. Unit of distance, equivalent to 1,852 metres

Number Above	The number of daily aircraft events that are higher than a given noise level threshold in a day. For example, the term N70 20 events means 20 or more daily aircraft noise events with a noise level 70 dB L_{Amax} or greater
RAAF	Royal Australian Air Force
SAAWR	Salt Ash Air Weapons Range
SEL	Sound Exposure Level – the sound level of one second duration which has the same amount of energy as the actual noise event measured. Usually used to measure the sound energy of a particular event, such as a train pass-by or an aircraft flyover
Sensitive receptor	Places that are likely to have high sensitivity to noise emissions and must include, but not be limited to residential dwellings, schools, hospitals, childcare centres, churches and public buildings.
SSR	Secondary Surveillance Radar
Transition period	The period anticipated to span between 2018-2022 during which F/A-18A/B Hornet operations reduce and cease and the F-35A aircraft operations commence and increase until all aircraft have arrived in Australia.

APPENDIX B REFERENCES

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Marshall Day Acoustics, 2014, *Rp 004 R01 2011106ML RAAF Base Williamtown and SAAWR F-35A aircraft Noise Impact Assessment*, dated 20 June 2014

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Royal Australian Air Force, 2018, *RAAF Base Williamtown Base Aircraft Noise Management Plan, ID G1082525/G14263835*

APPENDIX C APPROVAL CONDITIONS CROSS REFERENCE TABLE

No.	Condition	Relevant report sections
1.	*Ensure, during the transition period, aircraft noise levels at sensitive receptors at RAAF Base(s) do not exceed the F-35A Lightning II aircraft noise levels predicted in the Environmental Impact Statement. During the transition period monitoring must be undertaken, reported biennially to the Department, …*	
	… and, if noise levels exceed the F-35A Lightning II aircraft noise levels predicted in the Environmental Impact Statement, then corrective measures must be developed and implemented, until agreed in writing by the Minister.	Section 5.2
3.	*Prepare and implement Aircraft Noise Management Plan(s), as described in the Aircraft Noise Management Strategy, at RAAF Base(s) to minimise noise disturbance at sensitive receptors from the flying operations of the F-35A Lightning II aircraft. The plan(s) must include, but not be limited to, the following measures:*	
	…	
3.e.	*Reporting, to ensure clear and timely public access to noise levels and flight activity monitoring data. This must include, but not be limited to:*	
	…	
3.e.ii	*biennially publication on the Defence Aircraft Noise website of:*	
3.e.ii.i.	*noise levels and flight activity monitoring data of the F-35A Lightning II aircraft; and*	Section 4.0, Section 5.2, Section 5.3 Appendix E
3.e.ii.ii.	*a comparison of actual noise levels and flight activity of the F-35A Lightning II with those predicted in the Environmental Impact Statement. This must include, but not be limited to:*	Section 4.0, Section 5.2, Section 5.3 Appendix E
3.e.ii.ii.a)	*noise management measures;*	Section 4.9
3.e.ii.ii.b)	*days and hours of operation;*	Section 4.3, Section 4.4
3.e.ii.ii.c)	*flight paths used to reduce noise; and*	Section 4.6, Section 4.9
3.e.ii.ii.d)	*frequency and type of activities that occur at Salt Ash Weapons Range.*	Section 4.8

APPENDIX D DATA LIMITATIONS

This section provides discussion on the limitations of the data sources used in this report and the implications for the analysis and comparisons to forecasts presented in the EIS.

D1 ACG flight records

As noted in Section 4.4, ACG records are maintained for the dates and times of F-35A aircraft departure operations only. A review of NFPMS records indicated a varying duration of F-35A aircraft sorties. The average sortie duration was added to the records of F-35A aircraft departure times to derive an estimate for the arrival times for the purpose of presenting hourly operational times.

A review of NFPMS records confirmed the general trends evident in the figure, specifically:

- More than 80 % of F-35A aircraft operations occurred between 9 am and 12 noon, and between 1 pm and 4 pm; and
- Limited activity (<10 %) between 5 pm and 9 pm.

The counts for F-35A aircraft departures have also been used as a representation of the number of arrivals at RAAF Base Williamtown. This is based on the premise that the majority of departures related to operations in areas around RAAF Base Williamtown. It is understood that a small number of unscheduled operations involved flights to other bases, however this constitutes approximately 3 % of all arrivals during the period December 2018 – December 2020 and is therefore inconsequential to the analysis presented herein.

Records of F-35A aircraft touch and go (circuit) operations are not kept by ACG. Records for the number of touch and go operations are based on information from the contractors responsible for the Noise and Flight Path Monitoring System (NFPMS).

D2 Noise and Flight Path Monitoring System

Defence operates a Noise and Flight Path Monitoring System (NFPMS) at three RAAF bases, including RAAF Base Williamtown and SAAWR. It is maintained by independent contractors Envirosuite, and while the physical elements of the system are based upon a common platform used at major civilian airports in Australia and overseas, the data analyses have been enhanced to specifically monitor, track and record operations by the RAAF and military fast jet operations.

The core of the system monitors aircraft noise in accordance with International Standard ISO 20906 *Unattended Monitoring of Aircraft Sound in the Vicinity of Airports*. Envirosuite employ additional technology and processes to address characteristics specific to operations and noise from military aircraft to enhance the quality of the data measured by the system.

The NFPMS uses aircraft position data to correlate discrete noise events measured at Noise Monitoring Terminals (NMT) to aircraft operations.

Noise monitoring terminals

Approval conditions 1 and 3 require a review of aircraft noise levels at sensitive receptors. The approval decision defines sensitive receptors as:

> *Places that are likely to have a high sensitivity to noise emissions and must include, but not be limited to residential dwellings, schools, hospitals, child care centres, churches and public buildings.*

Long-term measurement data of aircraft noise levels are only available from Noise Monitoring Terminals (NMT) associated with the NFPMS. NMT locations have been historically selected to be representative of the range of aircraft noise levels at sensitive receptor locations around RAAF Base Williamtown and SAAWR. A number of NMT are also in place in strategic locations (e.g. runway ends) for the purpose of identifying and confirming aircraft operations.

A review of the suitability of NMT locations to represent the majority of noise sensitive receptors has been undertaken to address Condition 3.c.iv. and is detailed in the Marshall Day Acoustics report (2021).

Fight track radar data

Envirosuite provided the geospatial aircraft flight track data for this report. The geospatial data included details on the aircraft type, runway and operation type (arrival, departure, local and training flights), altitude and airspeed.

Envirosuite has advised on the known limitations with the radar data for military fast jets, summarised as follows:

- Sections of flight paths can be missed by the radar if aircraft fly at particularly low altitudes, including segments of departure and arrival flight paths close to the base. This is particularly relevant to initial and pitch arrivals and training circuits which occur at relatively low altitude within 3 km of the runway. Some arrival and departure flight paths were considerably short and terminated relatively close to the Base. Flight paths for passes of SAAWR have not been provided due to the limited radar coverage of the low altitude passes.
- For most types of formation flying, only the lead aircraft of the formation activates their tracking transponder to be recorded by the Secondary Surveillance Radar (SSR) that is fed to the NFPMS, and therefore no flight path data is recorded for the other subsequent aircraft in the formation. There are also occasions where pilots do not activate their transponder for the entire flight. Primary Surveillance Radar can provide additional tracking information in this case, however it is purely positional and does not include additional information such as altitude, speed and aircraft type. Regardless of the method, military fast jet tracking is challenging due to the low-radar profile design of the aircraft. To enable a representation on the total number of actual operations, additional noise monitors are used (at the end of each runway and close to SAAWR) to count and classify operations and noise events based on the acoustic signature.
- There are also limitations with the NFPMS classification of aircraft events. There are instances where a military fast jet's departure, training operations away from base and the subsequent arrival are classified as one flight path and hence a single operation type, which was noted as a 'training' operation. These training operations only comprised approximately 6 % of all F-35A aircraft operations identified by the NFPMS. These operations have been split in the two equal sections and noted the first half to be a departure operation and the second half to be an arrival operation to classify these events as part of an arrival or departure operations. Therefore, there will be instances where aircraft noise events are incorrectly designated as an arrival or departure, when it may in fact have been transiting between training areas.
- The NFPMS flight path data does not distinguish and separate a touch and go training circuit movement (where the aircraft lands on the runway and takes off again without stopping) from an arrival or departure flight path. i.e. touch and go circuits are embedded in arrival and departure flight paths. Additionally, the quality of low altitude flight path data close to the base means that these touch and go segments of flight paths cannot be readily identified or extracted from arrival and departure flight path data. Therefore, there will be instances where aircraft noise events at NMT close to the base are designated as an arrival or departure, when it may in fact have been undertaking a touch and go training circuit.
- Flight paths are occasionally identified by the system but cannot be assigned to a particular aircraft type. In these instances, the movement is assigned to a broad aircraft category such as 'military fast jet', 'civil jet' etc. Operations and noise events by unknown aircraft types assigned to 'military fast jets' categories have not been considered in this report, they may have been due to F-35A aircraft, F/A-18A/B Hornet or Hawk Lead In Fighter aircraft. For F-35A aircraft operations, this is addressed by using ACG flight records correlated with the available NFPMS data.

Aircraft noise events

Envirosuite has provided a consolidated list of F/A-18A/B Hornet and F-35A aircraft noise events at each NMT that were correlated to a known flight track. For each event, the aircraft type, operation type, runway used, maximum noise level (L_{Amax}), sound exposure level (SEL) and effective perceived noise level (EPNL) was provided.

The following limitations apply to the classification of aircraft noise events:

- Occasionally, aircraft noise events are identified by the NMT but cannot be assigned to a recorded flight path or a particular aircraft type for reasons discussed above. Without the supporting information, it cannot be confirmed whether these unassigned noise events resulted from commercial, private or military aircraft, including F/A-18A/B Hornet or F-35A aircraft. Logged noise events by 'unknown' aircraft have therefore not been considered in this study.
- The presence of ambient noise from inclement weather, wind-disturbed vegetation, local and distant traffic and other anthropogenic noise sources may prevent some aircraft noise events from being clearly measured and defined. Detected noise 'events' of more than 120 seconds in duration are considered likely to be extraneous and are excluded from this analysis. The presence of ambient noise at most NMT locations generally limited the identification of aircraft noise events below 65 dB L_{Amax}.
- A single noise event can result from formation flying of multiple closely grouped aircraft, where the noise level at the NMT from each individual aircraft is 'combined' into one measured noise event. This is more likely to occur further from the base as trailing aircraft catch up to the lead aircraft. In contrast, the EIS noise model and predictions only considered aircraft flying individually and did not feature 'combined' noise events from formation flying. This does mean that for the same number of aircraft operations, the total measured noise exposure can be compared with the total predicted noise exposure, but there may be instances where measured maximum noise levels are greater than predicted maximum noise levels as a result of more than one (1) aircraft present at the time of measurement.
- The NFPMS data sets include gaps caused by preventative and corrective maintenance to the radar systems and noise monitoring terminals (NMT). These instances are considered to be relatively limited and inconsequential given the two (2) year duration of the report period.

Number of events recorded

Table 14 presents the number of aircraft noise events identified by the NFPMS during the period December 2018 – December 2020. Importantly, these values do not represent the total number of aircraft operations (arrivals, departures, circuits), but the number of noise events; e.g. multiple noise events can arise when the aircraft passes near a NMT on more than once occasion during an aircraft operation. Conversely, an aircraft operation may not pass near a NMT and therefore not trigger a 'noise event.'

Table 14: Number of aircraft noise events identified at each NMT

NMT	Name	December 2018 – December 2019		January 2020 – December 2020	
		F/A-18A/B Hornet	F-35A aircraft	F/A-18A/B Hornet	F-35A aircraft
1	Grahamstown Public School	1,928	458	699	1,290
3	Salt Ash Public School	942	210	333	589
4	Lakeside Drive, Campvale	2,307	553	820	1,304
5	Wirreanda Public School	633	119	163	244
9	Cabbage Tree Road, Williamtown	3,716	880	1,130	2,099
10	Frederick Drive, Oyster Cove	655	89	166	121
11	Runway 30 *	2,291	492	730	1,345
12	Runway 12 *	2,551	605	866	1,441
13	Disabled Riding School	1,511	290	528	856
17	Tanilba Golf Club	556	56	124	132
18	Salt Ash Fire Station	577	103	234	284
19	Ferodale Road, Sewerage Pump Station	1,286	231	347	473
20	Water Pump Station, Ferodale	2,610	762	1,015	1,948
70	Tanilba Primary School	432	33	93	92
80	Pacific Dunes Golf Course	829	296	240	704
140	Waste Transfer Station	1,359	282	469	880
150	Rees James Road, Raymond Terrace	1,242	237	432	669

* Strategic NMT for aircraft counting

The operators of the NFPMS employ numerous processes and algorithms to augment the techniques provided in ISO 20906 to mitigate the monitoring challenges outlined in the sections above. The NFPMS will however identify fewer F/A-18A/B Hornet and F-35A aircraft noise events that occurred at each NMT.

Accordingly, for this report, ACG flight records have been used as the basis for the total number of F-35A aircraft movements. The measured aircraft noise events at each NMT, obtained from the NFPMS data, have then been scaled/increased to reflect the difference between the two (2) datasets and address the flying activity not recorded by the NFPMS (12 % for December 2018 – December 2019 and 16 % for January 2020 – December 2020).

APPENDIX E DETAILED AIRCRAFT NOISE LEVEL INFORMATION

This section summarises the measured F/A-18A/B Hornet and F-35A aircraft noise levels at each Noise Monitoring Terminal (NMT) around RAAF Base Williamtown and SAAWR for the period December 2018 - December 2020. The measured aircraft noise levels are compared with predicted noise levels from the EIS noise model. The key points for this comparison are:

- The EIS was an assessment of the predicted change in noise levels as a result of the replacement of the F/A-18A/B Hornet with the F-35A aircraft. The analysis therefore considers differences between measured F/A-18A/B Hornet and F-35A aircraft noise levels as well as differences between measured F-35A aircraft noise levels and the predictions presented in the EIS. Given that F/A-18A/B Hornet movements were considerably reduced in 2019 and 2020 and F-35A aircraft operations were increasing as additional aircraft were delivered, the comparison is primarily relevant to noise level ranges, average and highest maximum noise levels, and the distribution of aircraft noise events;
- The EIS predictions for F-35A aircraft operations were based on a forecast year 2025, when all aircraft would have been delivered and FOC is achieved. As not all F-35A aircraft have been delivered to date, there were fewer aircraft events than presented in the EIS; and
- The EIS predictions considered military aircraft operations averaged over 240 days per year, whereas the analysis of measured aircraft events when presenting average daily number of events, have been averaged over the actual number of days that the aircraft operated, as detailed in Table 15.

Table 15: RAAF Base Williamtown – Days of flying activity

Period	F/A-18A/B Hornet	F-35A aircraft
December 2018 – December 2019	197	116
January 2020 – December 2020	138	168

The following subsections include the detailed aircraft noise level metrics at each NMT:

- Number Above: N70 and N85 presented as annual average daily values for 2019 and 2020, as well as average daily value per calendar quarter (3 month periods, Q1, Q2, Q3, Q4);
- Event level histograms: presented as average daily aircraft noise events and percentage per maximum noise level (in 5 dB bands), consistent with the format presented in the EIS. The use of the percentage value is provided as a method to consider the lower number of actual F-35A aircraft events compared with the EIS which was based on all aircraft delivered. These histograms allow trends in the range of maximum noise levels to be more readily identified and compared;
- Maximum noise levels: presented as average and highest maximum noise levels for both arrival and departure operations. Specifically, these operations relate to arrivals and departures to and from the Base. While these metrics were not presented in the EIS, they are included as additional information and as a simplified method to summarise and compare highly variable noise levels associated with complex military aircraft operations. Statistics are shown as:
  - Average: derived as the arithmetic mean for aircraft noise events greater than 65 dB L_{Amax};
  - Highest: The EIS value is derived from the absolute highest predicted level from the noise model, that considered typical operations. The highest measured noise level presented is based on the 90th percentile of all measured aircraft noise events above 65 dB L_{Amax}. This value for both aircraft would typically be above the highest predicted level in the EIS and is to be expected given atypical operations that occur in practice and result in relatively high noise levels which are not represented in the modelling.
- Australian Noise Exposure – presented as contribution of F/A-18A/B Hornet and F-35A aircraft operations to the overall noise exposure, measured using the Australian Noise Exposure (ANE) metric.

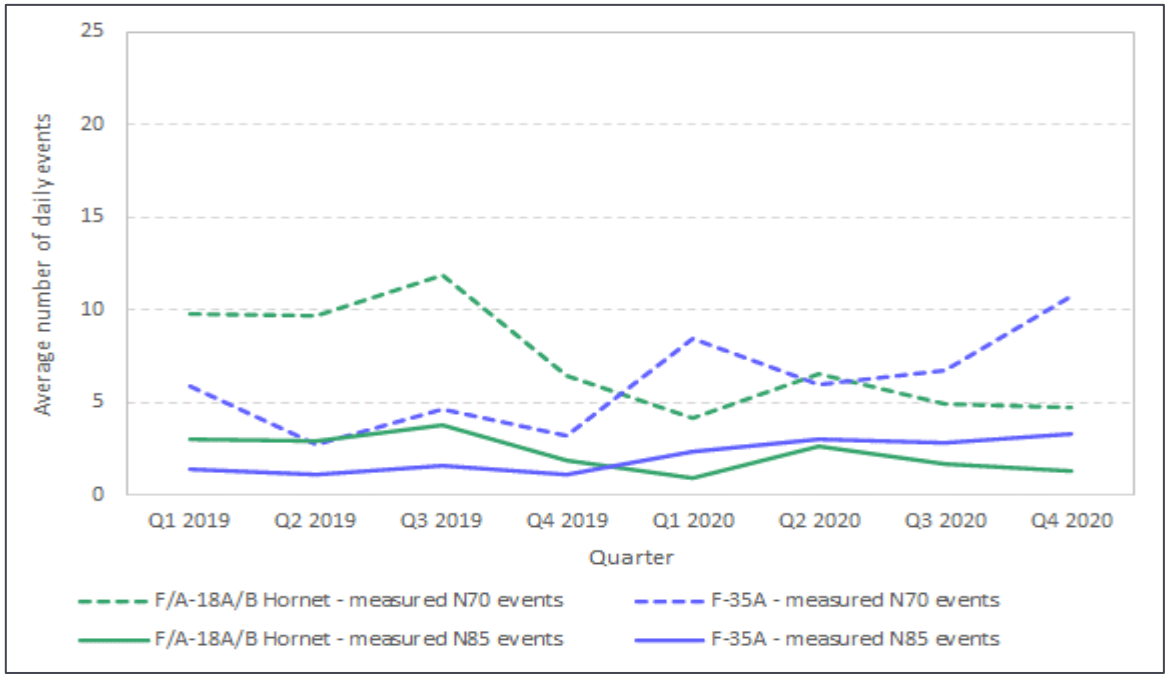
E1 NMT 1 – Grahamstown Public School

Number Above

Table 16: NMT 1 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	32	9 - 10	5 - 6
F-35A	28	3 - 4	7 - 8
N85 events			
F/A-18A/B Hornet	13	2 - 3	1 - 2
F-35A	3	1 - 2	2 - 3

Figure 20: NMT 1 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS;
- There were few aircraft noise events higher than 85 dB L_{Amax} for either aircraft; and
- The trend in the quarterly number above values demonstrate an increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 21: NMT 1 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

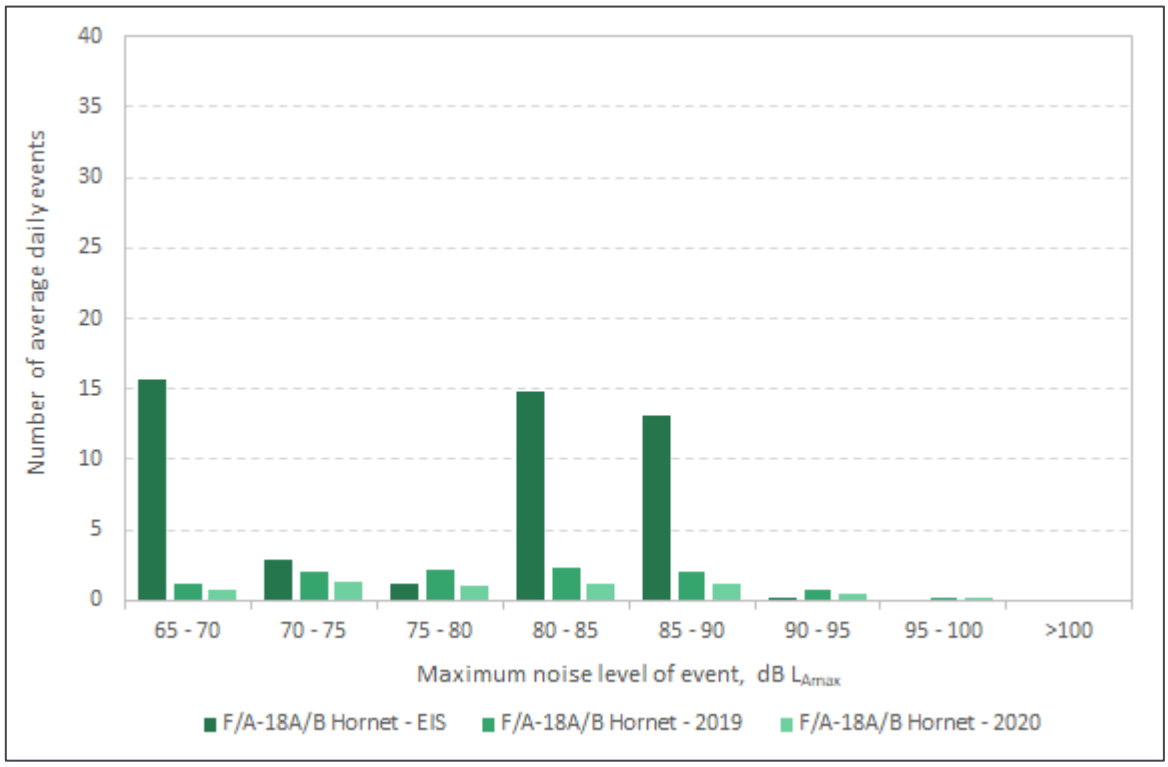


Figure 22: NMT 1 – EIS predictions and measurements – Event level histogram F-35A aircraft

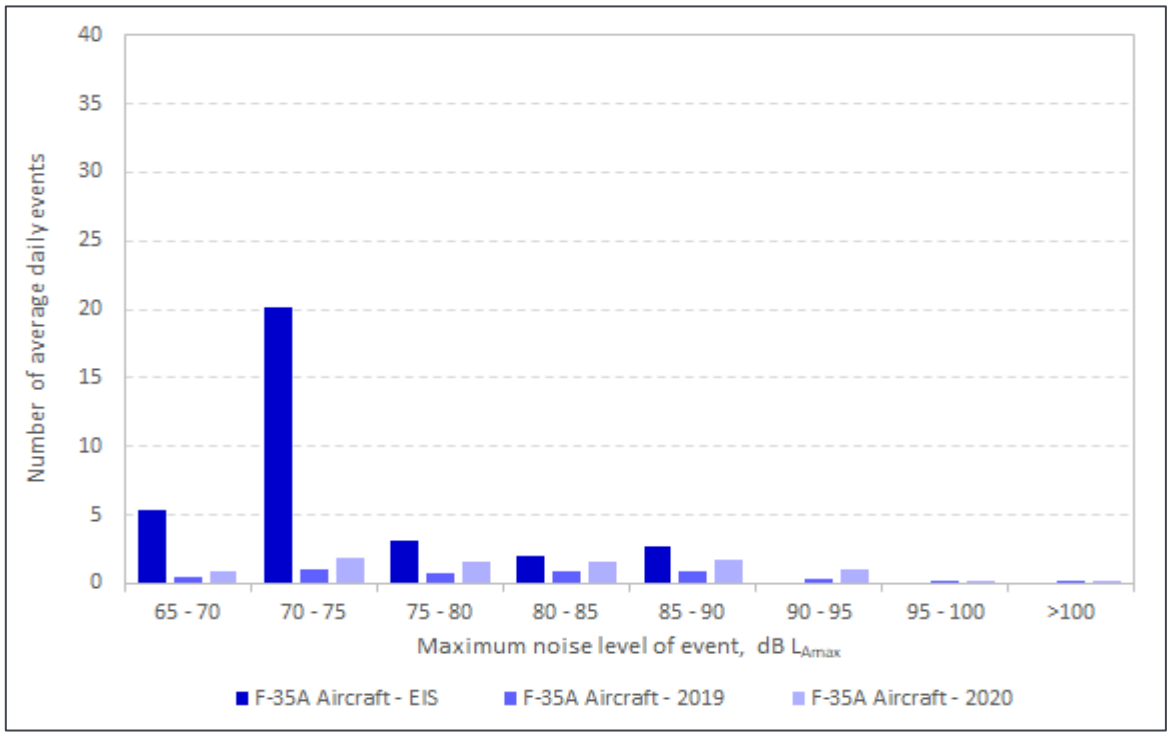


Figure 23: NMT 1 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

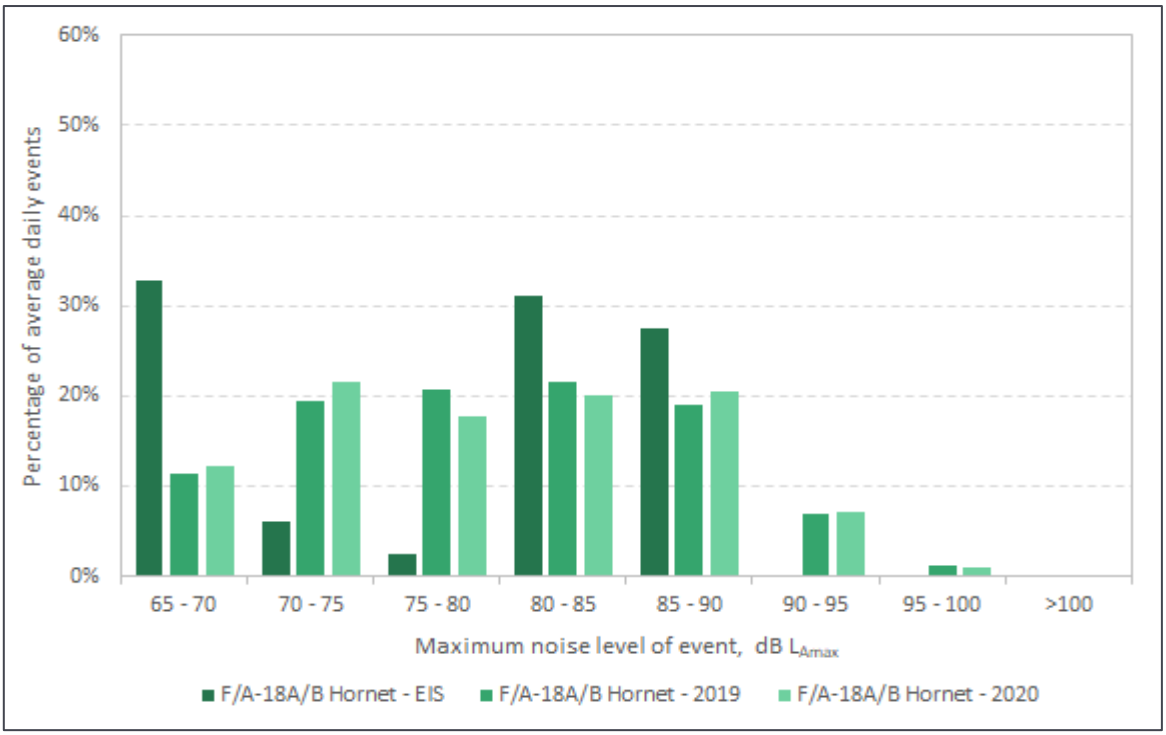
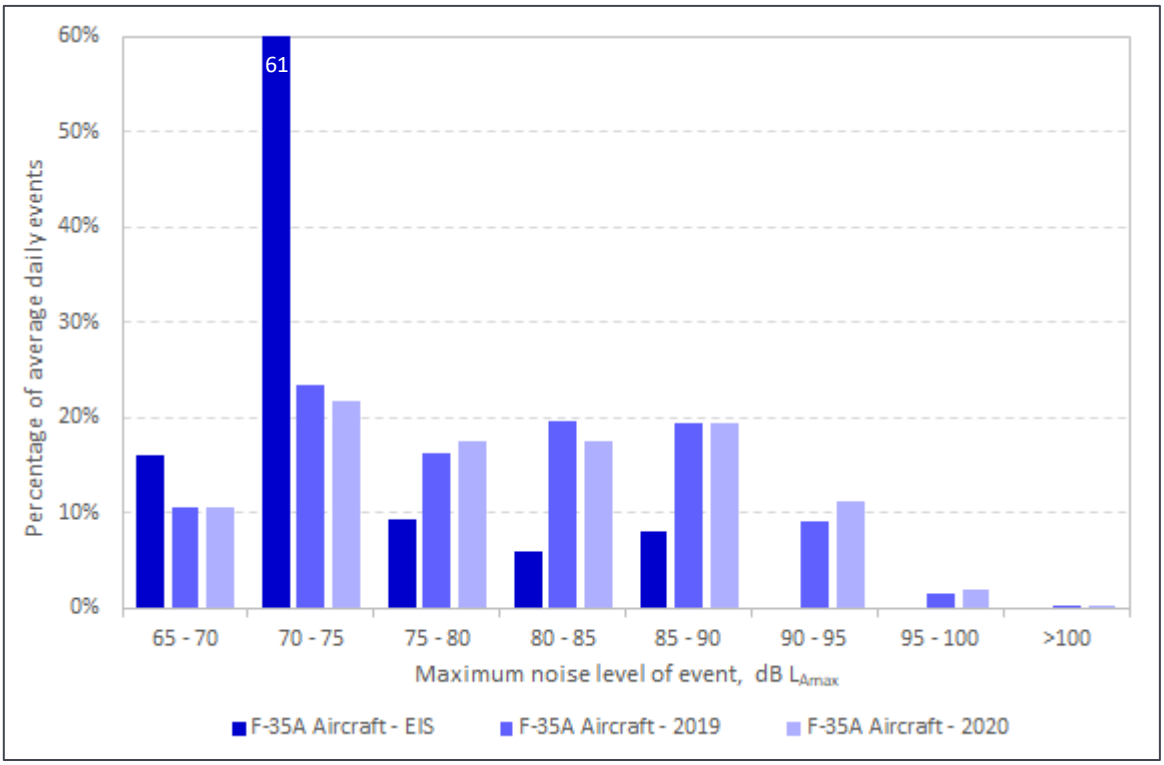


Figure 24: NMT 1 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The majority (more than 75 %) of measured F-35A aircraft noise levels were between 70 – 90 dB L_{Amax} compared with the EIS predictions where the majority (75 %) of aircraft noise levels ranged between 65 – 75 dB L_{Amax};
- The histograms above demonstrate that measured events were smoothly distributed across the noise level ranges, whereas the EIS predictions feature one or two noise level bands that would occur much more often than other noise levels (seen as 'spikes' in the histograms). This is due to greater variation in real world operations compared to what can be reliably and practically represented in the noise modelling;
- The measurement data indicates that operations by both aircraft generally result in similar distribution of occurrences of noise levels, whereas the EIS predicted a notable reduction in occurrences of aircraft noise events between 80 and 90 dB L_{Amax} when replacing F/A-18A/B Hornet operations with F-35A aircraft operations; and
- The measured data indicates there were similar occurrences of noise levels below 90 dB L_{Amax} for the two aircraft.

Maximum noise levels

Table 17: NMT 1 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	85	79	72	81
	F-35A	76	78	73	85
Highest	F/A-18A/B Hornet	91	90	83	90
	F-35A	89	89	90	93

The following points are noted following a comparison of the data in the above table:

- The average and typical highest measured noise levels for arrival operations by both aircraft were comparable;
- The measured departure noise levels were higher than the EIS predictions for both aircraft. The key factor contributing to this difference for both aircraft was that runway 30 departure flight tracks being flown closer to Raymond Terrace than what was considered in the EIS noise model, as discussed in Section 4.6.2; and
- The measured F-35A departure noise levels were higher than those of the F/A-18A/B Hornet. This is in contrast with the EIS which predicted the average departure noise levels of the F-35A to be slightly lower. This can be attributed to the need to adopt higher thrust settings for safety, as discussed in Section 4.7.2.

Australian Noise Exposure

Table 18: NMT 1 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	EIS	Measured in 2019	Measured in 2020
F/A-18A/B Hornet	20	18	14
F-35A	19	13	19

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and is below that presented in the EIS, as the number of operations has also decreased;

  The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is below that presented in the EIS for 2019 and equivalent for 2020. The higher-than-expected measured 2020 value for the F-35A aircraft is due to the higher measured departure noise levels discussed above.

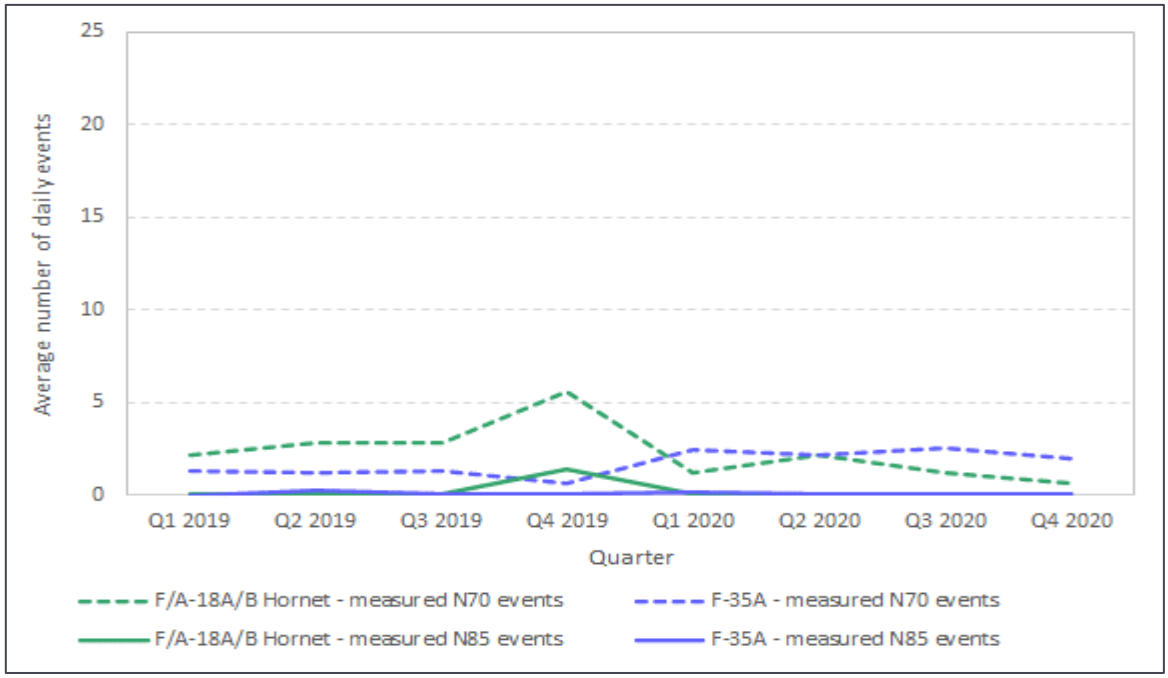
E2 NMT 3 – Salt Ash Public School

Number Above

Table 19: NMT 3 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	53	3 - 4	1 - 2
F-35A	16	1 - 2	2 - 3
N85 events			
F/A-18A/B Hornet	2	0 - 1	0 - 1
F-35A	0	0 - 1	0 - 1

Figure 25: NMT 3 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS;
- Aircraft noise events higher than 85 dB L_{Amax} by either aircraft were uncommon, consistent with the EIS; and
- The trend in the quarterly number above values demonstrate an increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 26: NMT 3 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

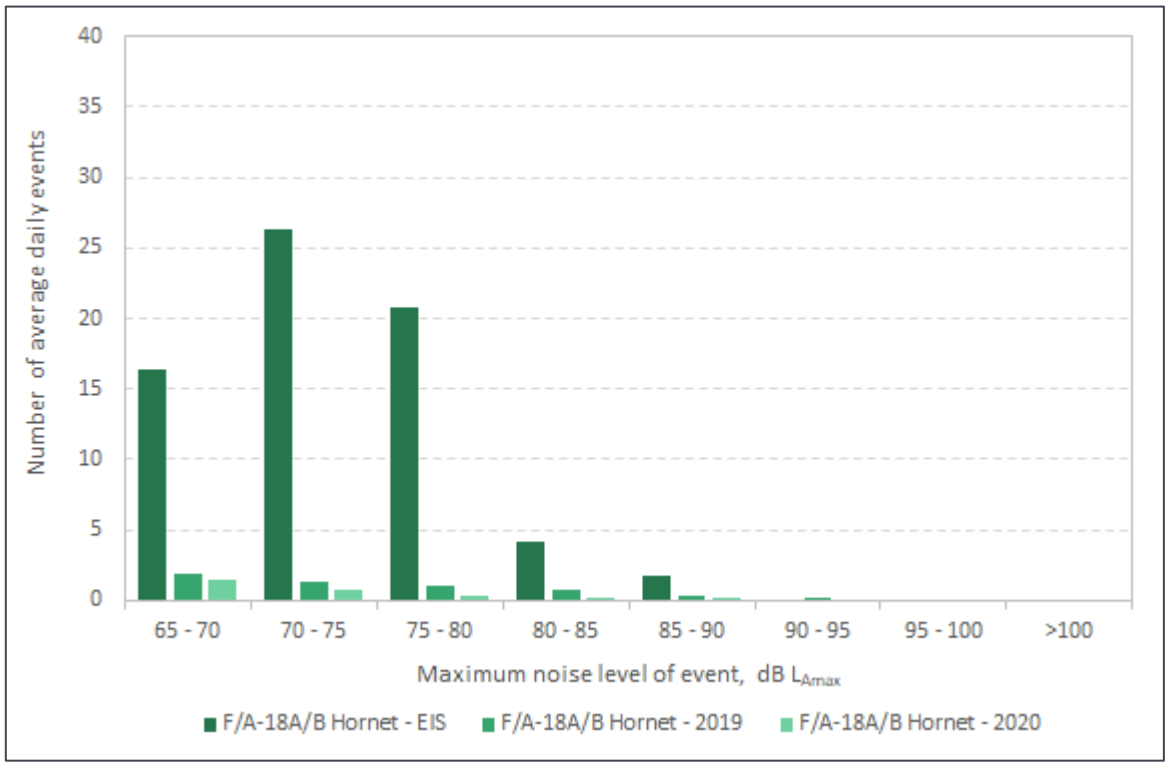


Figure 27: NMT 3 – EIS predictions and measurements – Event level histogram F-35A aircraft

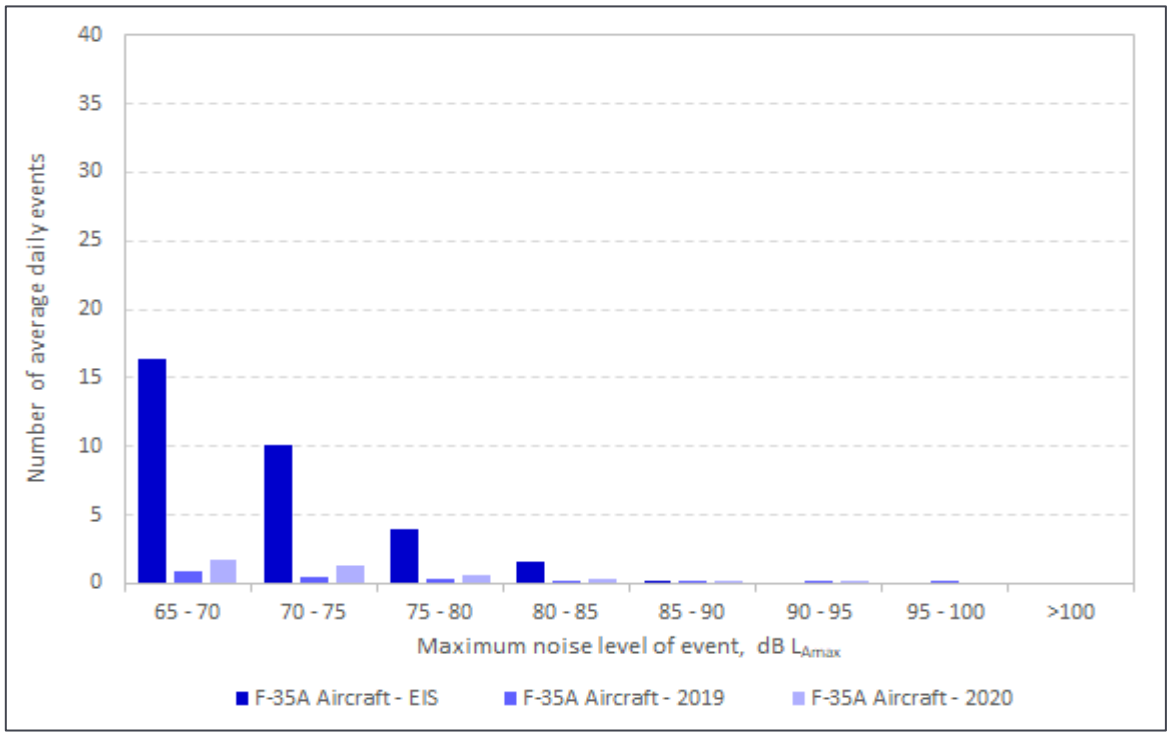


Figure 28: NMT 3 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

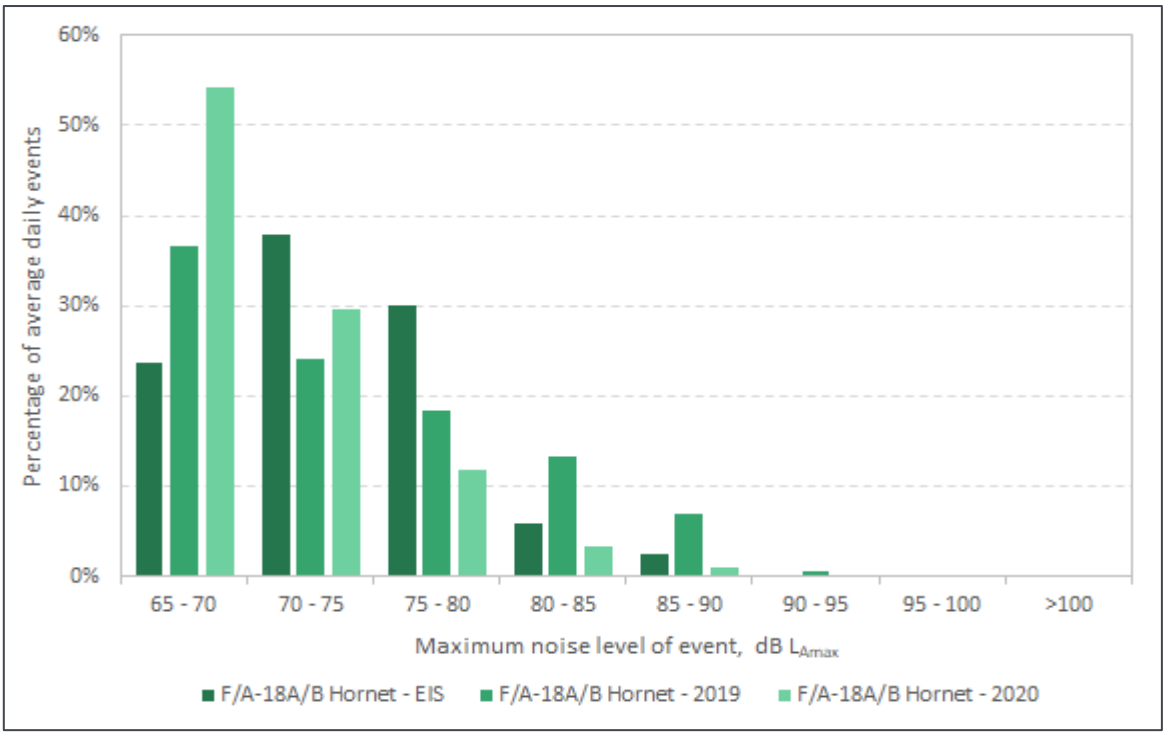
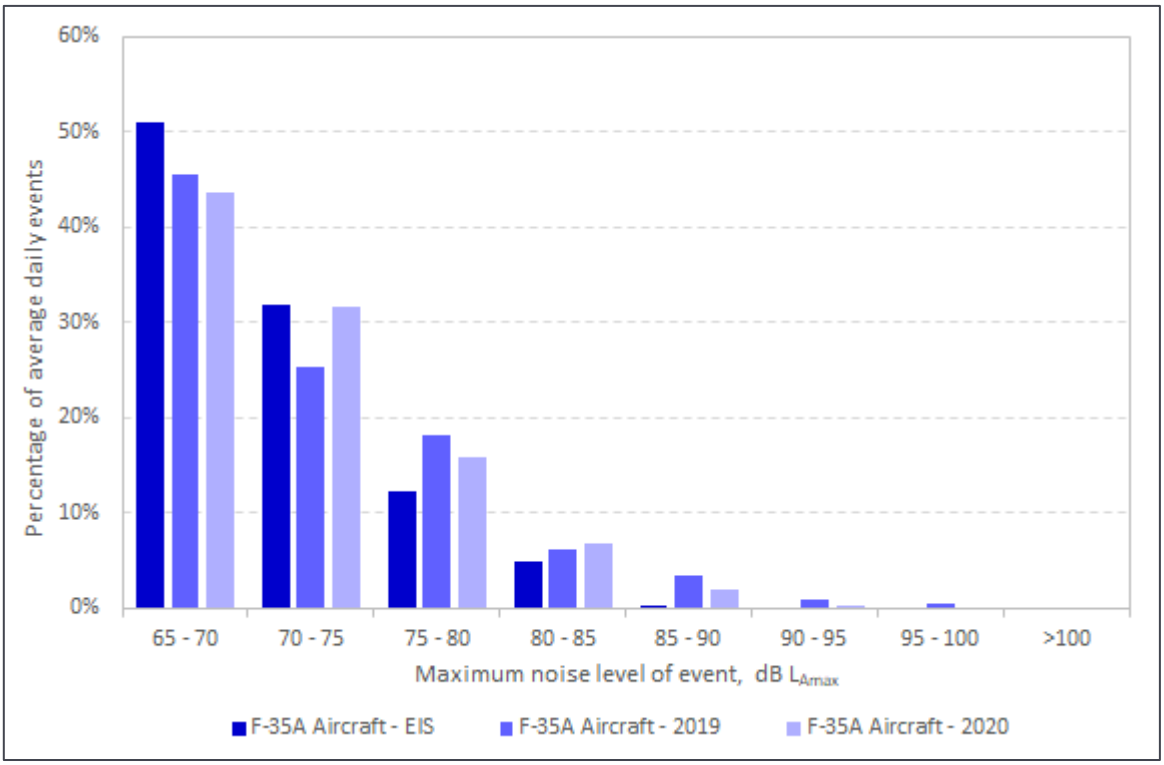


Figure 29: NMT 3 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The low number of aircraft noise events measured at this location can be attributed to the limited activity by both aircraft at SAAWR;
- The majority (>90 %) of noise levels for both aircraft are less than 85 dB L_{Amax} for both EIS predictions and measurement data; and
- The measurement data indicates that operations by both aircraft generally result in similar distribution of occurrences of noise levels, which is comparable to the EIS predictions.

Maximum noise levels

Table 20: NMT 3 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	<65	74	72	73
	F-35A	<65	71	71	73
Highest	F/A-18A/B Hornet	<65	84	89	83
	F-35A	<65	77	87	81

The following points are noted following a comparison of data in the above table:

- The average and typical highest measured noise levels for both aircraft were comparable for departure operations, while the measured F-35A aircraft arrival noise levels were lower than for the F/A-18A/B Hornet;
- Arrival noise level measurements for both aircraft were higher than the EIS predictions;
- The average measured noise levels from departure operations for both aircraft are comparable, as per the EIS predictions; and
- The highest measured noise levels from departure operations are lower than the EIS predictions for both aircraft.

Australian Noise Exposure

Table 21: NMT 3 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	EIS	Measured in 2019	Measured in 2020
F/A-18A/B Hornet	16	8	1
F-35A	16	3	7

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is below that presented in the EIS for both 2019 and 2020.

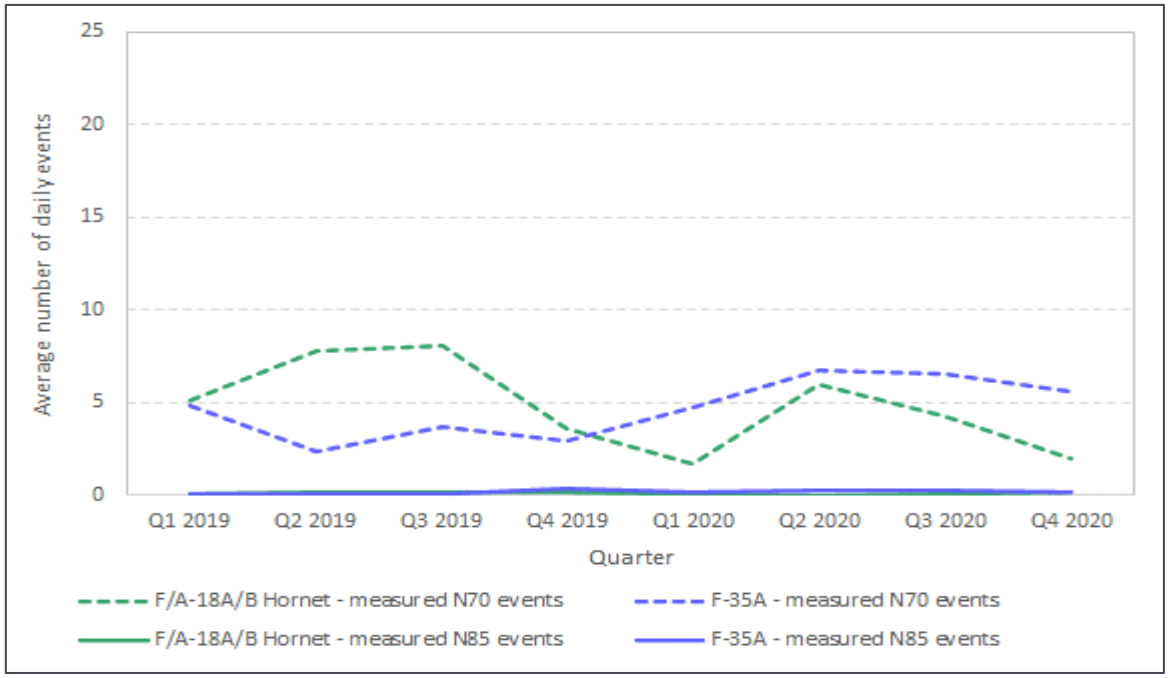
E3 NMT 4 – Lakeside Drive, Campvale

Number Above

Table 22: NMT 4 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	27	6 - 7	3 - 4
F-35A	19	3 - 4	5 - 6
N85 events			
F/A-18A/B Hornet	0	0 - 1	0 - 1
F-35A	0	0 - 1	0 - 1

Figure 30: NMT 4 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS;
- Aircraft noise events greater than 85 dB L_{Amax} by either aircraft were uncommon, consistent with the EIS predictions; and
- The trend in the quarterly number above values demonstrate an increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 31: NMT 4 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

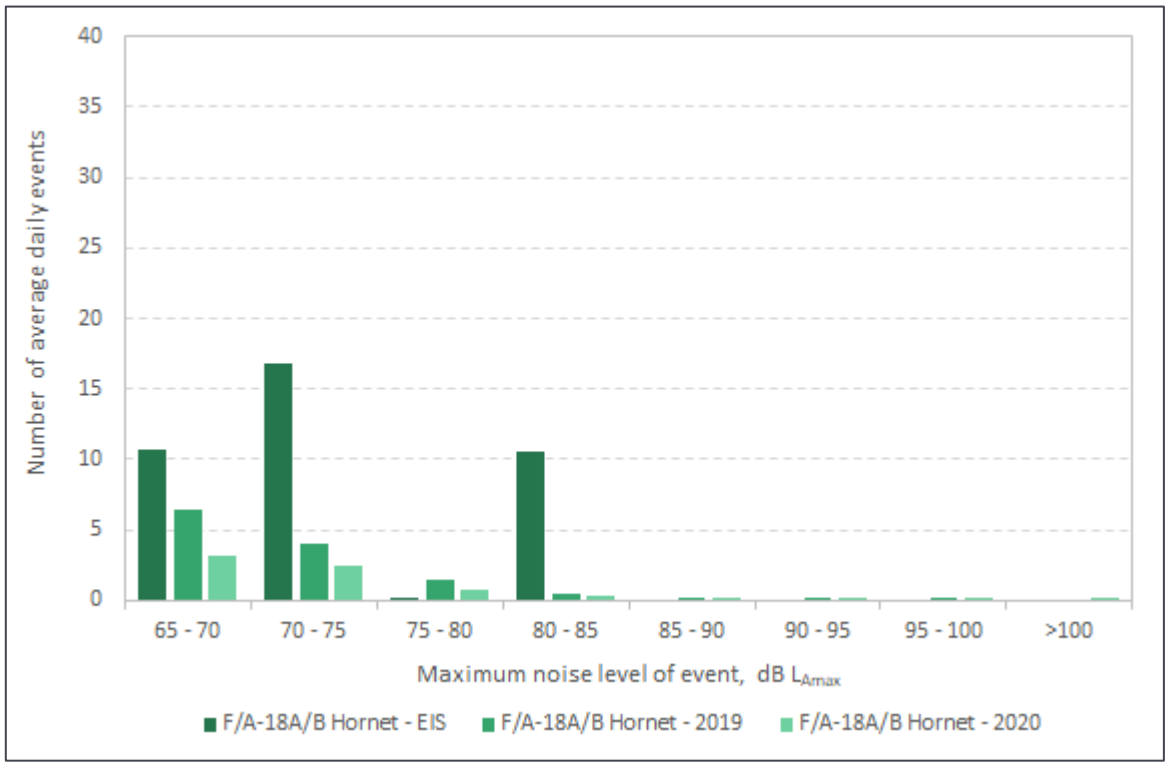


Figure 32: NMT 4 – EIS predictions and measurements – Event level histogram F-35A aircraft

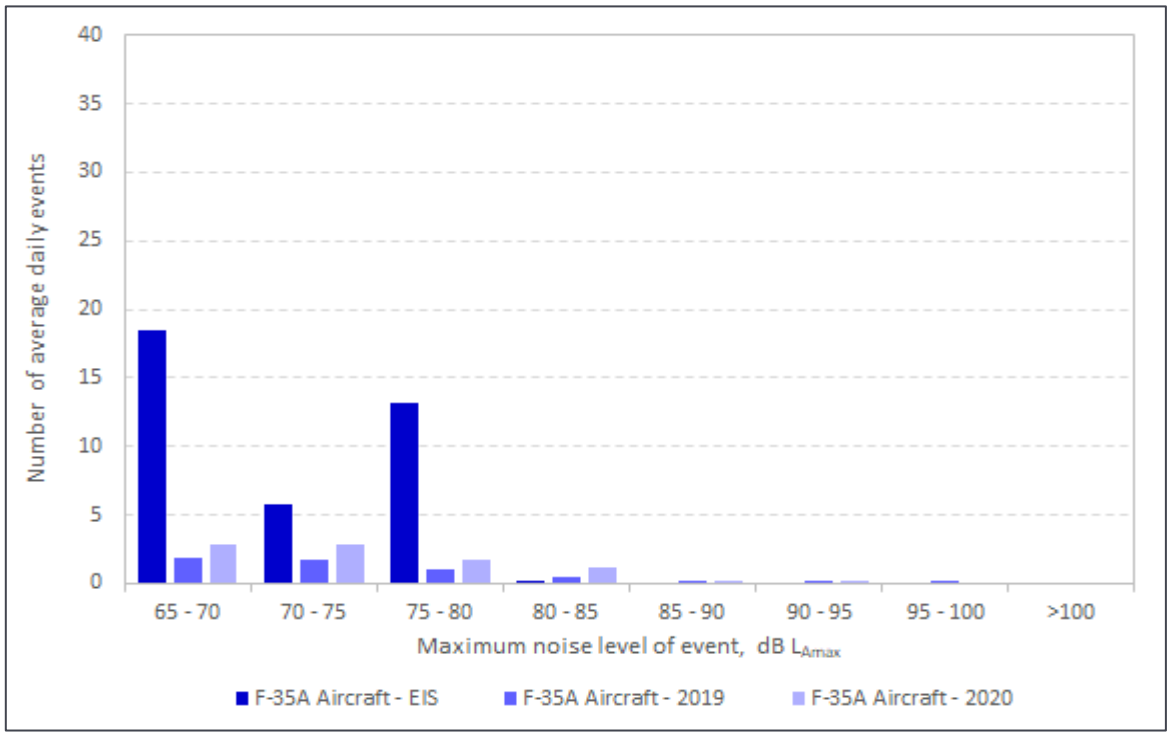


Figure 33: NMT 4 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

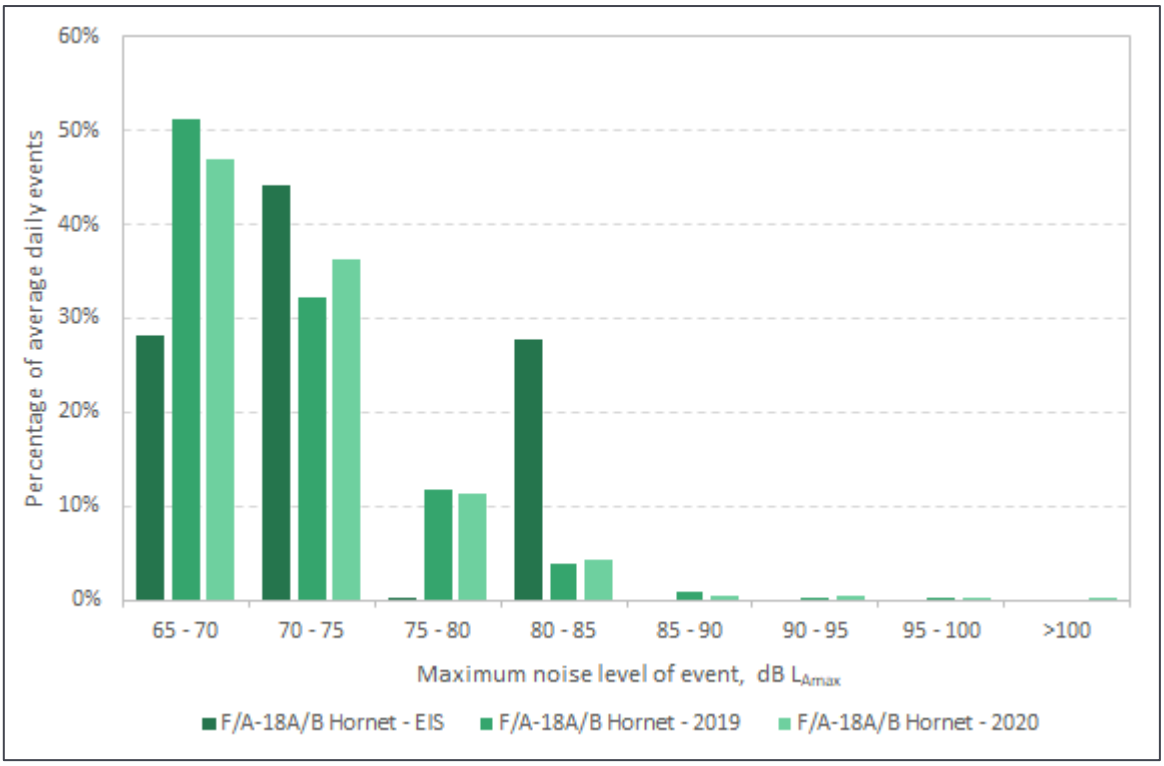
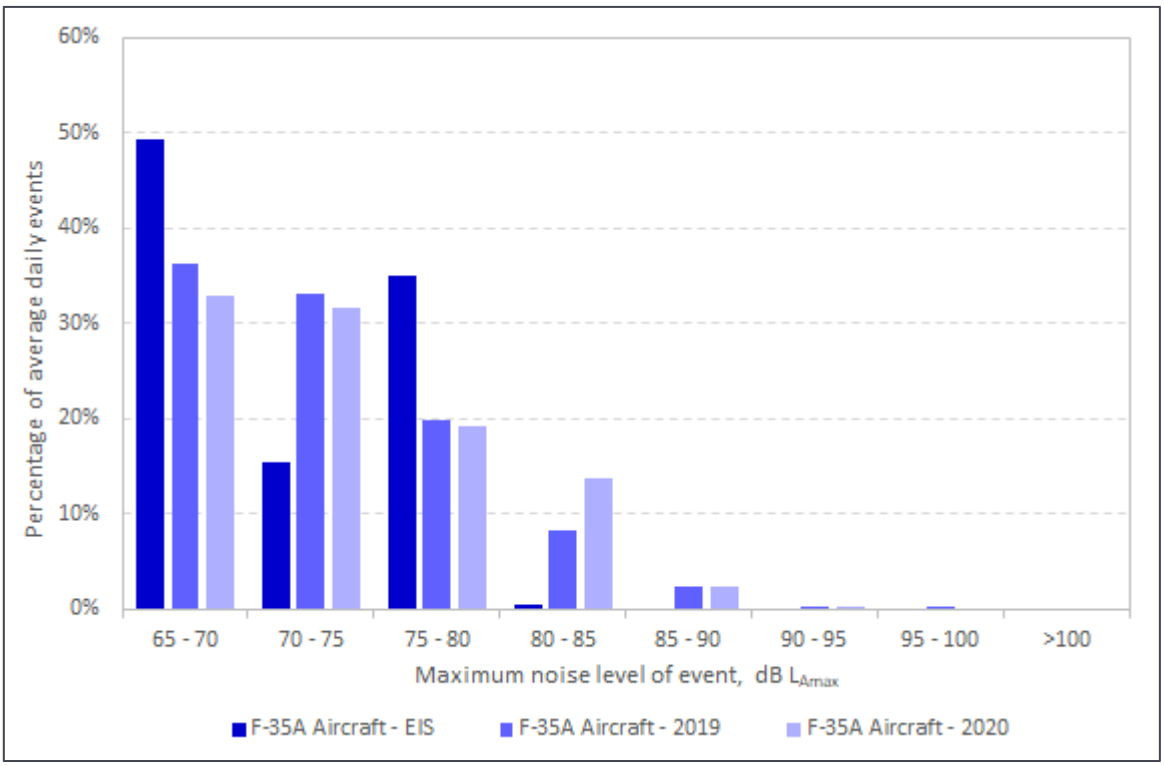


Figure 34: NMT 4 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The majority (>85 %) of measured F-35A aircraft noise levels were between 65 – 80 dB L_{Amax} which was similar to the EIS predictions;
- The histograms above demonstrate that measured events are smoothly distributed across the noise level ranges, whereas the EIS predictions feature one or two noise level bands that would occur much more often than other noise levels (seen as 'spikes' in the histograms). This is due to greater variation in real world operations compared to what can be reliably and practically represented in the noise modelling; and
- The measurement data indicates that operations by both aircraft generally result in similar distribution of occurrences of noise levels, whereas the EIS predicted a notable reduction in occurrences of aircraft noise events between 80 – 85 dB L_{Amax} when replacing F/A-18A/B Hornet operations with F-35A aircraft operations.

Maximum noise levels

Table 23: NMT 4 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	66	71	75	71
	F-35A	<65	72	73	74
Highest	F/A-18A/B Hornet	69	77	80	77
	F-35A	<65	79	83	83

The following points are noted following a comparison of data in the above table:

- The average and typical highest measured noise levels for arrivals by both aircraft were comparable;
- Arrival noise level measurements for both aircraft were higher than the EIS predictions; and
- The average and typical highest measured noise levels for departures by F-35A aircraft were comparable to EIS predictions, but were higher than the F/A-18A/B Hornet departure noise measurements.

Australian Noise Exposure

Table 24: NMT 4 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	EIS	Measured in 2019	Measured in 2020
F/A-18A/B Hornet	18	10	6
F-35A	18	6	11

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is below that presented in the EIS for both 2019 and 2020.

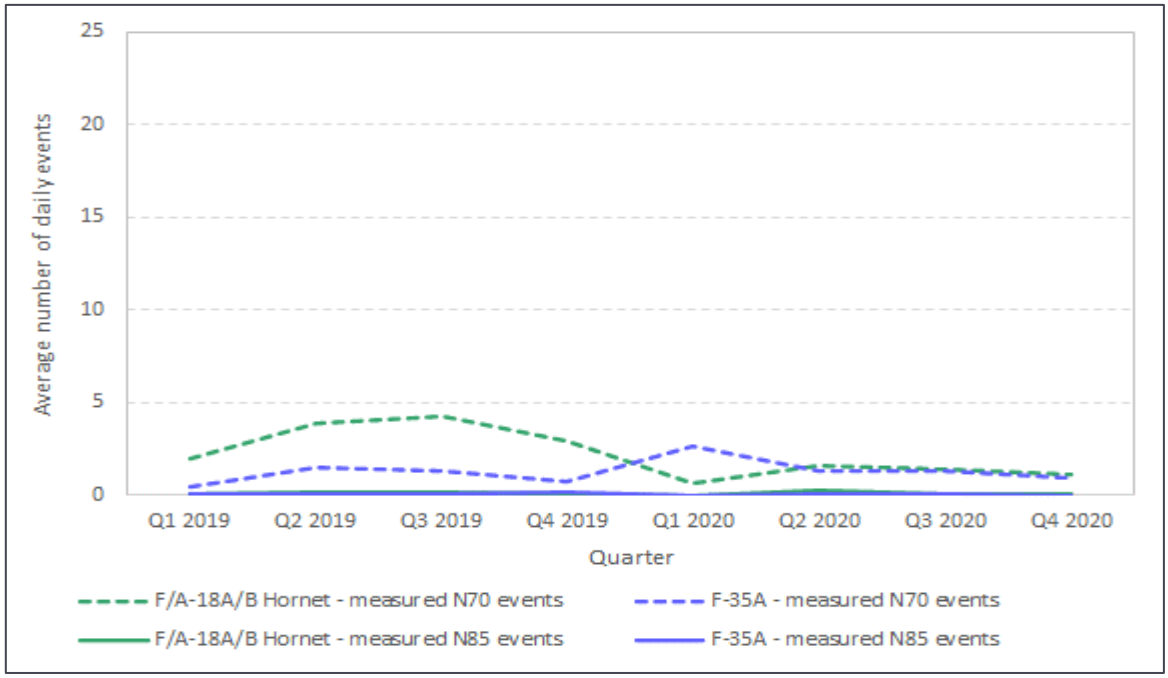
E4 NMT 5 – Wirreanda Public School

Number Above

Table 25: NMT 5 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	13	3 - 4	1 - 2
F-35A	20	1 - 2	1 - 2
N85 events			
F/A-18A/B Hornet	0	0 - 1	0 - 1
F-35A	0	0 - 1	0 - 1

Figure 35: NMT 5 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS;
- Aircraft noise events higher than 85 dB L_{Amax} by either aircraft were uncommon, consistent with the EIS; and
- The trend in the quarterly number above values demonstrate an increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 36: NMT 5 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

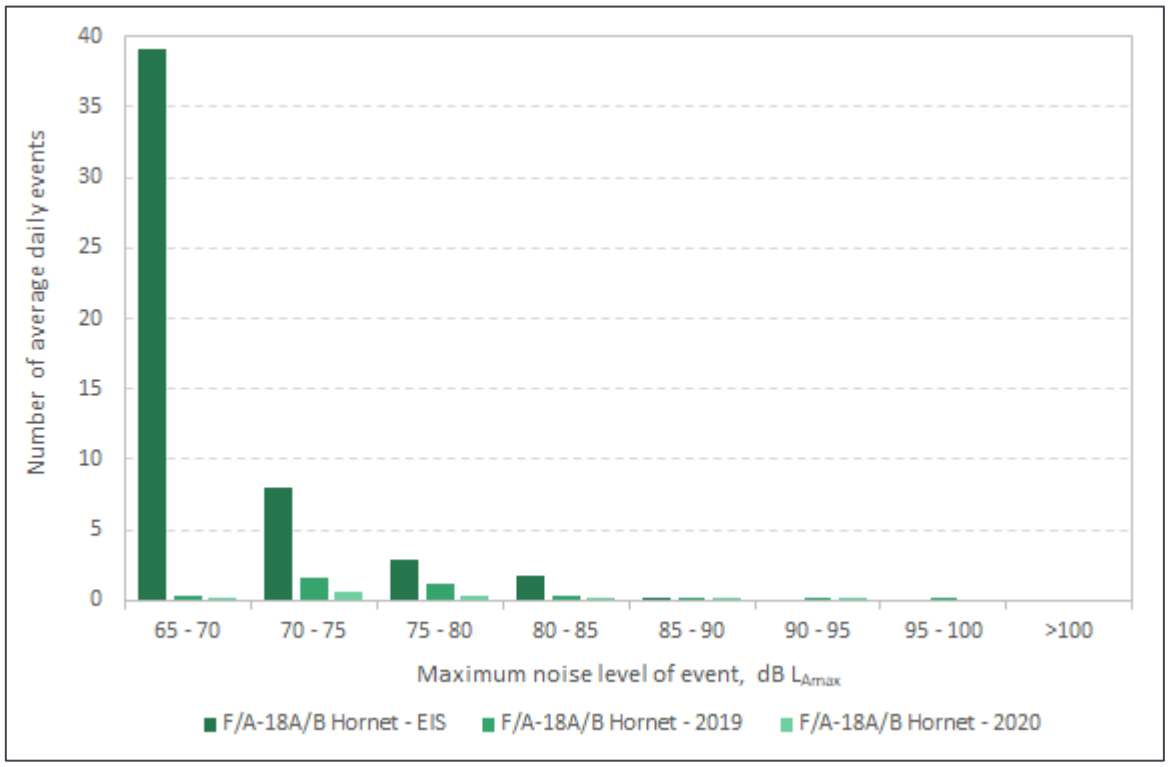


Figure 37: NMT 5 – EIS predictions and measurements – Event level histogram F-35A aircraft

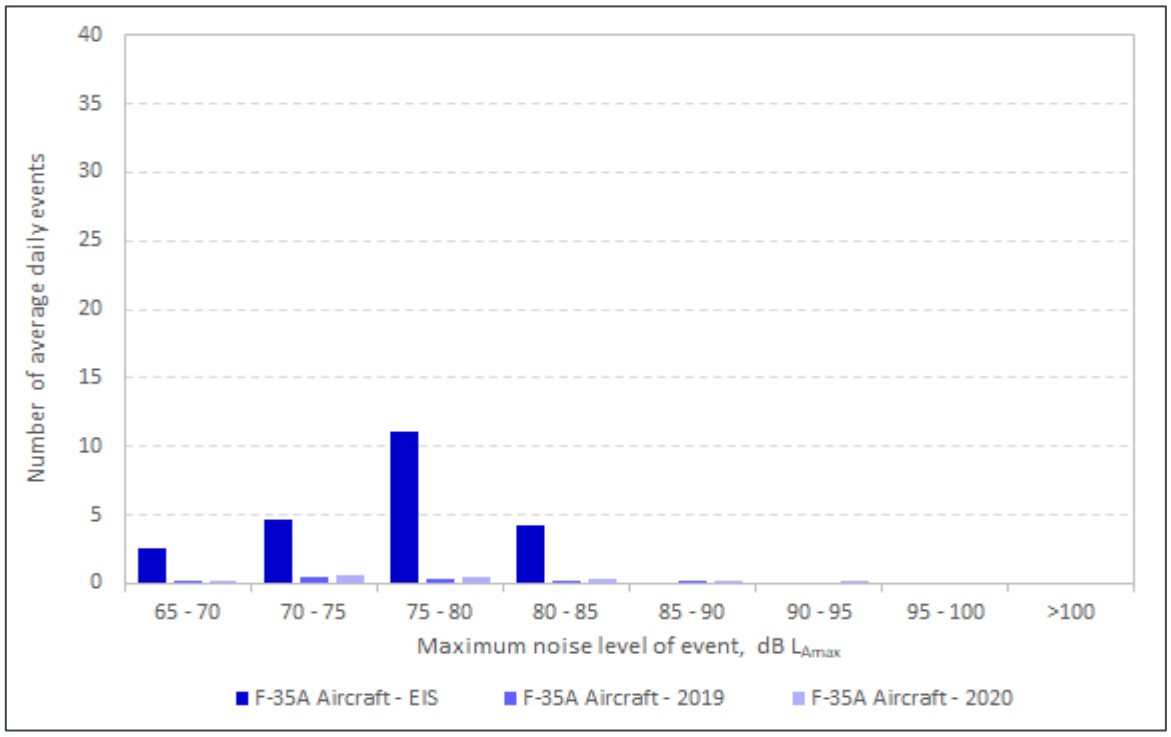


Figure 38: NMT 5 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

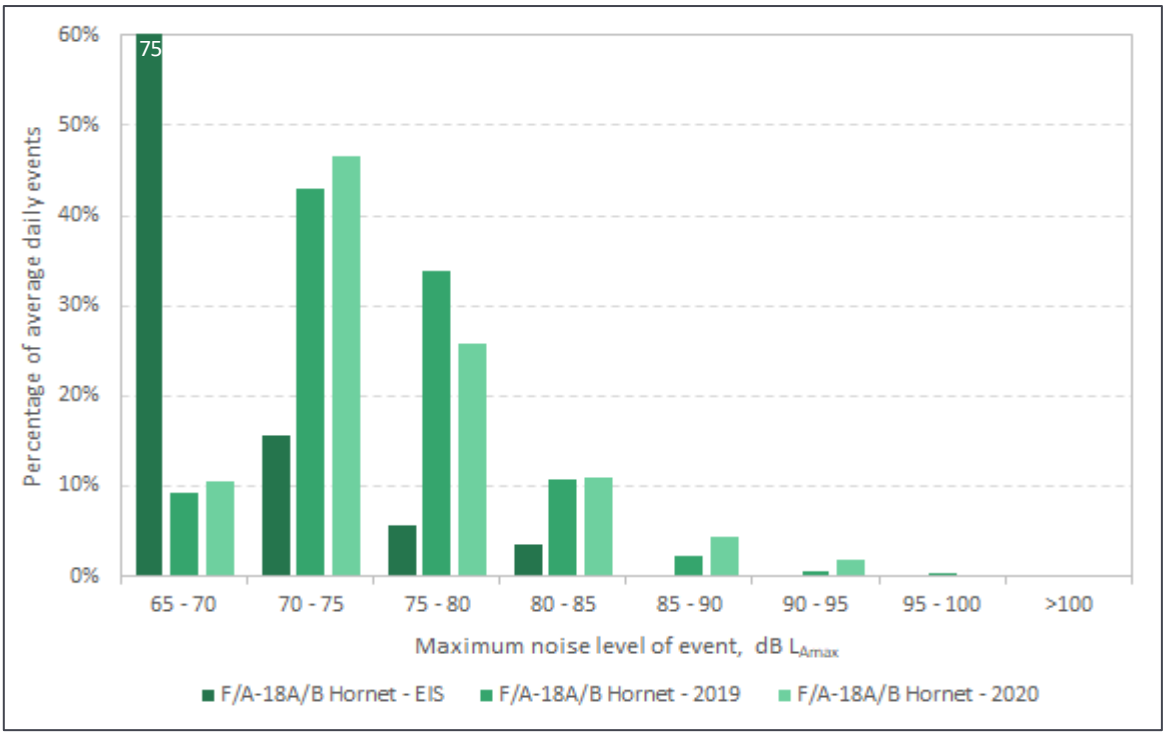
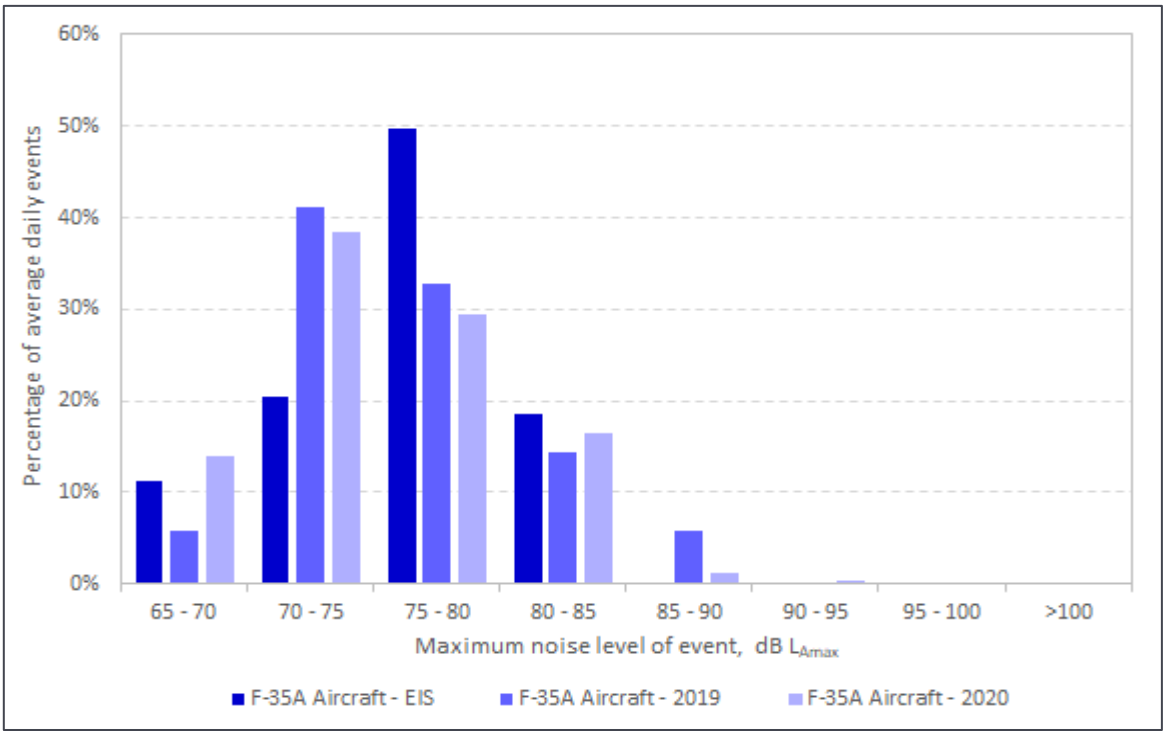


Figure 39: NMT 5 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The majority (>80 %) of events were between 70 – 85 dB L_{Amax} for both F-35A aircraft events predicted by the EIS and measured during the period December 2018 – December 2020; and
- The measurement data indicates that operations by both aircraft generally result in similar distribution of occurrences of noise levels, whereas the EIS predicted a notable increase in occurrences of F-35A aircraft noise events between 75 – 85 dB L_{Amax} compared with F/A-18A/B Hornet operations.

Maximum noise levels

Table 26: NMT 5 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	76	74	76	76
	F-35A	79	75	73	76
Highest	F/A-18A/B Hornet	88	78	82	83
	F-35A	79	80	82	83

The following points are noted following a comparison of data in the above table:

- The average and typical highest measured noise levels for arrival and departure operations by both aircraft were comparable;
- Average noise levels from F-35A aircraft arrival operations were lower than EIS predictions, however, average noise levels from F-35A aircraft departure operations were higher than EIS predictions; and
- The typical highest measured noise levels from F-35A aircraft operations are consistent with the EIS predictions and F/A-18A/B Hornet measurements.

Australian Noise Exposure

Table 27: NMT 5 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	**EIS**	**ANEI measured in 2019**	**ANEI measured in 2020**
F/A-18A/B Hornet	14	6	2
F-35A	16	1	3

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is well below that presented in the EIS for both 2019 and 2020.

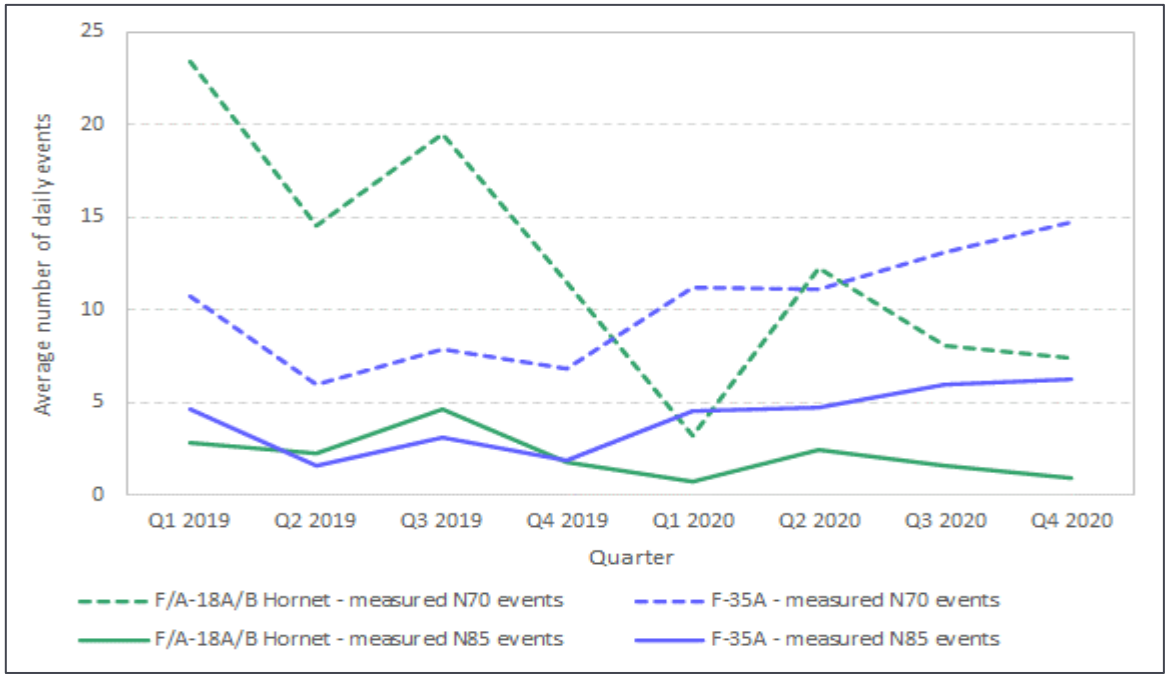
E5 NMT 9 – Cabbage Tree Road, Williamtown

Number Above

Table 28: NMT 9 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	60	17 - 18	7 - 8
F-35A	59	7 - 8	12 - 13
N85 events			
F/A-18A/B Hornet	15	2 - 3	1 - 2
F-35A	20	2 - 3	5 - 6

Figure 40: NMT 9 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS; and
- The trend in the quarterly number above values demonstrate an increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Figure 41: NMT 9 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

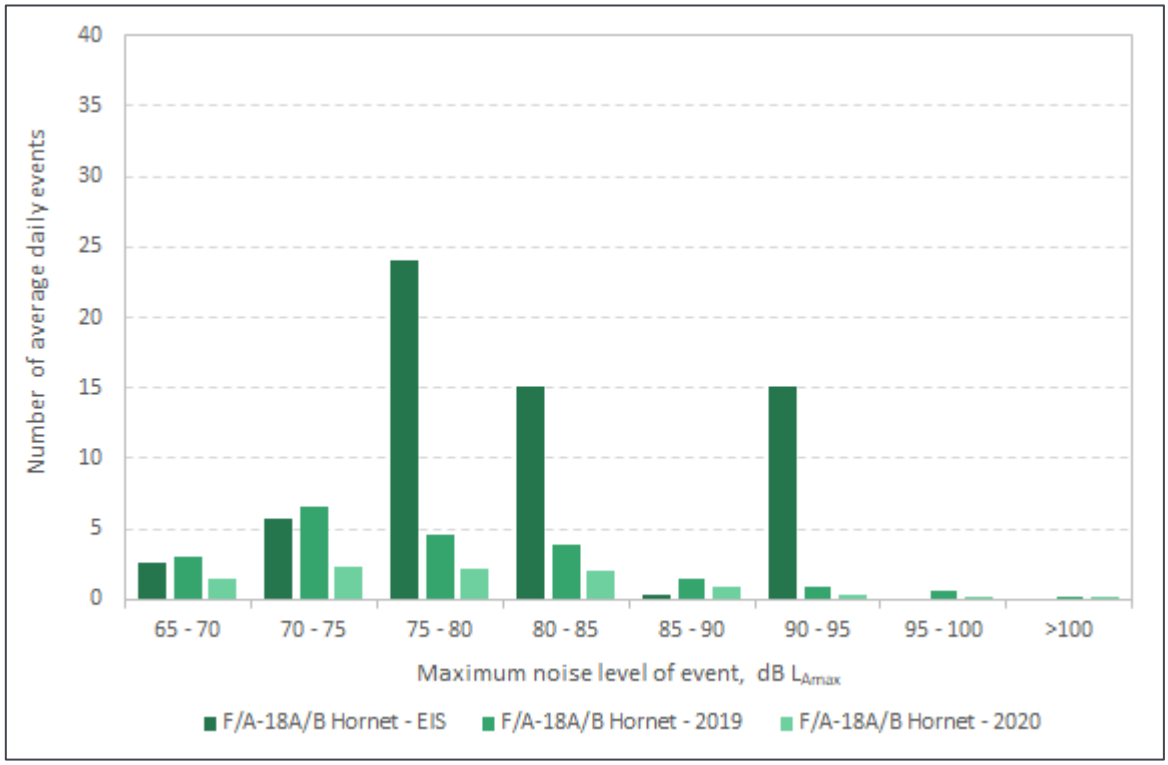


Figure 42: NMT 9 – EIS predictions and measurements – Event level histogram F-35A aircraft

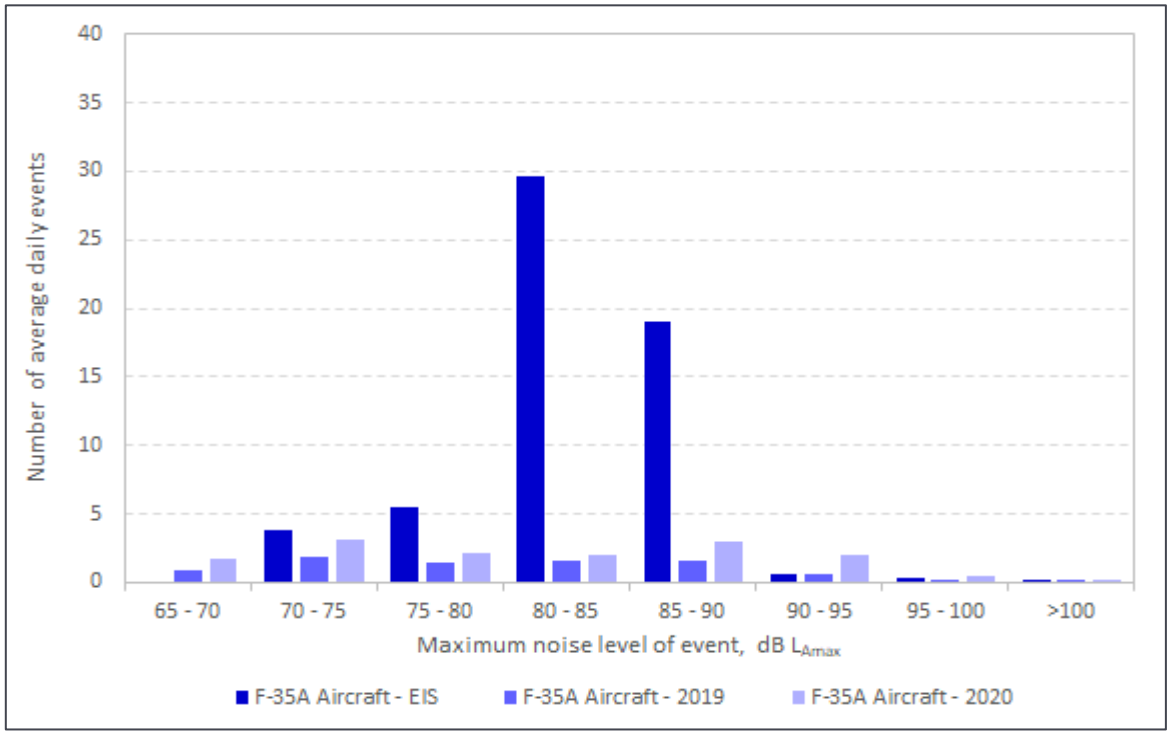


Figure 43: NMT 9 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

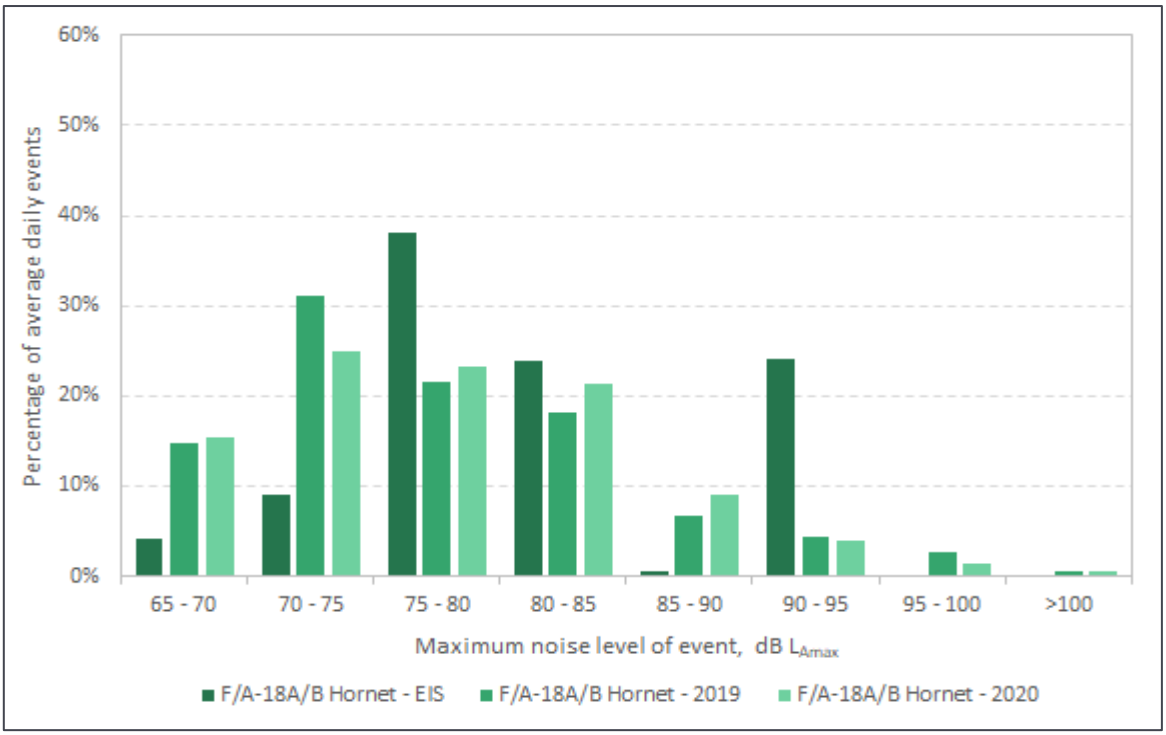
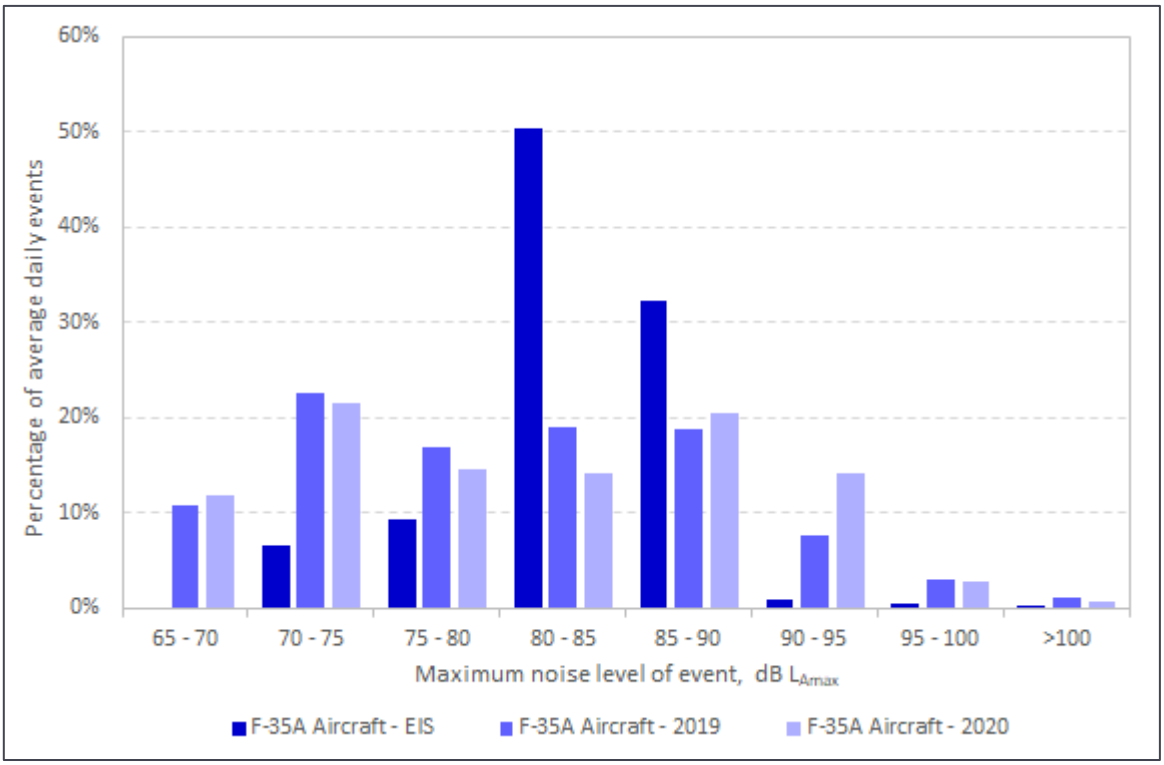


Figure 44: NMT 9 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The majority (80 %) of measured F-35A aircraft noise levels were between 70 – 90 dB L_{Amax} compared with the EIS predictions where the majority (>80 %) of aircraft noise levels ranged between 80 – 90 dB L_{Amax};
- The histograms demonstrate that measured events were distributed across the noise level ranges, whereas the EIS predictions feature more prominent noise levels that would be experienced more often. This is due to greater variation in real world operations compared to what can be reliably and practically represented in the noise modelling;
- The measurement data indicates that operations by both aircraft generally result in similar distribution of occurrences of noise levels, whereas the EIS predicted a notable reduction in occurrences of F-35A aircraft noise events between 90 – 95 dB L_{Amax} compared with F/A-18A/B Hornet operations; and
- There was a higher percentage occurrence of measured F-35A aircraft events (30 %) between 85 – 95 dB L_{Amax} than F/A-18A/B Hornet events (15 %).

Maximum noise levels

Table 29: NMT 9 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	76	77	85	78
	F-35A	79	79	84	84
Highest	F/A-18A/B Hornet	89	91	90	86
	F-35A	87	92	89	91

The following points are noted following a comparison of data in the above table:

- Measured noise levels due to arrival operations were comparable for both aircraft, consistent with the EIS;
- The average and highest measured noise levels for F-35A departure operations were 5 – 6 dB higher than F/A-18A/B Hornet departure operations, though were comparable to EIS predictions.

Australian Noise Exposure

Table 30: NMT 9 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	EIS	Measured in 2019	Measured in 2020
F/A-18A/B Hornet	29	21	17
F-35A	28	18	22

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is below that presented in the EIS for both 2019 and 2020.

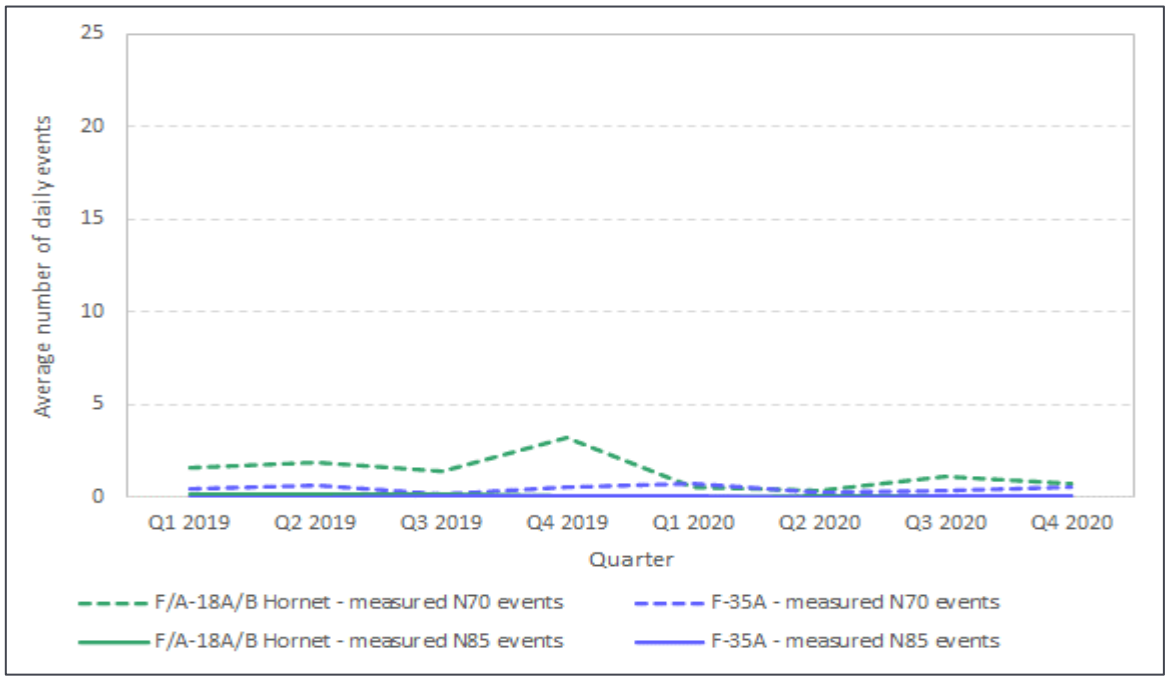
E6 NMT 10 – Frederick Drive, Oyster Cove

Number Above

Table 31: NMT 10 – EIS predictions and measurements – average daily number above event

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	21	1 - 2	0 - 1
F-35A	14	0 - 1	0 - 1
N85 events			
F/A-18A/B Hornet	0	0 - 1	0 - 1
F-35A	0	0 - 1	0 - 1

Figure 45: NMT 10 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS;
- Aircraft noise events higher than 85 dB L_{Amax} by either aircraft were uncommon, consistent with the EIS; and
- The trend in the quarterly number above values demonstrate an increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 46: NMT 10 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

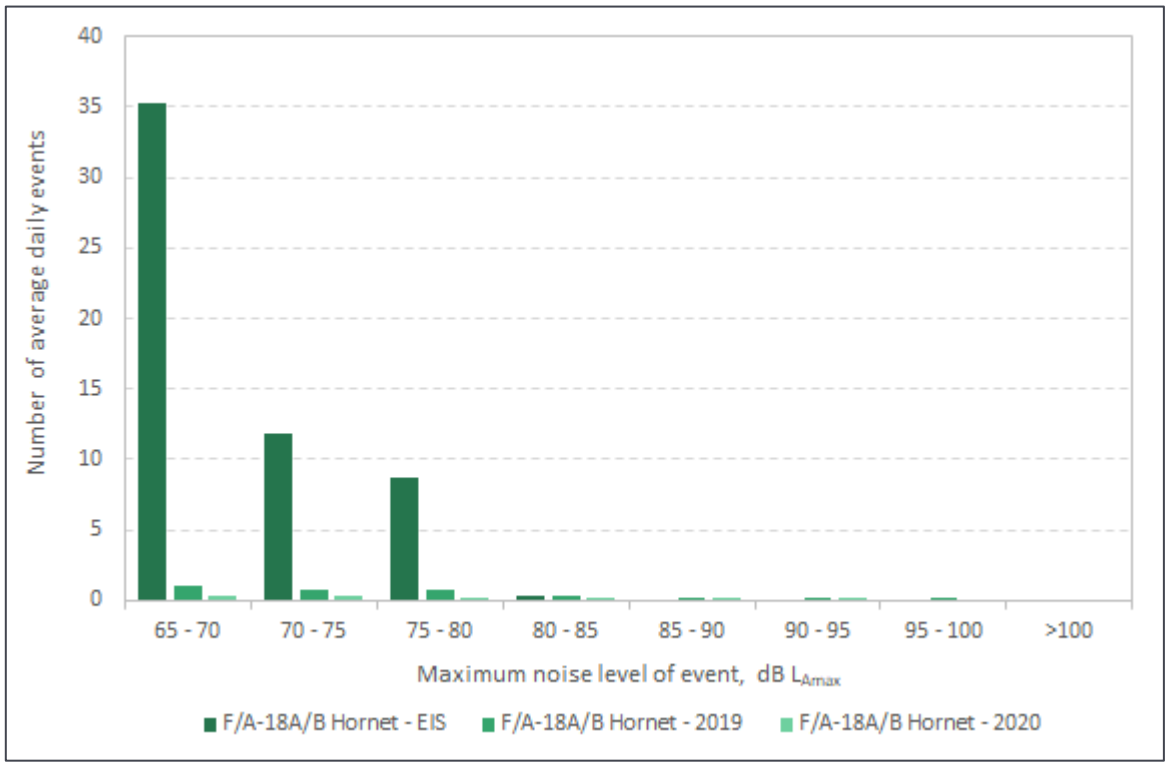


Figure 47: NMT 10 – EIS predictions and measurements – Event level histogram F-35A aircraft

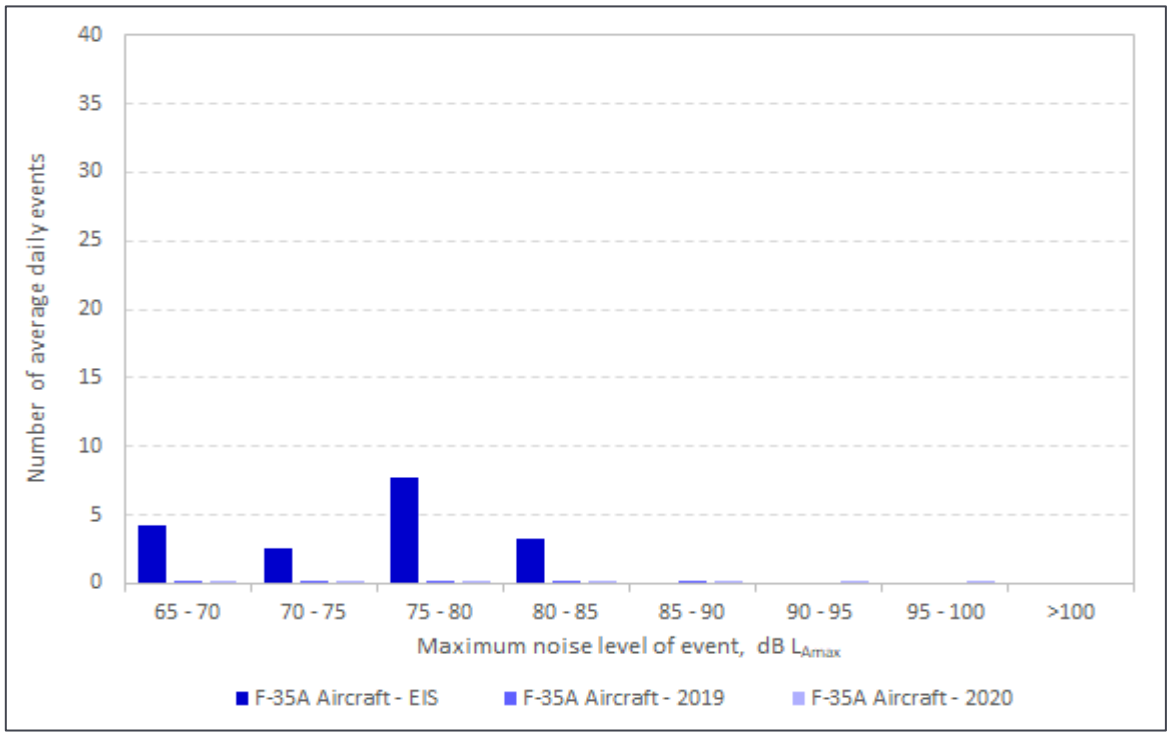


Figure 48: NMT 10 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

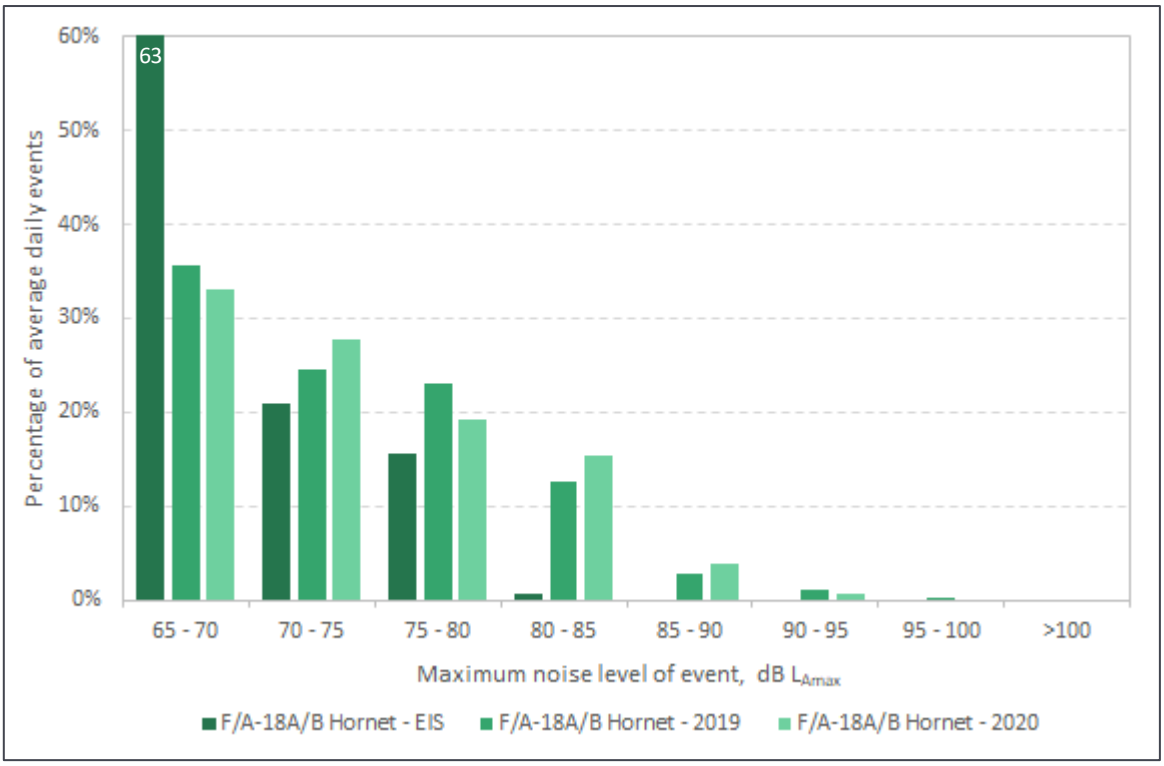
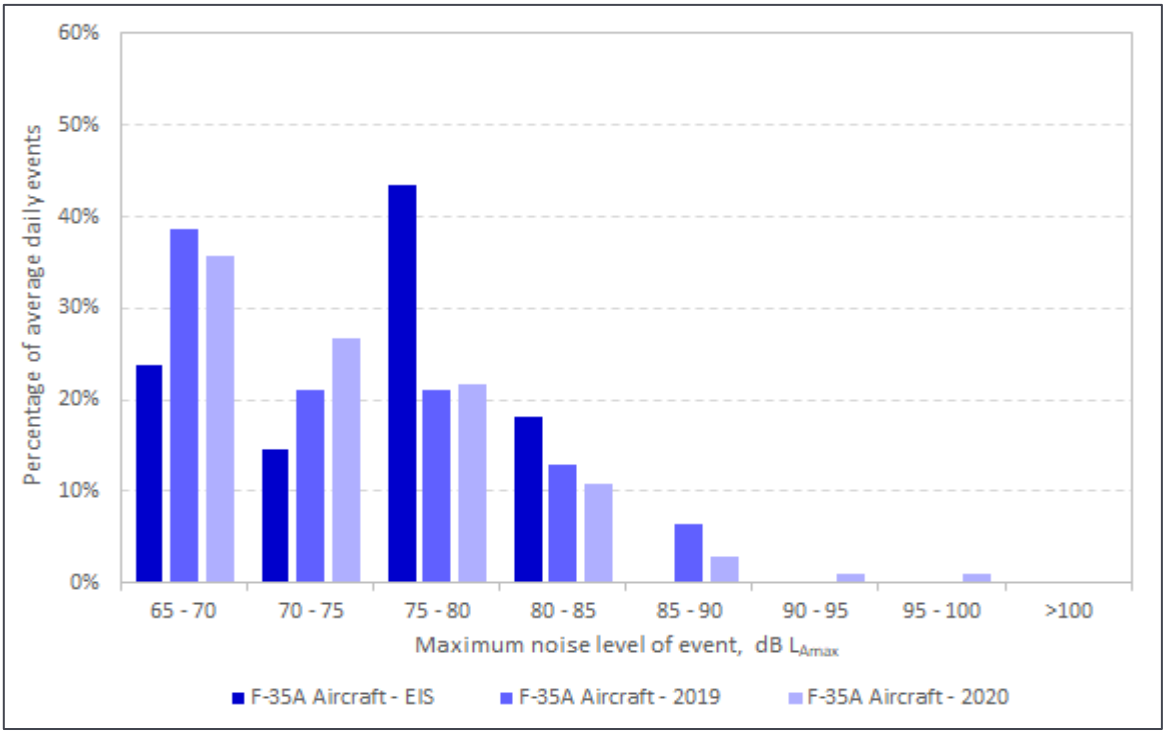


Figure 49: NMT 10 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The low number of aircraft noise events measured at this location can be attributed to the limited activity by both aircraft at SAAWR; and
- The measurement data indicates that operations by both aircraft generally result in similar distribution of occurrences of noise levels, whereas the EIS predicted a notable increase in occurrences of aircraft noise events between 75 – 85 dB L_{Amax} when replacing F/A-18A/B Hornet operations with F-35A aircraft operations.

Maximum noise levels

Table 32: NMT 10 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	68	73	74	74
	F-35A	66	74	70	73
Highest	F/A-18A/B Hornet	69	82	83	82
	F-35A	67	84	81	82

The following points are noted following a comparison of data in the above table:

- The average and typical highest measured noise levels for arrival and departure operations by both aircraft were comparable;
- Arrival noise level measurements for both aircraft were higher than the EIS predictions;
- The average measured noise level due to F-35A aircraft departures was marginally higher than the EIS prediction; and
- The typical highest measured noise levels from F-35A aircraft operations are consistent with the EIS predictions and F/A-18A/B Hornet measurements.

Australian Noise Exposure

Table 33: NMT 10 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	**EIS**	**Measured in 2019**	**Measured in 2020**
F/A-18A/B Hornet	13	7	1
F-35A	14	-	2

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is well below that presented in the EIS for 2019 and 2020.

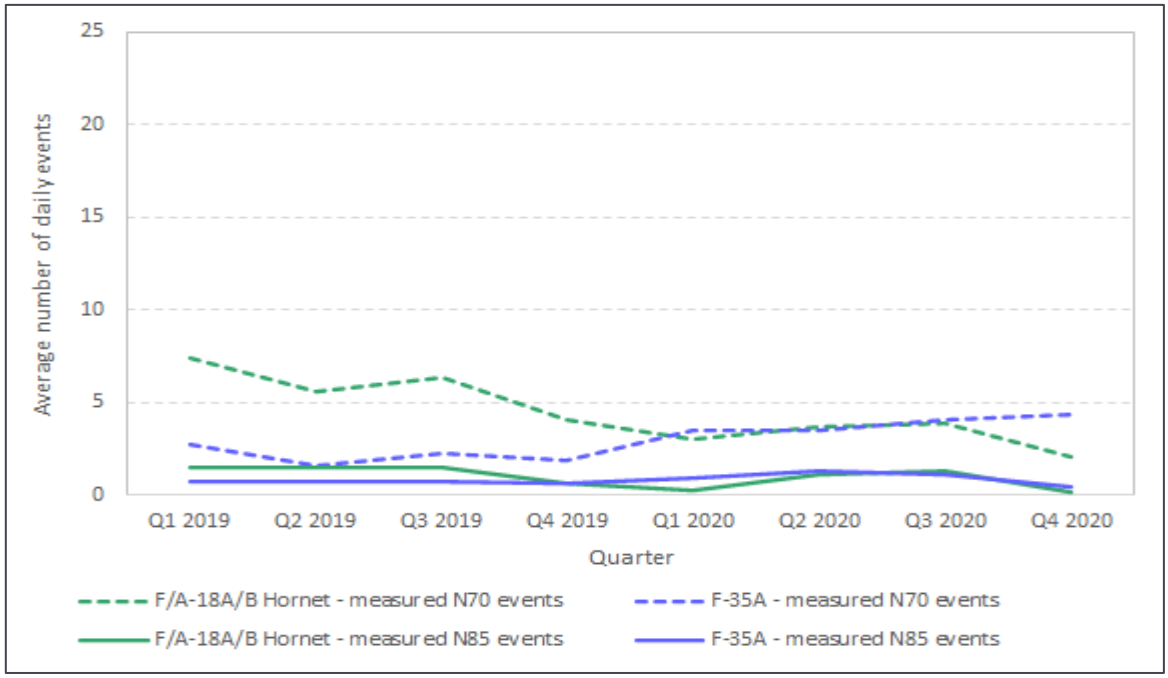
E7 NMT 13 – Disabled Riding School

Number Above

Table 34: NMT 13 – EIS predictions and measurements – average daily number above events

Aircraft	EIS noise modelling	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	25	5 - 6	3 - 4
F-35A	16	2 - 3	3 - 4
N85 events			
F/A-18A/B Hornet	1	1 - 2	0 - 1
F-35A	0	0 - 1	0 - 1

Figure 50: NMT 13 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS;
- Aircraft noise events higher than 85 dB L_{Amax} by either aircraft were uncommon, as predicted by the EIS; and
- The trend in the quarterly number above values demonstrate an increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 51: NMT 13 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

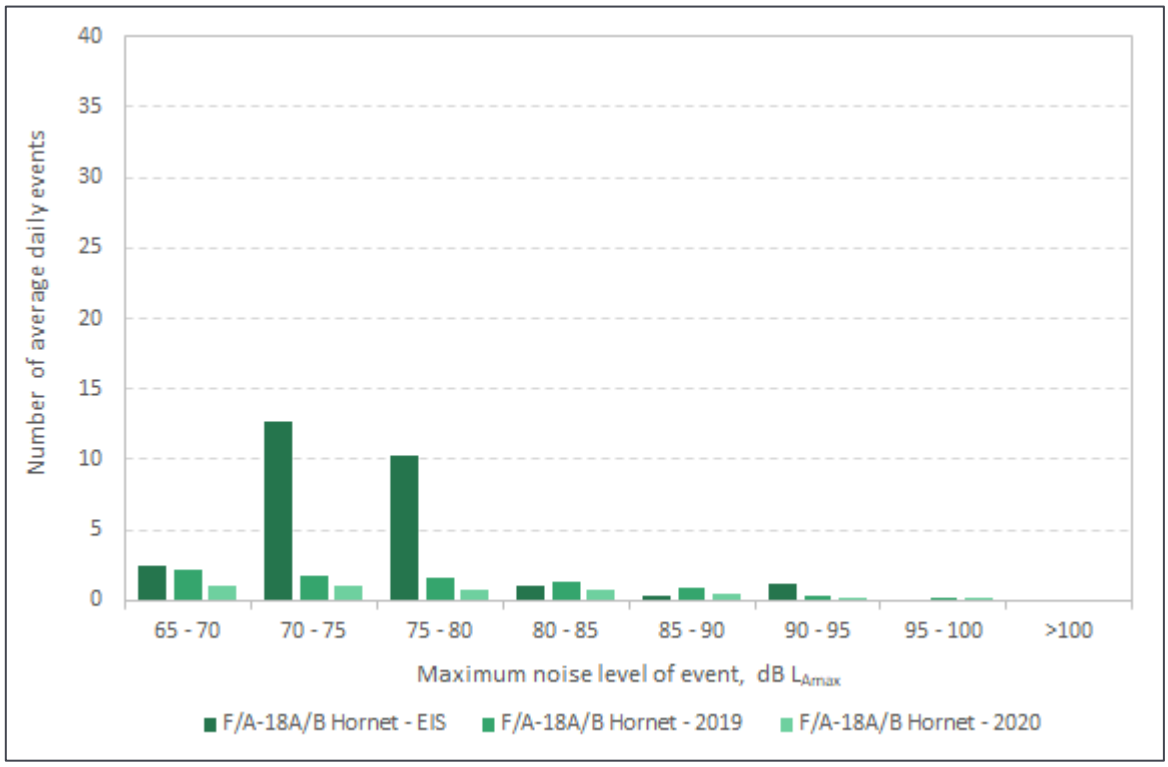


Figure 52: NMT 13 – EIS predictions and measurements – Event level histogram F-35A aircraft

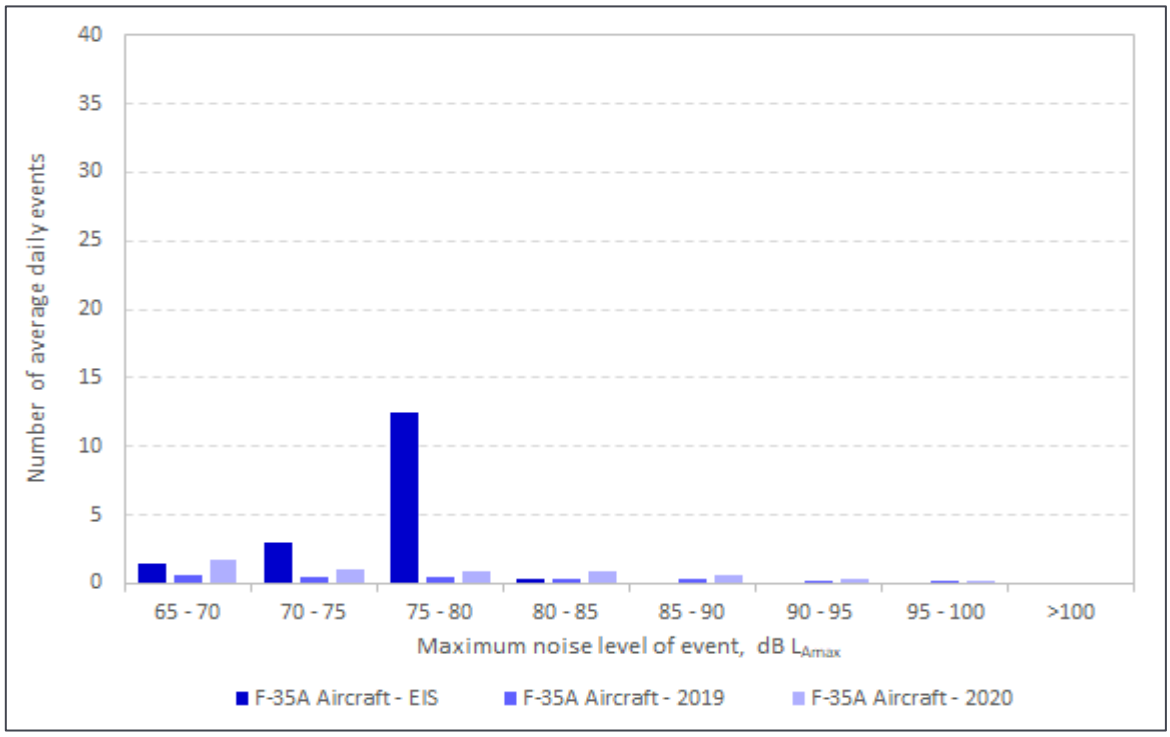


Figure 53: NMT 13 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

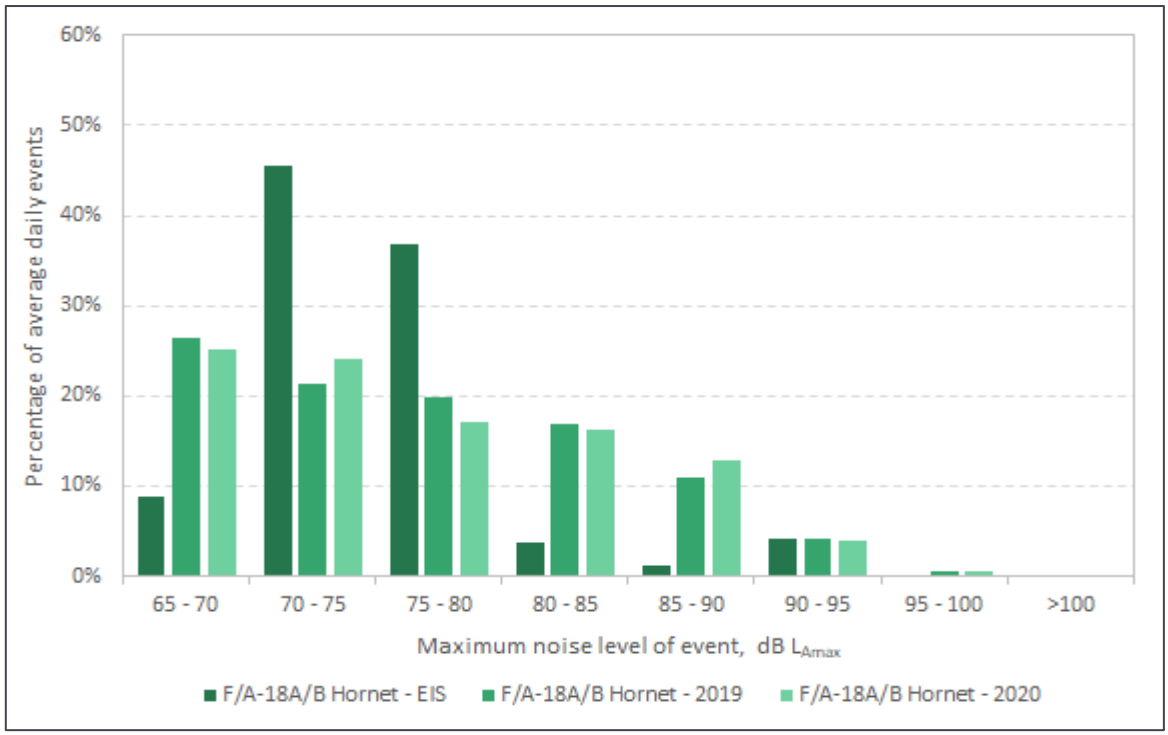
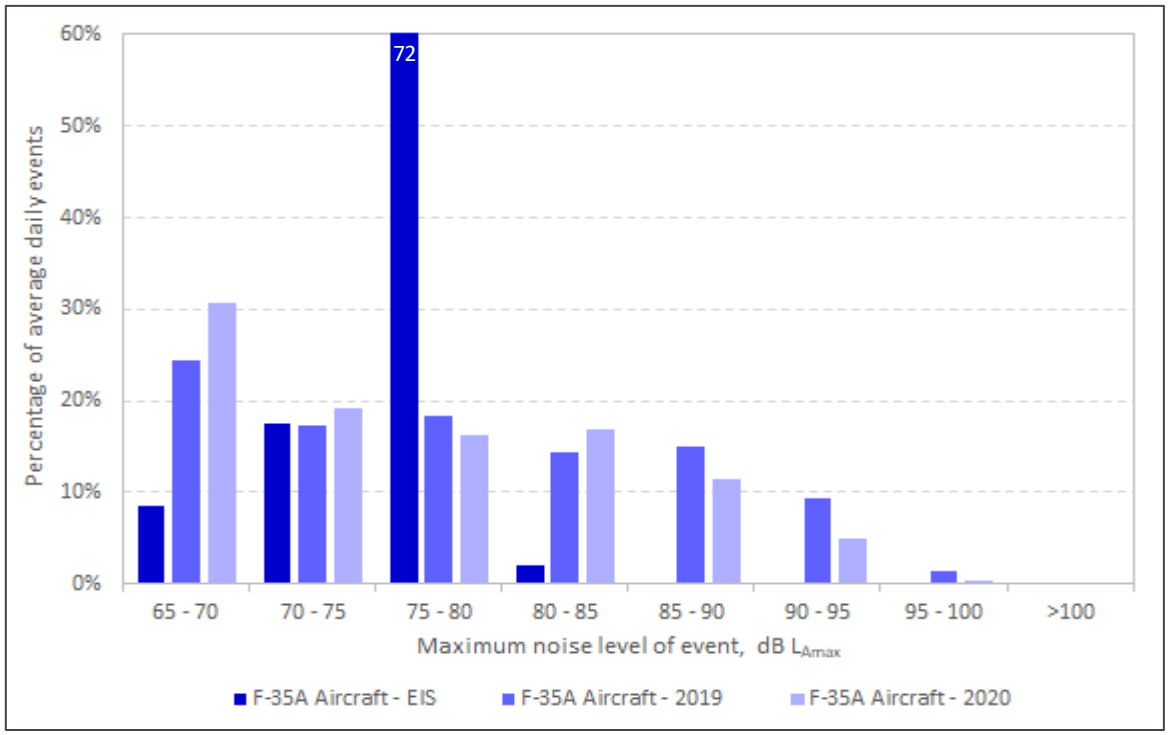


Figure 54: NMT 13 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The key observations are noted:

- The occurrence of noise events above 80 dB L_{Amax} was higher than predicted by the EIS for both aircraft operations. This is likely associated with runway 30 departure flight tracks being flown closer to the NMT than what was considered in the EIS noise model, as discussed in Section 4.6.2;
- The histograms demonstrate that measured events are smoothly distributed across the noise level ranges, whereas the EIS predictions feature one or two noise level bands that would occur much more often than other noise levels (seen as 'spikes' in the histograms). This is due to greater variation in real world operations compared to what can be reliably and practically represented in the noise modelling; and
- The measurement data indicates that operations by both aircraft generally result in similar distribution of occurrences of noise levels, whereas the EIS predicted an increase in occurrences of F-35A aircraft noise events between 75 – 80 dB L_{Amax} compared with F/A-18A/B Hornet operations.

Maximum noise levels

Table 35: NMT 13 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	75	74	75	80
	F-35A	74	73	75	82
Highest	F/A-18A/B Hornet	93	83	79	90
	F-35A	81	82	85	91

The following points are noted following a comparison of data in the above table:

- Average measured noise levels due to arrival and departure operations were comparable for both aircraft, consistent with the EIS;
- The measured typical highest noise levels were comparable for both aircraft.
- The measured departure noise levels were higher than the EIS predictions for both aircraft. The key factor contributing to this difference for both aircraft was that runway 30 departure flight tracks being flown closer to Raymond Terrace than what was considered in the EIS noise model, as discussed in Section 4.6.2; and
- The measured F-35A departure noise levels were higher than those of the F/A-18A/B Hornet. This is in contrast with the EIS which predicted similar average departure noise levels. This can be attributed to the need to adopt higher thrust settings for safety, as discussed in Section 4.7.2.

Australian Noise Exposure

Table 36: NMT 13 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	EIS	Measured in 2019	Measured in 2020
F/A-18A/B Hornet	16	14	11
F-35A	15	11	14

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased;
- The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is below that presented in the EIS for 2019 and 2020. The higher-than-expected measured 2020 value for the F-35A aircraft is due to the higher measured departure noise levels discussed above.

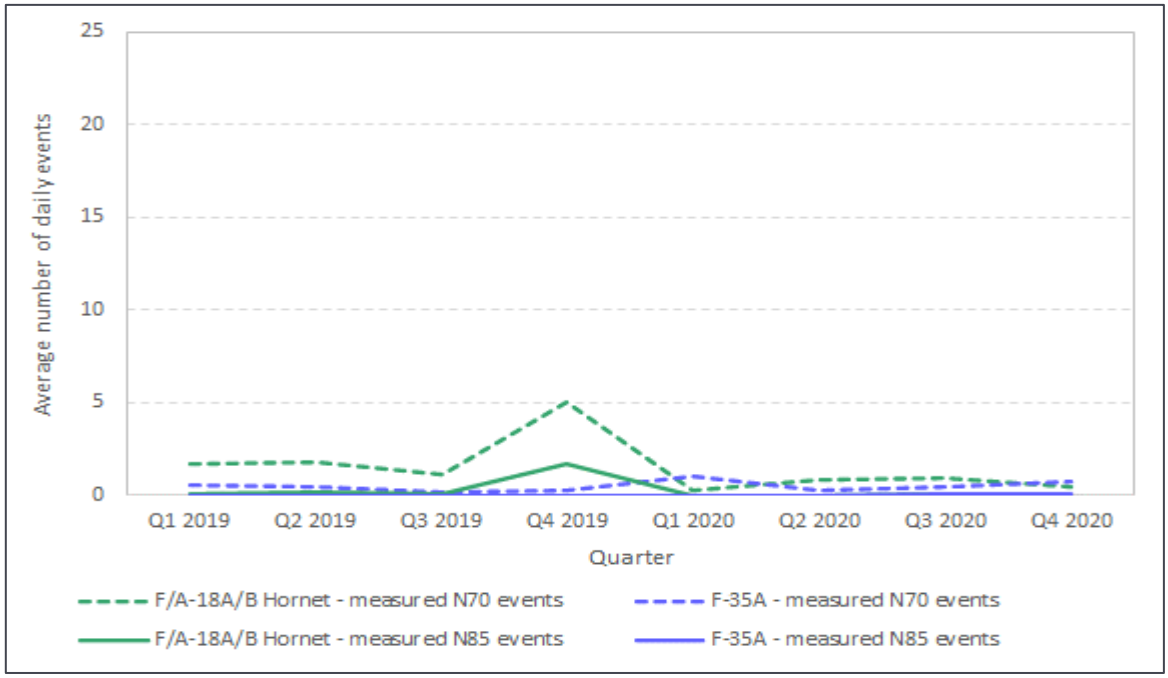
E8 NMT 17 – Tanilba Golf Club

Number Above

Table 37: NMT 17 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	24	2 - 3	0 - 1
F-35A	6	0 - 1	0 - 1
N85 events			
F/A-18A/B Hornet	0	0 - 1	0 - 1
F-35A	0	0	0 - 1

Figure 55: NMT 17 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS;
- Aircraft noise events higher than 85 dB L_{Amax} by either aircraft were uncommon, as predicted by the EIS; and
- The trend in the quarterly number above values demonstrate an increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 56: NMT 17 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

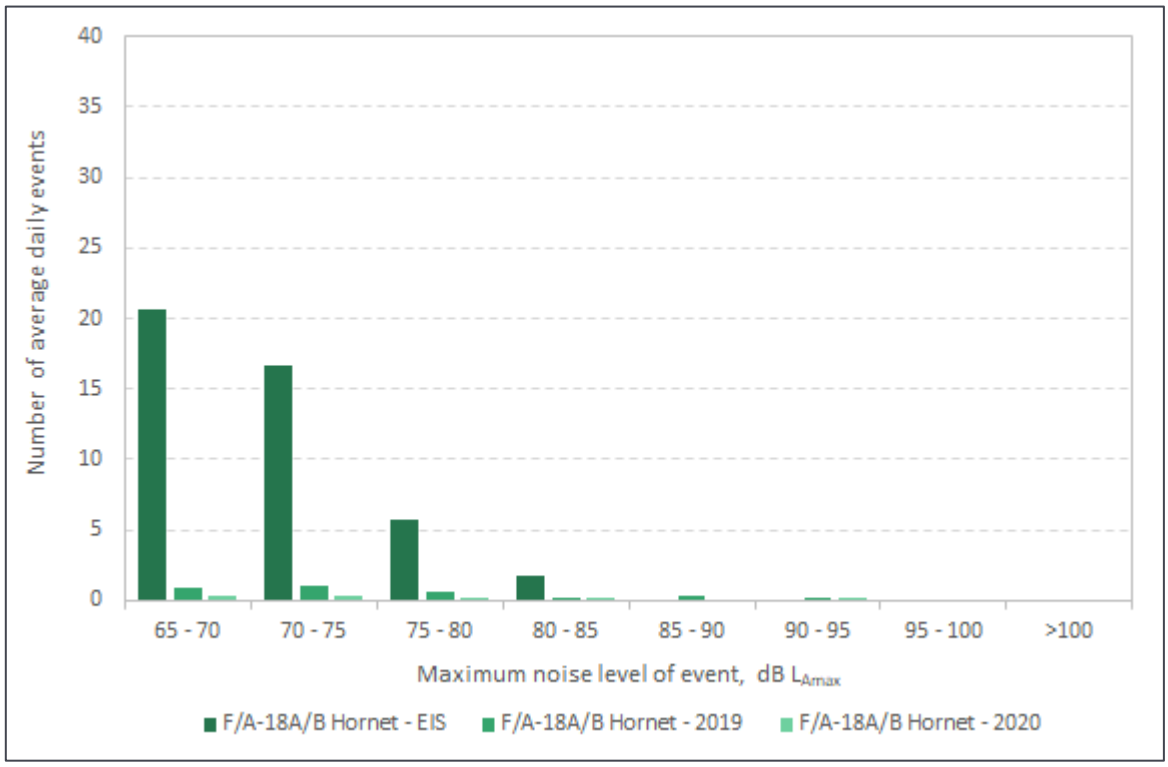


Figure 57: NMT 17 – EIS predictions and measurements – Event level histogram F-35A aircraft

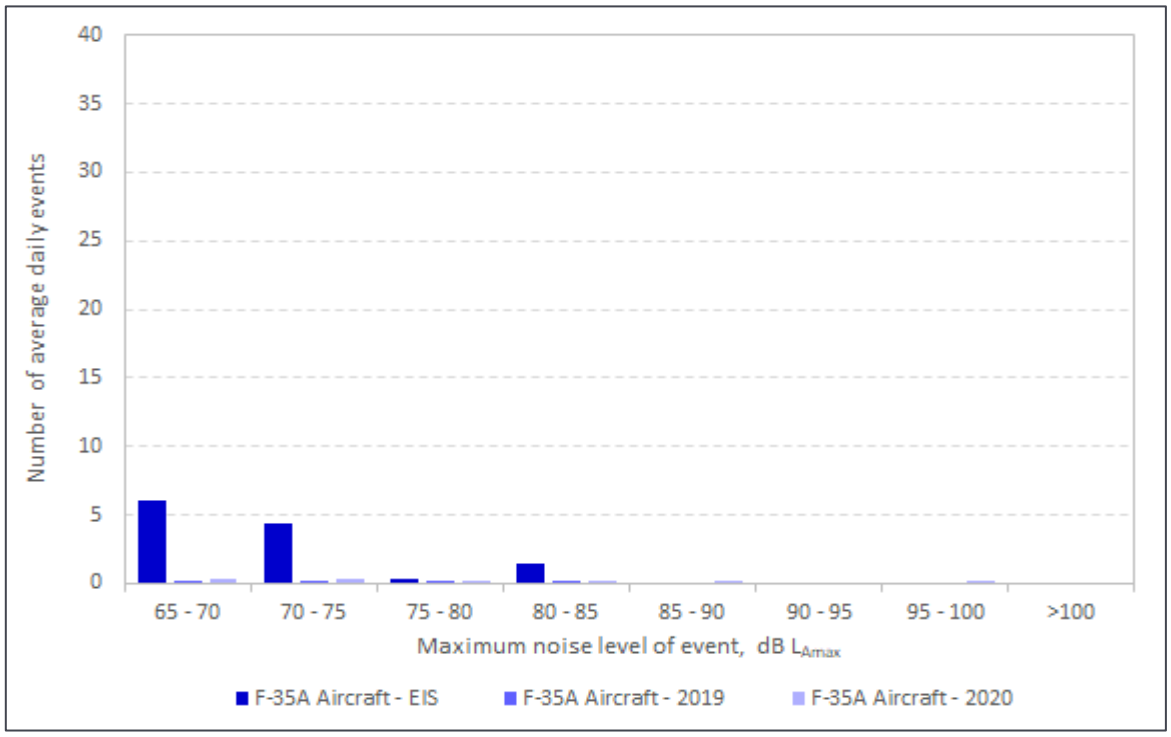


Figure 58: NMT 17 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

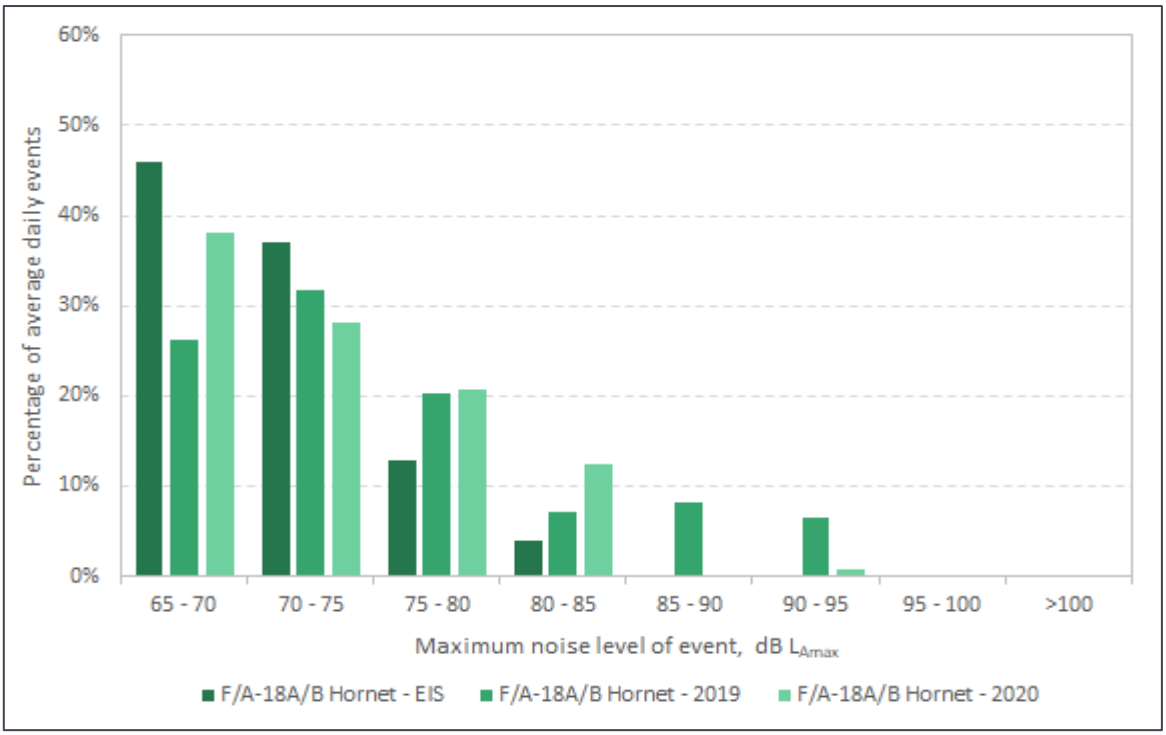
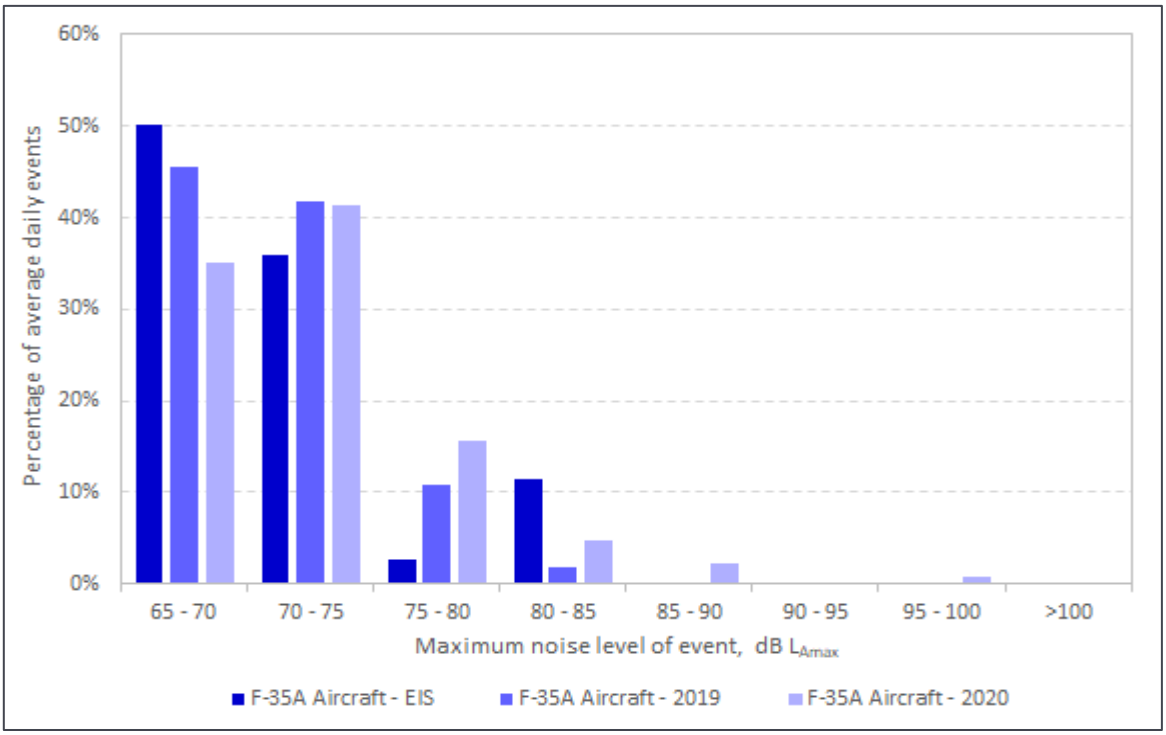


Figure 59: NMT 17 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The measurement data indicates that operations by both aircraft generally result in similar distribution of occurrences of noise levels, which generally matched the EIS predictions.

Maximum noise levels

Table 38: NMT 17 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	66	75	73	75
	F-35A	<65	73	74	71
Highest	F/A-18A/B Hornet	67	88	78	87
	F-35A	<65	80	83	76

The following points are noted following a comparison of data in the above table:

- The average and typical highest measured noise levels for F-35A operations were lower than F/A-18A/B Hornet operations, except for average arrival noise level measurements which were similar for both aircraft;
- Arrival noise level measurements for both aircraft were higher than the EIS predictions; and
- F-35A departure noise levels were lower than the EIS predictions.

Australian Noise Exposure

Table 39: NMT 17 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	**EIS**	**Measured in 2019**	**Measured in 2020**
F/A-18A/B Hornet	10	8	-
F-35A	14	-	0

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure is well below that presented in the EIS.

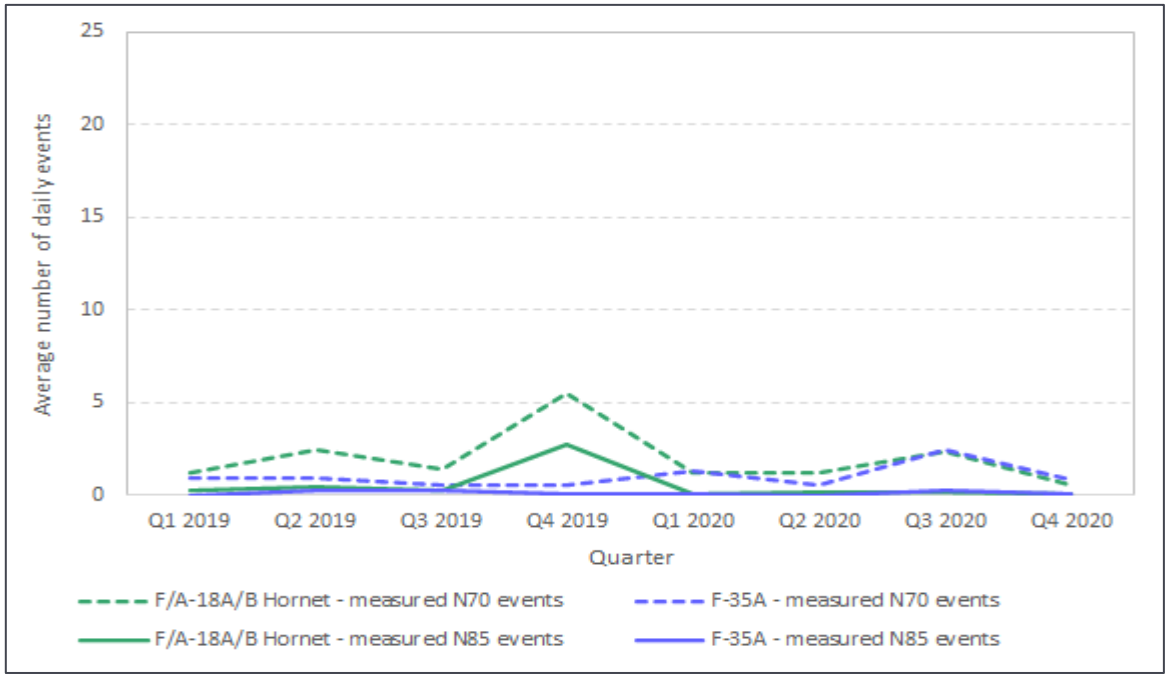
E9 NMT 18 – Salt Ash Fire Station

Number Above

Table 40: NMT 18 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	48	2 - 3	1 - 2
F-35A	17	0 - 1	1 - 2
N85 events			
F/A-18A/B Hornet	15	0 - 1	0 - 1
F-35A	1	0 - 1	0 - 1

Figure 60: NMT 18 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS, likely due to the limited activity at SAAWR;
- Aircraft noise events higher than 85 dB L_{Amax} by either aircraft were uncommon; and
- The trend in the quarterly number above values demonstrate a slight increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 61: NMT 18 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

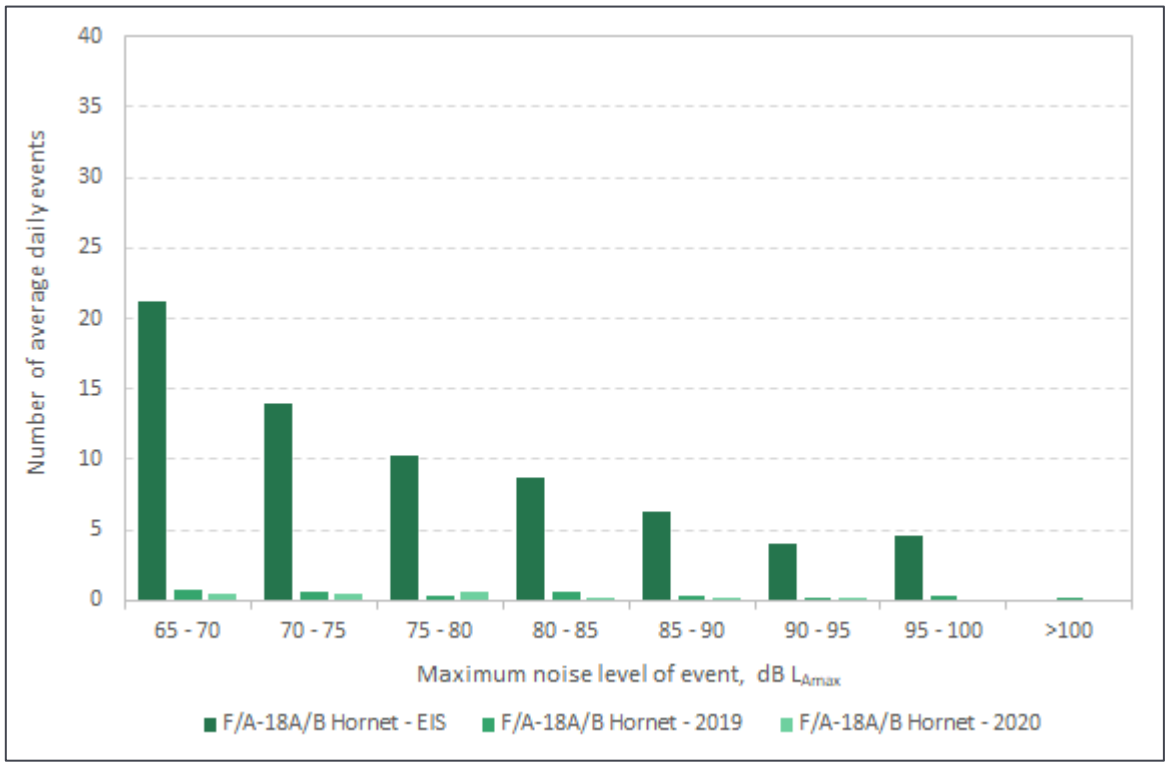


Figure 62: NMT 18 – EIS predictions and measurements – Event level histogram F-35A aircraft

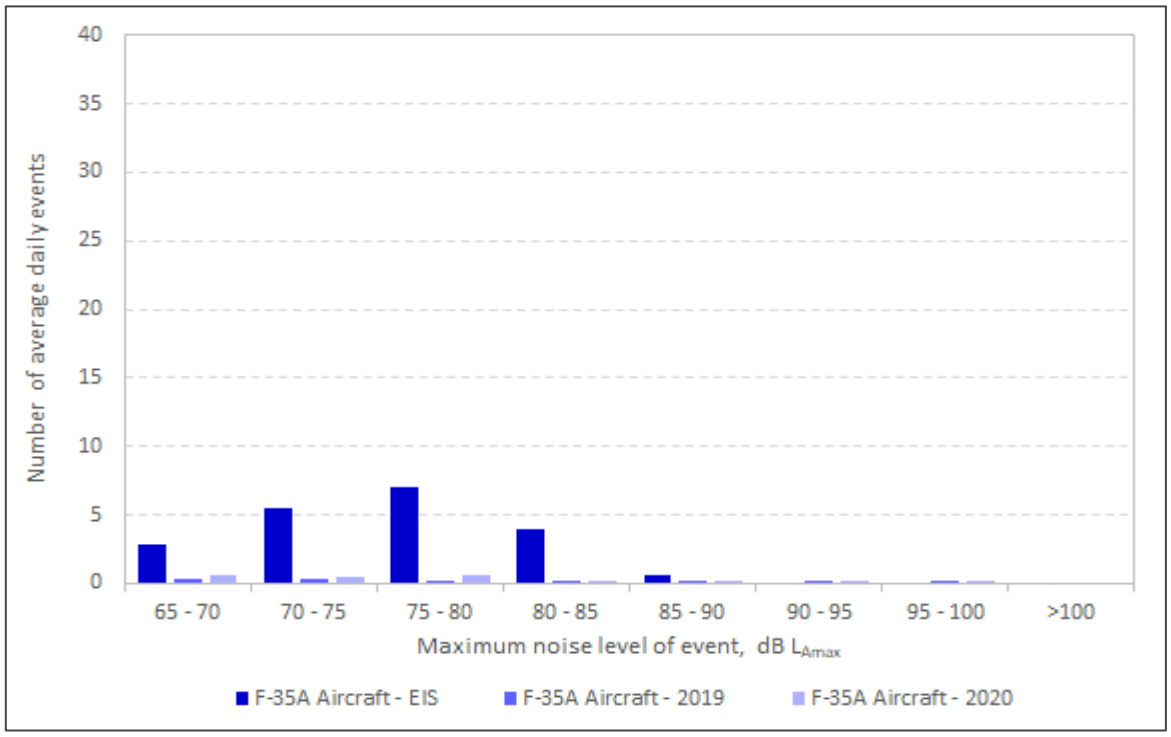


Figure 63: NMT 18 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

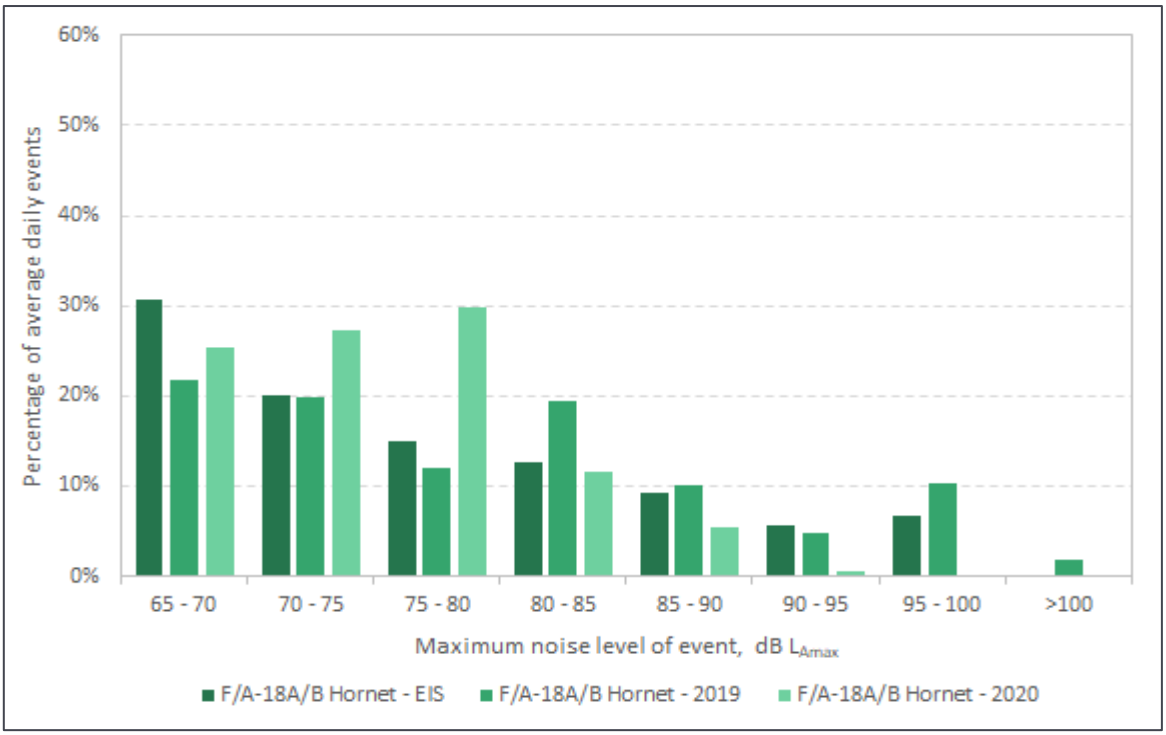
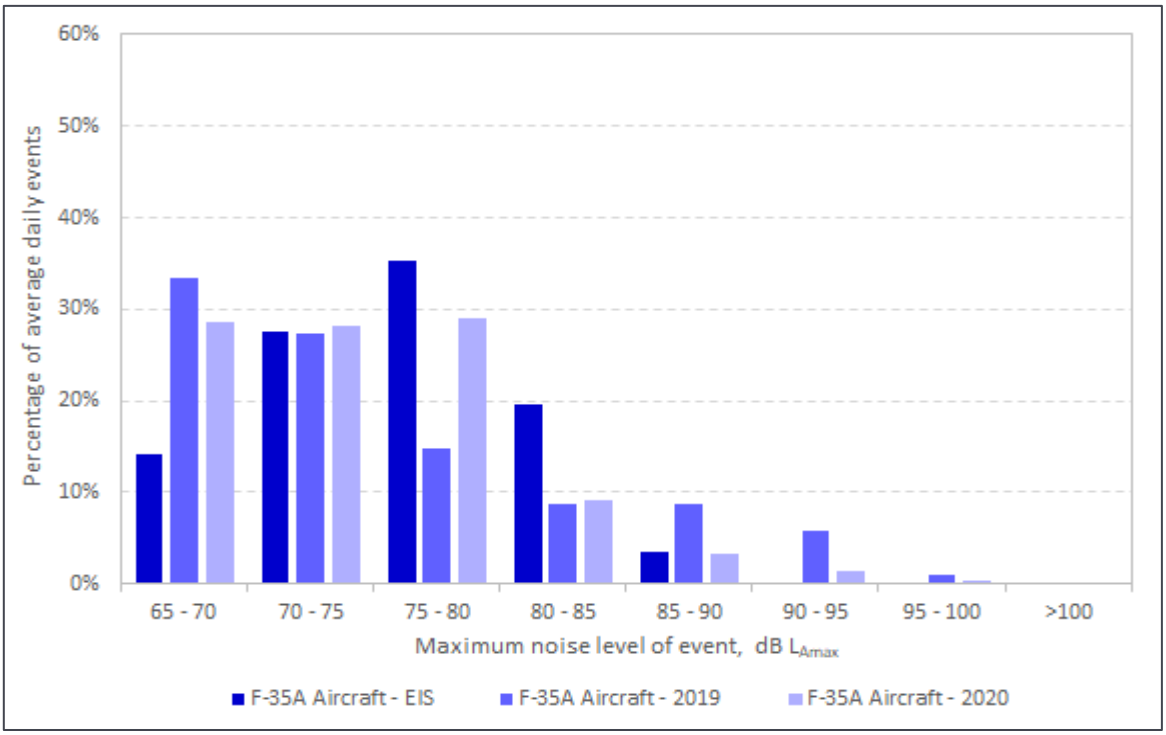


Figure 64: NMT 18 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The low number of aircraft noise events measured at this location can be attributed to the limited activity by both aircraft at SAAWR;
- The majority (>70 %) of measured F-35A aircraft noise levels were between 65 – 80 dB L_{Amax} which was comparable to the EIS predictions; and
- The measurement data indicates fewer occurrences of aircraft noise events above 85 dB L_{Amax} when comparing F/A-18A/B Hornet operations with F-35A aircraft operations, which is comparable to the EIS predictions.

Maximum noise levels

Table 41: NMT 18 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	<65	78	71	78
	F-35A	<65	74	72	75
Highest	F/A-18A/B Hornet	<65	88	89	98
	F-35A	<65	83	87	83

The following points are noted following a comparison of data in the above table:

- The average and typical highest measured noise levels for F-35A operations were lower than F/A-18A/B Hornet operations;
- Arrival noise level measurements for both aircraft were higher than the EIS predictions;
- The average measured noise levels from departure operations are higher than the EIS predictions for both aircraft; and
- The typical highest measured F-35A aircraft departure noise levels were lower than the EIS.

Australian Noise Exposure

Table 42: NMT 18 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	**EIS**	**Measured in 2019**	**Measured in 2020**
F/A-18A/B Hornet	25	15	6
F-35A	16	1	6

The following points are noted from the data in the table above:

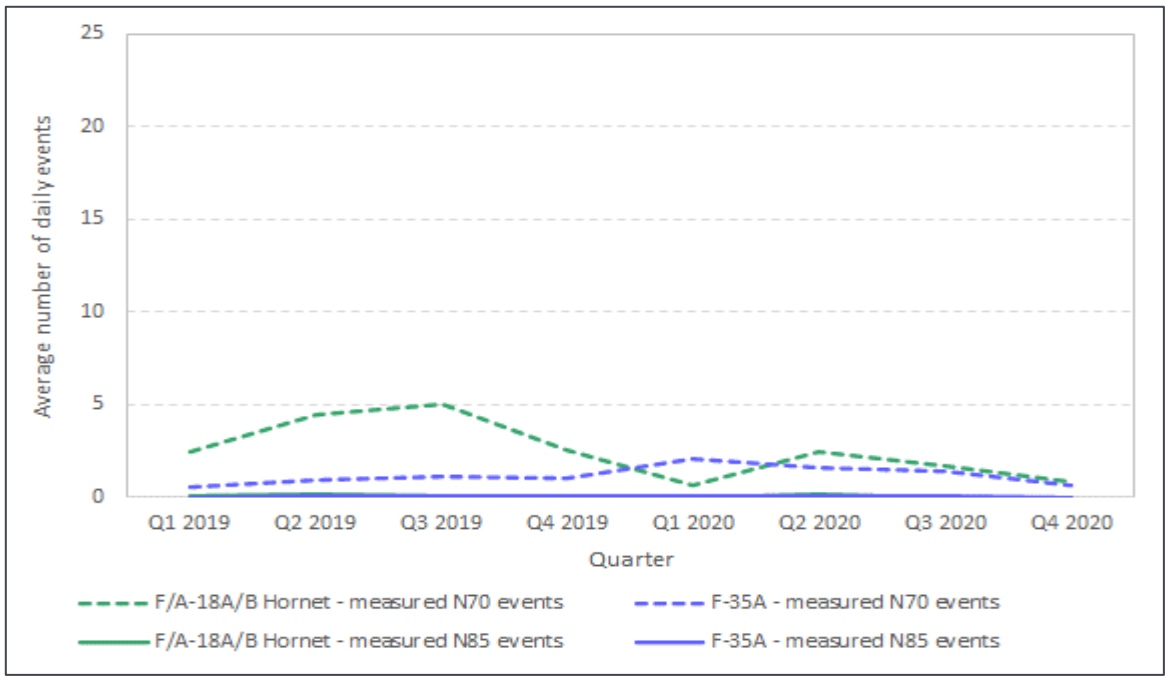
- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is well below that presented in the EIS for 2019 and 2020.

E10 NMT 19 – Ferodale Road, Sewerage Pump Station

Table 43: NMT 19 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	7	3 - 4	1 - 2
F-35A	19	0 - 1	1 - 2
N85 events			
F/A-18A/B Hornet	0	0 - 1	0 - 1
F-35A	0	0 - 1	0 - 1

Figure 65: NMT 19 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS;
- Aircraft noise events higher than 85 dB L_{Amax} by either aircraft were uncommon, consistent with the EIS; and
- The trend in the quarterly number above values demonstrate a slight increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 66: NMT 19 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

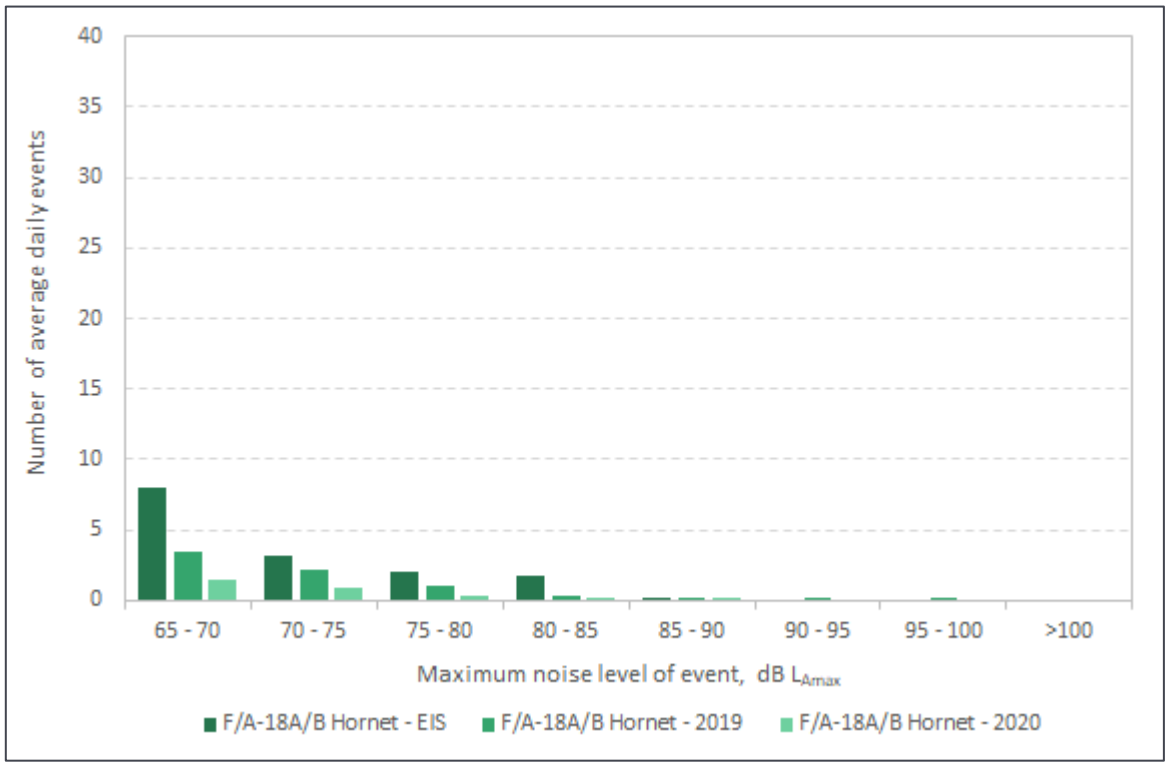


Figure 67: NMT 19 – EIS predictions and measurements – Event level histogram F-35A aircraft

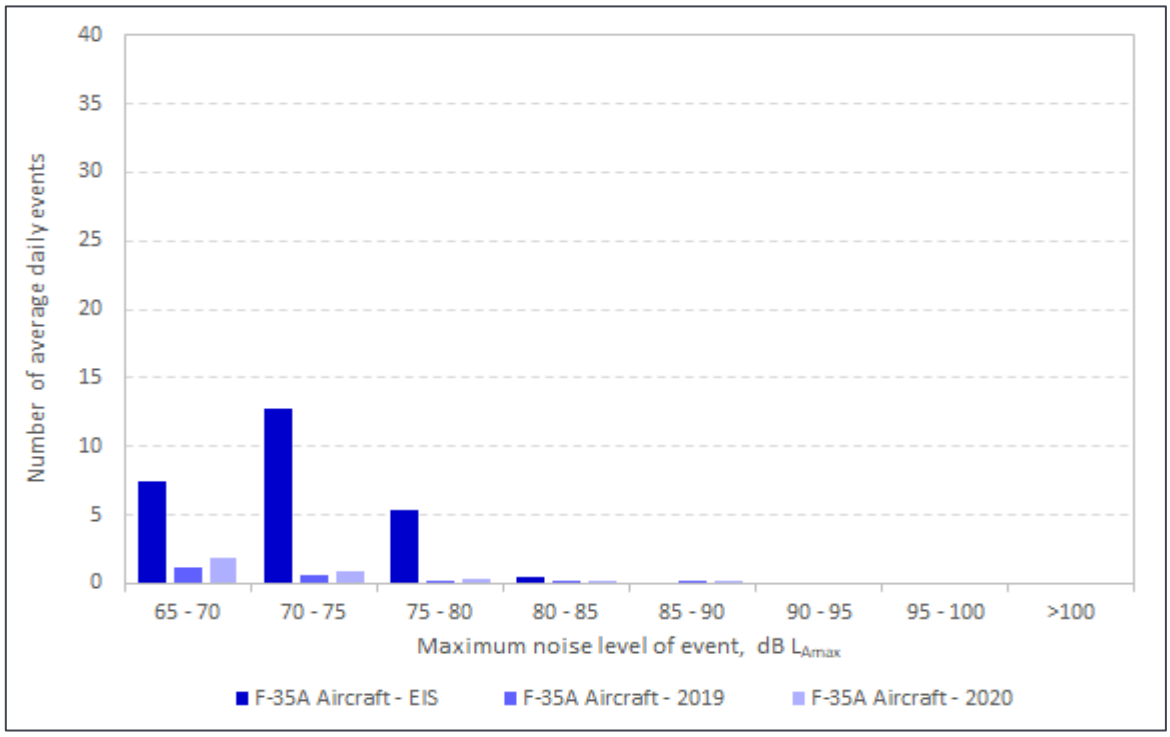


Figure 68: NMT 19 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

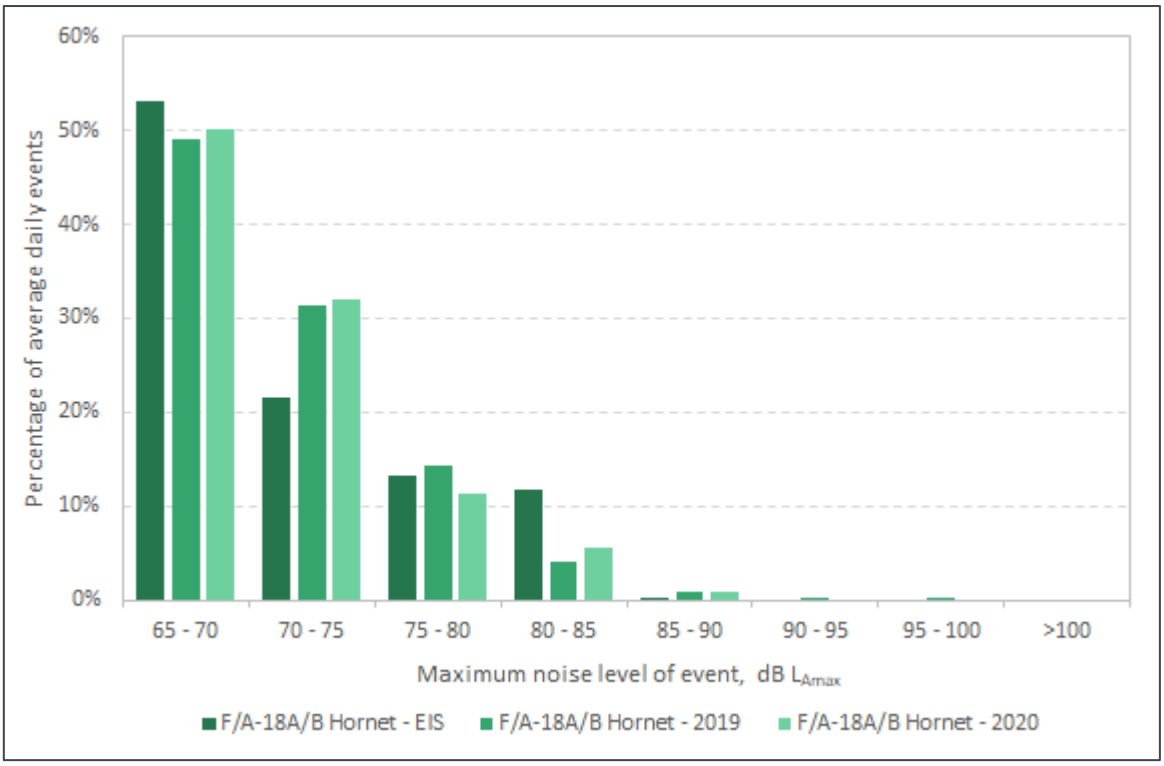
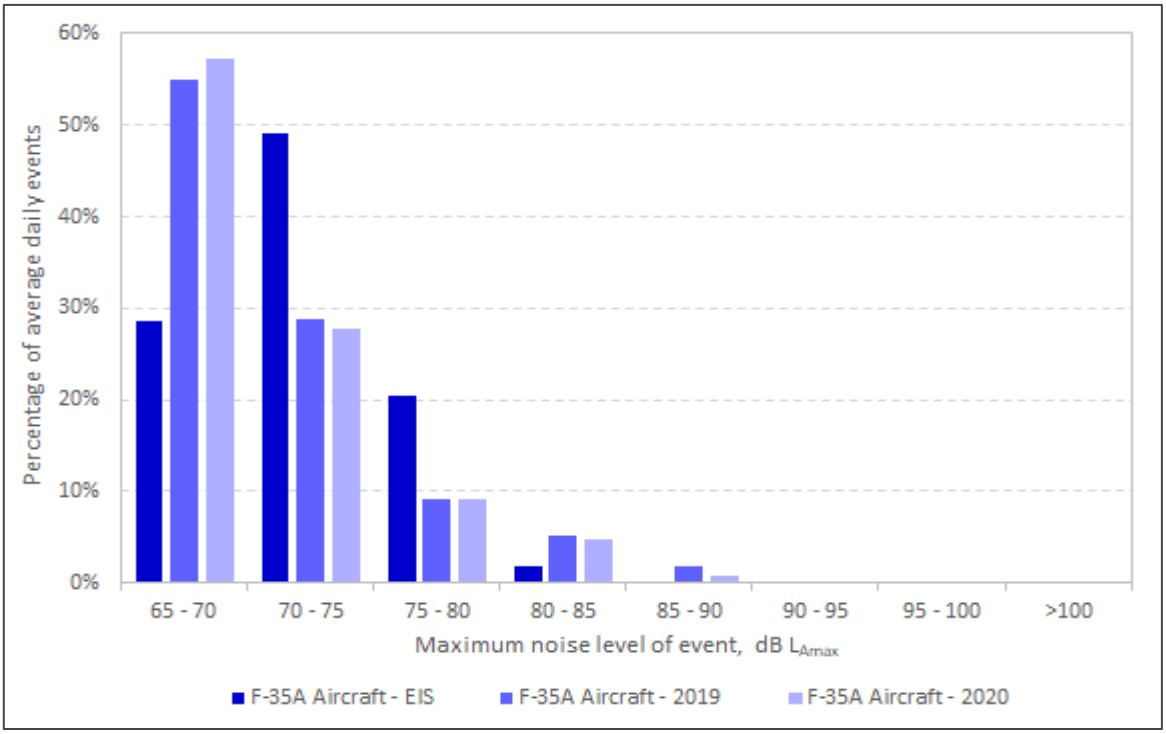


Figure 69: NMT 19 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The majority (>85 %) of measured F-35A aircraft noise levels were between 65 – 80 dB L_{Amax} which was similar to the EIS predictions; and
- The measurement data indicates that operations by both aircraft generally result in a similar distribution of noise levels, whereas the EIS predicted an increase in the portion of aircraft noise events between 70 – 80 dB L_{Amax} when replacing F/A-18A/B Hornet operations with F-35A aircraft operations.

Maximum noise levels

Table 44: NMT 19 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	71	70	72	72
	F-35A	74	70	72	71
Highest	F/A-18A/B Hornet	86	76	84	78
	F-35A	74	76	83	77

The following points are noted following a comparison of data in the above table:

- The average and typical highest measured noise levels for arrival and departure operations by both aircraft were comparable; and
- Noise levels from F-35A aircraft arrival and departure operations were comparable to or lower than EIS predictions.

Australian Noise Exposure

Table 45: NMT 19 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	EIS	Measured in 2019	Measured in 2020
F/A-18A/B Hornet	13	8	2
F-35A	15	1	3

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure has slightly increased as the number of operations has increased, although is well below that presented in the EIS for 2019 and 2020.

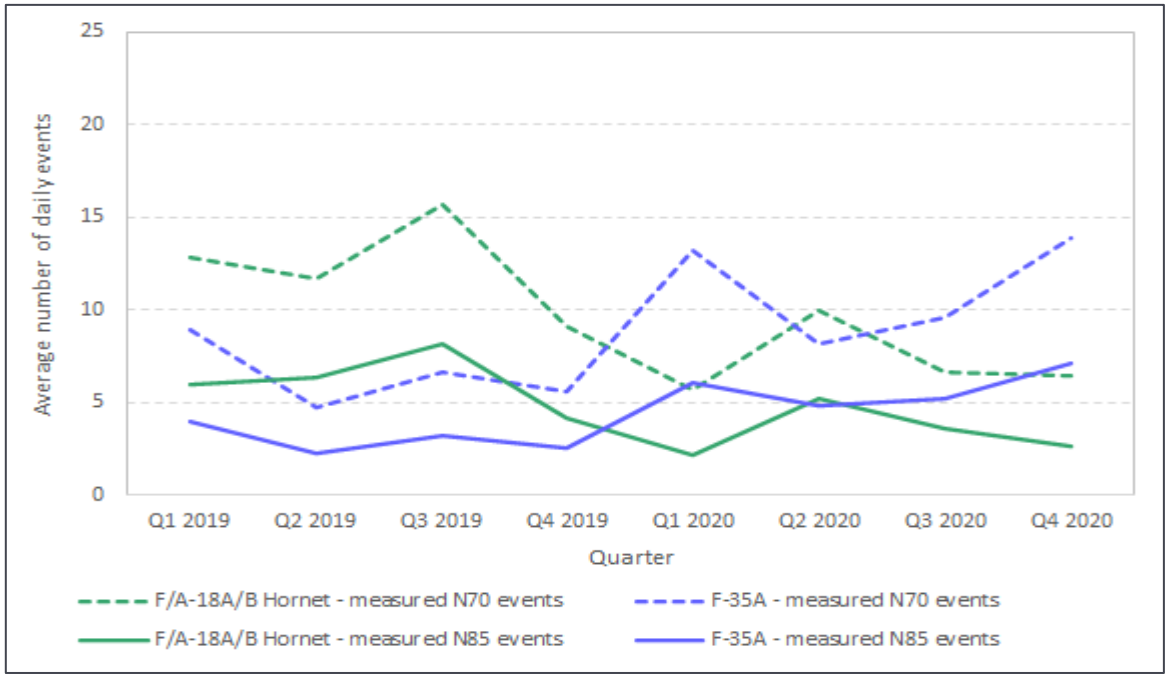
E11 NMT 20 – Water Pump Station, Ferodale

Number Above

Table 46: NMT 20 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	50	12 - 13	7 - 8
F-35A	38	6 - 7	11 - 12
N85 events			
F/A-18A/B Hornet	31	6 - 7	3 - 4
F-35A	19	2 - 3	5 - 6

Figure 70: NMT 20 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS; and
- The trend in the quarterly number above values demonstrate an increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 71: NMT 20 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

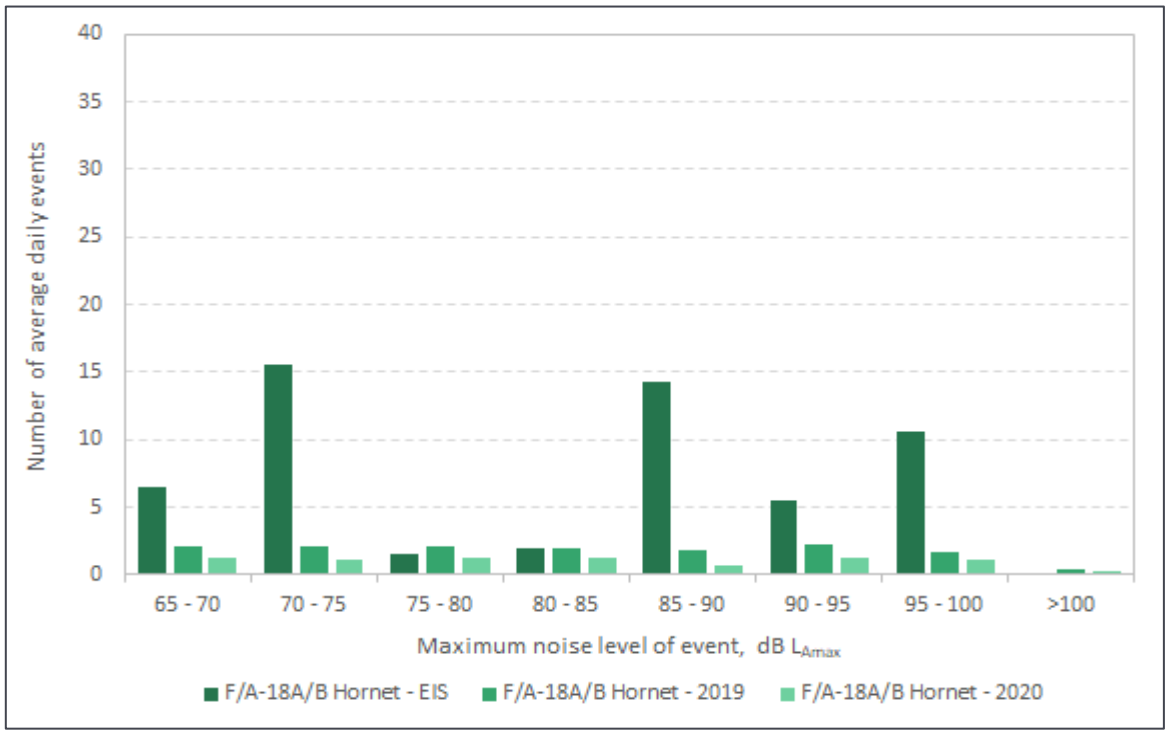


Figure 72: NMT 20 – EIS predictions and measurements – Event level histogram F-35A aircraft

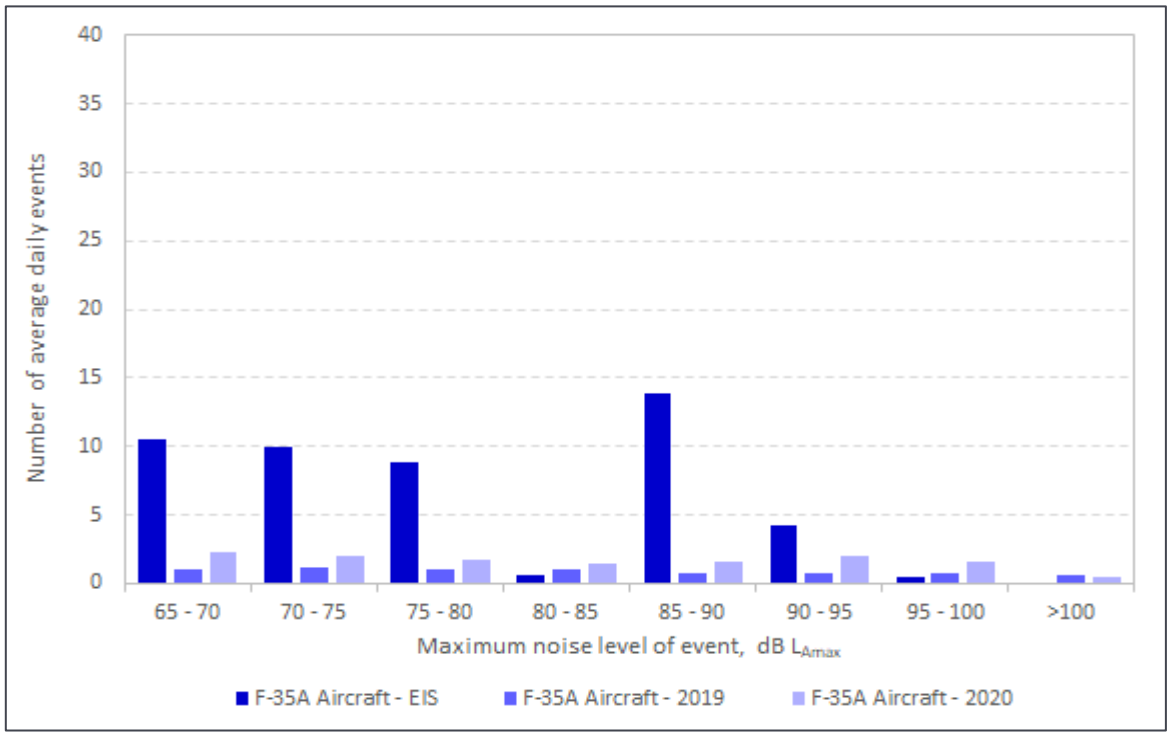


Figure 73: NMT 20 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

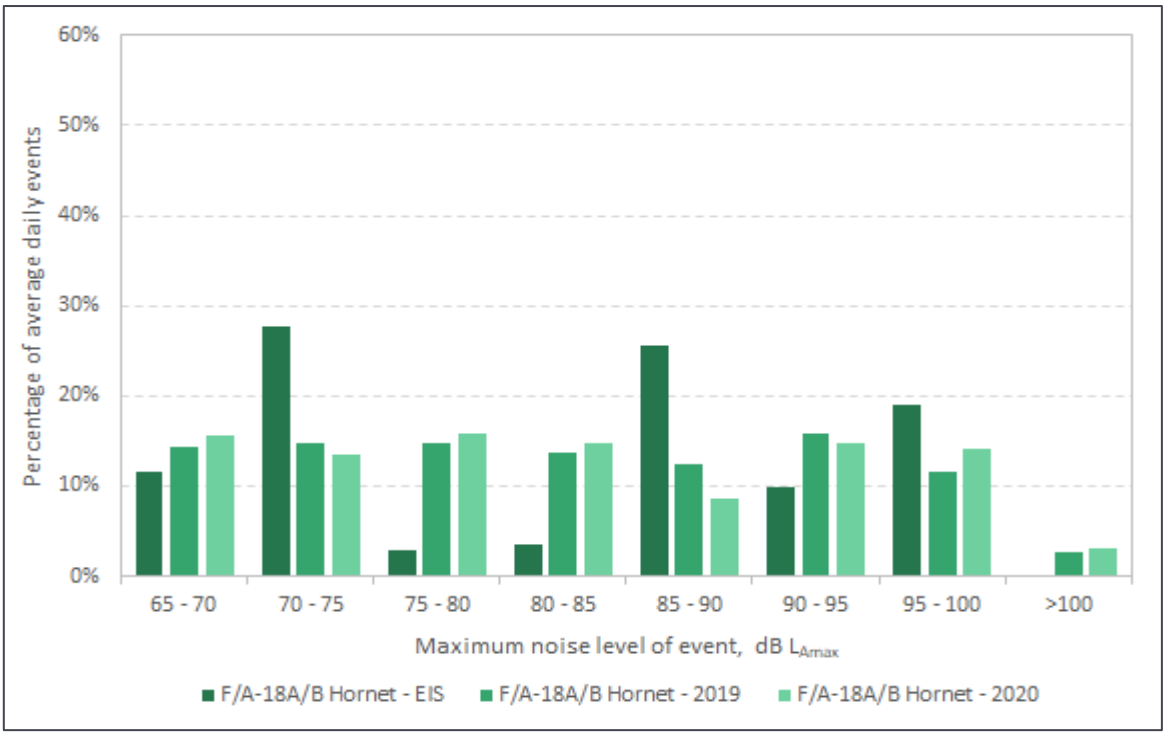
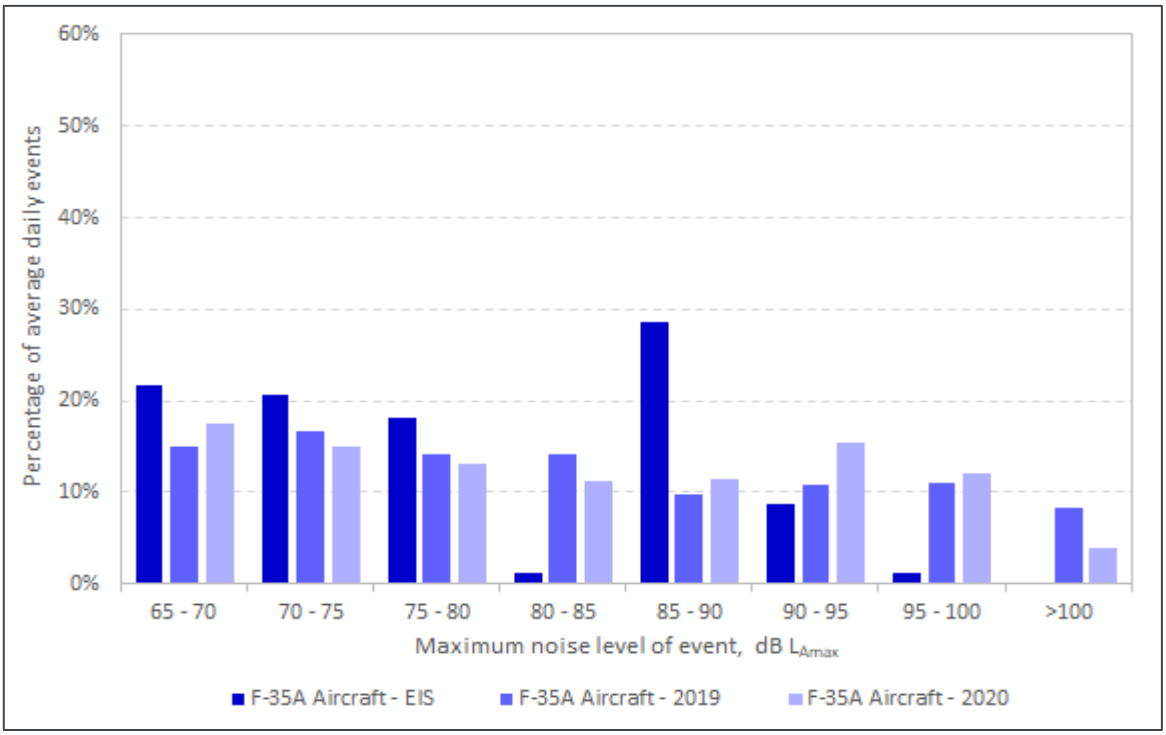


Figure 74: NMT 20 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- Both measured F/A-18A/B Hornet and F-35A aircraft noise levels were generally evenly distributed across a wide range of noise levels up to 90 dB L_{Amax}, comparable to the distribution predicted EIS predictions; and
- The measurement data indicates comparable occurrences of F/A-18A/B Hornet and F-35A aircraft noise events above 95 dB L_{Amax}.

Maximum noise levels

Table 47: NMT 20 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	84	80	82	88
	F-35A	79	80	80	89
Highest	F/A-18A/B Hornet	93	93	97	99
	F-35A	95	94	98	102

The following points are noted following a comparison of data in the above table:

- The measured average and typical highest noise levels for both aircraft were comparable;
- Measured average arrival noise levels were comparable for both aircraft, whereas the EIS predicted a lower average arrival noise level for F-35A aircraft arrivals compared to F/A-18A/B Hornet arrival operations;
- The measured departure noise levels were higher than the EIS predictions for both aircraft. The key factor contributing to this difference for both aircraft was that runway 30 departure flight tracks being flown closer to Raymond Terrace than what was considered in the EIS noise model, as discussed in Section 4.6.2; and
- The measured F-35A departure noise levels were higher than those of the F/A-18A/B Hornet. This is in contrast with the EIS which predicted the average departure noise levels of the F-35A to be slightly lower. This can be attributed to the need to adopt higher thrust settings for safety, as discussed in Section 4.7.2.

Australian Noise Exposure

Table 48: NMT 20 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	**EIS**	**Measured in 2019**	**Measured in 2020**
F/A-18A/B Hornet	27	25	21
F-35A	27	23	26

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is below that presented in the EIS for 2019 and similar for 2020. The higher-than-expected measured 2020 value for the F-35A aircraft is due to the higher measured departure noise levels discussed above.

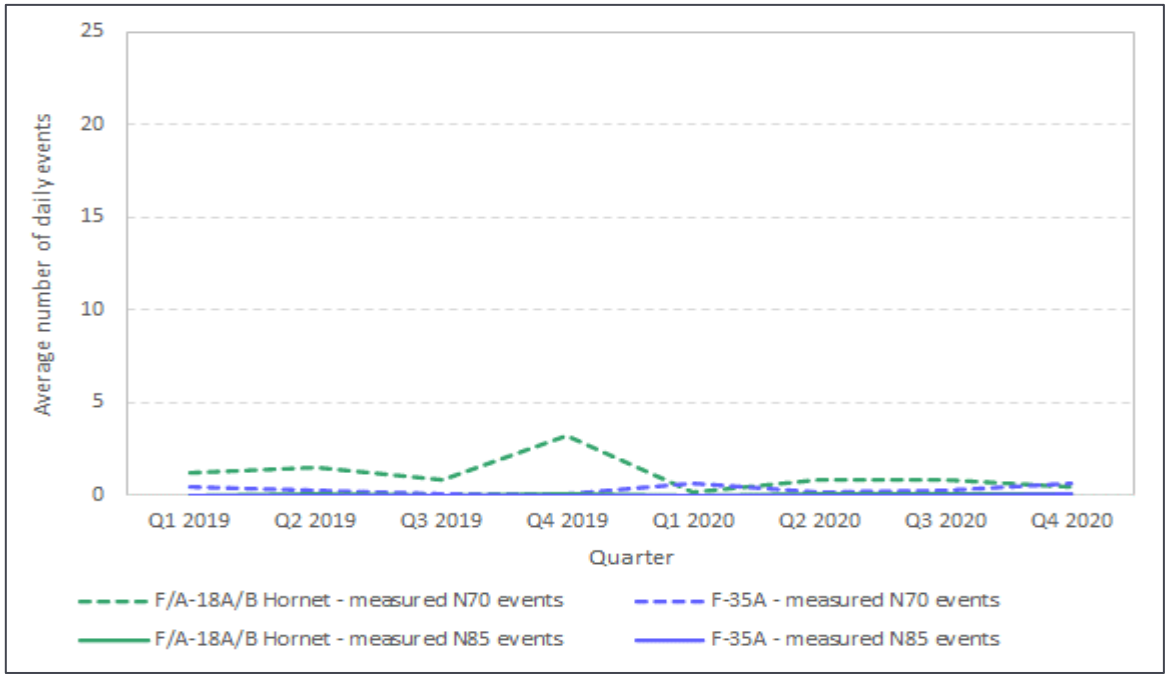
E12 NMT 70 – Tanilba Primary School

Number Above

Table 49: NMT 70 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	6	1 - 2	0 - 1
F-35A	5	0 - 1	0 - 1
N85 events			
F/A-18A/B Hornet	0	0 - 1	0 - 1
F-35A	0	0	0 - 1

Figure 75: NMT 70 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS;
- Aircraft noise events higher than 85 dB L_{Amax} by either aircraft were uncommon, as predicted by the EIS; and
- The trend in the quarterly number above values demonstrate limited changes in daily F-35A or F/A-18A/B Hornet aircraft noise events across the two (2) years.

Event level histograms

Figure 76: NMT 70 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

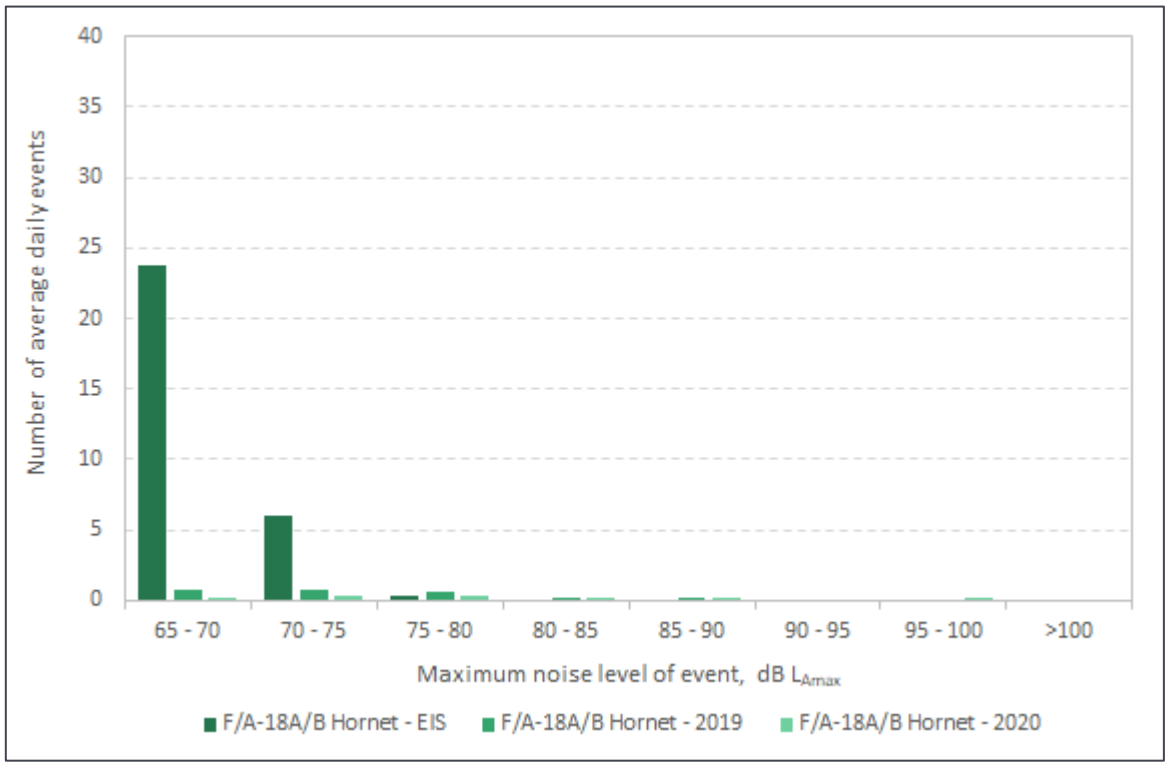


Figure 77: NMT 70 – EIS predictions and measurements – Event level histogram F-35A aircraft

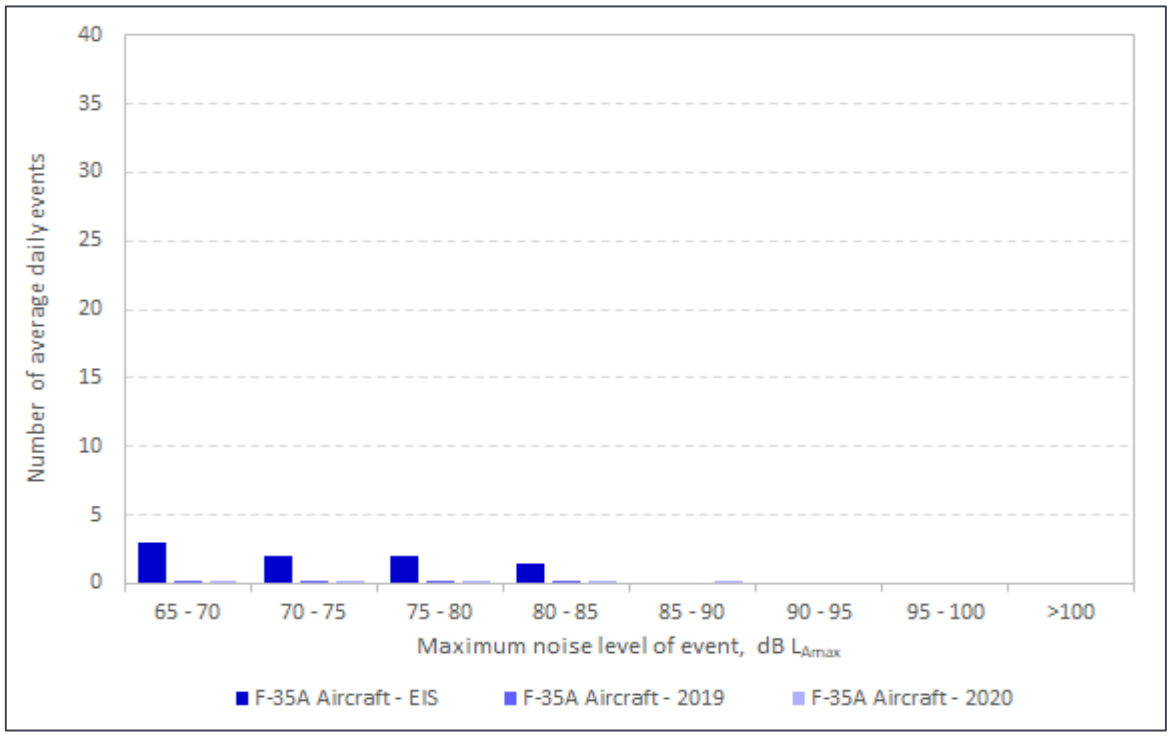


Figure 78: NMT 70 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

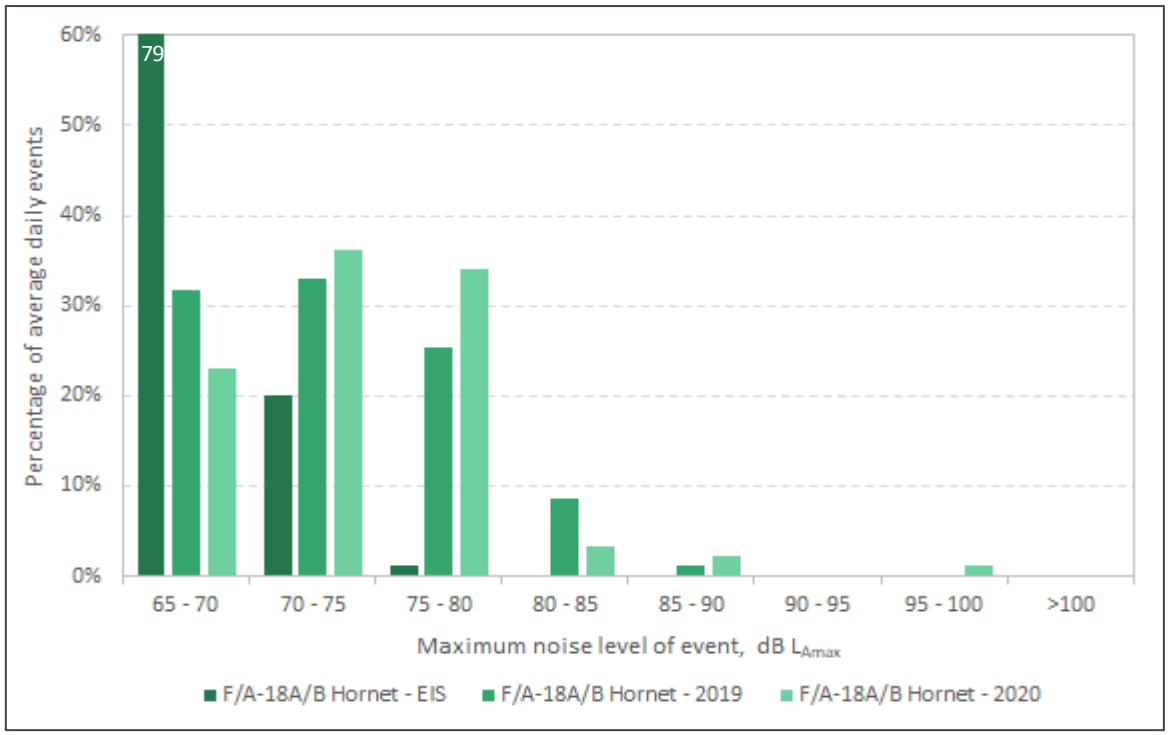
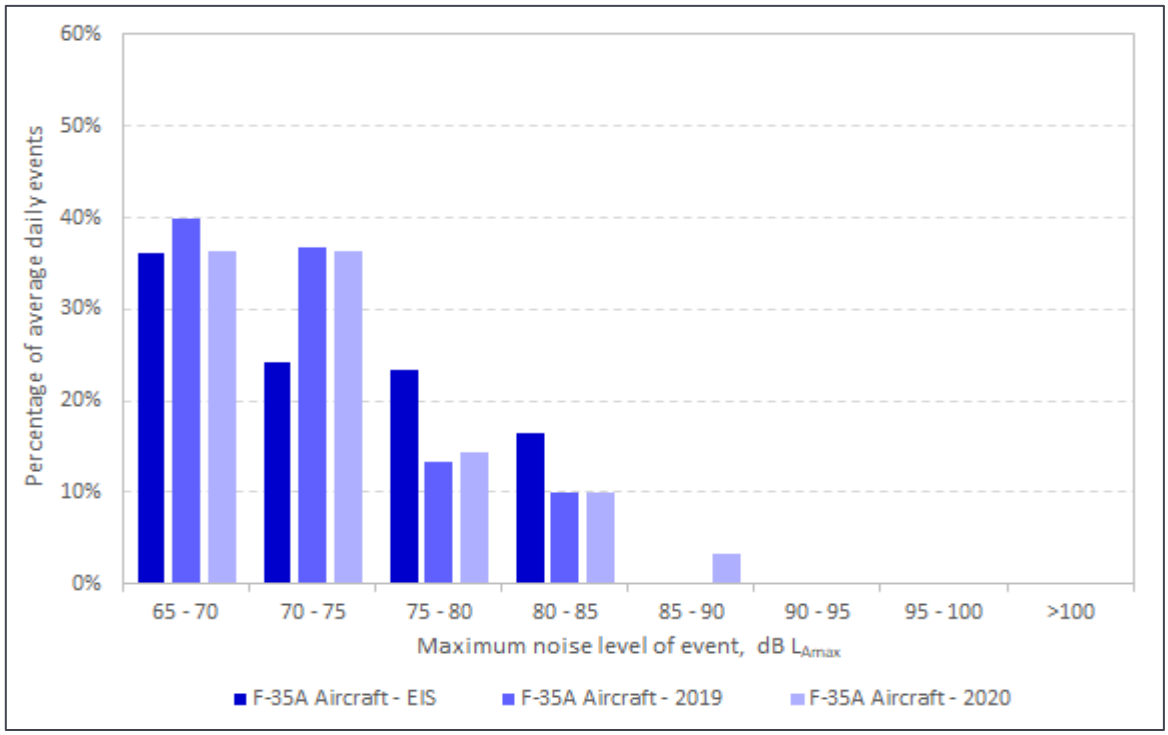


Figure 79: NMT 70 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The measurement data indicates that F-35A operations resulted in a similar distribution of occurrences of noise levels to the EIS predictions, with almost all events resulting in a noise level between 65 – 85 dB L_{Amax}; and
- The measurement data indicates there were fewer occurrences of F-35A aircraft noise events between 75 – 85 dB L_{Amax} compared to F/A-18A/B Hornet. However, the EIS predicted an increase in the portion of aircraft noise events between 75 – 85 dB L_{Amax} with the introduction of the F-35A aircraft.

Maximum noise levels

Table 50: NMT 70 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	67	73	70	74
	F-35A	<65	72	73	72
Highest	F/A-18A/B Hornet	67	79	77	80
	F-35A	<65	81	82	79

The following points are noted following a comparison of data in the above table:

- The measured noise levels for F-35A aircraft operations were comparable to F/A-18A/B Hornet operations;
- Measured arrival noise levels for both aircraft were higher than the EIS predictions; and
- The measured F-35A aircraft departure noise levels were comparable to the EIS predictions.

Australian Noise Exposure

Table 51: NMT 70 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	**EIS**	**Measured in 2019**	**Measured in 2020**
F/A-18A/B Hornet	6	3	1
F-35A	13	-	0

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure is well below that presented in the EIS for both 2019 and 2020.

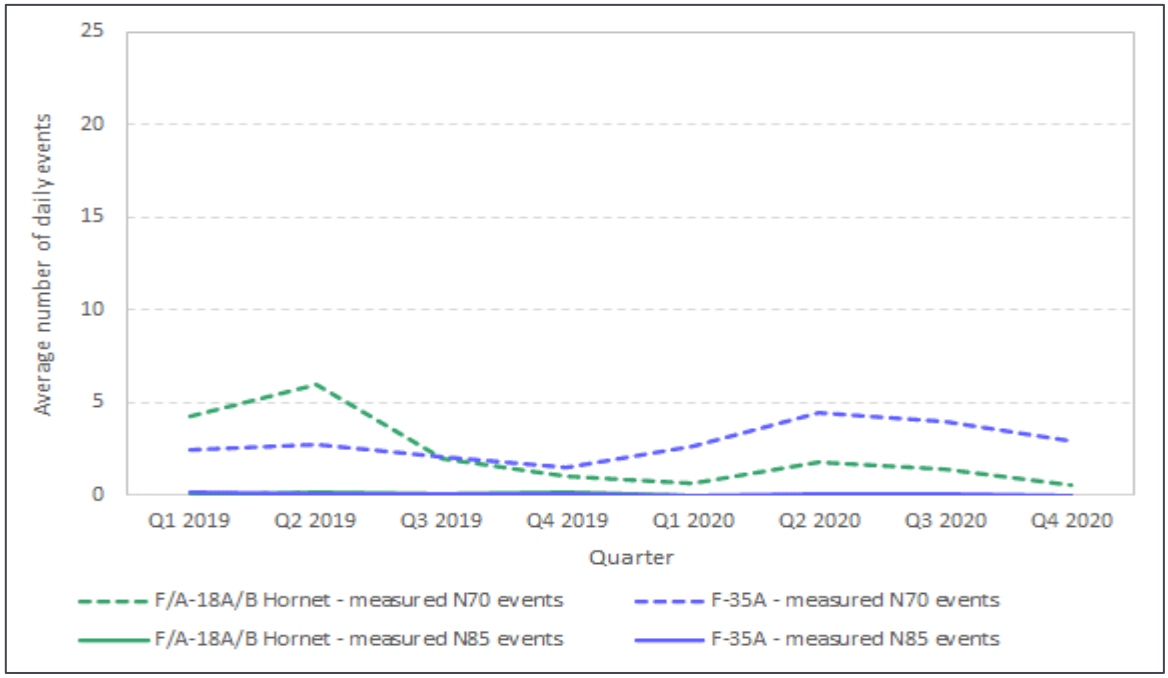
E13 NMT 80 – Pacific Dunes Golf Course

Number Above

Table 52: NMT 80 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	26	3 - 4	1 - 2
F-35A	21	2 - 3	3 - 4
N85 events			
F/A-18A/B Hornet	0	0 - 1	0
F-35A	0	0 - 1	0 - 1

Figure 80: NMT 80 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS;
- Aircraft noise events higher than 85 dB L_{Amax} by either aircraft were uncommon, as predicted by the EIS; and
- The trend in the quarterly number above values demonstrate a slight increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 81: NMT 80 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

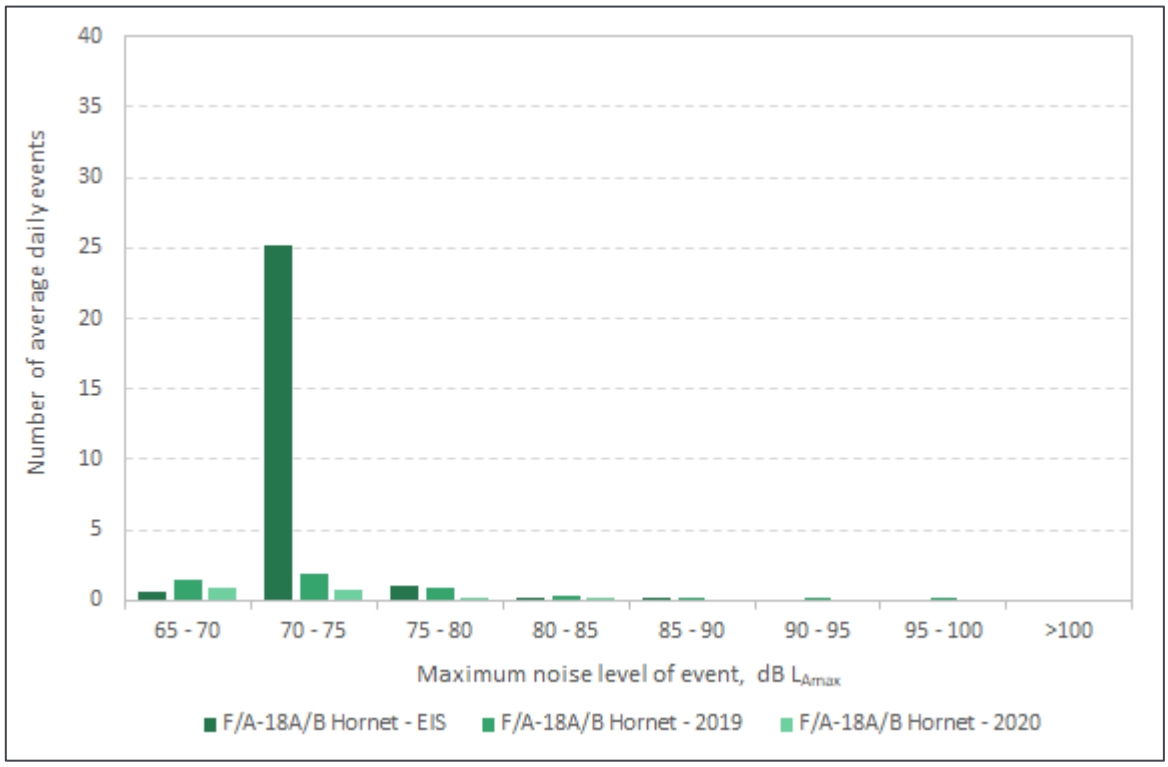


Figure 82: NMT 80 – EIS predictions and measurements – Event level histogram F-35A aircraft

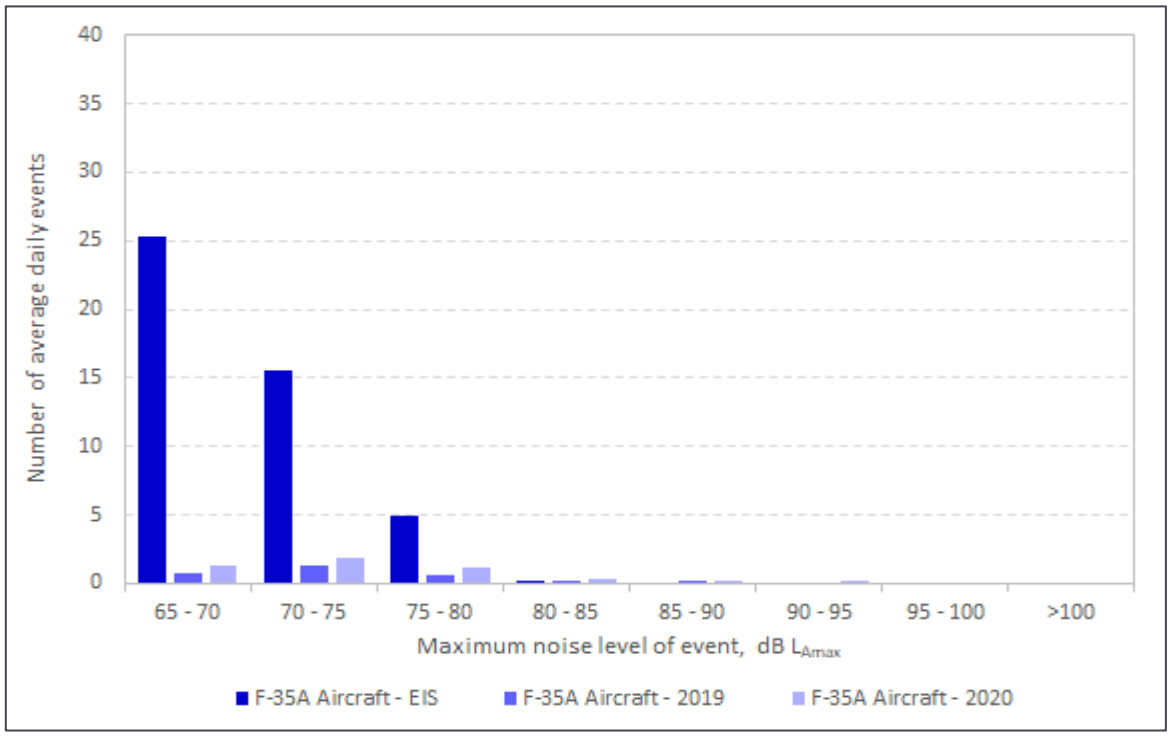


Figure 83: NMT 80 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

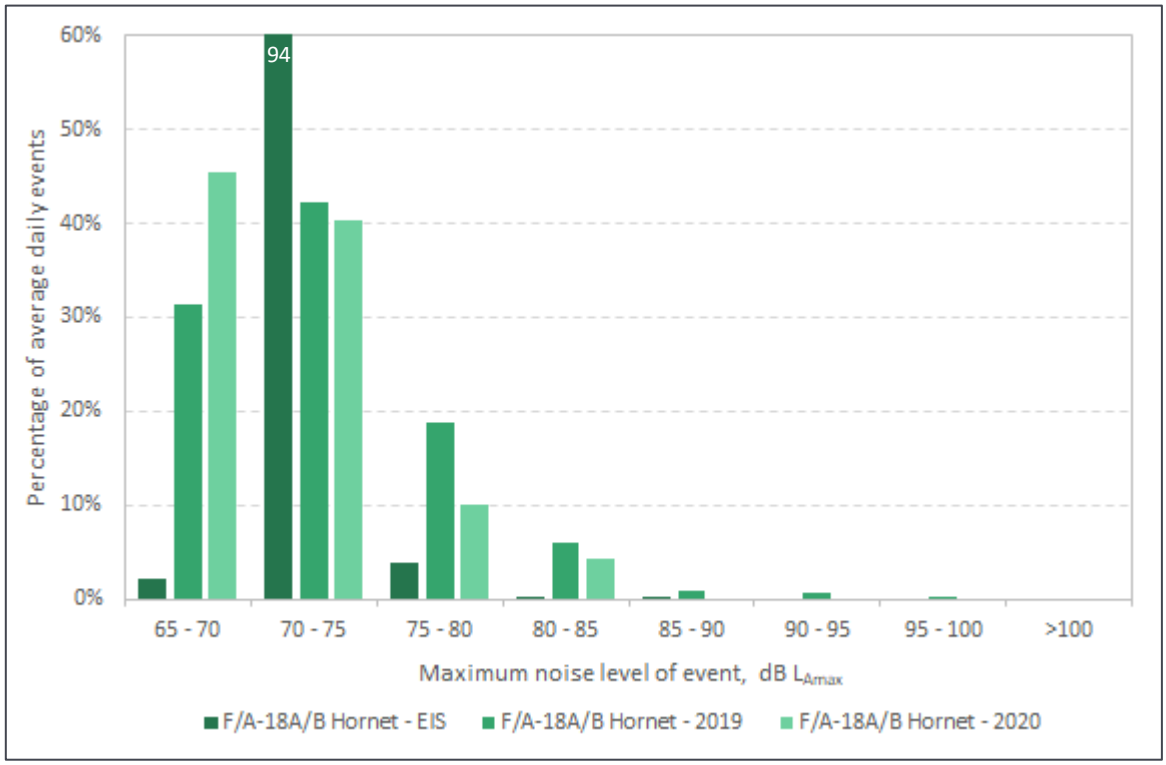
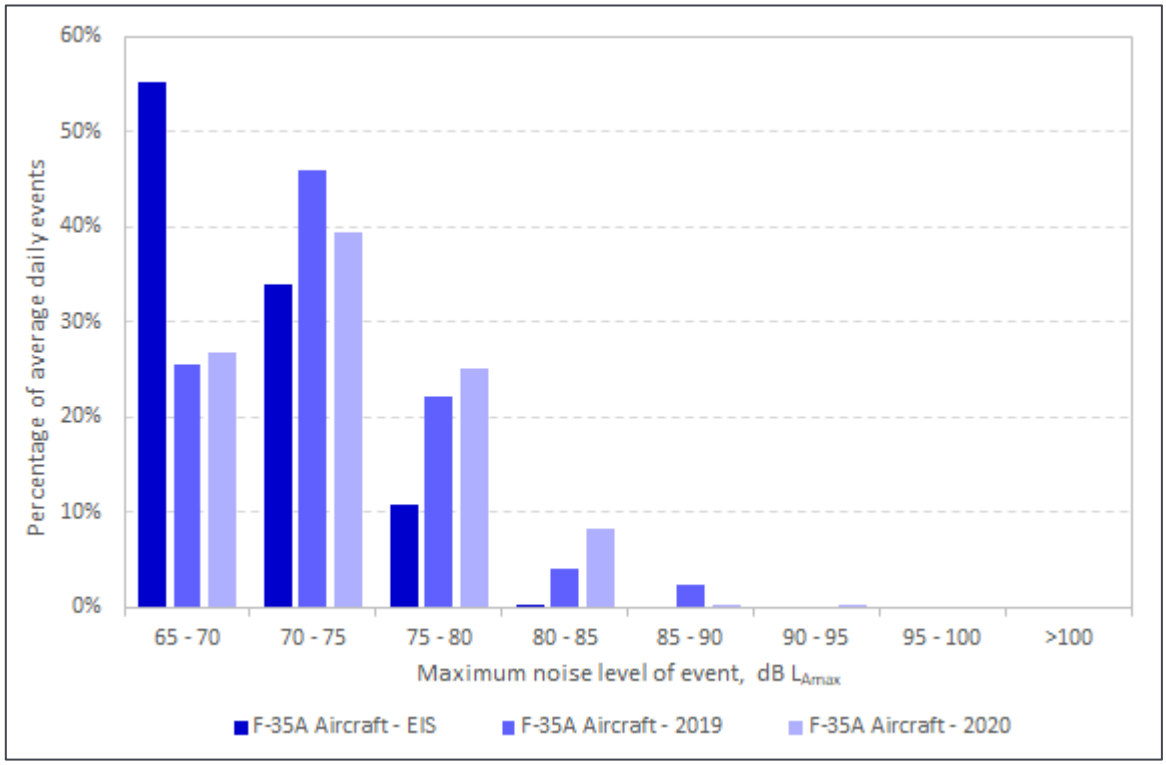


Figure 84: NMT 80 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The histograms above demonstrate that measured events were smoothly distributed across the noise level ranges, whereas the EIS predictions feature more prominent noise levels that would be experienced more often. This is due to greater variation in real world operations compared to what can be reliably and practically represented in the noise modelling; and
- The measurement data indicates that operations by both aircraft generally result in similar distribution of occurrences of noise levels, consistent with the EIS predictions.

Maximum noise levels

Table 53: NMT 80 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	65	73	72	72
	F-35A	<65	72	70	74
Highest	F/A-18A/B Hornet	65	79	86	77
	F-35A	<65	77	84	80

The following points are noted following a comparison of data in the above table:

- The average and typical highest measured noise levels for arrival and departure operations by both aircraft were comparable, with the exception of the typical highest F-35A aircraft departure noise levels, which were higher than those for F/A-18A/B Hornet;
- The measured arrival noise levels for both aircraft were higher than the EIS predictions;
- The average measured F-35A aircraft departure noise levels were higher than the EIS prediction, though the typical highest measured departure noise levels were lower than the EIS predictions.

Australian Noise Exposure

Table 54: NMT 80 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	**EIS**	**Measured in 2019**	**Measured in 2020**
F/A-18A/B Hornet	15	6	-
F-35A	17	2	6

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is well below that presented in the EIS for 2019 and 2020.

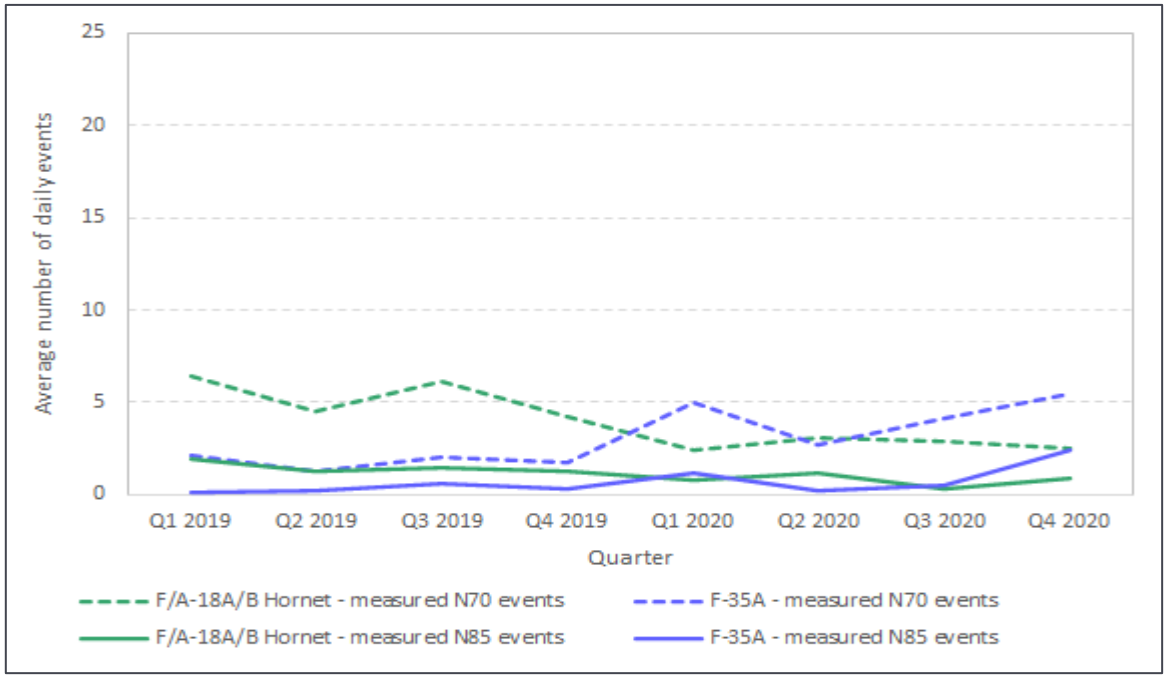
E14 NMT 140 – Waste Transfer Station

Number Above

Table 55: NMT 140 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	17	5 - 6	2 - 3
F-35A	7	1 - 2	4 - 5
N85 events			
F/A-18A/B Hornet	8	1 - 2	0 - 1
F-35A	3	0 - 1	1 - 2

Figure 85: NMT 140 – average daily number above events per quarter



The following key observations are noted:

- There were fewer F-35A aircraft events during the period December 2018 – December 2020 when compared with the EIS;
- There were few F-35A aircraft noise events higher than 85 dB L_{Amax} as predicted by the EIS; and
- The trend in the quarterly number above values demonstrate an increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 86: NMT 140 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

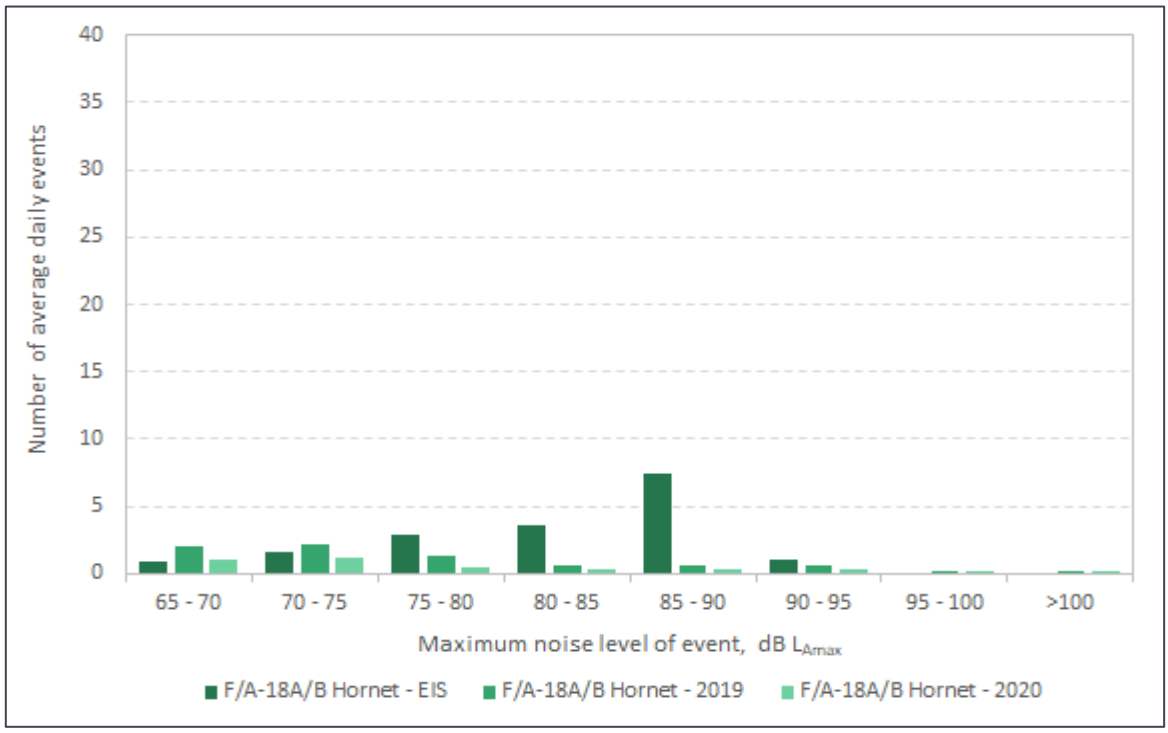


Figure 87: NMT 140 – EIS predictions and measurements – Event level histogram F-35A aircraft

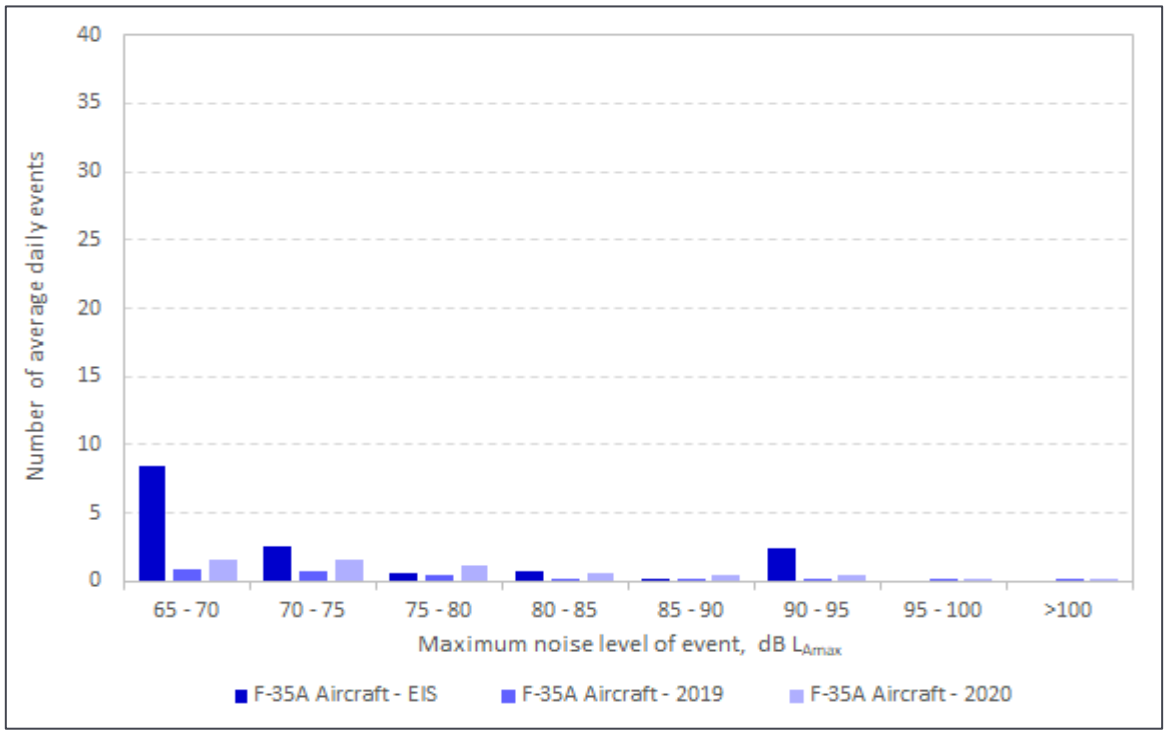


Figure 88: NMT 140 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

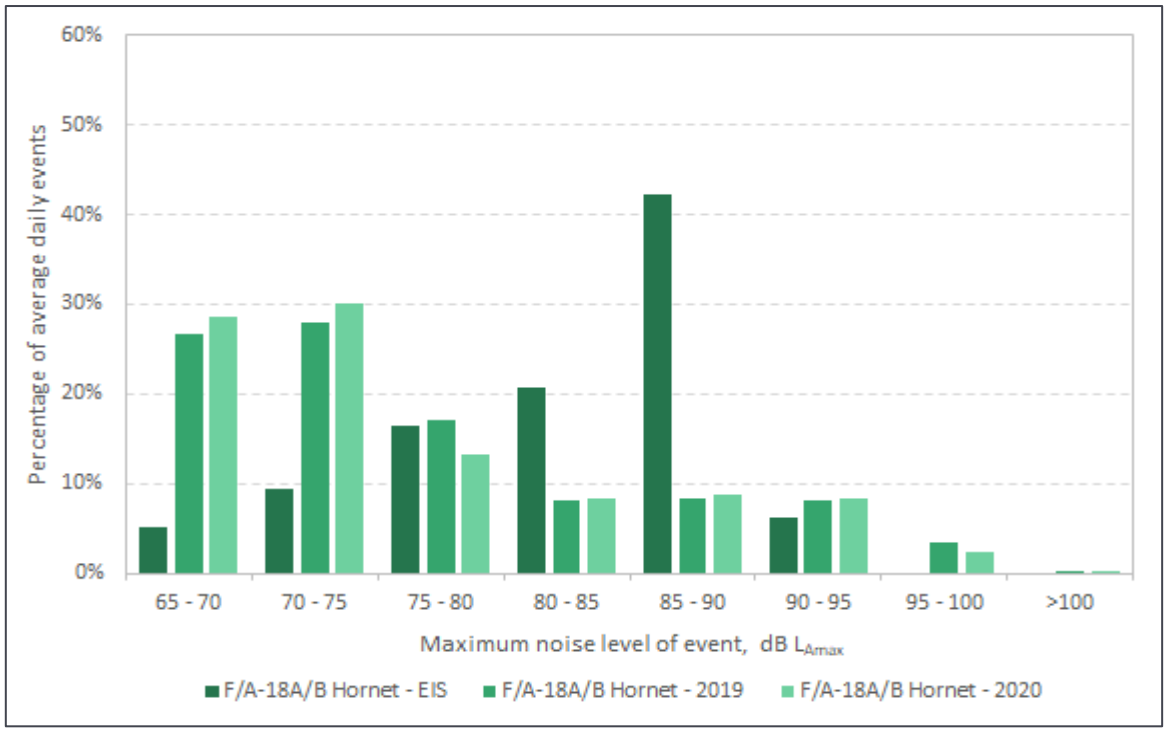
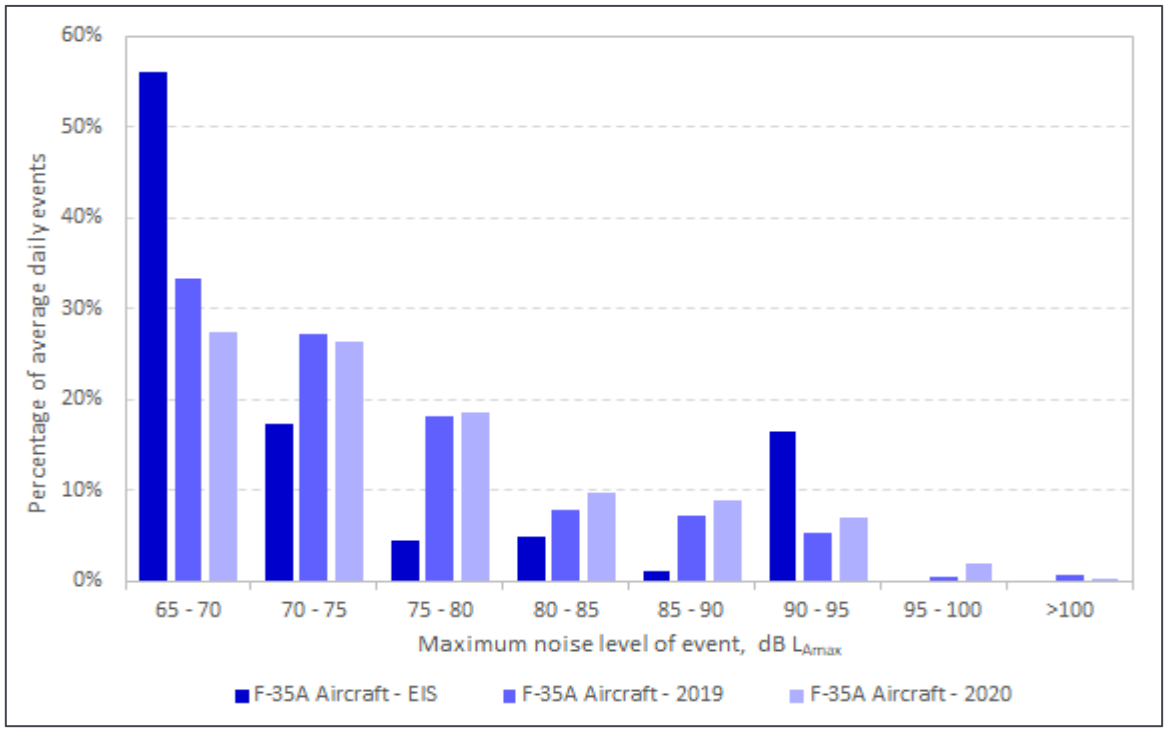


Figure 89: NMT 140 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The histograms above demonstrate that measured events were smoothly distributed across the noise level ranges, whereas the EIS predictions feature one or two noise level bands that would occur much more often than other noise levels (seen as 'spikes' in the histograms). This is due to greater variation in real world operations compared to what can be reliably and practically represented in the noise modelling; and
- The measurement data indicates that operations by both aircraft generally result in similar distribution of occurrences of noise levels.

Maximum noise levels

Table 56: NMT 140 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	82	78	<65	72
	F-35A	76	77	68	74
Highest	F/A-18A/B Hornet	94	92	<65	79
	F-35A	90	92	74	80

The following points are noted following a comparison of data in the above table:

- The measured F-35A aircraft noise levels were comparable to both F/A-18A/B Hornet arrival operations and the EIS predictions;
- Measured F-35A aircraft departure noise levels were comparable to the F/A-18A/B Hornet;
- The measured departure noise levels were higher than the EIS predictions for both aircraft. The key factor contributing to this difference for both aircraft was that runway 30 departure flight tracks being flown closer to Raymond Terrace than what was considered in the EIS noise model, as discussed in Section 4.6.2; and
- The measured F-35A departure noise levels were higher than the EIS predictions, which can be attributed to the need to adopt higher thrust settings for safety, as discussed in Section 4.7.2.

Australian Noise Exposure

Table 57: NMT 140 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	**EIS**	**Measured in 2019**	**Measured in 2020**
F/A-18A/B Hornet	19	19	13
F-35A	18	9	16

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased; and
- The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is below that presented in the EIS for 2019 and similar for 2020.

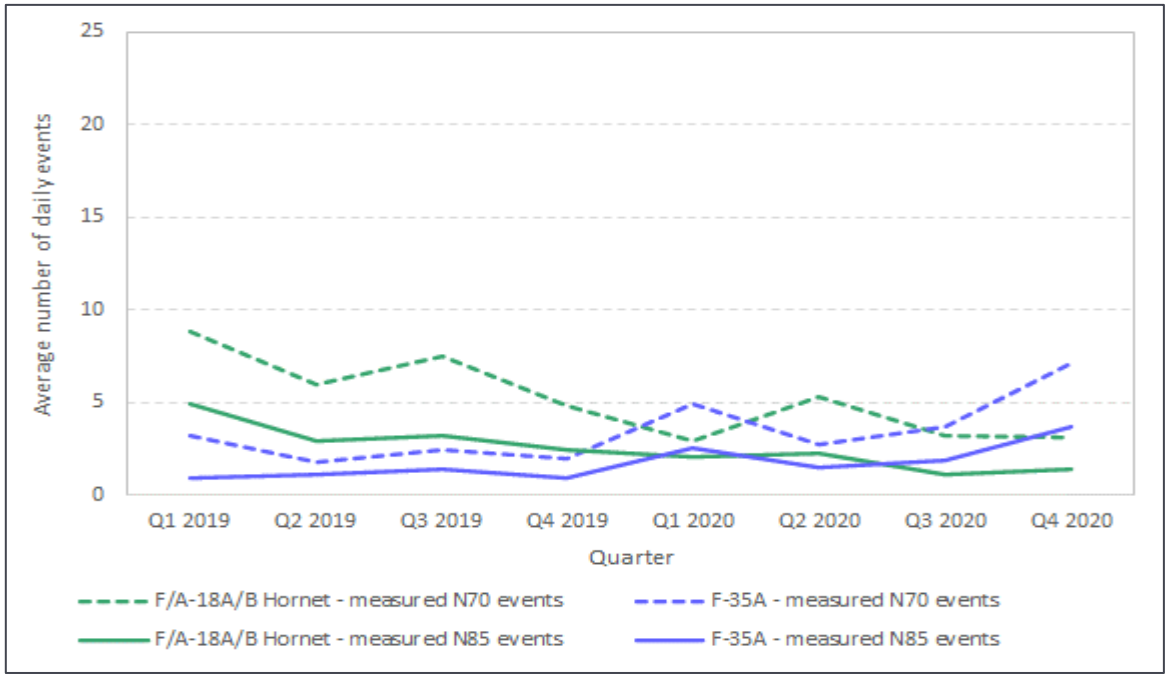
E15 NMT 150 – Rees James Road, Raymond Terrace

Number Above

Table 58: NMT 150 – EIS predictions and measurements – average daily number above events

Aircraft	EIS	Measured in 2019	Measured in 2020
N70 events			
F/A-18A/B Hornet	31	6 - 7	3 - 4
F-35A	27	2 - 3	4 - 5
N85 events			
F/A-18A/B Hornet	12	3 - 4	1 - 2
F-35A	2	1 - 2	2 - 3

Figure 90: NMT 150 – average daily number above events per quarter



The following key observations are noted:

- There were considerably fewer F-35A aircraft events during the period December 2018 – December 2020 compared with the EIS;
- There were few F-35A aircraft noise events greater than 85 dB L_{Amax} consistent with the EIS; and
- The trend in the quarterly number above values demonstrate an increase in daily F-35A aircraft noise events in 2020 compared to 2019, while there was a decrease in daily F/A-18A/B Hornet aircraft noise events in 2020.

Event level histograms

Figure 91: NMT 150 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet

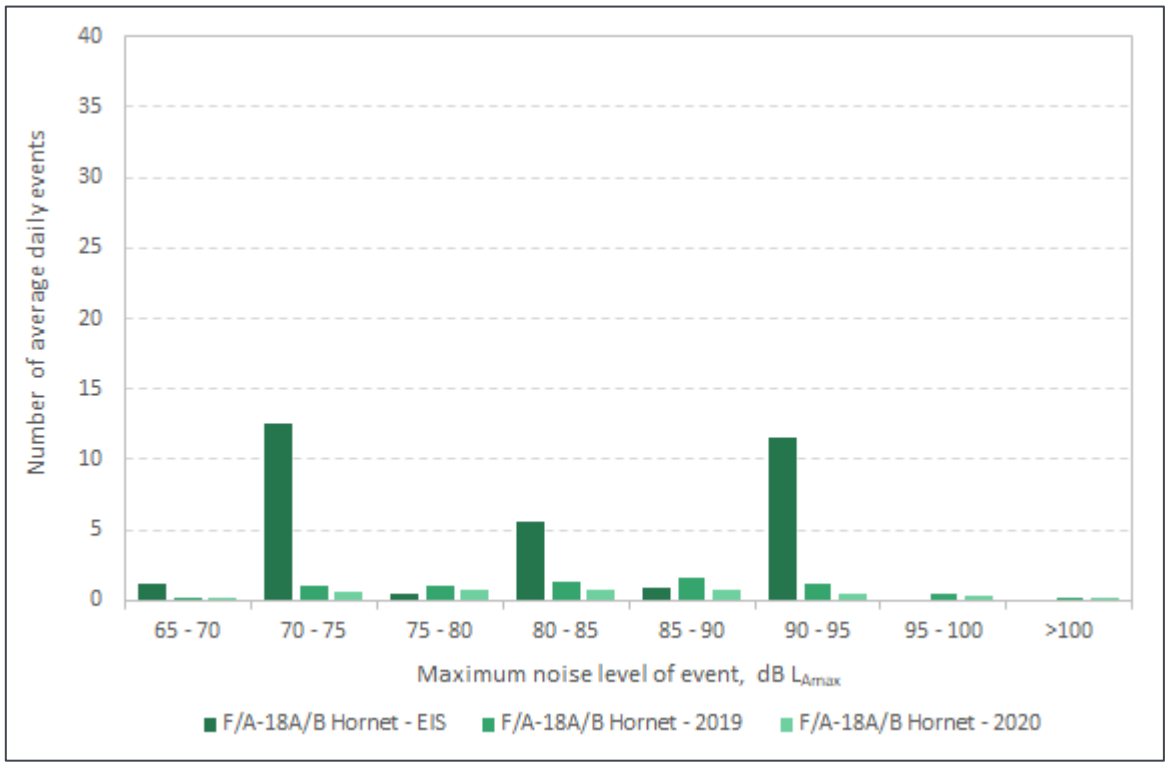


Figure 92: NMT 150 – EIS predictions and measurements – Event level histogram F-35A aircraft

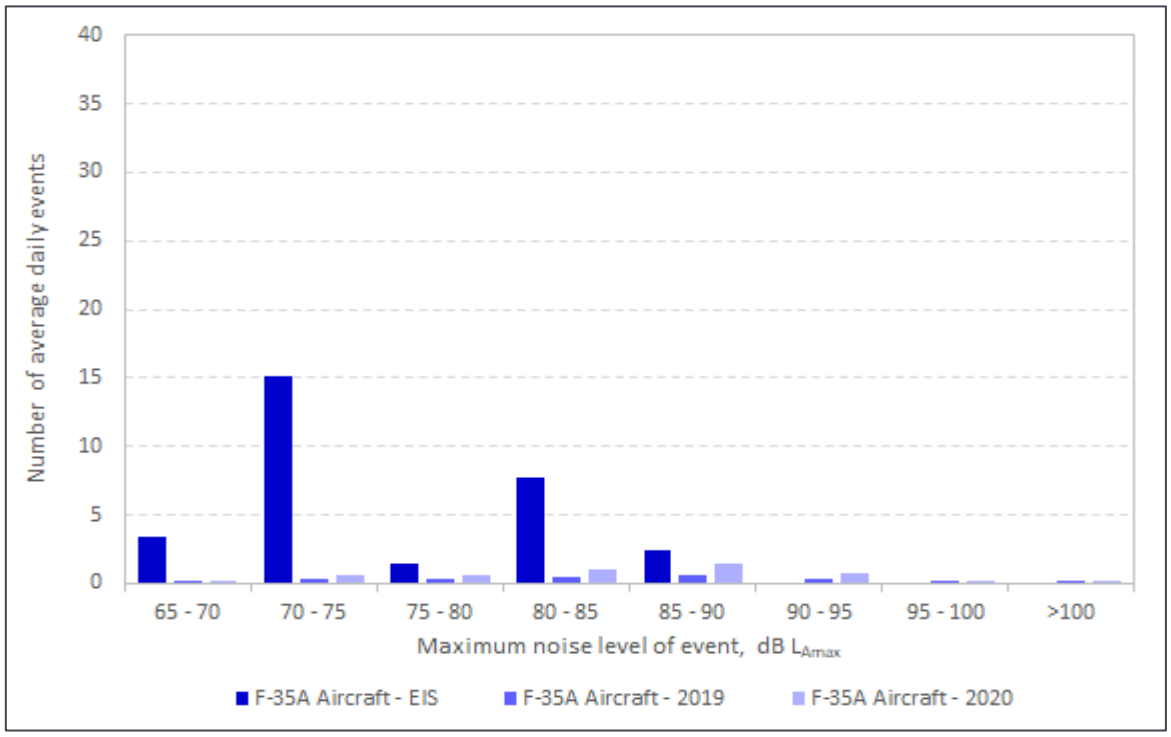


Figure 93: NMT 150 – EIS predictions and measurements – Event level histogram F/A-18A/B Hornet (percentage)

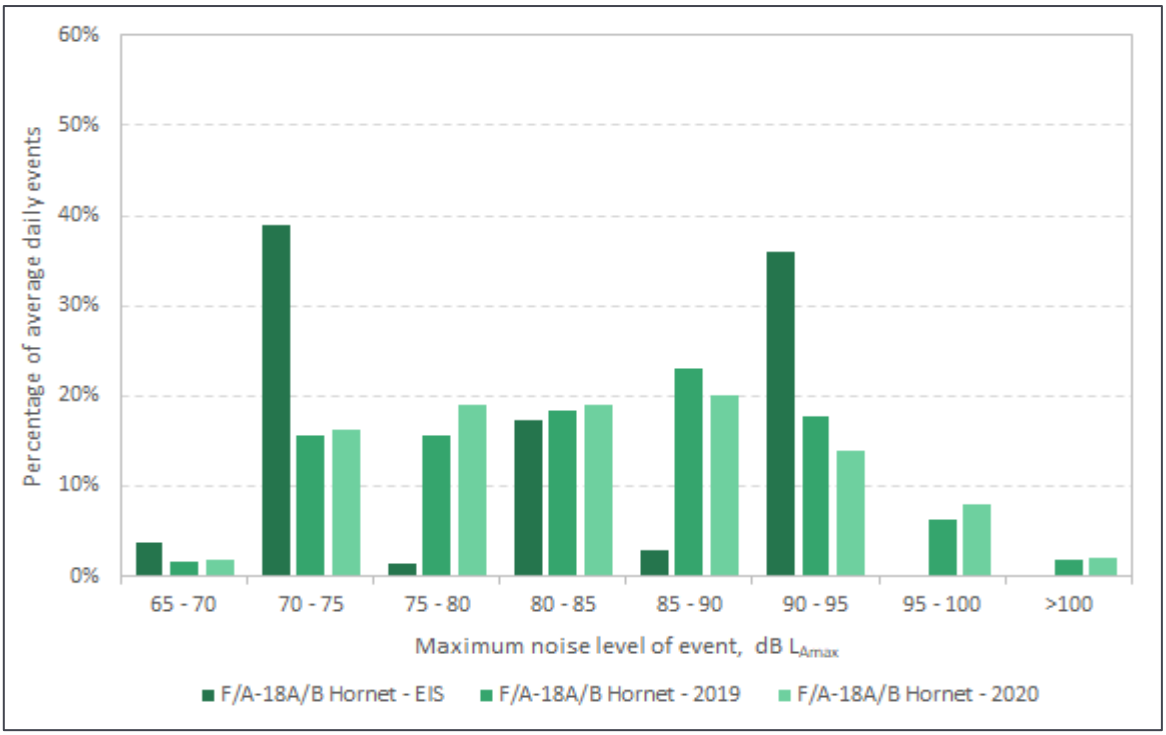
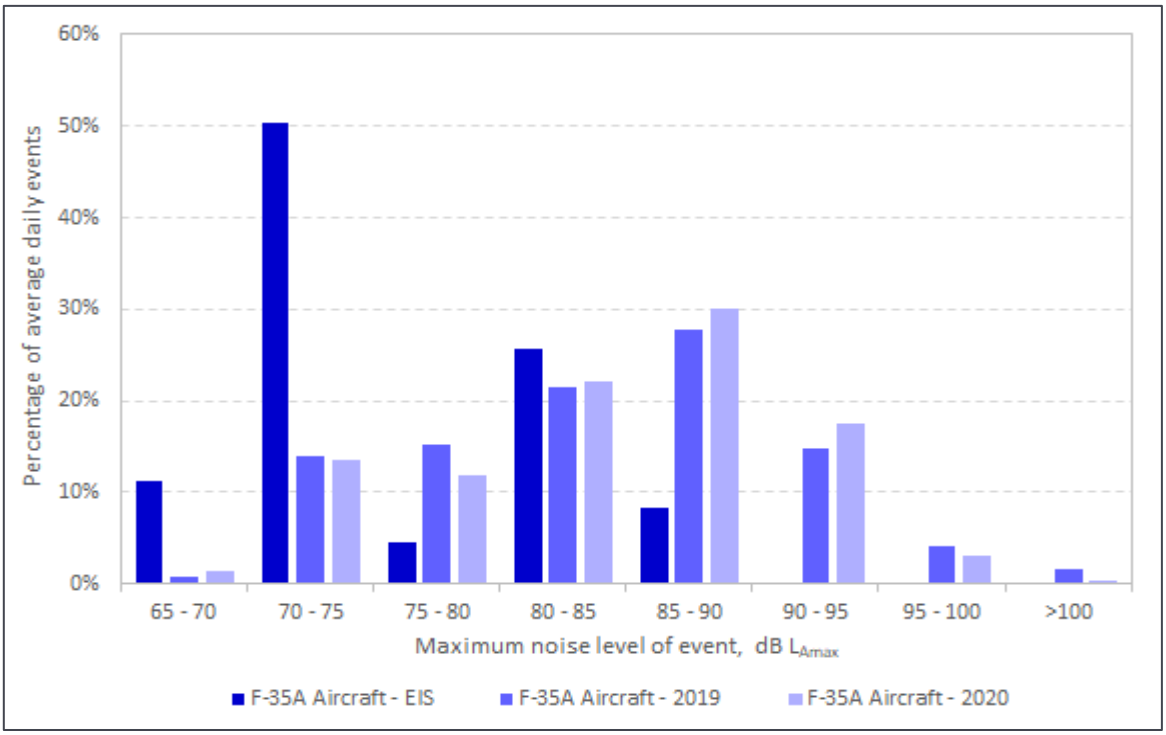


Figure 94: NMT 150 – EIS predictions and measurements – Event level histogram F-35A aircraft (percentage)



The following key observations are noted:

- The highest measured maximum aircraft noise levels for both the F/A-18A/B Hornet and F-35A aircraft were above the absolute highest predicted level in the EIS noise modelling. This is to be expected as there would have been atypical operations that occurred in practice which are not represented in the EIS noise modelling;
- The majority (65 %) of measured F-35A aircraft noise levels were between 80 – 95 dB L_{Amax} compared with the EIS predictions where the majority (70 %) of aircraft noise levels ranged between 60 – 80 dB L_{Amax};
- The histograms above demonstrate that measured events were smoothly distributed across the noise level ranges, whereas the EIS predictions feature one or two noise level bands that would occur much more often than other noise levels (seen as 'spikes' in the histograms). This is due to greater variation in real world operations compared to what can be reliably and practically represented in the noise modelling; and
- The measurement data indicates that operations by both aircraft generally result in similar distribution of occurrences of noise levels.

Maximum noise levels

Table 59: NMT 150 – EIS predictions and measurements – maximum noise level statistics, dB L_{Amax}

		Arrivals		Departures	
Statistic	**Aircraft**	**EIS**	**Measured**	**EIS**	**Measured**
Average	F/A-18A/B Hornet	90	86	74	80
	F-35A	82	84	70	85
Highest	F/A-18A/B Hornet	95	96	75	87
	F-35A	87	93	83	91

The following points are noted following a comparison of data in the above table:

- The average and typical highest measured F-35A aircraft arrival noise levels are comparable or lower than the F/A-18A/B Hornet;
- The measured departure noise levels were higher than the EIS predictions for both aircraft. The key factor contributing to this difference for both aircraft was that runway 30 departure flight tracks being flown closer to Raymond Terrace than what was considered in the EIS noise model, as discussed in Section 4.6.2; and
- The measured F-35A departure noise levels were higher than the EIS predictions, which can be attributed to the need to adopt higher thrust settings for safety, as discussed in Section 4.7.2.

Australian Noise Exposure

Table 60: NMT 150 – EIS predictions and measurements – Contribution to Australian Noise Exposure rating

Aircraft	EIS	Measured in 2019	Measured in 2020
F/A-18A/B Hornet	24	21	17
F-35A	18	13	17

The following points are noted from the data in the table above:

- The contribution of F/A-18A/B Hornet operations to overall noise exposure has reduced and was below that presented in the EIS, as the number of operations has also decreased;
- The contribution of F-35A aircraft to overall noise exposure has increased as the number of operations has increased, although is below that presented in the EIS for 2019 and similar for 2020.