Future Sustainable Aircraft

An Outline of Potential Issues for Nelson Airport

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September 9, 2022
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1. Executive Summary

- Nelson Airport is a key driver of the Nelson/Tasman economy.
- 1.07 million passengers used Nelson Airport in 2019 (pre-Pandemic) and 1.8 million passengers are forecast to use the airport annually by 2050.
- The bulk of passenger movements at Nelson are accomplished with Bombardier Dash 8–Q300 and ATR72-600 operated by Air New Zealand Ltd.
- Nelson Airport has one of the shortest runways in the world for Code C aircraft operations.
- On occasion some operations at Nelson are payload constrained by the short 1347 metre runway length.
- Global emissions reduction targets are driving major changes to an industry that has evolved slowly over the last 100+ years.
- New energy sources, aircraft, and powertrain developments are necessary to achieve sustainable aviation goals, especially for short range turboprop equivalent aircraft.
- Essential new aircraft types capable of serving Nelson's high demand market are likely to be larger and heavier than current types for a given configuration.
- It is anticipated that these new aircraft will enter the New Zealand market in the near to medium term (2030-35).
- Nelson's runway, which has limited capability, may not be long enough to sustain the volume of operations necessary to support future demand from these new aircraft types.

The objective of this paper is to provide an outline of the issues confronting regional aviation, specifically at Nelson Airport as global and environmental climate challenges influence the availability and choices of aircraft able to serve the Nelson/Tasman region.

2. Background

Nelson Airport links the Nelson and Tasman regions with the rest of New Zealand. Nelson's remoteness relative to other metropolitan centres combined with limited land access and a lack of marine connectivity has created a high dependence on having a viable airport and robust aviation services. This is evidenced by the volume of passengers transiting Nelson Airport annually which substantially exceed the volume of passengers at every other regional New Zealand airport served by Air New Zealand's Code C turboprop aircraft.

In the year to Mar 31, 2019 (pre the COVID 19 Pandemic) 1.07 million arriving and departing passengers transited Nelson Airport and conservative growth forecasts estimate that by 2050, 1.8 million passengers will pass through Nelson Airport.

The airport is currently served by a number of small airlines with a fleet mix that includes Cessna C208 (12 seats), Pilatus PC12(12 seats), and Jetstream J32(19 seats). The largest operator, Air New Zealand, operates a busy schedule with Bombardier Dash 8-Q300 (50 seats) and (Avions de Transport Regional) ATR72-600 (68 seats) aircraft.

Nelson Airport's main runway is 1347 metres in length, amongst the shortest in the country and unusually, shorter than most airports across the globe accommodating Code C aircraft. This is further constrained by a lack of sufficient land to accommodate larger aircraft. There is a risk that future sustainable aircraft designs will require more runway length than is currently available.

For aviation planning purposes Nelson is categorized as a Code number 3C airport. Aircraft are grouped in categories for planning purposes based on their wingspan and outer Main Gear Wheel Span.

Table 1-1. Aerodrome reference code
(see 1.6.2 to 1.6.4)

Code element 1	
Code number	Aeroplane reference field length
1	Less than 800 m
2	800 m up to but not including 1 200 m
3	1 200 m up to but not including 1 800 m
4	1 800 m and over
Code element 2	
Code letter	Wingspan
A	Up to but not including 15 m
B	15 m up to but not including 24 m
C	24 m up to but not including 36 m
D	36 m up to but not including 52 m
E	52 m up to but not including 65 m
F	65 m up to but not including 80 m

[1]

The smaller aircraft serving Nelson fit within the ICAO Code letter B classification with both the Q300 and ATR72 aircraft operated by Air New Zealand Ltd being ICAO Code C aircraft. On occasion certain weather conditions combined with Nelson's short runway cause payload limitations which compromise the airport's ability to fully support the region's market demand. Going forward Nelson Airport will need to retain the ability to support aircraft in the Code C category with the objective of meeting market growth over time.

The balance of the paper focuses on the practical drivers of the coming changes and how the commercial aviation industry will meet the emissions reduction targets it has agreed to. The paper also explores how those changes will likely influence in some

[1] ICAO Annex 14, 8th Edition, 1.6 Aerodrome Reference Code

way, aircraft design, operational performance, industry behaviour, and potential infrastructure impacts such as a requirement for longer runways at regional airports.

Commercial aviation globally is really on the cusp of unavoidable major change. Air travel currently accounts for 2% of global CO2 emissions and that is expected to rise to between 12 and 27% by 2050. 40% of the worldwide emissions is caused by short haul flying. Flights to and from Nelson fall into this category which is generally considered flights lasting between 30 minutes and 3 hours. It is clear that novel solutions will be required if the aviation industry targets are to be met.

Aircraft that operate in this category are likely to experience the most redesign or re-development in the near to mid-term. i.e., turboprop and single aisle aircraft which are essential to Nelson's continued connectivity over the longer term (beyond 2035).

Due to their inability to operate at Nelson the challenges related to larger aircraft operating medium to long haul flights are not evaluated in this paper.

The next section outlines key dependency options under development for short haul aircraft.

3. Sustainable Aviation and Alternative Fuels

The aviation industry has committed to achieve a reduction of emissions to 2019 levels by 2050. That goal however cannot be met without the industry moving away, where possible, from fossil-based fuels (Jet A) to more environmentally sustainable energy sources or fuel. To meet the emissions reduction targets substantial re-organization of commercial aviation will take place in the period between 2025 and 2035. A variety of solutions will be required which include alternative energy sources, new propulsion systems, technologies, and aircraft designs. These are substantial challenges in a relatively short timeframe for an industry that has evolved incrementally over the last 100+ years. Airlines and airports, as well as the creation of essential regulations and the infrastructure required to support these new types of operations will require considerable investment in resources and funding.

With respect to new energy sources there are three areas of focus for reducing emissions;

Sustainable Aviation Fuel (SAF).

ICAO defines sustainable aviation fuels as renewable or waste derived aviation fuels that meet sustainability criteria[2]. SAF is refined to a specific standard (ASTM D7566 and DefStan 91-91) that enables substitution or blending with the current standard jet and turboprop fuels – Jet A1. SAF is blended proportionally up to a 50/50 ratio with Jet A1

[2] ICAO, Annex 16 - Environmental Protection, Volume IV, Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

and is usable (drop-in) with today's jet and turboprop powertrains. It is also accepted that SAF is not a fully carbon neutral solution to aviation's challenges[3].

There are also a number of challenges with respect to SAF. SAF production today, derived from waste materials such as cooking oils is 0.1% of the current 330 million tonnes[4] global demand for Jet A. Adequate non fossil feedstock supply and a reported production cost 8 times that of Jet A fuel types are substantial issues to be overcome. While there are potential alternatives for short haul flying, SAF is likely to be the only viable option for medium to long-haul commercial jet operations for the foreseeable future. Given SAF production cost and associated availability challenges operators will probably seek to adopt alternative fuel and power options for smaller aircraft wherever possible.

Battery/electric;

The use of current technology batteries for aviation is hampered by battery weight and insufficient sustainable output to support payload/range considerations for anything other than short flight sectors. Battery energy outputs presently are approximately 2% of aviation fuel energy (9.6 kWh/litre) and substantial gains in battery technology are required to support larger (battery) aircraft and improved payload/range capabilities. This technology which is driving new smaller aircraft designs is most suited to aircraft in the 12 – 20 seat group and route lengths of 100 – 150nm. These aircraft, while delivering a zero emissions solution can serve shorter routes such as Nelson or Blenheim/Wellington but due to their limited seat capacity will be unable to fully accommodate Nelson's high demand volumes. Notwithstanding these limitations Sounds Air has announced that it has signed a Letter of Intent with Heart Aerospace for three of Heart's proposed ES-19 electric aircraft currently under development. Certification is targeted for 2026.

Hydrogen;

Hydrogen (120MJ/kg) has higher energy by mass than jet fuel (43MJ/kg) but has lower energy by volume which poses storage challenges for use in aircraft in either gaseous or liquid form.

On an energy equivalence basis hydrogen is also currently more expensive than jet fuel however as hydrogen production expands to meet expected demand from multiple sources (land, marine, and aviation) the price will become more competitive than fossil fuels, including blended SAF.

Hydrogen can be used as a combustion fuel; trials having been undertaken last century in the 1950s (NASA) and 80s (Aviakor). Hydrogen burnt as combustion produces NO_x

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[3] IATA, Sustainable Aviation Fuels, Fact Sheet 5

[4] https://www.forbes.com/sites/michaelgoldstein/2021/09/23/can-oil-industry-giants-like-shell-provide-sustainable-jet-fuel-by-2025/

and consequently does not benefit the aviation industry's emissions reduction challenge. This will likely render hydrogen as combustible fuel, absent any mitigation solutions, a non-starter and hydrogen/fuel cell combinations a more likely solution for aviation short haul operations.

Green hydrogen, rather than blue and grey hydrogen does offer the potential to enable short haul aircraft such as the Bombardier Dash 8-Q300 and ATR72 that currently serve Nelson to utilize hydrogen/fuel cell/electric powertrains for a sustainable zero emission outcome, albeit with presently unspecified runway performance.

The use of hydrogen in aviation has significant but resolvable challenges before it can be applied to commercial aviation. Resolution of these will also drive new powertrain and aircraft designs.

Other Related Challenges

There are a number of additional challenges confronting aircraft manufacturers in the development of new technologies which makes the exact timeline for introduction uncertain, albeit the climate urgency does dictate that solutions are developed as quickly as possible. These include;

1. Regulatory safety and certification systems which have been geared towards the incremental development of aviation technology since the inception of modern flight need revision and adaptation. Electric motor technology and the potential use of non-traditional fuels such as hydrogen in aviation requires new understandings, regulation design, and acceptance.
2. Development of more advanced and sustainable batteries.
3. Development of more powerful electric powertrains suitable for aviation use, whether they be battery or hydrogen dependent. Current designs fall well short of required power outputs to support existing large turboprop sized aircraft. For example, 40-70 seat aircraft similar to the Dash 8-Q300 or ATRs operated by Air New Zealand will require certification of 1.8 – 2 Mw electric motors still in development.
4. New larger turboprop equivalent aircraft, either new designs or conversions, will likely utilize green hydrogen combined with fuel cells to produce the required power outputs for larger aircraft electric motors.
5. Additional challenges in utilizing hydrogen for aircraft include the storage volume required for economic route lengths where gaseous hydrogen is used, the ability to store liquid hydrogen at -253°C, combined with the weight penalties that arise from storage solutions and fuel cell/electric motor combinations that are substantially heavier than existing turboprop technology.

4. Nelson's Future Needs

Nelson is well served currently by Air New Zealand's Q300 and ATR fleet with multiple daily services to Auckland, Wellington and Christchurch where passengers connect with flights to other New Zealand and international destinations. It is the only New Zealand based operator with sufficient aircraft size and capacity to support the region's passenger demand.

Nelson's current runway length of 1347 metres limits options to accommodate future growth with any aircraft larger than an ATR72. The only other aircraft type that might be considered for Nelson operations as an alternative to the ATR is the Bombardier Dash 8-Q400 series with 80-90 seat configurations. There are no Q400 aircraft operating in New Zealand at present and importantly the required runway length for this aircraft at maximum take-off weight is approximately 1425 metres, longer than Nelson's current runway. Operation of this aircraft, should it enter service in New Zealand, would likely necessitate payload restrictions at Nelson.

The present runway limitation has the potential to constrain future passenger growth and further inhibit the already limited ability to support exports of Nelson's agriculture and marine products. With forecast growth to 1.8 million annual passengers by 2050 the Nelson region is dependent on a number of variables;

1. Frequency increases of existing aircraft;
2. Additional fleet being acquired by its current supplier;
3. Larger aircraft with further infrastructure development; or
4. The introduction of new operator(s).

This last point is best understood with an understanding of airline fleet practices using the existing largest aircraft at Nelson, the ATR72-600 operated by Air New Zealand, as a surrogate.

Market demand and annual growth drives airlines to add capacity through additional frequency or larger aircraft. Initially airlines will adjust their schedule designs within their existing fleet (ATR) serving an airport to optimize aircraft and resource utilization and capitalize on any available excess capacity. Eventually this may lead to multiple flights at peak demand times, assuming sufficient aircraft are available which in itself may justify a larger aircraft at peak times.

Absent excess existing ATR fleet capacity, the airline operator will evaluate the availability of excess capacity in its other fleets and the feasibility of utilizing that to meet demand. Assuming of course that the alternative aircraft is capable of using Nelson's runway. If this is not achievable it may be necessary to increase the ATR fleet numbers by acquiring additional aircraft of the same type, re-organizing its fleet use to the detriment of other routes, or considering other aircraft types that might suit the purpose.

Influencing any up-gauging of aircraft type will be the seat configuration of the larger aircraft and the volume of seats that are likely to be introduced into the market. With the ATR being the largest aircraft capable of operating commercial services at Nelson the next largest available aircraft currently in the New Zealand market is the Airbus A320 (2 operators) which has 171 seats compared with the ATR's 68 seats, a 151% seat capacity increase.

Introduction of an aircraft this size into the Nelson market, if it was operationally possible, before demand justifies it destroys any opportunity to incrementally manage the demand/growth and capacity inter-relationships. It also places substantial pressure on airport infrastructure to accommodate the sudden increase in demand and the larger aircraft. It is important to note here that the Nelson's current runway length is incapable of accommodating the A320 or any aircraft of similar size and there is no suggestion here that this is a proper course.

Ideally an aircraft in the 100-120 seat capacity range is more suitable. This would represent a still substantial but more manageable 47% capacity increase.

As there are no turboprop alternatives currently in the 100-120 seat range the option becomes the Embraer E190/195 (118 seats) series and the Airbus A220 – 100 (120 seats). These are jet aircraft, which operationally require more than Nelson's 1347 metre runway length for both take-off (wet or dry), and a wet runway landing. Higher operating and maintenance costs are also dis-incentives for the operator. Relatively low passenger volumes at other regional locations do not support the higher configuration aircraft nor do these aircraft fit logically into main trunk operations for the two operators on those routes. In summary utilization of these aircraft at Nelson is academic given both the limited runway length and the inability to accommodate these aircraft into other regional routes to achieve effective utilisation and economics.

In the near to medium term (2025-35), growth in the Nelson/Tasman region is dependent to a great extent on Air New Zealand, (or a competitor), continuing to operate ATR72-600 size aircraft. How Air New Zealand, or any other operator, optimizes its fleet to meet Nelson's future needs through increasing frequency or acquiring additional aircraft and of what type will be key for the local economy.

Market growth will not be limited to Nelson and any additional or alternative aircraft acquisition will have to be supported by robust demand/capacity and environmentally sustainable trade-offs. Of note also is that the Bombardier Dash 8-Q300 (50 seats) type in Air New Zealand's fleet serving Nelson is no longer manufactured. These aircraft were delivered in 2007 and probably have a limited remaining life.

In summary that's the present situation but as noted earlier the aviation industry is moving quickly to address environmental concerns. The next section addresses issues and potential solutions under consideration by the industry.

5. The Sustainable Aircraft Challenge

Over the recent past the aviation industry has striven to reduce emissions through operating efficiencies and powertrain improvements however future global forecasts indicate that broader solutions than just operational will be required to achieve 2050 targets.

Driven by that environmental challenge existing aircraft manufacturers have been joined by a number of start-up manufacturers promoting the development of new powertrain technologies, new aircraft designs, and conversions of existing aircraft types.

To achieve the required reductions new proposed propulsion types include battery electric, hydrogen electric, and sustainable (bio) aviation fuels (SAF). These technologies require new engine and aircraft designs. Of the three, SAF's will enable continued use of existing aircraft types, albeit with reduced environmental benefits for the foreseeable future due to the requirement for blending with Jet A. As noted earlier reliable longer term SAF supply requires feedstock challenges to be resolved. Compounding these challenges also is the potentially high cost of SAF production which will have an influence on shorter route aircraft choices made by airlines. The limited availability of SAFs also means that traditional fuels for larger aircraft will continue to be utilized for commercial aviation for some time.

The initial transition to sustainable fuel and power technologies will commence in the latter part of this decade with new smaller aircraft types in the 12-20 seat category. For example, Eviation and Heart Aviation are already developing new battery electric aircraft in the 12-20 seat configuration with ambitious entry to service timelines between 2026 and 2030.

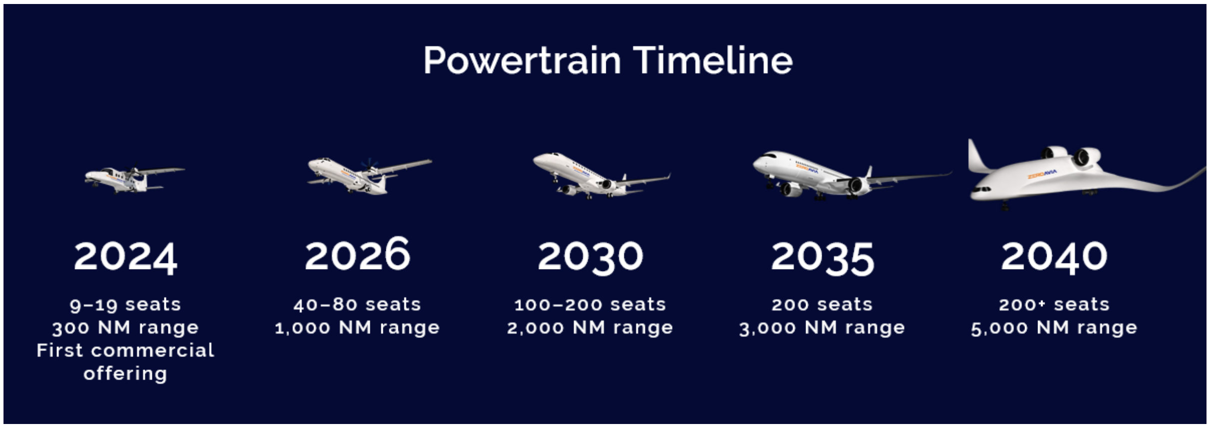
Proposed conversions of existing aircraft such as the Bombardier Dash 8 series and ATR by ZeroAvia and Universal Hydrogen are also anticipated to enter service during the 2026-2030 timeframe.

Evolving timelines for aircraft and powertrains suggest that new "clean sheet" environmentally sustainable larger aircraft designs, especially for short haul aircraft will most likely enter the market in the latter part of the 2030-35 timeframe.

Air New Zealand[5] has indicated publicly that it is moving towards a zero emissions strategy. The company also recently canvassed the sustainable aviation market to assess potential options and designs to meet its future needs[6]. It has also announced a collaboration with Airbus S.A.S for Airbus' proposed zero emission (ZeroE)[7] commercial aircraft initiative which is focused on a range of aircraft from a 90-100 seat hybrid-hydrogen turboprop equivalent through turbofan (< 200seats) and a unique larger Blended Wing Body design. Initial delivery is targeted in the 2030-2035 timeframe.

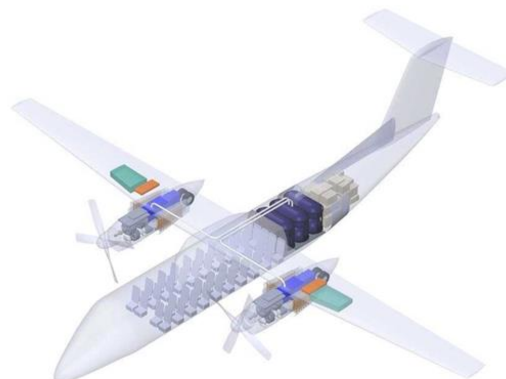
ZeroAvia[8], a Washington, USA based company has a number of hydrogen related projects underway including new electric powertrain designs, conversions of Bombardier Dash 8-Q400 aircraft to hydrogen/electric propulsion engines, and a proposed new design 100 seat hydrogen/electric aircraft for delivery in the 2030 – 2035 timeframe. ZeroAvia is targeting 2026-2030 for converted Q400 introduction and are collaborating on developing airport infrastructure solutions to support these plans.

[5] Air New Zealand Press Release: https://www.airnewzealand.co.nz/press-release-2021-airnz-and-airbus-to-research-future-of-hydrogen-powered-aircraft
[6] Air New Zealand Press Release: https://p-airnz.com/cms/assets/PDFs/2021-air-nz-zero-emissions-aircraft-prd.pdf
[7] Airbus website: https://www.airbus.com/en/innovation/zero-emission/hydrogen/zeroe
[8] https://www.zeroavia.com/



[9]

Universal Hydrogen[4], a California, USA based company are also developing conversions for Bombardier Dash 8-Q300/Q400 aircraft and the ATR72. Universal's approach is to incentivize the market with a unique supply solution that utilizes existing infrastructure rather than rely on new infrastructure investment.



ATR have yet to announce any alternative sustainable propulsion developments for its current designs and to date has focused its efforts on testing the efficiencies of its existing aircraft types using a SAF/Jet A (50/50) fuel blend.

We should also note that conversions of the existing Dash 8 and ATR aircraft to hydrogen/fuel cell/electric motor results in a lesser number of seats than the existing aircraft.

The variety of options available to airline operators creates a major challenge for future fleet decisions. The environmental challenge is immediate, new designs are sufficiently time bound to create uncertainty around fleet replacements in the near term. Consideration of interim solutions is a justifiable exercise. For operators seeking immediate zero emissions solutions new battery/electric and converted hydrogen/electric aircraft are currently the best options in the near to medium term pending the appearance of new "clean sheet" fleet types in the mid to late 2030s.

[9] Universal Hydrogen Website: https://hydrogen.aero/product/

Insufficient SAF resources will encourage airlines to hedge their bets with respect to their aircraft choices ensuring that enough SAFs are available to support medium and longer routes. Alternatives such as hydrogen and battery powered aircraft will be more cost-effective solutions for shorter routes.

With battery/electric aircraft being limited by payload/range considerations and therefore seat configurations of 20 or less seats, important airport planning considerations such as apron sizing and runway length are probably no more challenging than today.

The issue of course is that larger markets drive a need for larger aircraft and we can assume that in the short-term, existing aircraft types will continue to serve the market. It is the next generation of aircraft in the short haul medium/large size turboprop aircraft fleet that serve regional routes where hydrogen is the more likely "fuel" source that will challenge the status quo.

Existing aircraft designs cannot accommodate hydrogen in either a gaseous or liquid form. Current aircraft tanks are not designed to accommodate the volume and high pressures required to achieve adequate range with a gaseous version, nor to contain the volume and sub-zero temperatures of liquid hydrogen for any period of time.

This will lead to in-fuselage storage solutions meaning longer and potentially heavier aircraft for a given configuration as indicated by Airbus and ZeroAvia with their 100 seat aircraft concepts.

With the unlikelihood of hydrogen combustion engines for turboprop aircraft the more likely solution will be hydrogen/electric powered aircraft utilizing an electric motor of approximately 2 – 2.5 megawatts power, a fuel cell, and stored hydrogen. Fuel cell/electric motor/propellor combinations of this type are approximately twice as heavy as the current gas turbine/propellor combinations of existing aircraft types.

All of this leads to a conclusion that zero emissions aircraft are more likely to be larger and heavier than equivalent configurations of existing aircraft and will require either better or longer runway performance than current types. Aircraft runway performance on any day is a combination of aircraft capability, runway length, payload, and weather conditions. With initial powertrain developments focused on matching the existing gas turbines the more likely outcome will be a longer runway performance requirement for proposed designs which for Nelson could be additionally problematic.

The current ATR72-600 design with a 68-seat configuration has a maximum take-off weight of 22,800 kg. On some days at Nelson, conditions combine to inhibit achieving the maximum payload possible on the current runway length. This limits the operator's revenue and also impacts Nelson residents and freight shippers. An increase in ATR frequency to accommodate growth will exacerbate these issues.

As the industry moves to environmentally sustainable aircraft the introduction of a 100 seat zero emissions turboprop equivalent into the New Zealand market, possibly as early as 2030 and probably by the mid-2030s, Nelson Airport will have to have ready solutions available or risk a reduction in market access.

Manufacturers of new sustainable aircraft designs are insufficiently advanced in their design effort to confirm actual performance before the aircraft have been test flown. While they quote a goal of comparable performance to existing aircraft types there is a strong risk that aircraft weight and size required to achieve economic loadings will be larger than today's types and will require more runway capability than is presently required for the ATR72-600 at Nelson, albeit payload limited on occasions.

6. Conclusion

Nelson Airport and the surrounding regions have a strong dependency on the aircraft that operators will choose to support demand and meet their network requirements. A reality in our environment is that future aircraft designs will reflect the requirements on size, range, and performance made by the largest (offshore) customers. If those design choices do not meet the operational performance requirements for short runways such as those at Nelson the region is vulnerable to service limitations. As noted earlier in this paper Nelson is already to a great extent an outlier in terms of runway length relative to market size.

In the near-term Nelson's operations will be well supported by the existing fleet types potentially into the early 2030's. Beyond that time it is likely that new sustainable aircraft will enter the New Zealand market.

Given that zero emissions aircraft will likely be larger and heavier than equivalent designs and configurations of existing aircraft operating at Nelson, Nelson Airport will be required to provide additional runway length if it wishes to accommodate these new aircraft types. In my opinion, it would be prudent for NAL to develop contingency plans that ensure Nelson Airport can accommodate future aviation requirements and continues to serve the Nelson/Tasman region. Especially with respect to runway requirements and essential support infrastructure.

Appendix A

Eric Morgan, the author of this report, is a former senior airline executive with experience in airline and airport operations, ground handling, airline strategy, master planning, and airport noise issues. He has operated as an independent aviation consultant since 2003 and has undertaken commissions in New Zealand, Australia, Oman, Canada, United Kingdom, and Indonesia. He is currently consulting for Universal Hydrogen, a USA company developing sustainable aviation solutions. He is a graduate of the University of California L.A executive management programme, a former member of the Auckland Airport Noise Committee Consultative Group, a sitting member of the Wellington International Airport Air Noise Management Committee, and has appeared as an expert witness in Environment Court proceedings.