AIR NEW ZEALAND

zero EMISSIONS AIRCRAFT

Product Requirements Document

Air New Zealand's specifications and requirements for **a new generation of aircraft**

2021 V2.0

Contents

Section 1

Section 2

Section 3

Our Vision

Aviation connects New Zealand to the world and enables our economic and social success. Air travel is vital to the basic functioning of our economy, our critical infrastructure and our health system. It is necessary for our exporters to distribute high-value, often perishable, goods to the rest of the world and for our country to import the critical goods and services needed to keep our economy functioning. It ensures our people can continue to connect with others at home and abroad, and it is fundamental to the ongoing success of our world-class tourism proposition. To this end, aviation and its infrastructure, delivers a strategic public good.

However, flying creates carbon emissions, and these are hard to abate. Even with the full deployment of aviation decarbonisation technologies, including electric, hybrid and hydrogen powered aircraft, and sustainable aviation fuel (SAF), there is no current technology mix that can enable the industry to absolutely decarbonise by 2050. Furthermore, the industry's share of emissions will continue to increase in coming decades as other sectors decarbonise more quickly given available technologies and policy support.

While we recognise the challenge aviation faces to decarbonise, we see New Zealand as being uniquely placed to lead the world in the deployment of zero emissions aircraft allowing low carbon alternatives to New Zealand's current domestic air transport network. Our domestic network is ideally suited to adopt zero emissions aircraft with a number of short range routes suited for early aircraft demonstration, with New Zealand's largely renewable electricity grid allowing for cost effective infrastructure to be established.

This Product Requirements Document (PRD) shares our vision for zero emissions aircraft deployment and allows current, and future aircraft developers to recognise both the opportunity here in New Zealand and Air New Zealand's ambition to make this a reality as soon as possible.

Section

01

PRD Process

This section of the PRD outlines key principles and processes underlying Air New Zealand's product requirement process for zero emissions aircraft. For respondents this section contains important details relating to the submission and process outcomes.

<BACK TO CONTENTS

1.1 | Zero Emissions PRD Mission

What can the aircraft developer provide to Air New Zealand?

- Air New Zealand is seeking long term partnerships with aircraft developers looking to develop zero emissions aircraft. From the PRD process Air New Zealand is seeking to gain an understanding from the aircraft developers of the realistic implementation timeline and technology feasibility to enable long term fleet strategy evaluation.
- The PRD Response Document is designed to ensure all key aircraft characteristics are captured, allowing a consistent comparison between concepts. Honest and genuine responses from aircraft developers is encouraged so as to create a mutually beneficial environment and long term partnerships.
- Noting the challenges of novel propulsion, if demonstrator aircraft are being manufactured by aircraft developers for flight test purposes, any possible opportunities that may exist for testing of aircraft within New Zealand in collaboration with Air New Zealand are encouraged as part of the submission.

What can Air New Zealand offer?

- **Formal collaboration:** Air New Zealand is committed to working collaboratively with multiple partners across the aviation value chain to make zero emissions aircraft a reality. Increased collaboration will be the first step for successful suppliers. This could take various forms – with an Memorandum of Understanding (MoU) or letter of support the likely options initially.
- **Operator data:** Air New Zealand has developed a significant amount of operator specific analysis related to implementation of zero emissions aircraft and will be willing to share this information as part of ongoing collaborations with successful suppliers.
- **Retrofit donor aircraft**: Air New Zealand would be willing to discuss the options to retrofit an existing turboprop aircraft for demonstrator purposes with novel propulsion technology. Aircraft may be available for retrofit as they exit the operational fleet over time.
- **R&D funding partnerships:** There are options within New Zealand to apply for research funding and this could be attractive for an OEM to partner with Air New Zealand in a joint application for a pilot study or demonstrator project.

Next Steps

- A possible timeline of events is outlined as follows with the overall goal to make tangible steps forward zero emissions aircraft deployment in the next 5 years.
- Increased coordination with airports, energy companies and Government over the next 12 months will also need to take place to ensure the infrastructure requirements are visible for companies to start planning future investment.

FIGURE 01

What we could do with the right aircraft development partners

Q2 **2022**	**Increased Collaboration** Example: MOU / Letter of Support
Q4 **2022**	**Possible Aircraft Commitments** Example: Letter of intent (LOI)
2023[1]	**Firm Order Contract** Example: Purchase Order
2024[1]	**NZ Pilot/ Demonstrator** Example: Demonstration missions, infrastructure tests
2025[1]	**Aircraft Delivery**

Footnotes

1. Dates are indicative and dependent on technology evolution

1.2 | Definition of **Enabling Energy Technologies**

This PRD has been designed to enable Air New Zealand to accelerate the deployment of aircraft which benefit from energy and propulsion systems which produce significantly lower life cycle carbon emissions than current gas turbine designs today.

While aspiring to have aircraft which produce "zero emissions", Air New Zealand recognises the use of "zero emissions" as a catch all phrase for aircraft designs does not reflect the true value chain emissions generated by different designs or the nuance possible in many emerging hybrid designs.

Throughout this PRD Air New Zealand will adopt the term "novel propulsion" when describing aircraft design options. The term novel propulsion reflects the breadth of aircraft concepts emerging. Whether it be hydrogen/battery electric, hydrogen combustion or hybrid. All these designs are capable of achieving a step change in emissions reductions beyond what is achievable with conventional gas turbine designs. The term novel propulsion also recognises that in some cases such as hybrid or hydrogen combustion designs, total emissions are not brought to zero. Moreover full value chain analysis must be taken into account when considering battery and hydrogen options to ensure direct aircraft emissions are not replaced by another source of emissions, for example no renewable electricity generation.

Air New Zealand recognises that for aircraft developers the emissions intensity of their choice of energy source is outside the scope of their aircraft concepts. The insights gleaned through this PRD process will allow Air New Zealand to work with energy providers to ensure the carbon reduction possibilities of novel propulsion aircraft are fully released by minimising full value chain emissions.

Table 01 shows the spectrum of novel propulsion concepts this PRD considers relevant.

Novel Propulsion Concepts in Scope

TABLE 01

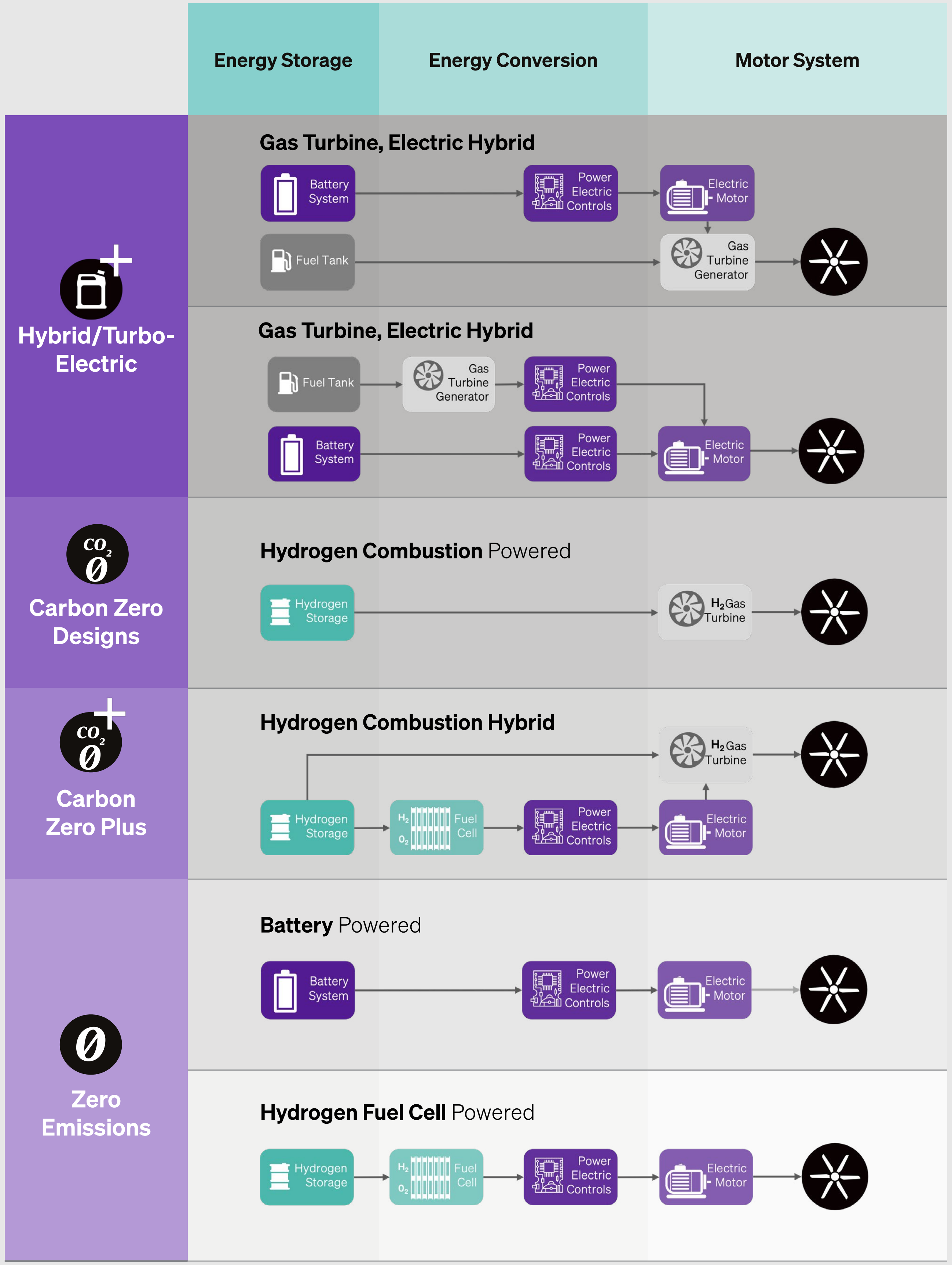
	Hybrid/ Turbo-Electric	Carbon Zero Designs	Carbon Zero Plus	Zero Emissions
Emission reductions	Low	Moderate	High	Highest
Description	Gross emissions are partly reduced[2]	Zero carbon, but residual, non-carbon emissions remain[1,2]	Zero carbon emissions with reduced non-carbon emissions[1,2]	Zero aircraft emissions
Technology solutions	Hybrid electrification of gas turbine engines SAF use possible	Direct hydrogen combustion	Hybrid hydrogen combustion and hydrogen fuel cell	Hydrogen fuel cell Battery Electric

Footnotes
1. NOx Emissions still present
2. Radiative forcing impacts likely to remain prevalent, however extent still unproven

<BACK TO CONTENTS

Novel Propulsion Concepts in Scope

FIGURE 02



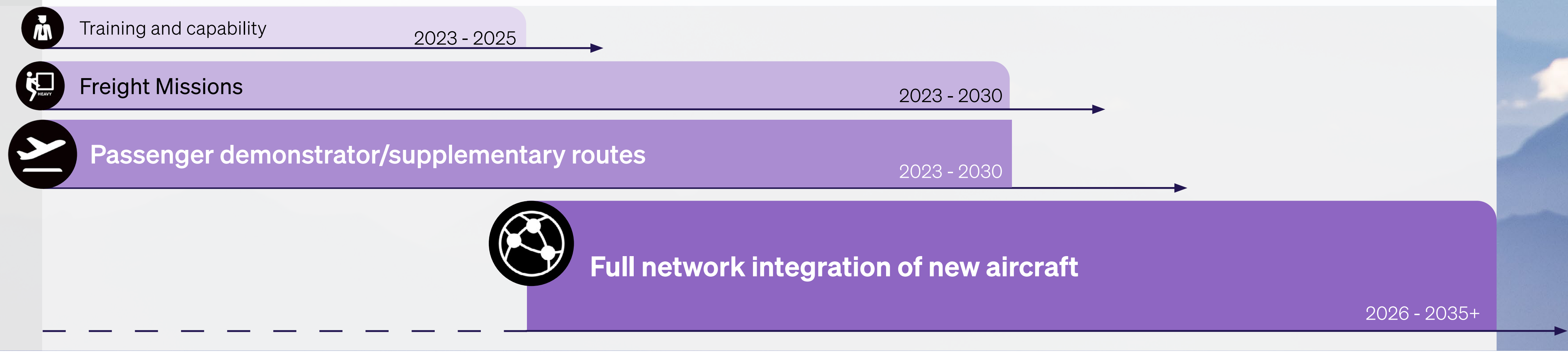
1.3 | Aircraft Acquisition Timing & Options

Options and Use Cases The PRD will make reference to the three aircraft adoption options outlined below.

TABLE 02

	Option 1. *Early Adoption*	Option 2. *Supplementary*	Option 3. *Replacement Fleet*
Timelines	2023-2025	2026-2030	2031-2035
Seats	1 - 9 seats	10 – 50 seats	50+ seats
Novel Propulsion systems envisaged	1. Electric (hydrogen fuel cell or battery) 2. Hybrid electric (including the use of SAF)	1. Electric (hydrogen fuel cell or battery) 2. Hydrogen combustion 3. Hybrid electric (including the use of SAF)	1. Electric (hydrogen fuel cell or battery) 2. Hydrogen combustion 3. Hybrid electric (including the use of SAF)
Description	• This option covers technology that is currently in development, likely at the ground testing phase (TRL 5 or 6), but moving quickly towards first flight in the next 24 months with commercial certification underway. • Air New Zealand's ambition is to be an early adopter of technology to enable operational learnings and develop infrastructure for future zero emissions fleet additions. • The use case for these aircraft could be varied including freight, training and single lines of flying.	• Concepts in this option are targeted at medium sized aircraft or retrofit solutions that are well advanced (TRL 4 or 5) and likely be available for commercial entry from 2025. • This type of aircraft will be deployed in the fleet to supplement existing routes or enter new routes • The types of missions will ideally be passenger services however freight concepts are also of interest especially if the aircraft progression is targeted at a later passenger version.	• From 2030 the turboprop fleet replacement becomes the key use case for new technology acquisition. • There is no replacement technology available in the market today for a 50 seat turboprop with improved economics and lower emissions potential. • The ideal candidate aircraft will be a drop in replacement for the Q300 for seamless integration into the existing Air New Zealand turboprop network, which may include retrofit of the existing aircraft.

Potential ***Use Cases***



1.4 | Process Introduction & Milestones

Introduction to PRD Process

Air New Zealand (Air New Zealand) is releasing this "Product Requirement Document" (PRD) to several suppliers for the provision of zero emissions/novel propulsion aircraft (specified in section 1.3) with the intention of entering into a long term collaboration.

Suppliers are requested to comply with the terms and conditions contained within this PRD, failure to follow these requirements may result in the proposal being rejected.

Communication regarding this PRD

All queries should be made in writing to the primary email address referred to below, unless of an urgent nature, in which case they should be telephoned and confirmed in writing. Air NZ reserves the right to communicate the substance of any queries received along with replies given to all proposing suppliers, at its discretion.

Primary Contact Email: zero.emissions@airnz.co.nz

Submission of Proposals

The closing time and date in New Zealand for receipt of proposals in response to this PRD is 11:59am (NZT) 1st March 2022.

If you require a copy of the PRD Response Document, please send a request to the Primary Contact Email.

PRD Timelines

TABLE 03

Milestone	Date (NZST)
PRD released	**10th December 2021**
Deadline for acceptance of confidentiality agreement	**20th December 2021**
Deadline for questions from suppliers	**11th February 2022**
Deadline for proposals	**1st March 2022**
Supplier presentations	**From 7th March 2022**
Evaluation and feedback	**Q2 2022**

Note - the time frame may be changed at Air New Zealand's discretion.

All dates and times are New Zealand Standard Time.

<BACK TO CONTENTS

1.5 | Technology Readiness Levels

Technical readiness levels (TRL) provide a simple means of differentiating the distinct stages of aircraft development. Table 04 is the TRL's Air New Zealand has adopted for zero emissions aircraft, modifying the original NASA defined TRL levels. Reference to different TRL stages is used within this PRD as well as throughout the PRD Response Document.

Air New Zealand recognises that for a number of early aircraft concepts, the design principles mentioned throughout this document may only be able addressed at early TRL's. Regardless Air New Zealand will look for aircraft developers to include the current TRL of their various aircraft designs (airframe/systems/components) in the PRD Response Document and also provide indicative timelines on when the different TRL stages will be reached for their respective aircraft.

TRL Table[1]

TABLE 04

TRL	TRL Applicable for Systems	TRL Applicable for Complete Aircraft
9	Actual system flight proven through successful mission operations	Early operational experience leads to refinements in aircraft design
8	Actual system completed and "flight qualified" through test and demonstration	Certification completed, entry into service (EIS) begins, following flight test campaign with full production aircraft
7	System prototype demonstration	Full prototype developed and used in flight testing under normal conditions
6	System/subsystem model or prototype demonstration in a relevant environment	Full prototype developed and used in ground testing
5	Component and/or breadboard validation in relevant environment	Larger prototypes developed and tested at subscale
4	Component and/or breadboard validation is laboratory	Early prototypes developed and tested using computer modelling
3	Analytical and experimental critical function and/or characteristic proof-of-concept	Simple aircraft feasibility experiments
2	Technology concept and/or application formulated	Aircraft design concept
1	Basic principles observed and reported	Initial idea generated

Footnotes

1. NASA Technology Readiness Levels

1.6 | Supplier Response Details

Supplier Response Format

Suppliers are required to respond to the PRD using the Microsoft Word format provided in the separate Response Document. Please fill out a separate PRD Response Document for each aircraft option proposed. All information requested should be replied to in full, unless covered in a prior aircraft option response.

FIGURE 03

Product Requirements Document (PRD)
- Guiding Principles
- Specification trade-offs

Step 1 — **Confidentiality Agreement**

Step 2 — **PRD Response Document**
(MS Word format)
- Supplier template
- Performance data set

Air New Zealand shall not be obliged to, but may in its absolute discretion, consider a proposal which is not in the format provided in the Response Document.

Suppliers are encouraged to attach supplementary documents to their response. However, these documents must be clearly referred to in the PRD Response Document.

Product Requirements Content

The PRD supplier response format comprises of two main sections:

1. Supplier information:
   - General Company Information
   - Engineering Capabilities Information
2. Aircraft requirements including:
   - Aircraft Overview
   - Aircraft Performance
   - Aircraft Powertrain
   - Navigational and Avionics Requirements
   - Aircraft Systems and Airframe Design
   - Enabling Infrastructure
   - Certification
   - Life Cycle Maintenance

Supplier Presentations

Suppliers may be required to present remotely on Microsoft Teams from **7th March to 25th March**, to be confirmed and agreed between the parties.

- Each Supplier will be provided with **2 hours** to present their proposal.
- The attendees from Air New Zealand will vary depending on the subject, however typical stakeholders may include Fleet Strategy/ Corporate Finance, Sustainability, and Engineering.
- Air New Zealand reserves the right to add or remove Suppliers at its absolute discretion and at any time during the process.

Section

02

Air New Zealand Context

Section two outlines the case for Air New Zealand's Zero Emissions Aircraft Project. This section provides an overview of Air New Zealand's broader decarbonisation strategy with additional insight into the airline's historical fleet and network. In addition this section identifies the unique opportunity here in New Zealand to be a first mover in novel propulsion aircraft technology.

2.1 | Air New Zealand Company information

Air New Zealand is a world-class airline, with a strong customer proposition and modern fleet. Underpinned by digital innovation, driving improvements in customer experience and profitability through its refreshed strategy, Kia Mau.

- Further Air New Zealand company information may be found here
- Please also read the Air New Zealand Supplier Code of Conduct here

82
Years in operation

18 million
passengers carried annually

#1
Corporate reputation in New Zealand for seven consecutive years

Pacific Rim
Focused international network

3.6 million
AirpointsTM loyalty scheme members

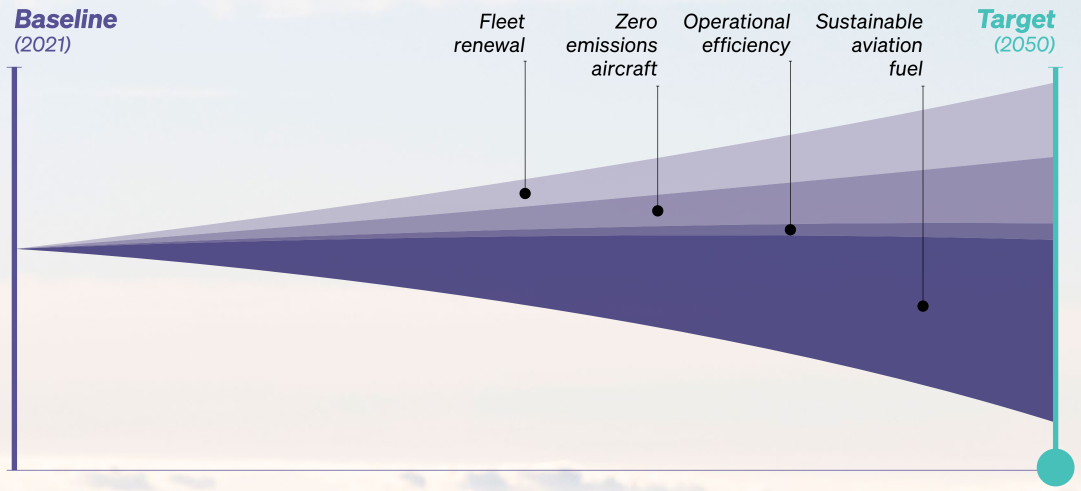
Baa2 (stable)
Investment grade credit rating from Moody's since 2016

16
Years of consecutive profitability before 2020

6.7 years
Average fleet age on a seat weighted basis

20
Domestic destinations

Indicative **decarbonsation potential** — CHART 01



2.2 | Our roadmap to decarbonisation

TABLE 05

New Zealand is an island nation at the bottom of the world, and air travel keeps us connected around the globe.

Whether it's connecting customers with their families or keeping our trade and export industry moving, air travel is key to keeping New Zealand connected. We acknowledge this means we have higher greenhouse gas emissions than many New Zealand companies and are committed to taking urgent and ambitious action to decarbonise.

Our decarbonisation roadmap identifies four main levers needed to reach net zero by 2050, illustrated in Table 05.

- The use of sustainable aviation fuel (SAF)
- The operation of zero emissions aircraft
- Continued investment in our modern fleet replacement programme
- Improvements in operational efficiencies (such as through optimised flight planning)

Significant innovation and close collaboration between the private and public sectors will be vital to dramatically reduce emissions in less than 30 years.

Even with the full deployment of available technologies, there is no known technology mix that can enable the aviation industry to reach absolute zero emissions by 2050. This is why offsetting remains in our roadmap to address residual emissions.

More information on our decarbonisation strategy can be found here

	Zero emissions aircraft	Sustainable aviation fuel (SAF)	Operational efficiency	Fleet renewal	Carbon offsetting
Description	**Future hydrogen or battery or hybrid aircraft technologies**	**Non-fossil derived jet fuel, carbon reduction potential of more than 80%, compatible with existing aircraft without modification**	**Optimising carbon efficiency from flight and ground operations**	**Rollover current fleet to new jets that achieve greater fuel efficiency**	**1. Purchasing industry-agnostic carbon credits;** **2. Using carbon capture technology that processes and safely stores CO_2 underground (~2040-2050)**
2050 Decarbonisation Potential	↓ 20%	↓ 50%	↓ <2%	↓ 20%	Residual
Key Initiatives	• **Q300 replacement programme** focused on electric or hydrogen substitute • **Memorandum of Understanding with Airbus** – hydrogen aircraft technologies • **Memorandum of Understanding with ATR** – battery/hybrid designs • **Partnering with future energy stakeholders** to enable both battery-electric and green hydrogen solutions	• **Government advocacy and engagement** on key policy, regulatory, and investment settings needed to make SAF a reality in New Zealand • Member of the **SAF Consortium** – joint research and advocacy on steps to establish domestic SAF production and a public-private aviation decarbonisation advisory body • **Memorandum of Understanding with the Ministry of Business, Innovation and Employment** to engage in a process seeking respondents to demonstrate the feasibility of establishing a domestic SAF plant	• **Optimising cabin weight to reduce fuel burn,** including our cost of weight calculator to inform decisions • Member of **New Southern Sky Programme** considering airspace efficiencies • **Ground efficiency improvements** through electric ground power and pre-conditioned air units	• Plan to replace the Boeing 777 fleet with **more efficient Boeing 787 aircraft** • Airbus domestic fleet **transitioning to Airbus A321neo aircraft**	• **Representation on government working group** to develop a framework for voluntary offsetting in New Zealand

2.3 | Air New Zealand's Zero Emissions Aircraft Project

Project Mission

As Air New Zealand's works towards its net zero 2050 goal, achieving in-sector carbon reductions through reducing aircraft emissions is critical. We have an ambition to be a global leader in driving a shift to novel propulsion aircraft with an entry to service before 2030.

New Zealand is well suited to become a leader in electric aircraft (battery or green hydrogen powered) as ~80% of electricity generated is from renewable sources. In addition our relatively short domestic network sector lengths are suited to the operation of these new technologies.

Project Context

Air New Zealand is aware of the significant challenges to overcome including battery technology, electric motor technology, integration of electric systems, new aircraft design, certification and new infrastructure particularly related to hydrogen fuel.

In the short-term we understand that specific energy limitations of batteries will reduce range and payload capabilities of aircraft, and therefore smaller aircraft that operate on regional routes will likely be more feasible.

Project Purpose

Air New Zealand is well positioned to acquire low emission, electric aircraft before 2030. This document provides an overview of our requirements based on our current network and fleet. It is intended to be used for discussion purposes and as an initial starting point for ongoing collaboration.

IATA Recommendations: Roadmap to 2050

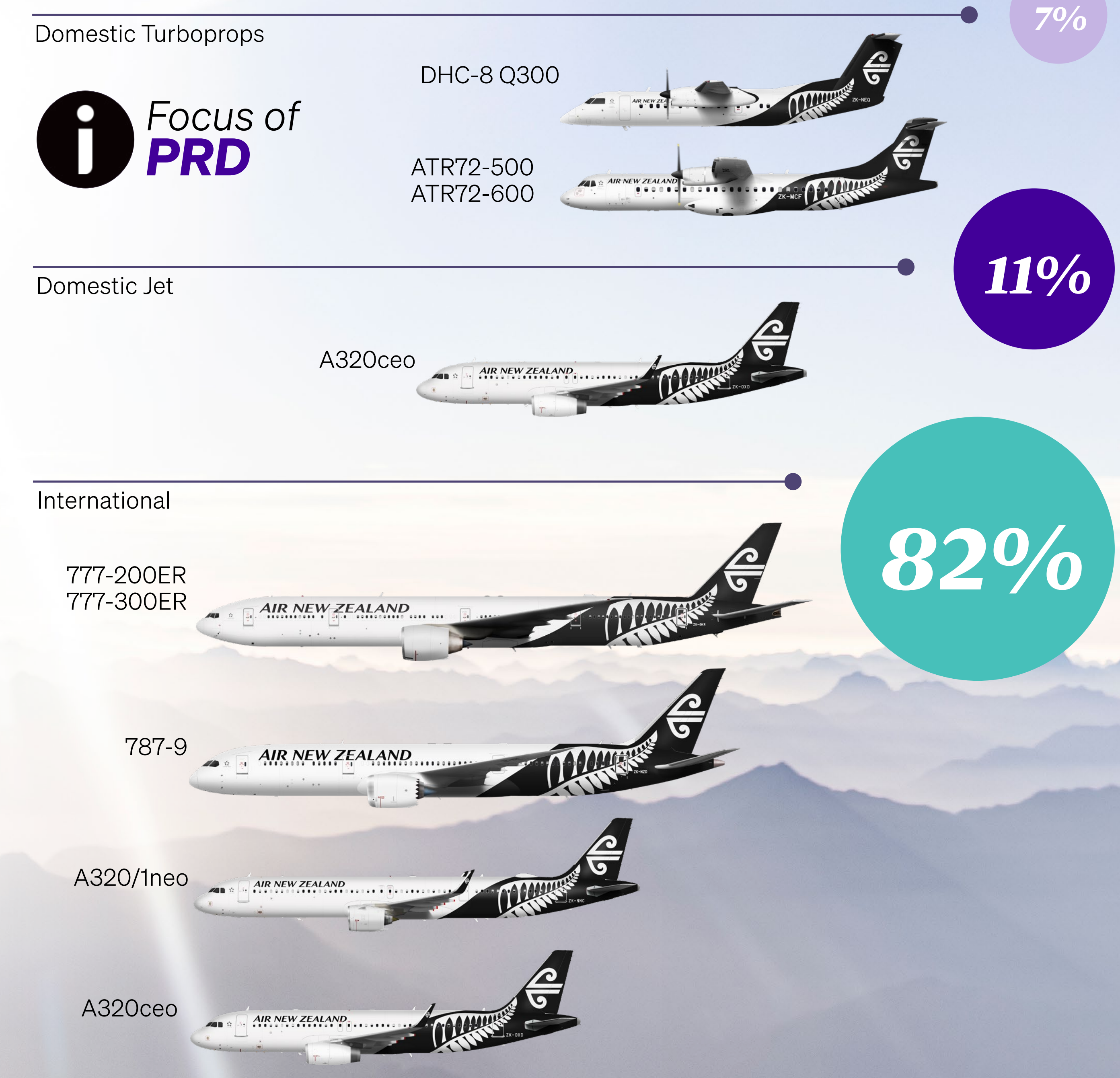
The following is an exert from the International Air Transport Associations (IATA's) recommendations relating to zero emissions aircraft in the context of a proposed road map for aviation to get to net zero carbon emissions by 2050.

Airlines are under public pressure to achieve substantial carbon reductions in future. They should clearly articulate their interest in aircraft with strong fuel efficiency improvements, including radically new ones in the longer term, to give aircraft manufacturers the confidence in potential demand that they need for starting new developments.

- It needs to be taken into account that the lead time for radically new aircraft is significantly longer than for conventional configurations.
- Airlines should work with governments to stress the importance of publicly funded research and technology to achieve the aviation industry's carbon reduction goals.
- Although numerous studies have been done on revolutionary aircraft configurations and technologies, more specific investigations on the implementation of these technologies into day-to-day operations are needed to give a more reliable projection on their operational, environmental and economic benefits.
- Airlines have an important role in the development of new aircraft and technologies. They should actively participate in their evaluation under day-to-day operational conditions, in order to ensure that aircraft and engine manufacturers and technology developers meet the users' requirements. As the development of a new aircraft program represents a very high investment, it is crucial to ensure that it fits the needs of a broad variety of customers including their requirements for operational flexibility.
- For a seamless market penetration of radical aircraft technologies, all aviation stakeholders such as airlines, manufacturers, airports, air navigation service providers, governments and research institutions, need to work together to prepare the prerequisites for the implementation of these technologies into the future air transport system and to overcome the challenges they impose on operational, regulatory and airspace. Such challenges could be, amongst others: accessibility of ground services and new maintenance procedures for radically new aircraft configurations, availability of batteries with sufficient energy density for regional flights, standardisation of batteries to allow easy exchange and high-power electricity supply at airports to recharge batteries.
- Electric aircraft producers and other technology innovators will enter the industry as new stakeholders. They will need to build up the same level of cooperation with other stakeholders in the industry as the traditional manufacturers to ensure that radically new aircraft can be integrated into the future air transport system. Partnerships between airlines, innovation companies and research establishments are already taking place and should be extended.

Emissions Profile | FY2019

FIGURE 04



> "Air New Zealand is committed to working collaboratively with manufacturers to make this happen"

2019	2020	2021
Zero emissions aircraft project launch	Technology feasibility modelling	Market review and PRD development

2.4 | Applicability of **Zero Emissions Technology**

Air New Zealand is ideally placed for the early deployment of novel propulsion aircraft

- Large turboprop fleet deployed within a highly productive domestic network.
- Short sector lengths across the network: The max range for a turboprop on our current domestic network is 768km, 60% of turboprop flights are <350km.
- Large market share in aviation within NZ and a connected international network.
- Upcoming fleet replacement of turboprops with no 'like for like' Q300 replacement technology available in the market.

New Zealand is an ideal location to trial early market entry with supportive local partners

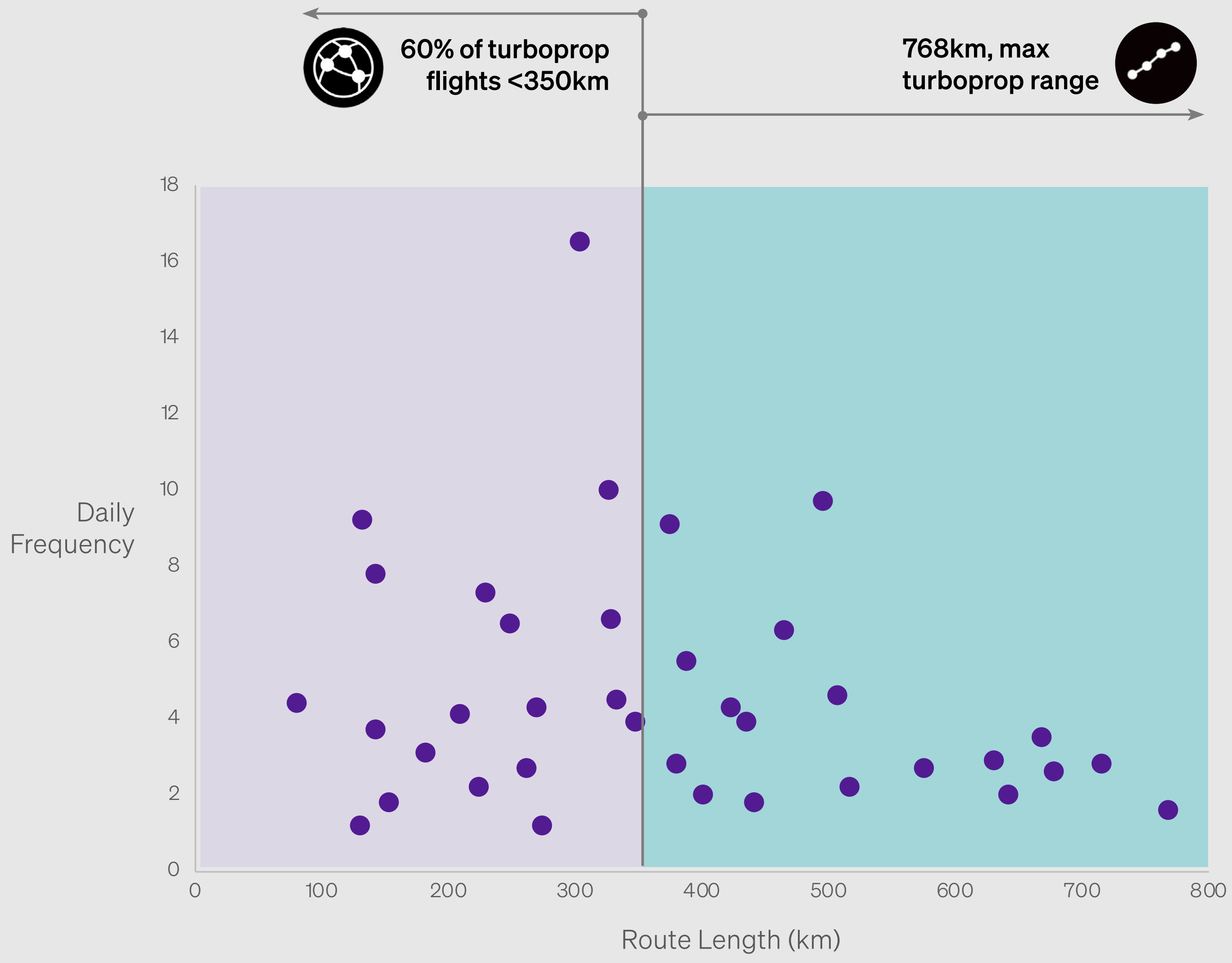
- Limited substitutes and challenged geography: New Zealand is a country reliant on air travel. This is driven by the geography, characterised by mountainous regions, islands and peninsulas, compounded by the fact New Zealand has no high speed train network and limited highway roading.
- High availability of renewable power: Currently 80% of grid electricity is renewable with power coming from both hydro and geothermal sites with recent growth in wind generation. New Zealand's grid is forecast to reach 90% renewable by mid 2020's with a government goal to reach 100% by 2030.
- Relatively uncongested airspace, with well managed and resourced air traffic management system, benefiting from recent technology upgrades.
- Supportive central government (one jurisdiction).
- Potential R&D tax benefits.

Air New Zealand is driven to realise the benefits of zero emissions aircraft

- Reduced emissions as the primary goal and focus.
- Reduced energy consumption to enable economic operations.
- Noise reductions for passenger comfort and improve ground noise noting that increased frequency may cause disruption due to the prevalence of noise.
- Short field operations to service regional ports with performance limitations.
- Reduced cost for maintenance and operation, due to simplified motor technology.
- Reduced compliance obligations under the New Zealand Emissions Trading Scheme.

Air New Zealand turboprop network **frequencies vs range**

CHART 02



2.5 | Replacement **Technology Availability**

Evolution of aircraft design

There has been a constant evolution of the current tube-and-wing aircraft configuration powered with hydrocarbon fuel combustion engines. Since the early jet age, aircraft fuel burn per passenger-km has been reduced by over 70%, and there is still potential to reduce today's fuel burn further without going to radically different aircraft configurations and novel propulsion concepts.

The potential of these evolutionary technologies however, will diminish over the next decade. Improvements in aerodynamics, lightweight materials and structures, new engine architecture and aircraft systems will not be enough to meet our net zero 2050 carbon reduction goals. We believe radical configuration changes and novel propulsion concepts will be required in addition to continued evolution of existing aircraft technology.

New entrants, start-ups or well established players in adjacent industries, need to have clear market entry strategies, well-adapted to the specific challenges of the aerospace sector with substantial emissions reductions (>15%).

Air New Zealand Fleet

Air New Zealand currently operates 52 turboprop aircraft made up of 23 Q300 aircraft and 29 ATR72-600 aircraft. These aircraft connect several regional areas across New Zealand, with a maximum sector length of 770km. These aircraft are the likely candidates for replacement with novel propulsion technology.

Air New Zealand expects to begin phasing out the Q300 fleet towards the end of this decade and we see significant value in acquiring novel propulsion aircraft to initially supplement, and then ultimately replace/modify the Q300, to support ongoing services to existing Q300 markets.

The ATR72 will also come up for retirement from the mid 2030s and replacement aircraft will most likely be required to have significant emission reductions at this stage, preferably zero.

Projected 2025 **Domestic Fleet Types & Age Profile** FIGURE 05

FLEET COUNT		AVERAGE AGE
7x	A321neo | 217 seats	**2.5**
13x	A320ceo | 171 seats	**11.3**
*Focus of **PRD***		
29x	ATR72-600 | 68 seats	**8.4**
23x	DHC-8 Q300 | 50 seats	**18.4**
+	Future novel propulsion aircraft	

zero EMISSIONS AIRCRAFT

2.6 | Historic Deployment of Smaller Turboprops

Network Insights:

Air NZ has historically had a breadth of domestic markets and smaller fleet including the 19PAX B1900 which operated several short missions within the network, mostly between **80 – 400km.**

With the exit of the B1900, the smallest aircraft available in the Air NZ fleet became the 50PAX Q300 which limits the possible regional destinations in some cases due to airfield limitations.

Aircraft gauge impacts:

It is Air New Zealand's intent to deploy smaller zero emissions aircraft in the future to regional markets to continue to build and grow the airlines domestic network proposition, noting that gauge impacts network service in the following ways:

- **Down gauges:** reduces aircraft utilisation, improves passenger timing options, (may result in frequency saturation).
- **Up gauges:** generally drives favourable operating cost economics though frequency consolidation, but may result in decreased passenger timing options.

Spotlight | Beechcraft 1900D

Air New Zealand Fleet: **2001 - 2016**

Credit: NZ AIRCRAFT

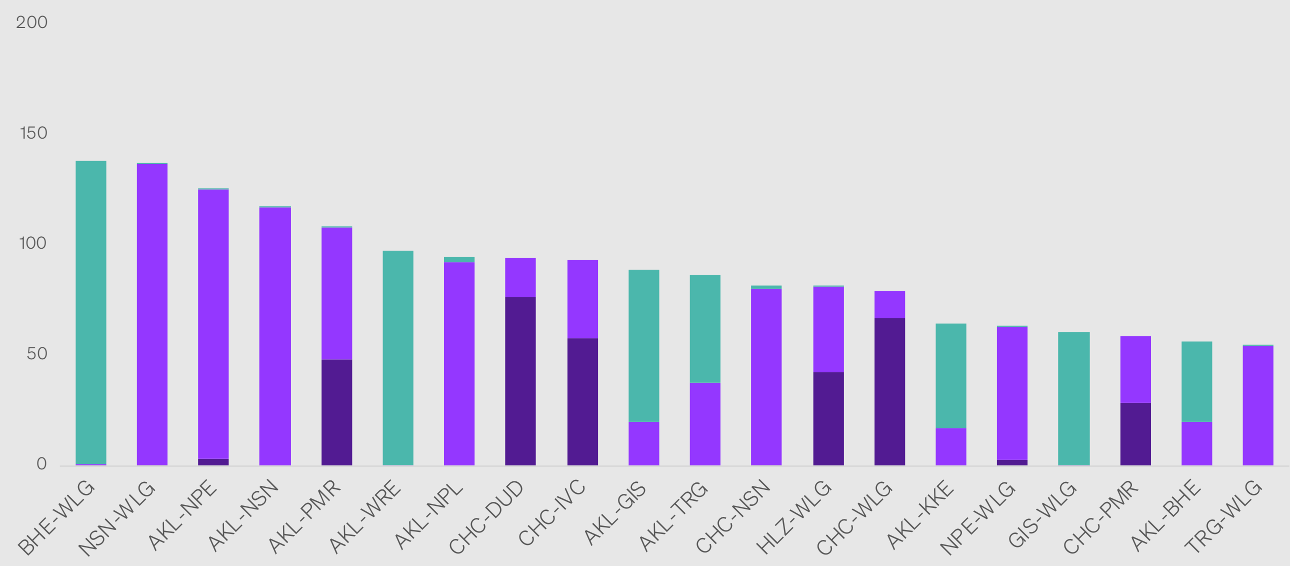
Specifications

Seats	19
Flight Crew	2
Range	+1,000km
MTOW	7,765kg
Takeoff field perf.	~1,000m min
Speed	270KTAS
Ceiling	25,000ft (pressurised)
Power plant	PT6-67D, 1,279HP
Cabin	1 toilet, no cabin crew

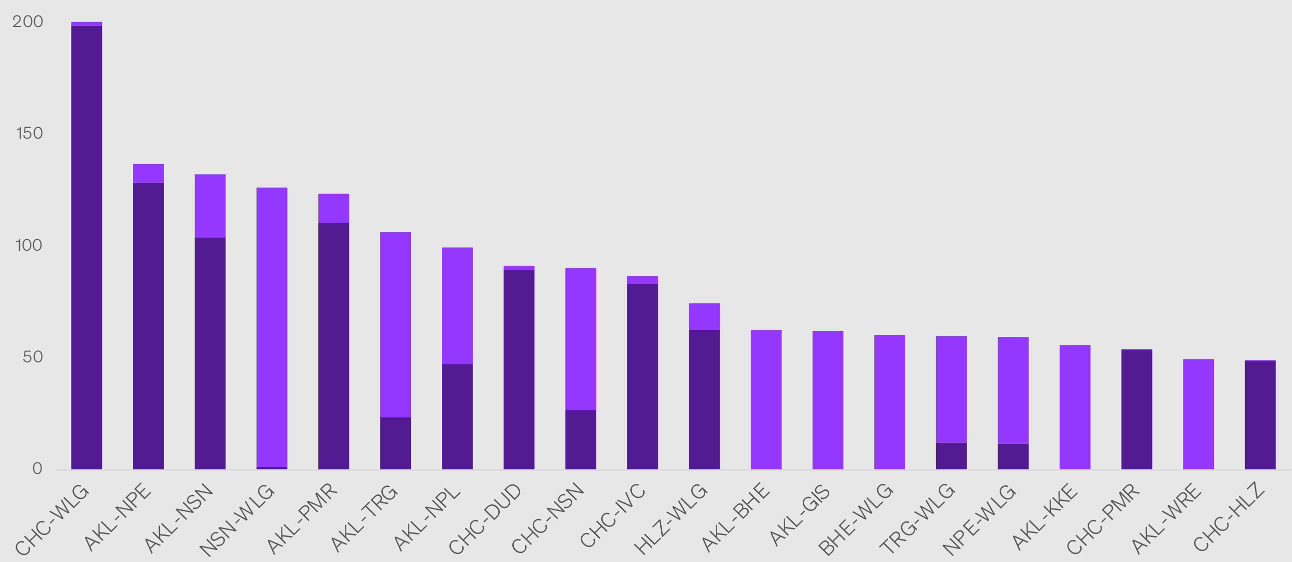
Historic and Current Turboprop Network

Top 20 Routes

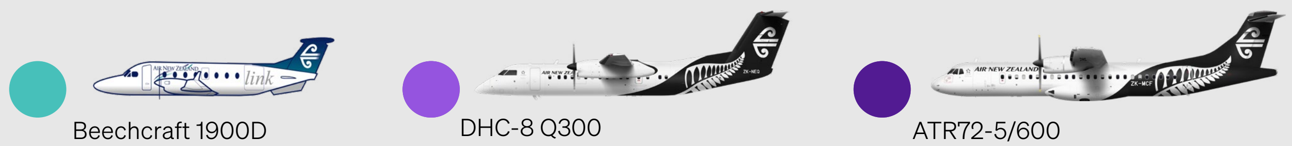
Weekly Departures | FY11 — CHART 03



Weekly Departures | FY19 — CHART 04



Key | Charts 03 & 04



Section 03

Aircraft Requirements

This section provides detailed guidance on Air New Zealand's novel propulsion requirements. Each subtopic within this section relates to a specific section within the PRD Response Document. Respondents should read this section alongside the PRD Response Document.

3.1 | Aircraft Acquisition Principles

Acquisition Principles Required for Options 1, 2, 3

1 Aligned to Long Term Fleet Pathway:

Early technology adoption needs to be balanced with the future technology availability, i.e. investing in early aircraft designs may be worth pursuing due to the learnings gained from operating the technology and developing infrastructure for future aircraft of the same type (e.g. hydrogen or battery electric).

2 Traditional Airfields:

To incorporate next generation aircraft into the fleet as Q300 replacement aircraft the most feasible economic model is to utilise existing aeronautical infrastructure with additional energy infrastructure expanded in line with aircraft deployment. This may allow for new routes where smaller novel propulsion aircraft open up new inter-regional point to point services.

3 At least +200km, practical range:

A minimum range of 200km enables entry replacement of aircraft on existing/new routes with large markets that will be resilient to prototype aircraft and enable a sufficient sub-fleet to be built to complement the network without having unprofitable single lines of flying.

Note - shorter range missions on new intracity routes (Advanced Air Mobility[1]) would be considered separately by the airline, differentiated primarily through their requirement for non-traditional airport locations (i.e. vertiports).

Footnotes
1. Advanced Air Mobility, AAM : Is a concept where highly automated aircraft provide commercial services to the public over densely populated cities. AAM will rely on new aircraft and technologies, as well as new operational procedures to enable practical, cost-effective air travel as an integral mode of transportation in metropolitan areas.

Acquisition Principles

TABLE 06

	Option 1 *Early Adoption*	Option 2 *Supplementary*	Option 3 *Replacement Fleet*
Air New Zealand Deployment Options			
Entry into service	2023-2025	2026-2030	2031-2035
Network Deployment	• Early adoption	• Supplementary	• Fleet replacement • Growth aircraft
Use Case Possibilities	• Freight missions • Training/demo aircraft • Demonstrator routes	• Freight missions • Demonstrator routes • Commercial services	• Freight • Commercial services
Aircraft Specification			
Total Payload Capability (kg)	110 - 990kg	1,100 - 5,500kg	5,500kg +
Pax Capacity	1 - 9 seats	10 – 50 seats	50+ seats
Cargo Volume[1] (m³) (Instead of pax capacity)	0.5 - 5	5 - 25	25+
Cruise Speed (KTAS)		>150kts	
Magnitude of Opportunity			
Total fleet seats	30-90	200-600	1,000-4,000
Number of Aircraft Examples	• 3-10x 9 seaters or, • 2-5x 19 seaters	• 10-30x 19 seaters or, • 5-15x 40 seaters	• 20-80x 50 seaters or, • 10-40x 100 seaters

Footnotes
1. For options with a specific freight use case

3.2 | Performance: **Mission assumptions**

Introduction

Air New Zealand operates four fundamental missions, with this PRD focusing solely on the domestic mission set. Future decarbonisation technology options will likely be sought for the other categories:

1. **Domestic (focus of PRD)** within New Zealand only: **0 – 2 hours**
2. **Short Haul** International missions e.g. Tasman/Pacific: **2 - 6 hours**
3. **Mid/Long Haul** International missions e.g. to/from Hawaii, Perth: **6 -10 hours**
4. **Ultra Long Haul** International missions e.g. to/from Asia, North America: **10+ hour**

Analysis and calculations should wherever possible use the standard units outlined in Table 7:

Payload: **Passenger and Baggage Weight**

Air New Zealand carries out a 5 yearly passenger survey to determine an assumed passenger weight per the methodology outlined by CAA NZ regulations.

In operations, baggage is weighed for every flight to determine that weight and balance parameters are met, however payload potential should be evaluated with the weights provided below.

These values are based on baggage limits for international services, therefore alignment across the domestic and international operation is required to ensure passenger connectivity with sufficient baggage capacity.

Oversize baggage is also an important baggage consideration for customer journeys and additional capacity for baggage is desirable for sporting equipment, wheelchairs and baby travel equipment (specific weights are not included in the baseline assumptions).

The most recent passenger survey results as of November 2021 defines the following passenger weights to be used on Air New Zealand domestic services (110kg should be used for all max passenger payload calculations).

Payload: **Cargo Type and Density for Freight Missions**

Assume **bulk cargo** which can be loaded through the passenger door with a density of **210kg/m3.**

Units used throughout PRD

TABLE 07

Item	Units
Weight	Kilograms (kg)
Height	Feet or flight levels
Speed	Cruise KTAS
Energy calculations	Jet Fuel = kg Hydrogen (gaseous or liquid) = kg Battery = kWh
Distance	Kilometer (km), or Nautical Mile (NM)
Time	Hours and decimals of hours (e.g. 10 hours and 36 minutes to be presented as 10.6hrs)
Wind	Knots, headwinds negative
Cargo Volume	cuft or m3

Passenger and Baggage Weight

TABLE 08

Adults	Passenger Bags	Children[1] (For Reference Only)	Infants[1] (For Reference Only)
87kg (incl. 7kg of carry on baggage)	**23kg** (230kg/m³)	**40kg**	**10kg**

Passenger + **Bag** weight

+ =**110kg**

Footnotes

1. Provided for reference only, not to be included in mission assumptions

3.3 | Performance: **Weight Build-up**

Background

The weight build-up for the Operating Empty Weight (OEW) must be agreed upon between the manufacturer and Air New Zealand before any route analysis is undertaken. The total should made-up of the Manufacturer's Empty Weight and Operator's Items.

Air New Zealand **Operating Weight Build Up** Formula

FIGURE 06

Manufacturer's Empty Weight + Operator's Items = Operating Weight

Manufacturer's Empty Weight

A. Avionics Equipment
- See PRD section 3.7.

B. Security Reinforced cockpit
- Door and doorway monitoring system to ICAO Annex 6 standards (if applicable to regulatory requirements).

C. Safety equipment
- FDR1, CVR, QAR, fixed ELT.
- Intercom capability at each cabin crew station.

D. Galley Standard[1]
- Nil for aircraft of less than 20 seats.
- 20+ seats: Half tray meal service, beverages. Standard hot jugs for hot water (1 hot jug per 40 seats) ATLAS standard. Wet and dry waste capability. One half cart for dry waste stowage.

E. Toilet/Lavatory
- Not req. up to 20 passengers. One toilet up to 80 passengers. Two toilets above 80 passengers.

F. Seating standard
- Economy seats with fold down tray-tables.

+

Operator's Items

G. Crew and Baggage Weight (per the below)[2]
- Minimum Cabin crew passenger ratio 1:50.
- Individual crew member weight 86kg.
- Individual crew baggage weight 10kg.

H. Unusable fuel

I. Oil including engine, APU and systems

J. Water (washing)[2]

K. Toilet chemicals[2]

L. Emergency equipment
- The following minimum allowances should be included: First Aid Kits. Allow 5kg for additional first aid kit requirements, Fire extinguishers, Portable Oxygen. Allow 3.5kg per crew member for weight of portable oxygen equipment, Life jackets – sufficient for all occupants plus 10% (0.5kg per jacket).

M. Passenger Service Items[2]
- 4.0kg per passenger. These cover food, drink, blankets, pillows, give-aways, food/liquor carts and inserts.

Footnotes
1. Galley weight does not include cart/insert weight, this is covered under passenger service items
2. Below 20 seats it may be possible to dispense with the cabin attendant, toilet and onboard passenger service items

<BACK TO CONTENTS

3.4 | Performance: Airfield and En Route

Background

Air New Zealand currently operates to ~20 regional airports imposing various aircraft performance limitations due to terrain and obstacles. A selection of routes has been identified for initial evaluation to capture a variety of performance scenarios based on the following performance. **Performance standard: FAR**

Performance Details

City Pair Selection & Characteristics — TABLE 09

Conceptual zero mission routes designed to test performance

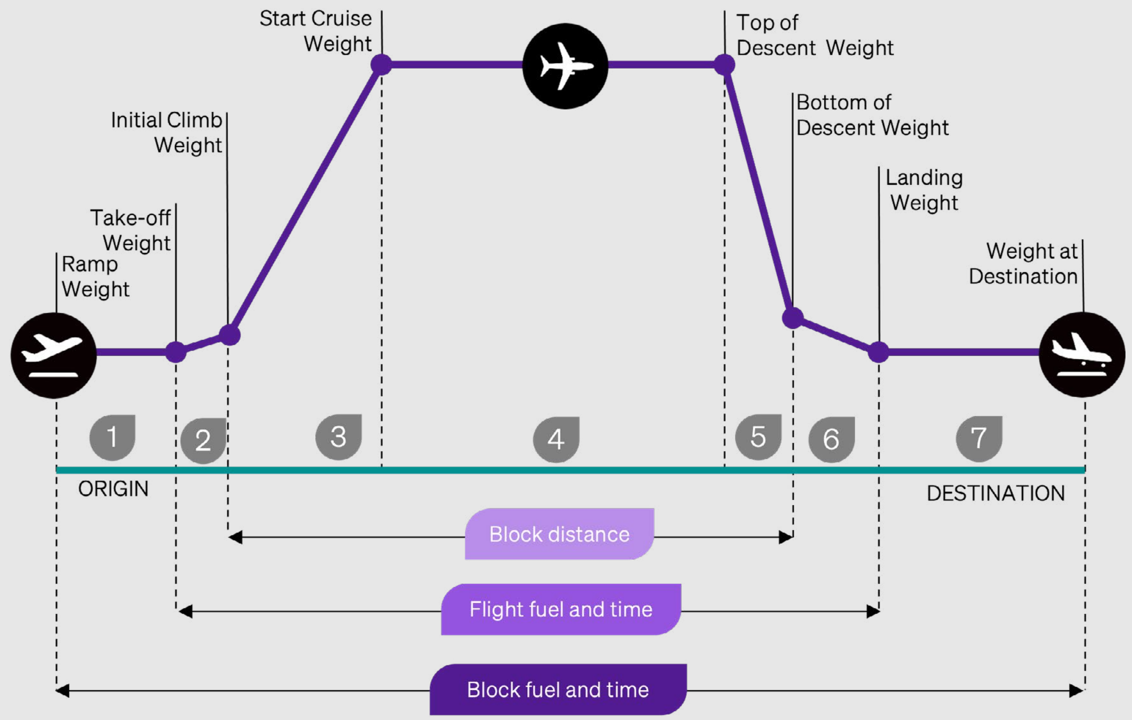
WLG-BHE	AKL-HLZ	AKL-WRE	AKL-TRG	CHC-WKA	AKL-GIS	AKL-NSN	CHC-TRG
Short range route over water	Short range route over land	Short take off and landing performance	High passenger demand	High route MSA's	Take off obstacles	Runway limitations	Long range route

Performance Specifications — TABLE 10

Airfield Performance	
Airfield characteristics	NIL wind, ISA +10degC unless otherwise stated.
Pavement strength	Assumed to be suitable for candidate aircraft.
Runway surface condition	Wet and dry.
Runway direction	Both vectors.
Runway width	All runways are assumed to meet the required minimum standards except where specified.
Runway slope	Sign convention is positive uphill, negative downhill.
Single engine out stabilising altitude	ISA +10degC, MTOW 95%, de-icing ON.
En Route Performance	
Sector distances and alternate information	See PRD Response Document.
Temperature	ISA+10degC.
En route winds	Defined in response doc. Sign convention is headwind negative.
Cruise	Optimum economical technique.
Flight Levels	Optimum based on NZ semi circular rules i.e. North – odd FL, South – even FL.
Jet A1 Fuel density (hybrid concepts)	0.80kg/L (6.65lb/USG).
Aircraft weight assumption	Best and worst case take-off / landing weights.
Payload	Maximum payload to be evaluated on all sectors (adult passenger and baggage weight).
Max Payload Range Performance	
Baseline assumptions	See Figure 07, no alternate required, assume max passenger and baggage weight, with and without 30 minutes energy/fuel reserve.
Environmental conditions	NIL wind, ISA +10degC, airfield at sea level.

Airfield and En Route Performance Diagrams

FIGURE 07



Fuel = Energy Storage Potential (Jet Fuel, H2, Battery)

Notes to Figure 07 — TABLE 11

Note	Phase	Description
1	Fuel and Time to Start Engines and Taxi-out	This fuel and time is to be included in block fuel and to be constant for a particular aircraft type. The allowances shall be: Engine start = 1 minute Taxi-out = 3 minutes
2	Fuel and Time for Take-off & Climb to 1500ft	1 minute. This fuel and time is to be included in the block fuel and block time with NO CREDIT FOR DISTANCE.
3	Fuel, Time & Distance from 1500ft to Cruise Altitude	The fuel, time and distance to climb from 1500 ft to cruise altitude is to be included in block fuel and block time.
4	Fuel, Time & Distance to Cruise	Fuel, time and distance to cruise are to be included in block fuel and block time.
5	Fuel, Time & Distance to Descend to 1500ft	Fuel, time and distance to descend to 1500ft over destination are to be included in the block fuel and block time.
6	Fuel & Time for Instrument Approach	Include fuel and time for instrument approach from 1500ft to touch down. Assume a time of 4 minutes.
7	Performance Deterioration Allowance (PDA)	An amount of fuel equal to 5% inclusive items 2-6 is to be included in the block fuel. This allowance is a proxy for the propulsion and energy system deterioration over its operational life.
8	Fuel & Time for Taxi-in	This fuel and time (2 minutes) is to be included in the block fuel and block time.
9	Ground Time	Included in the block fuel calculation should be an allowance (10 minutes per sector) for the use of an APU or the running of an engine on the ground for power i.e. "Hotel Mode".

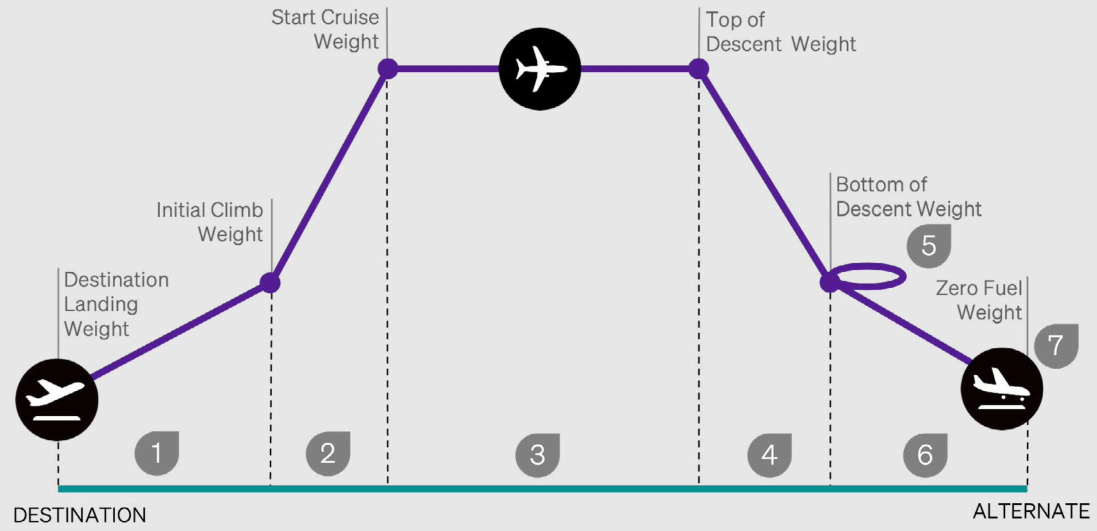
Notes to Table 11

- Apply same deterioration allowance to battery systems as fuel systems (although degradation mechanism for battery systems is physically different)

<BACK TO CONTENTS

Airfield and En Route Performance Diagrams

FIGURE 08



Fuel = Energy Storage Potential (Jet Fuel, H2, Battery)

Notes to Figure 08 — TABLE 12

Note	Phase	Description
1	Fuel for Missed Approach	An amount of fuel sufficient to execute a realistic missed approach i.e. clean-up and climb from sea level to 1500 ft with no credit for distance.
2	Fuel and Distance on climb to Alternate Cruise Altitude	Include fuel and distance for climb from 1500ft to the cruise altitude.
3	Fuel and Distance to Cruise	Include fuel and distance to cruise at a constant altitude as specified using a long range cruise (LRC) procedure.
4	Fuel and Distance to Descend	Include fuel and distance to descent to 1500ft over alternate.
5	Hold fuel at alternate	Include fuel for 30 minutes holding at 1500ft.
6	Approach and Landing Fuel	Include fuel for 4 minutes in landing configuration at 1500ft.
7	Contingency Allowance	An amount of fuel equal to 6% of Flight fuel (origin to destination). An amount of fuel equal to 3% of Alternate fuel (destination to alternate).

3.5 | Aircraft Technology Principles

Technology Acquisition Principles

Air New Zealand has a relatively young fleet of jet and turboprop aircraft with ongoing modernisation and simplification of the fleet built into the future fleet plan until 2030, however early adoption of technology is warranted to develop operational understanding across the value chain.

Aircraft specifications in the traditional sense, are required for the configuration, weight and performance, however, Air New Zealand is willing to concede certain trade-offs to **prioritise emission reduction technology.**

Air New Zealand recognises that a broad scope of technology options can contribute to aircraft fuel efficiency improvement and emissions reduction including:

- **Airframe:** aerodynamics, lightweight materials and composite structures, nav equipment and avionics systems, energy management.
- **Propulsion:** engine/motor architecture type, thermal and propulsive efficiency, electrification.

Air New Zealand recognises the certification and investment challenge. As an operator we are committed to providing information and data to guide and influence the development of novel technology which will encompass a wide range of concepts, and require multiple iterations of development and incremental progress towards a certified product.

A new generation of aircraft typically commands a 15-20% operating cost improvement over existing technology (predominantly from fuel savings), however it is recognised the future cost base for implementation of novel propulsion may not meet this threshold in the short term (prior to 2030).

The Product Requirements outlined in this PRD document focus on aircraft development. A separate workstream covers Air New Zealand's focus on SAF.

Clean Sheet Design Principles

Clean sheet aircraft designs will likely enable a greater range of emissions reduction features, however the certification pathway for novel propulsion aircraft is likely to be longer.

Air New Zealand supports the long term strategy of new aircraft production focussed on zero emissions technology as the base standard.

Retrofit Design Principles

Scope: Engine and other systems impact.

Air New Zealand views novel retrofit concepts for emissions reduction technology as a viable implementation strategy depending on the scope and complexity of the modification required to existing aircraft.

The modification of existing aircraft types is a common methodology employed by Air New Zealand with the inhouse engineering capability and either STC or OEM SB processes (previous modifications include major interior modifications to widebody aircraft, 767 winglet STC modification, and Q300 FMS addition via OEM SB etc).

With a low average fleet age, and a ~20 year life cycle on airframes, Air New Zealand's fleet will not require major replacement until 2030, beginning with the Q300. This means the majority of the fleet will remain in operation well into the 2030s with high mid-life asset values.

Air New Zealand would consider modifying its existing fleet of turboprops (23x Q300 aircraft, 29x ATR72-600 aircraft) to create a sub-fleet of zero emissions aircraft for passenger operations through an STC process.

In addition, Air New Zealand has aircraft in the fleet which over time may offer the opportunity to use as early adoption demonstrators.

Engine Propulsion Improvements

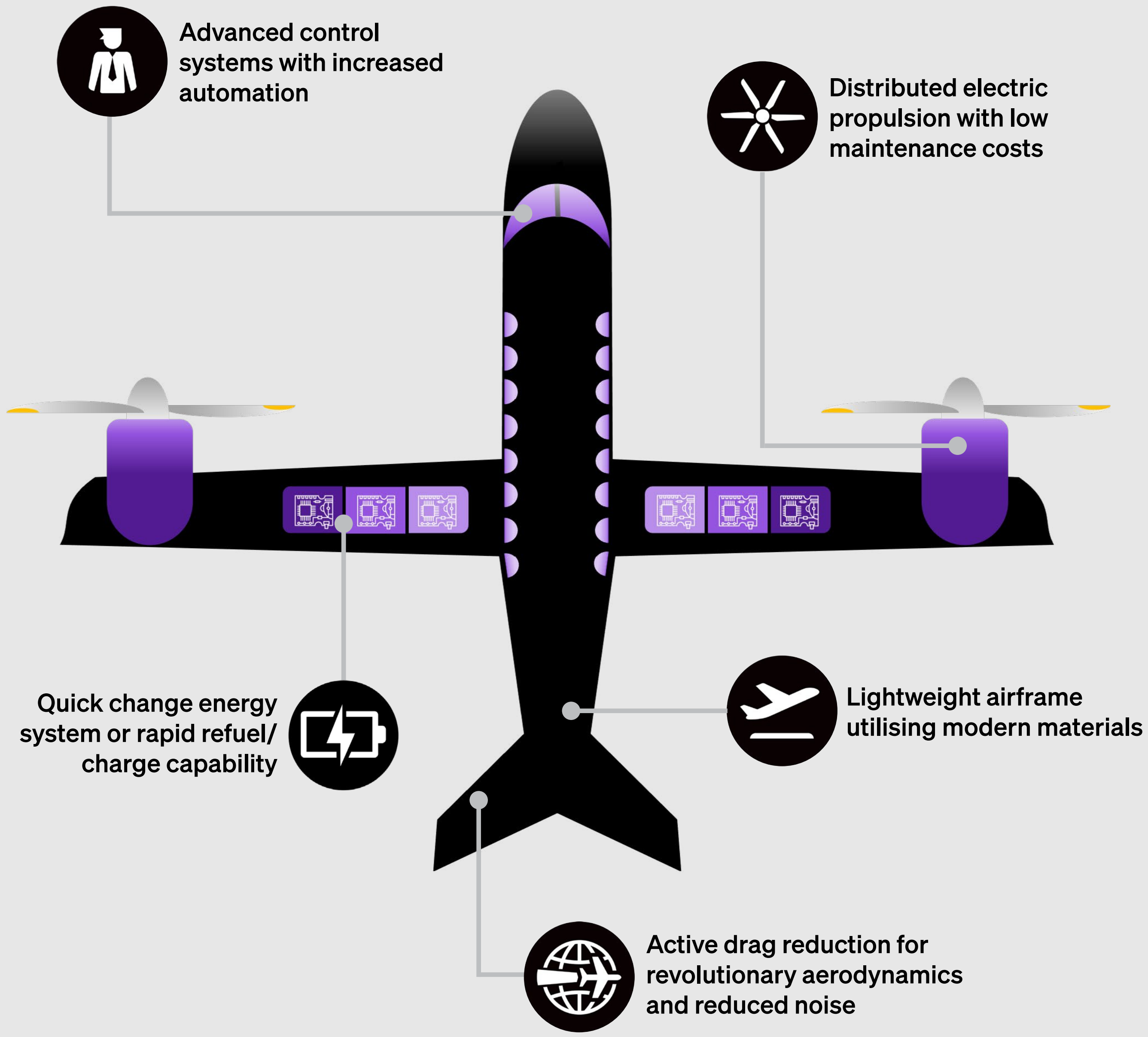
For specific engine performance a fuel burn saving of +15% fuel burn is required to be considered as part of our novel propulsion roadmap (not incremental gains).

We believe that to achieve a material step change will require implementation of revolutionary technology. For the purposes of this PRD engine propulsion improvements are those which only involve systems contained in the nacelle (no other impact to aircraft systems, otherwise it will be considered a full retrofit option).

Air New Zealand aims to move as fast as it can to shift its fleet to lower emissions technology, therefore intermediate steps to update the fleet with more efficient engine concepts may create a net benefit in the transition period while zero emissions aircraft are being developed. This would be considered an early adoption solution.

Novel Propulsion Design Concepts

FIGURE 09



3.6 | Aircraft Propulsion Principles

Background

Air New Zealand currently operates exclusively Jet A1 powered aircraft using the best available present aircraft technology. Powering these existing aircraft with SAF will be critical to the airline's future decarbonisation roadmap.

Novel propulsion technology, however, represents the second largest decarbonisation lever initially focused on domestic missions, but expanding to short haul missions in the future.

Propulsion Technology Principles

Air New Zealand is focused on the novel propulsion concepts described below. Air New Zealand is willing to consider the deployment of all these technologies in parallel, accepting some fleet complexity as a means to reduce total network emissions and understanding each technology concept could be suited to a particular network application.

Battery Electric Propulsion[1]

Electric motors drive conventional propellers powered by electrical energy stored in batteries, which have a much higher energy value chain efficiency compared to fuel cells.

The main attraction of battery electric propulsion for Air New Zealand is the zero emissions from operations. The widespread availability of renewable energy in New Zealand makes this a desirable solution for short range missions with efficient use of energy.

Distributed propulsion is potentially a suitable way to improve efficiency and Air New Zealand considers this to have additional safety benefits with increased redundancy in an engine out situation. Air New Zealand currently only operates twin engine aircraft.

Hybrid Electric Propulsion[1]

Hybrid electric concepts potentially combine the advantages of both combustion and electric propulsion systems, to provide lower emissions solutions, which if applied to larger aircraft may represent a greater emissions reduction across the airline network compared to zero emissions technology with range limitations.

Hybridisation is also a possible intermediary step towards pure electric propulsion. Air New Zealand considers this type of development pathway a viable option for consideration as it allows earlier entry into service of lower emissions technology and provides alignment to the longer term technology, with less risk investing in technology that may quickly become redundant.

Hydrogen Propulsion

The use of green hydrogen technology concepts as the primary energy source for aircraft propulsion has recently gained significant market attention (refer Table 13). Green hydrogen is a key lever in Air New Zealand's decarbonisation roadmap with a emerging green hydrogen supply chain in New Zealand being led by the renewable energy sector.

Air New Zealand believes that green hydrogen should be the predominant form of hydrogen produced domestically in the future. Green hydrogen has the right sustainability credentials to decarbonise aviation in New Zealand. While we recognises the energy inefficiencies and costs associated in electrolysis and fuel cell losses, we believe it provides the most viable long term solution. As such, Air New Zealand supports investments focused on green hydrogen development over other low carbon hydrogen sources, as we believe the limited resources available should be allocated to the most viable long term solutions.

The network Air New Zealand operates is well suited to the greater payload range offered by hydrogen aircraft propulsion. In particular, there is benefit in the greater reserve fuel capacity of these aircraft and the ability to access a wider range of locations (this is especially important in New Zealand's challenging weather and terrain environment).

The poor volumetric energy density of hydrogen is a trade-off to be considered, and therefore Air New Zealand supports both gaseous and liquid hydrogen concepts. We believe the weight and volume savings from cryogenically cooled liquid hydrogen systems offer the best payload range and emission reduction outcomes in the long term.

Fuel cells: the use of green hydrogen for zero emissions aircraft propulsion is considered the most appropriate application for hydrogen in the short to medium term due to the synergies with the electric motor technology emerging.

Combustion: there are significant efficiency savings to be gained by using hydrogen as a direct combustion fuel in modified conventional thermal engines. Air New Zealand considers this a possible use case for hydrogen especially for narrowbody aircraft and larger aircraft concepts.

TABLE 13

Energy	Energy Use
Battery	100% Electric
	Hybrid Electric
Hydrogen	Hydrogen Fuel Cells
	Hydrogen Combustion

Footnotes
1. IATA Waypoint Study

3.7 | Navigational & Avionics Principles

Background

New Zealand's airspace system is already very efficient, benefiting from a relatively uncongested traffic environment, designed around modern Performance Based Navigation (PBN) principles. Despite these benefits, the airspace system must contend with the operational challenges that result from significant mountainous terrain, frequent adverse weather events and a small network of airports, with only four commercial airports supporting precision ground based navigation.

The New Southern Sky (NSS) programme was launched in 2014 and has led a technological transformation of the airspace system, expected to be complete by 2025[1]. The NSS programme is introducing new PBN, surveillance and communication standards across New Zealand's domestic and oceanic FIR's.

From 2025 New Zealand's domestic airspace will be characterised by the following:

- RNP2 navigation standards for all domestic en route airspace.
- RNP1 navigation standards for all terminal procedures.
- Mandatory ADS-B surveillance.
- SBAS capable[2] approach and departure procedures at regional airports with RNP with APV where possible based on Baro-VNAV.
- RNP-AR approach procedures (RNP<0.3) at selected domestic airports.

Airport Navigational Facilities | 2025-2030

TABLE 14

Airports	ILS/GLS	RNP-AR	RNP APV	SBAS	Navaids[1]	Controlled Airspace
AKL, WLG, CHC	Y[5]	Y	Y	N[4]	Y	Y
DUD	Y[5]	N/Y[2]	Y	N[4]	Y	Y
ZQN	N	Y	Y	N[4]	Y	Y
HLZ, TRG, ROT, GIS, NPE, NPL, PMR, BHE, NSN, IVC	N	N/Y[2]	Y	Y	Y	Y
KAT, KKE, WRE, WHK, TUO, WAG, PPQ, MRO, HKK, WSZ, TIU, OAM, WKA, TEU	N	N[2]	Y[3]	Y	N	N

Notes to Table 14
1. Excludes NDB installations
2. It is hoped further RNP-AR procedure design will expand to regional airports
3. RNP approaches with vertical guidance to low minima will be dependent on SBAS deployment
4. SBAS roll out for ILS capable airports possible beyond 2030
5. For WLG and DUD, ILS approach capability may not be replaced in favour of RNP-AR technology

Footnotes
1. https://www.nss.govt.nz
2. Dependant on New Zealand SBAS rollout

Design Principles

Initial scoping of novel propulsion aircraft technology highlighted potential compromises in both aircraft performance and economics when compared to conventional aircraft today. In order to minimise the impact of these trade offs, Air New Zealand considers advanced navigation and avionics capabilities as being a key design principle allowing the performance and economic trade offs to be minimised.

This section has been split into two discrete focus areas, navigation and avionics principles. In order to maximise the benefits of novel propulsion aircraft and leverage the future airspace capabilities, Air New Zealand would expect to see these design principles considered in future aircraft designs.

Navigation Design Principles

Key to maximising the benefits of zero emissions aircraft will be ensuring maximum range, thus allowing a greater number of current domestic routes to be substituted away from conventional aircraft. To realise this goal, the following navigational design principles are sought:

1. Navigation capabilities that meet modern commercial aircraft minimum standards.
2. Navigation capabilities that allow aircraft to benefit from most advanced PBN standards and reduce total mission track miles.
3. Navigational tools that reduce flight crew workload and improve situation awareness, i.e. FMS, advanced nav displays.
4. Navigational capabilities that increase all weather capability, thus reducing reliance on alternate airports.

Potential Technology Enablers

- Advanced RNP and ADS-B capability meeting global PBN and surveillance equipment standards, enabling efficient flight planning and reduced en route track miles.
- RNP-AR capability enabling reduced arrival and departure track miles, greater operational certainty, and lowering alternate airport weather criteria.
- Augmented GPS capable, including SBAS and GBAS enabling reduced arrival and departure track miles, greater operational certainty, and lowering alternate airport weather criteria.
- Advanced real time weather uplink and onboard detection capability, enabling pre-emptive tactical weather avoidance, minimising total track miles and reducing the likelihood of en route diversion.
- Robust system redundancy through traditional systems such as, IRS ILS, VOR type systems.

Avionics and Communications Design Principles

In order to mitigate any potential commercial limitations, Air New Zealand would look to see advanced avionics communications incorporated in future aircraft designs. The airline would expect these capabilities to provide safer operations, greater dispatch reliability, lower maintenance costs and reduced crew costs when compared to conventional aircraft available today. To realise this goal, the following design principles are sought:

1. Avionics and communication capabilities that meet standard capabilities in modern commercial aircraft today.
2. Modern flight deck connectivity allowing instantaneous bi-direction exchange of digital information.
3. Advanced three dimensional auto flight capabilities with full FMS integration.
4. Automation capable of supporting single pilot operations (on smaller aircraft) while meeting Air New Zealand's safety requirements, including mitigations for pilot incapacitation.

Potential Technology Enablers

- For single pilot aircraft, new cockpit automation, emergency augmented GPS autoland functionality, or cabin crew intervention, ground based pilots etc.
- Airborne traffic awareness tools and collision avoidance capabilities, i.e. advanced TCAS systems, and ADS-B technology and E-GPWS terrain avoidance capability.
- Flight envelope protection.
- Portable EFB integration.

3.8 | Systems & Airframe Design

New Zealand Context

The Air New Zealand fleet has always been made up solely of traditional fixed wing, twin engine aircraft with tube and wing aircraft designs. With the emergence of novel propulsion and advanced airframe concepts Air New Zealand accepts the optimisation of existing aircraft topologies has nearly reached its potential.

Air New Zealand is realistic about the challenges involved in rapid system advancements with any new technology, demanding a high level of safety and risk analysis given the novelty and lack of operational test data.

Air New Zealand is interested in full life cycle cost and environmental impacts of the aircraft concept (full cradle to grave sustainability).

Aircraft Systems Principles

Future aircraft development will require a step change in system design to optimise energy use and maximise the overall power to weight ratio.

Systems which optimise energy use, improve safety, increase reliability and minimise turnaround time are all attractive propositions to focus development.

Airframe Design Principles

Modern materials and understanding of airframe structures has also advanced to a stage that suggests future aircraft implementation should leverage incremental efficiency gains to minimise airframe weight and maximise payload range potential of zero emissions aircraft.

Structures which are designed not just for performance, but also life cycle maintenance are desirable with easily repairable structures, with accessibility to key systems for removal and repair.

Passenger comfort and operational resilience are also key considerations for Air New Zealand to maintain passenger satisfaction, develop trust for zero emissions aircraft and manage terrain and weather environmental factors.

<BACK TO CONTENTS

System and Airframe Requirements

TABLE 15

System Design		
Description	**Air New Zealand Insights**	**Preference**
Icing protection systems	Certified for flight in icing conditions and any performance degradation impact highlighted	**No preference**
Landing gear and brakes	Triple redundancy retractable gear systems or fixed gear are both acceptable	**No preference**
Lighting	Standard certified lighting requirements	**No preference**
Flight controls	Preference for fly by wire systems with appropriate levels of systems redundancy	**Fly-by-wire**
APU vs ground power	Current Ground Power: • ATR72-600: utilises engine power for ground power by switching to 'hotel mode' on the ground • Q300: features a separate APU in the tail cone	**Ground power**
Battery swaps vs charging	Battery accessibility is important for battery swaps overnight or for battery upgrades (once higher energy density is available)	**Charging**
Mobile vs fixed charging/fuelling	Existing fuelling is done via mobile truck however for battery charging concepts it makes sense to have charging at the gate due to the energy connection required to the grid	**Mobile for fuel, at gate for charging**
Hydrogen fuelling vs capsules	Hydrogen logistics are viewed as a major hurdle for fleet integration and will be dependent on hydrogen production proximity	**No preference**

Airframe Design		
Description	**Air New Zealand Insights**	**Preference**
Pressurisation	• For engine efficiency, weather avoidance and passenger comfort, cruise altitudes above 10,000ft are preferred • Terrain also presents MSA requirements >FL150 on some routes	**Pressurised**
New aerodynamic systems	• Boundary layer ingestion • Winglet technology • Optimal wing aspect ratio • Increased L/D ratio	**No preference**

3.9 | Enabling infrastructure Principles

Background

Air New Zealand's Approach to Enabling Infrastructure

Initial scoping of novel propulsion aircraft deployment in New Zealand highlighted the scale of infrastructure investment required to enable their deployment. For decades airlines have benefited from a reliable energy supply chain, however, future energy needs will demand new partners, new cost structures, new airport infrastructure and new processes.

Air New Zealand is adopting a two staged approach to addressing these future energy infrastructure uncertainties. The first step is the release of this PRD process, with information gained used to inform the commercial viability and resultant on and off airport infrastructure needs. Post the PRD, Air New Zealand will expand engagement to include airports, energy providers and supply chain partners to ensure the enabling eco-system readiness is in line with aircraft technology.

New Zealand Airports Context

New Zealand's has less than 30 airports suitable to regular commercial air services. Of these airports the vast majority are small and regional airports which are primarily owned by their local councils,[1] while the three largest airports have a mix of ownership structures both private and public. The operation of smaller regional airports is commercially challenged, as such the deployment of novel propulsion aircraft requires significant investment in new infrastructure, presenting funding challenges.

New Zealand Energy Supply Chain

As described in the introduction, New Zealand benefits from a large proportion of grid sourced renewable electricity (>80%), with a government pledge to reach 100% by 2030. This capability enables true zero emission aircraft deployment with total value chain emissions capable of reducing to zero, as opposed to shifting higher up the value chain. For the purposes of this PRD, Air New Zealand is focused on understanding proposed enabling infrastructure requirements and solutions that are cognisant of New Zealand's energy system, i.e. battery charging needs or hydrogen refueling requirements.

Economic Analysis

The requirements stated in this section of the PRD should be accurately costed in PRD Response Document to allow analysis of total network costs in addition to direct operating costs.

Turn around time: 30mins, or less required

Airport Categorisation

Adapted from NZ Airports Association Report[2]

TABLE 16

	Isolated Airport	Regional Airport	Large Regional Airport	International Airport
Features	Sole scheduled air service, often funded by or subsidised by local council	Limited number of commercial operations, serving a small number of destinations	Multiple commercial operations, serving multiple domestic destinations	Multiple commercial operations, serving multiple destinations including international
Passengers per annum	<200k	200-500k	500-1M	>1M
Current capability to invest in new Infrastructure	**Limited**	**Marginal**	**Strong**	**Very Strong**
Examples	KAT, KKE, WHE, TUO,WAG, MRO, PPQ, HKK, WSZ, TIU, OAM, WKA, TEU	HLZ, TRG, ROT, GIS, NPL, IVC, BHE	NPE, DUD, NSN, PMR	AKL, WLG, CHC, ZQN

Footnotes

1. NZ Airports Association
2. Long White Cloud NZ Airports Position paper

<BACK TO CONTENTS

Enabling Infrastructure Design Principles

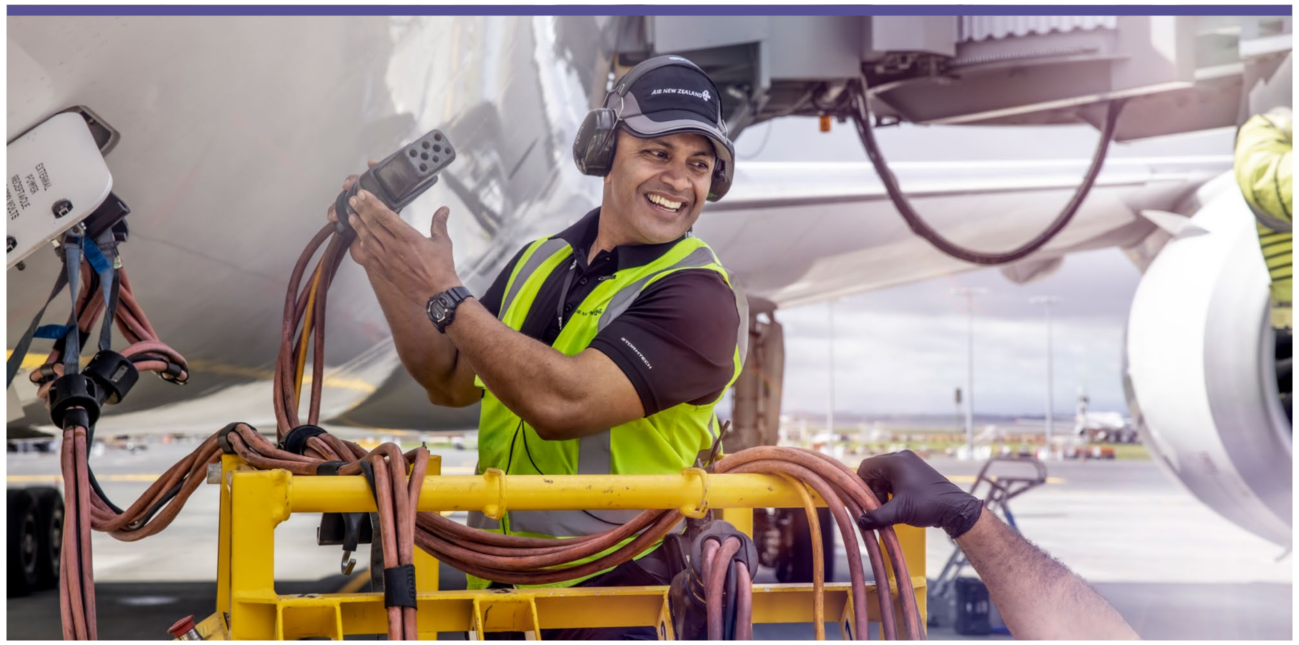
Air New Zealand has developed these key design principles to minimise the burden of infrastructure investment where feasible while also remaining open to novel and innovative concepts to support the future energy demands of future zero emissions aircraft.

Airport design considerations

1. Given the investment challenges outlined, Air New Zealand would look to minimise the initial investment burden where possible. In cases where airport infrastructure needs to be developed, solutions should maximise cross functionality and longevity. This will ensure the costs of the enabling airport infrastructure can be shared amongst a range of airport users over a longer life time (e.g. common charging points).
2. Infrastructure designs should minimise total value chain emissions, meaning either New Zealand's grid energy is used or bespoke energy generation is coming from renewable sources.
3. Infrastructure should be designed in a way which does not place onerous manpower needs on airports. Air New Zealand would look to see this new infrastructure be supported with ground crew needs of current aircraft.
4. Safety and Emergency Infrastructure: Additional fire fighting equipment/solutions for electrical/ hydrogen incidents will need to be considered where applicable.

Aircraft designs

1. To minimise capital investment at airports, aircraft designs should be capable of conforming within existing airport tarmac and gate footprints throughout Air New Zealand's domestic network, i.e PCN limitations, and wing/wheel span limits for gates. Air New Zealand's existing turboprop fleet meets airport Code C requirements and require PCN ratings of greater than 12.
2. Aircraft designs should look to minimise the burden on ground crew, the use of innovative technology to optimise baggage handling, streamline passenger disembarkation and reduce the need for supporting ground handlers. Such designs will improve the business case for new aircraft.
3. In order to minimise airport capital investment and ground crew support costs, aircraft specifications should consider (where feasible) maximising opportunities to tanker energy on sectors which allow. The PRD Response Document should be used to illustrate the cost benefit of tanker sectors using the example missions provided.
4. Aircraft designs should be optimised to minimise airport turn around time. Any solutions which reduce charging time, refuelling time and enables greater aircraft utilisation would be favoured.
5. In cases where the aircraft is not capable of being powered by its own power source, provisions must be made for ground power support through conventional GPU solutions.



3.10 | Type Certification Basis

Background

Air New Zealand operates within the Civil Aviation Authority of New Zealand (CAA NZ) regulations which are based on the ICAO guidance.

Air New Zealand has a good working relationship with CAA NZ and all the major global regulatory bodies for aircraft importation, operation and maintenance in New Zealand, including arrangements with EASA and the FAA.

Zero Emissions Aircraft Certification

New aircraft designs will need to fit within this New Zealand framework and early engagement will be required with CAA NZ between all parties.

The regulatory authorities must work collaboratively across the aviation industry to establish a path for zero emissions technology development with equivalent safety standards acceptable to airlines. The initial airworthiness certification for electric powered aircraft presents significant challenges, given the novel systems involved compared to conventional aircraft.

An important task to be performed early on in an electric powered aircraft project will be to assess the certification basis. Air New Zealand recognises that there are currently no specific requirements for electric aircraft propulsion and storage and transmission of significant amounts of electrical energy. The appropriate requirements will either have to be adapted from corresponding fossil fuel aircraft requirements or written anew in certain cases.

Broadly, the certification basis for novel propulsion aircraft will consist of:

1. Existing certification requirements which will apply unchanged; and
2. Existing certification requirements which will be adapted to electric propulsion; and
3. New certification requirements for electrical propulsion ("Special Conditions," "Certification Review Items"); and
4. Unique certification requirements for the specific project.

It is expected the pathway to certification will evolve as technology readiness increases, however, close alignment between manufacturers, and regulatory authorities in New Zealand will be required.

For retrofit concepts, a SB (Service Bulletin) from the OEM would be preferred or STC with OEM support for data and intellectual property access.

Certification Basis in a New Zealand Context

Currently, Air New Zealand operates Part 25 FAA and CS-25 EASA type certified aircraft which have been type accepted by CAA NZ to operate within New Zealand.

The details from AC21-1 below outline the categories of aircraft able to be operated within New Zealand for hire or reward (the equivalent of 'common carriage' in the FAA system.

AC21-1 Product Certification - Type Acceptance Certificates

Only aircraft in the standard or restricted category are eligible for hire or reward operations under Part 91 and only aircraft in the standard category are eligible for air transport operations under Parts 121, 125 or 135. Aircraft are only eligible to be issued with an airworthiness certificate in the standard or restricted category if they have been type certificated in New Zealand or type certificated in a foreign country and subsequently type accepted in New Zealand.

Design Standards - Standard Category

For the issue of a standard category type acceptance certificate, the set of airworthiness and environmental standards are prescribed in Part 21, Appendix C (a) and include:

- FAR Parts 23 to 35 inclusive
- Airworthiness standards that are found by the Director to:
  - Comply with the International Civil Aviation Organisation (ICAO) Annex 8 requirements; and
  - Provide levels of safety equivalent to the basic airworthiness standards of the FAR Parts 23-35

Equivalent Airworthiness Standards

Although the basic design standards are the FARs, the CAA NZ Director accepts as equivalent the standard which were in force at the time the type certificate was issued.

The CAA NZ Director also accepts as equivalent British or European design requirements, or their earlier versions.

Sets of standards accepted by the Director as being equivalent standards for the issue of a standard category type acceptance certificate are listed in AC21-1[1].

Footnotes

1. AC21-1 Product Certification - Type Acceptance Certificates (CAA NZ)

3.11 | Operational Certification Standards

Air New Zealand Flight Operations

Air New Zealand operates under a single Part 119 Air Operators Certificate issued by the Civil Aviation Authority of New Zealand (CAA NZ). Based primarily in Auckland, New Zealand, other listed bases include Christchurch, Nelson, Napier, New Plymouth, Tauranga, and Wellington.

All Air New Zealand aircraft are currently operated under Part 121 Air Operations for large aircraft. Air New Zealand will adjust this as required for integration of small or medium aircraft - the Q300 is currently the smallest aircraft in the fleet with 50 seats, however the B1900 was previously operated under Part 125 until its exit from the fleet in 2016.

Flight operations are all designated as IFR.

Flights are predominantly operated as scheduled passenger services and cargo transport, however other service types are designated in the certificate for non-regular (charter) flights for passengers or cargo.

Note – NZ Part 125 relates to 119 operations dependant upon aircraft size and single engine IFR, NOT large aircraft conducting operations other than common carriage, as is the case in the FAA system.

Air New Zealand Support Capabilities

Air New Zealand has world leading maintenance, design, training and continuing airworthiness capabilities covering relevant disciplines including mechanical, interiors, and avionics systems.

Air New Zealand has a certificated Part 145 maintenance organisation responsible for providing maintenance support functions throughout the Air New Zealand international & regional route structure and for customer airlines.

These capabilities offer potential engagement options for zero emissions aircraft development as technology readiness progresses and operational considerations are sought.

Current Air New Zealand Air Operating Certificates

Part 119 Air Operator Certification

- Stipulates the requirements for operators to become certificated in air transport operations.

Part 121 Air Operations Large Aeroplanes.

- A seating configuration of more than 30 seats, excluding any required crew member seat; or,
- A payload capacity of more than 3410 kg.

Other CAA NZ Rules

Part 125 Air Operations Medium Aeroplanes

- A passenger seating configuration of 10 to 30 seats; or,
- A payload capacity of 3410 kg or less and a MCTOW of greater than 5700 kg; or,
- A single engine and is conducting hire or reward operations using IFR.

Part 135 Air Operations

- An aeroplane with a seating configuration of nine seats or less, excluding any required crew member seat; and a MCTOW of 5700 kg or less.
- Except for a single engine aeroplane used for an air operation carrying a passenger under IFR.

3.12 | Life-cycle Maintenance Requirements

Background

Air New Zealand currently manages life cycle maintenance from within the Engineering and Maintenance division of the airline based in Auckland and Christchurch.

The majority of maintenance for turboprops and narrowbody aircraft is completed internally with dedicated facilities for light maintenance located in Auckland and Christchurch, and heavy maintenance in Christchurch, which also has an APU repair and overhaul facility.

Air New Zealand has excellent back shop capability with large composites repair facilities in both Auckland and Christchurch, power electronics labs and avionics testing/ certification.

Engine overhauls, widebody heavy maintenance and landing gear overhauls are currently all outsourced.

Air New Zealand operates within an intensive coastal environment which creates a challenging maintenance burden due to the susceptibility of corrosion and the intensive maintenance tasks required for inspection and repair.

Airframe Maintenance Principles

For existing aircraft in the Air New Zealand fleet the maintenance requirements are well understood therefore retrofit solutions may provide ease of transition for maintenance processes, however, ageing airframes represent risk and increasing cost depending on OEM service arrangements.

Clean sheet designs represent an opportunity to optimise maintenance characteristics with modern structures having less parts and complexities, minimising corrosion and other ageing effects.

For zero emissions aircraft, ideally Air New Zealand will be able to carry out airframe maintenance within existing frameworks and standard repairs will be specified in a typical Aircraft Maintenance Manual (AMM).

Engine/Motor/Fuel Cell Maintenance Principles

Currently engine maintenance is carried out by third party providers for the engines in the operating fleet.

The key considerations for new motor designs are as follows[1]:

Novel technologies may require service contracts with the OEM or development of internal capability to service and maintain new specialised propulsion systems (e.g. fuel cell systems).

It is assumed that all components for electric aircraft will be designed according to the high safety standards mandated by the relevant regulatory authorities. Given the degree of reliability expected by the market for modern aviation, all components such as the electric motors, power electronics, and cooling systems will need to be produced with high-quality materials and robust designs.

The electric motor does not need the same inspections as is required for popular conventional combustion turboprop engines. It may, however, be expected that components like bearings will need to be replaced during the aircraft's lifetime and damages can occur by foreign particles/objects entering the motor.

Since the lifetime of commercial aircraft is long and electric propulsion is at an early stage the motor may as well be replaced with newer and more efficient technology after a certain time.

Maintenance Scenario Assumptions for 20 year aircraft life

TABLE 17

Aircraft Option	Flight Hours / Cycle Ratio	Annual Utilisation hrs	Av. Daily Sectors
1. Early Adoption	0.75:1.0	1,900	7
2. Supplementary	0.9:1.0	2,300	7
3. Replacement	0.9:1.0	2,750	8

Footnotes

1. Introduction of Electric Aviation in Norway, March 2018

<BACK TO CONTENTS

3.13 | Customer Accommodation Requirements

Context of New Zealand Market/Customers

Air New Zealand carried 18 million passengers annually in FY19 (pre-Covid), of which 65% were domestic passengers.

Domestic departures represented 85% of flight departures in FY19 (approximately 30% of total passenger revenue), highlighting the importance of the domestic operation and in particular the turboprop aircraft to connect customers across the wider network.

Customer Principles

Air New Zealand has a strategic focus on the customer experience and satisfaction with future initiatives covering:

A. Continued customer obsession, with new and enhanced product offerings.

B. Recognising the importance of the loyalty programme, Airpoints™, which provides a critical customer base while driving engagement and retention. This offers a portal for customer insights across a wide range of customers to understand future travel trends.

C. Future focus on digital customer solutions:

- Investing in digital solutions to put greater control and flexibility in the customer's hands.
- Enhance the customer travel experience through innovations across our digital infrastructure.

A large part of this next generation technology development is the question of whether passenger will be willing to initially fly in an electric aircraft when the tech is first implemented – we do not have a definitive answer to this yet and may need to do some in depth market research to understand this more over the coming years.

<BACK TO CONTENTS

Customer Accommodation Requirements TABLE 18

Specification	Trade-off Details	Preference
Safety	Safety is fundamental to any new aircraft concept and critical from and a customer expectation perspective.	Critical
Seating	Single class economy with drop down tray table functionality (no recline). Air New Zealand's current seat pitch is +30" on the existing turboprop fleet.	Important
Lavatory (toilets)	Required for aircraft with >20PAX or flight times >1hr. For aircraft at the upper end of the range e.g. 19PAX the trade-off between a toilet or additional payload would be useful to understand.	Important
Oversized baggage	The domestic network relies on seamless connectivity between domestic routes and regional routes. Oversized baggage is able to be taken on all flights currently. Air New Zealand accepts that some items may not be able to be carried by passengers on smaller aircraft concepts however items such as wheelchairs, strollers, child car seats, and sports equipment would improve the customer proposition and network connectivity if able to be carried.	Important
Air conditioning	Required in some form for passenger comfort. New Zealand has a variety of climate conditions which require cabin heating/cooling throughout the year.	Important
Noise	Cabin noise less than < 79 EPNdB (Q300 benchmark).	Important
Catering	Nil for aircraft <20PAX. 20+ seats: Half tray meal service, beverages.	Secondary
Overhead bins	Preferred on aircraft with 20+ seats to enable customer baggage consistency across the wider network. Not essential for aircraft <20PAX. There is a boarding efficiency benefit from not having passenger access to lockers, but if no overhead bins are available, under seat storage is required for a passenger carry on bag of 7kg.	Secondary
IFE/WiFi	IFE not required. WiFi not required for aircraft concepts in this PRD. Future proofed WiFi capability would be preferred.	Secondary

3.14 | Operating Cost Comparisons

Fleet Replacement Background

Typically a 20-30% VoC/ASK benefit over the incumbent technology is required to justify a fleet replacement.

A lower PAX aircraft is always going to have difficulty competing on a per PAX cost basis.

The usual benchmark aircraft would also be the newest technology in the fleet, however, certain concessions will be made to enable early adoption of new technology.

Zero Emissions Operating Cost Principles

Air New Zealand will be using the DHC-8-Q300 operating economics as a benchmark reference for evaluation and comparison of alternatives.

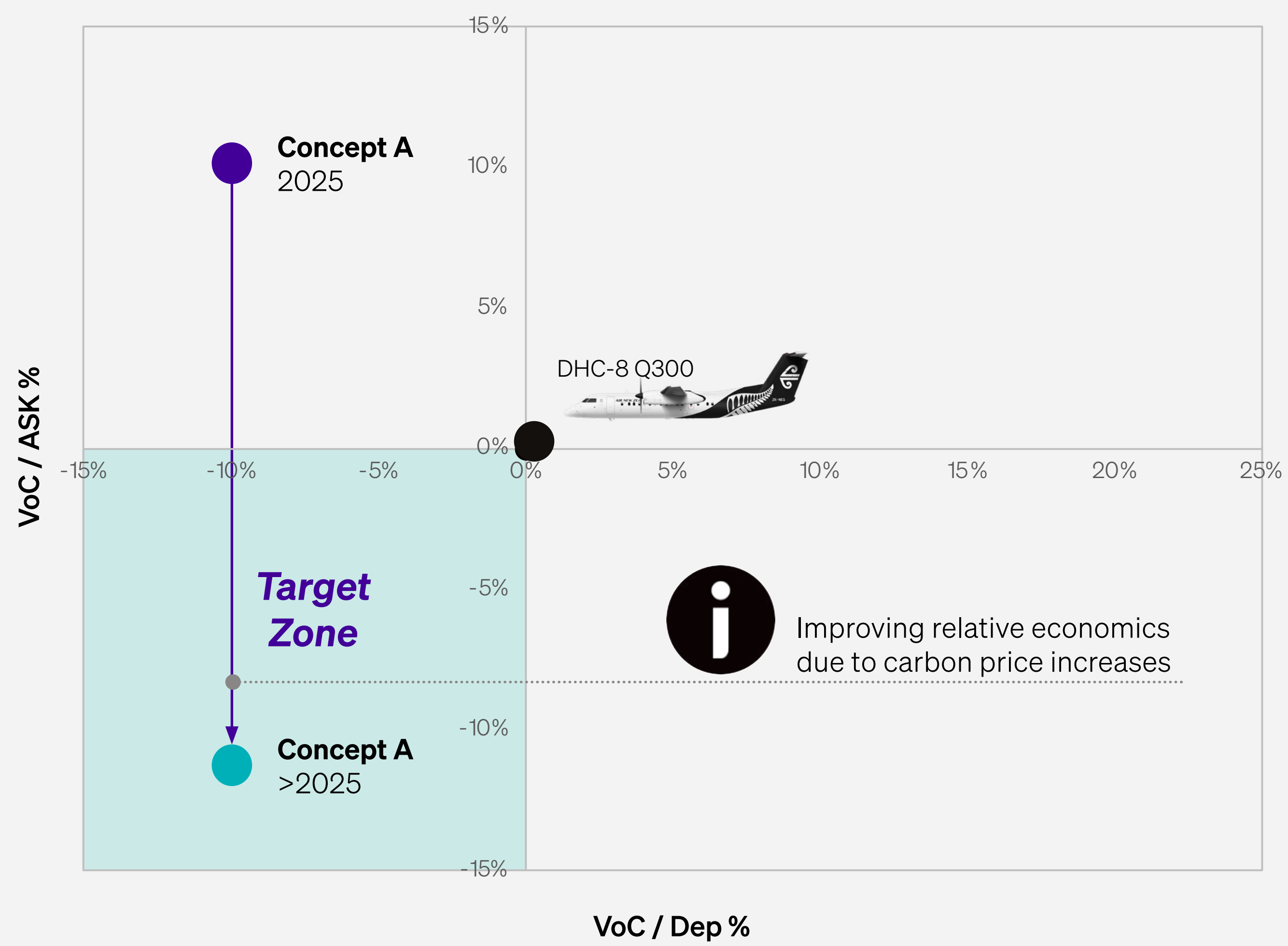
Electric aircraft propulsion powered via battery or green hydrogen relies on electricity costs in the respective market, and presents a reduction in the direct energy cost for zero emissions propulsion utilising electricity as the base energy source.

The cost of fuel and carbon also needs to be considered for comparative analysis and future assumptions used by Air New Zealand as of December 2021 are outlined below (note fuel is set constant for simplicity with carbon price increased over time):

Operating Costs Assumptions TABLE 19

Metric	2021	2027	2035
NZ Fuel Price	$2.0USD/USG	$2.0USD/USG	$2.0USD/USG
NZ Electricity Price	$100NZD/MWh	$75NZD/MWh	$50NZD/MWh
NZ Hydrogen Price	$10NZD/kg	$6NZD/kg	$3NZD/kg
Carbon Price	$70NZD/tonne	$124NZD/tonne	$300NZD/tonne

Q300 relative operating cost comparison CHART 05



Notes
1. VoC includes maintenance, crew, landing/nav fees, energy, and ownership
2. VoC excludes Passenger handling, services and disruption costs

Appendices

<BACK TO CONTENTS

Appendix 1
Nomenclature

Term	Definitions
AAM	Advanced air mobility
APV	Approach with vertical guidance
CAA NZ	Civil Aviation Authority of New Zealand
CEO	Current engine option, refers to Airbus A320 fleet variant
CVR	Cockpit voice recorder
EASA	European Union Aviation Safety Agency
EIS	Entry into service
ELT	Emergency locator transmitter
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FDR	Flight data recorder
FIR	Flight information region
GLS	GPS landing system
IFR	Instrument flight rules
ILS	Instrument landing system
KCAS	Calibrated airspeed in knots
KTAS	True airspeed in knots
LOI	Letter of intent
MCTOW	Maximum certified take off weight
MEW	Minimum empty weight
MSA	Minimum safe altitude
NEO	New engine option, refers to Airbus A320 fleet variant
OEM	Original equipment manufacturer
PAX	Passengers
PBN	Performance based navigation
PRD	Product requirement document
QAR	Quick access recorder
RNP	Required navigational performance
RNP-AR	Required navigational performance, approval required
SAF	Sustainable aviation fuel
SBAS	Satellite-based augmentation system (for GPS augmentation)
STC	Supplementary Type Certificate
TRL	Technology readiness level

<BACK TO CONTENTS

<BACK TO CONTENTS

AIR NEW ZEALAND