Aviation Green Paper

Introduction

This document is a detailed response to the proposed Aviation Green Paper. To have been named on page 157 of the green paper described “as being at the forefront in the development of charging and storage technologies for electric aircraft including the development of international standards” is humbling to see, and we will share our expertise openly to help drive policy and investment into the incredible opportunity that is AAM (Advanced Air Mobility) in Australia.

Electro.Aero has been working collaboratively with several high profile overseas partners leading the way in charging infrastructure for electric and hybrid electric development but we would like to see similar incentives in Australia. This will provide significant long term benefits to our aviation decarbonisation journey, and attract investment into the country. We will continue to work at the leading edge of AAM in the hope that our technology can prosper not only overseas but in our own back yard, bringing the wider benefits of AAM opportunity to our regions and cities.

Overview: Carbon, Noise and Lead.

During a recent conversation one of our team had with a recently retired commercial aviation pilot of some 50 odd years, he said “This whole AAM thing makes me nervous… aviation doesn’t like change. Language like: advanced, disruption, paradigm shift, rapid advancement, total restructure etc. scare many people in aviation. The fact that we can move millions of people through environments so deadly to humans with such incredible safety records is the result of decades of gradual incremental change and international collaboration. Change must continue to be incremental to retain the trust that our societies have come to expect from aviation.

At the same time, aviation is increasing its proportion of carbon pollution when compared to other industries that have much simpler paths to decarbonisation, so the focus on aviation decarbonisation and urgency to shift will rapidly increase as a counter pressure to the incremental steady changes authorities are used to dealing with. It is important that we find a balance between embracing the very real and in many ways far safer electric aviation transition whilst respecting the gradual implementation of change in aviation that maintains the levels of safety we’ve designed into global systems over decades of collaborative work.

Noise

Joby recently presented noise findings from their new eVTOL aircraft. They have engineered propellors which produce minimal tip vortices leading to reduced noise and compared with existing similar sized helicopters and aircraft. With electric engines far quieter than internal combustion engine equivalents, their findings suggested their aircraft were several orders of magnitude quieter

than all compared aircraft. In all comparisons they demonstrated at least 100 times less noise during hover.

Whisper Aero has engineered ducted fan technology into its CTOL aircraft promising 100x noise reduction to ICE (internal combustion engine) equivalent aircraft. They have engineered designs which create the majority of ducted fan noise outside the audible spectrum for humans leaving a far more enjoyable flying experience more compatible with urban and noise sensitive environments.

When Electro.Aero flew the worlds first commercial flights in the Pipistrel Alpha in 2018, we found that when the aircraft flew at 400ft the aircraft was inaudible from ground amongst normal city background noise. During take-off, taxi and landing it was extremely quiet.

A final point is the quality of noise. New aircraft designs are focusing on the quality of noise as well as the dB levels. Noise that imitates more natural sounds is more bearable than droning or pulsing noise and some frequencies are much more invasive than others. All these advances in noise reduction allow new airport designs in new locations more compatible with high density urban sites.

With reduced noise, vertiports can be situated in built up environments without adversely effecting the surrounding residents. This is key to public acceptance and will be key to seeing societies decide the benefits of AAM outweigh the impact of their new existence. Existing airports may be able to run electric flights (or hybrid flights) outside of noise-initiated curfew restrictions increasing the revenue of existing sites and allowing an easier transition to electric flight.

Regional Air Mobility (RAM)

Whilst in many places around the world, congestion is a major issue, Australia does not have significant congestion issues. It is very likely that there will be limited applications for eVTOL aircraft in cities for the sole purpose of beating the traffic unlike large cities in the Asia Pacific region where several hours of driving can be avoided through an eVTOL flight. The major benefit of AAM in Australia will likely be through regional air mobility. Revitalising the many regional airports for CTOL electric aircraft will be a significant market in Australia. Shifting from ICE aircraft to electric will reduce operating costs to between 30 and 60% and this cost saving can be passed on to both the customer and help fund the infrastructure required to support renewable electric and hybrid electric flight.

At both Electro.Aero and our partner FlyOnE across the road we have demonstrated flight operation cost reduction of around 50% with further reductions by switching to 100% renewable energy. With SAF and Hydrogen use likely to at least double or even triple flight costs, what we are possibly going to see is preference for a tightly interconnected system of regional airports within about 300km from each-other and flight routes that take on a number of ‘hops’ between destinations. There is a great opportunity to bring tourism to these interim destinations through required charging stops.

With an opportunity to decarbonise short range fully electric flight, we must now prepare remote ground infrastructure accordingly. Electro.Aero has been working on these solutions for several years and is already trialling ground solar/battery/charging systems in Perth (WA), the US and the UK with various e-mobility projects. What we have found is that by careful planning, the roll out of off-grid energy capture and storage aligns perfectly with the roll out of electric ground vehicles and renewable energy uptake. As Australian cars shift rapidly to electric, trucking is entering the electric phase and finally farming equipment is going electric, there is a great opportunity to make regional

airports the new Australian regional power stations that support their surrounding communities. If flights are prioritised, and EV hire cars and freight movements are given opportunistic free charging, assets can be amortised in only a few years whilst providing stable off grid energy to critical flight infrastructure. This RAM industry must grow with the electricity grid transition and general e-mobility transition to offer the greatest benefit to surrounding communities. As we've seen in the current green paper, almost half of regional airports are struggling and this new industry has the opportunity to bring investment and value back into the airport ecosystem rather than become an additional cost burden if aligned with other transitioning industries.

Pilots

There has been recent focus on pilots and the looming pilot shortage. Where a single pilot may have been required to move 200 passengers, an eVOTL might need a pilot for 4 passengers or a CTOL electric might require one pilot per 30 passengers. What we don't want to see is an already limited pilot quota reduced by this emerging AAM opportunity. What we would rather see is a completely new industry of short haul pilots that can access and enjoy the more family friendly lifestyles that short haul piloting can provide if done well.

Joby is doing exactly this by training their own wave of pilots for their upcoming fleet with specific guidance and training specific to electric flight. Korum at FlyOnE has also been training pilots in operating electric aircraft safely in Australia. Australia has a significant opportunity to become a leader in a new wave of pilot training in the Asia Pacific region dedicated to the AAM space. The low density land, renewable energy abundance and 'sandbox' potential are unmatched in this part of the globe.

Electro.Aero is working with several world leading electric aircraft manufacturing companies keen to run their trials in Australia but always ask the question "what is our government's appetite for bringing AAM tech to Australia and supporting the initial growth stages?". We hope this green paper will be the catalyst for a change in mindset for Australian state and federal governments to become a leader in this space and reap the long-term benefits of a thriving AAM opportunity. If investment is strategic we can provide excellent pilot training incentives that bring more people otherwise locked out of this career path into the piloting community.

Charging Technology. AS6968, GEACS and more

There is no aerospace standard for charging electric aircraft. 5 years ago Josh Portlock helped start the AE-7D committee working towards an international aircraft standard. For the last 4 years Electro.Aero have been sponsoring the AS6968 document for light electric aircraft charging. The aim is not to have the fragmented global charging systems seen in EVs. Aircraft are likely to travel between countries in the not-too-distant future and therefore must have consistent inlets on the aircraft. Our focus is on making one charging solution for all aircraft.

Joby have released their GEACS connector recently which incorporates liquid cooling into the plug alongside dual DC charging pins for redundant battery packs. This is a very specific use case and although it can be used without the liquid cooling, the high charger cost is likely to restrict implementation to high-cadence operational airports. Therefore we feel there is likely to be 3 main international connection sets eventuate.

1) AS6968 (GB/T). Using the physical GB/T DC only coupler, but implementing electric aircraft specific requirements, the AE7D committee has refined an excellent charging standard for most electric aviation use cases.

   Offering 250kW at 1000V non liquid cooled per inlet. For most aircraft with dual inlets this offers 500kW charging which we believe will be more than enough for regional airports around Australia offering charge times of about 30min.

   If liquid cooling is implemented then this power level increases to about 1MW per inlet at 25 degrees ambient or 2MW for dual inlet aircraft. This should adequately support most regional air mobility use cases especially if 2 plugs per side are used.

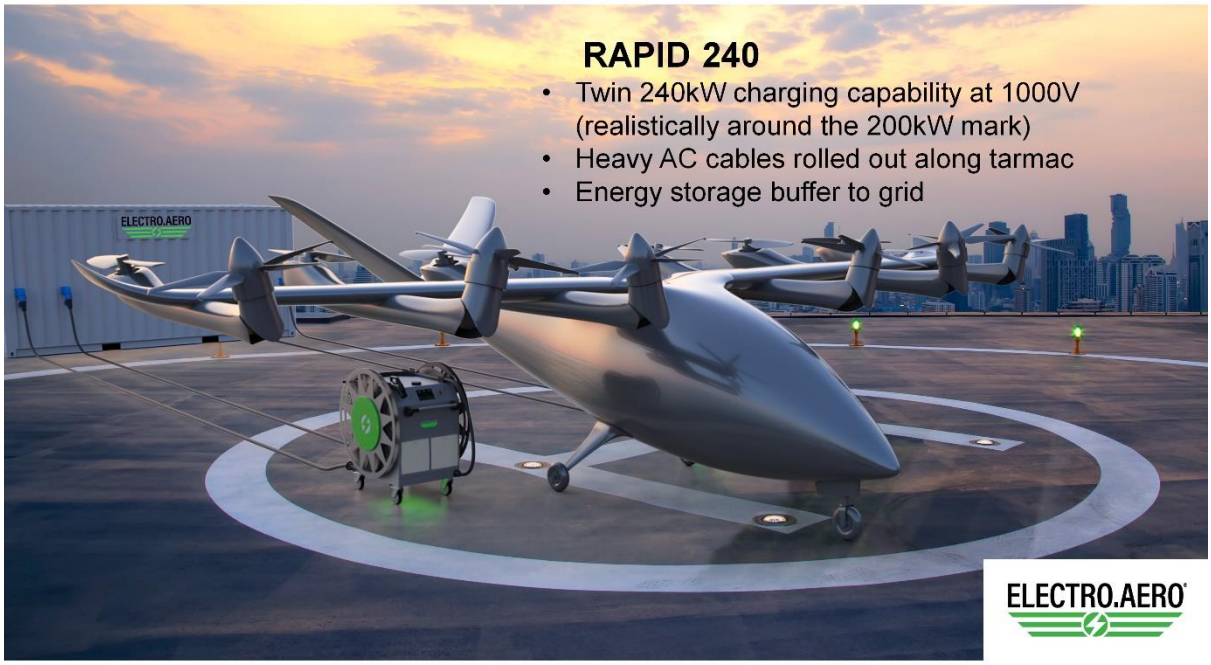
2) AIR7357 (MCS). Using the MCS coupler but adding electric aviation specific implementations, this may be the preferred solution for mini-liners in 5-10 years time. Whilst the potential voltage increase is unlikely to be preferred by electric aircraft, the higher current potential may be preferred accommodating about twice the power of AS6968. The downside is that the plug locking mechanism is on the aircraft side and the aux power available for battery pre-conditioning is much more limited. Although this solution shows promise there is every possibility that this solution will only find niche applications.
3) GEACS – a Joby specific implementation which can be used by other eVTOL and long range mini liner manufacturers for high turn around charging at high throughput airports.

Electro.Aero's charging solutions.

At Electro.Aero we build electric aviation chargers. These are bespoke systems designed to be light, portable, reliable and have an air of aviation familiarity about them. They have been used in several high-profile test campaigns around the world in the US and UK and have already proven reliable and versatile.

Electro.Aero's Rapid 80 Electric Aviation Charger. Light, Portable, Reliable and Robust.

Our increased power range includes a non liquid cooled charger offering 240kW charging and a liquid cooled 400kW charger for high power applications, although liquid cooling becomes exponentially more expensive and requires additional maintenance not ideal for remote and regional airports.



RAPID 240 – non liquid cooled charging with AeroCharge container for grid buffer & energy storage.

Energy Infrastructure

As energy grids become increasingly de-centralised, there is an opportunity to align this utility transformation with the rise of electric aircraft. The upfront capital required to set up infrastructure for AAM is not particularly expensive which will help regional air mobility. Key to rapid take up is the initial investments require to get operations to scale. Over the next 5 years it is important there is a focus on trial projects and real world trial operations to demonstrate and test infrastructure solutions. Australia is currently lacking in this investment leading to missed opportunities to capitalise on a thriving AAM market and the export of leading technologies and AAM related product.

In the US, we are seeing a rapid shift to airports accommodating AAM. It is now reflected in policy and funding outcomes through FAA terminology and it is likely CASA will follow suit: https://www.linkedin.com/pulse/faa-policy-definition-aeronautical-activities-aam-point-keith-sarich-aj0yc/?trackingId=rdgNP52eIchs25mi4FkH1w%3D%3D
If we had something similar in Australia, there would be considerable pressure on airports to adequately plan for AAM ground infrastructure in order to access financial support or grants.

Electric Vehicles

At our hangar in Jandakot Airport, about half our staff drive EVs to work. This set up is representative of a typical workplace in a 5-10 years' time. What we've found is that we can oversize our solar (12kW) and even on cloudy winter days get about 1.5kW of energy for most of the day. This is adequate for running our hangar where excess is stored in a 120kWhr battery. On sunny days our employees use surplus energy and charge their cars for free. This benefit amortises the battery/solar upfront cost in about 5 years. Furthermore, we have never been in a blackout (unlike many of our neighbours) and we have charged light electric aircraft off 100% renewable energy producing zero emissions.

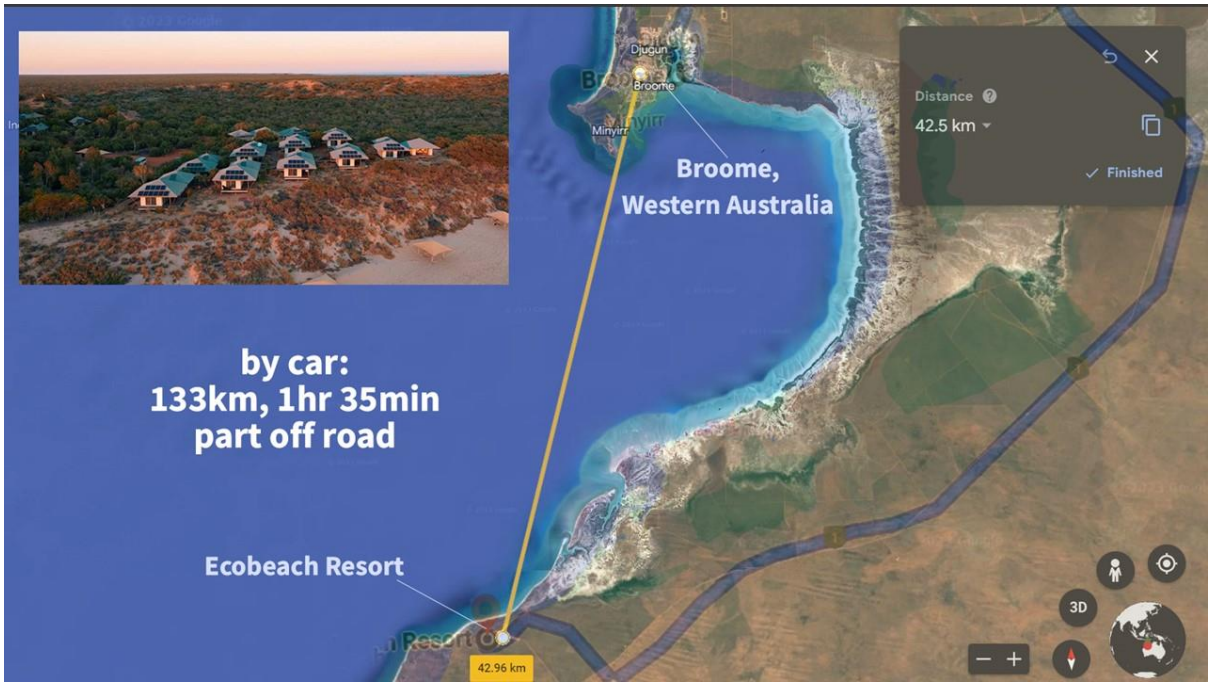
Electro.Aero roof spelling Electro in solar panels. This has allowed our business to go off grid.

Perth is the sunniest capital city in the world so we understand why this model works well here but as the cost of batteries drops, and more electric cars and trucks are used at worksites, the easier it is to make the business case for going off grid in the city. Regional airports have a fantastic opportunity to use electric hire cars as excess energy loads prioritising battery energy for electric aircraft.

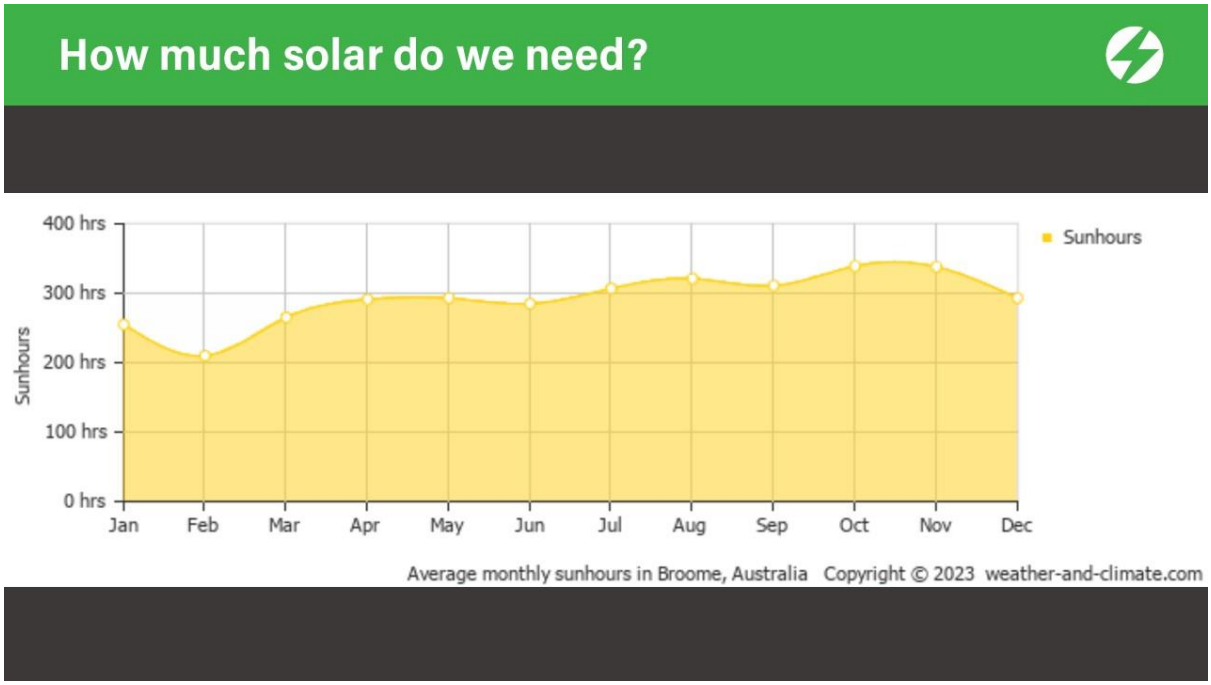
Case Study: Albany Airport

Albany Airport is the perfect RAM airport. It has regular existing flights connecting Perth airport over a 400km distance. This is well within the reserve range of the Eviation Alice aircraft available around 2030. This could be turned into an electric aviation friendly site with very little infrastructure modification. If the hire car fleet transitions to EVs with oversized roof solar on all buildings and containerised battery storage, then this site would be ideal for early electric flight trials. Rolling portable chargers out from AeroCharge energy storage containers can be done now without requiring much additional infrastructure at the site. Albany airport is a perfect site for trialling electric flight and we are in conversation with the airport and local council hoping to see this eventuate with the right support.

Case Study: Eco Beach – Broome

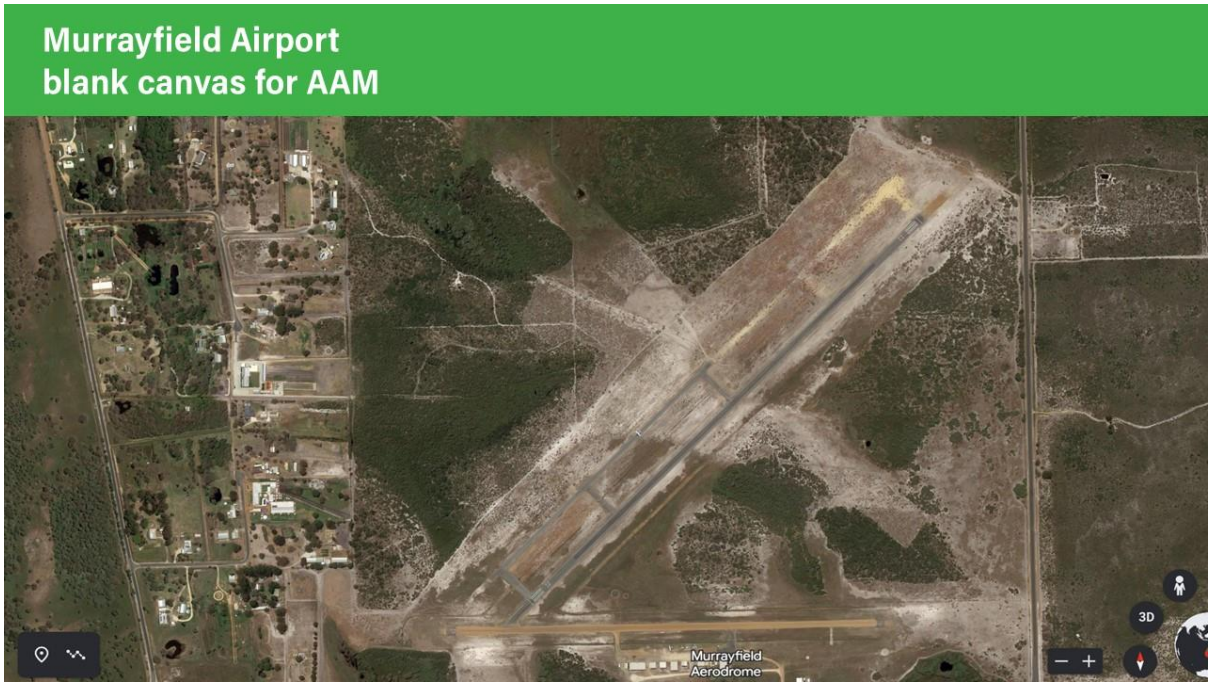


Ecobeach case study – 133km, 1hr 35min by car (part off road) vs 42km flight across beautiful bay.



Ecobeach CEO Karl Plunkett is very keen to see eVTOLa operations for tourists going from Broome airport to Ecobeach resort. This is an excellent initial remote use case focusing on the tourism market. No infrastrucutre upgrades would be needed as the sun hours per month would be adequate for regular flights using our AeroCharge off grid solutions providing 100% renewable energy for transport.

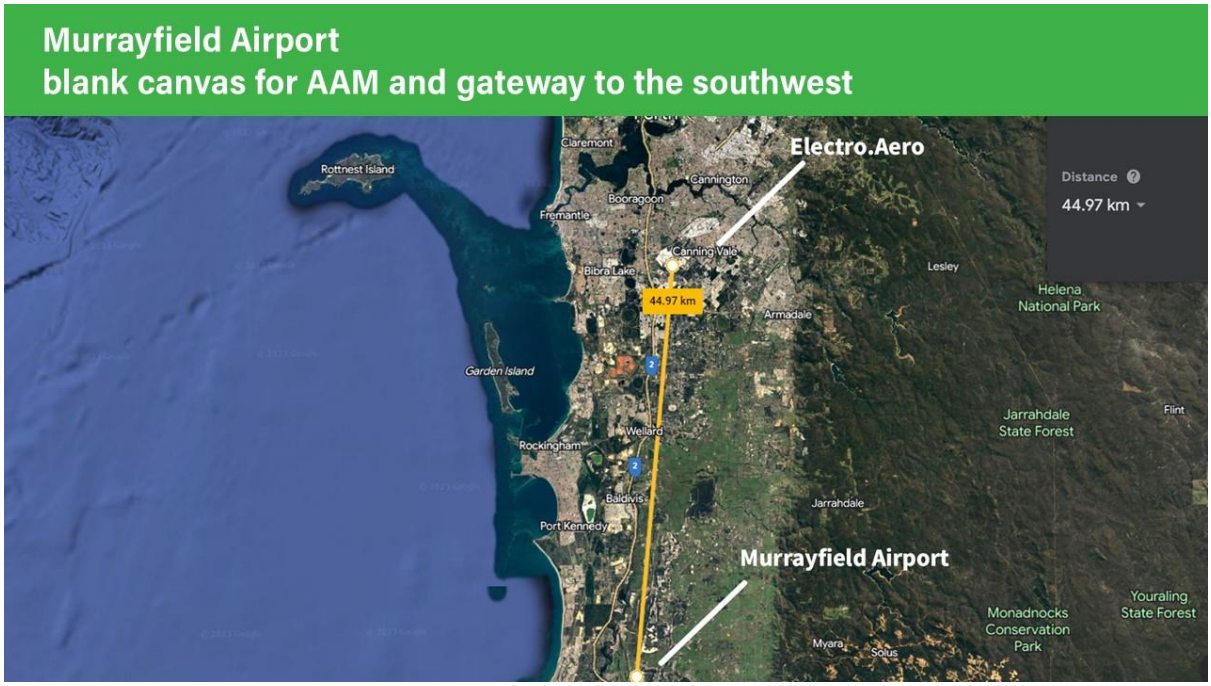
Case Study: Murray Field, Rottnest, Jandakot



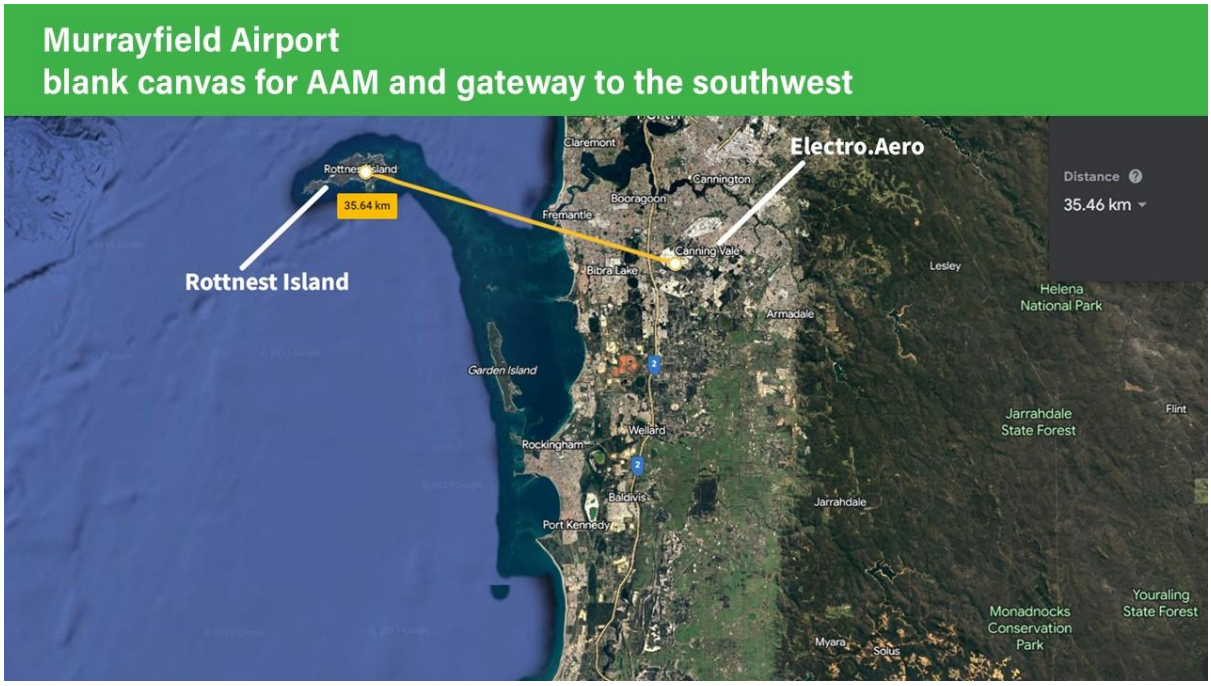
MurrayField Airport – blank canvas for AAM. Solar and offgrid opportunities.

Consistent solar: No need for grid infrastructure by sizing solar/battery for flights required.

Candidate aircraft – Archer's Midnight.



Close to our R&D and production base at Jandakot Airport.



Close to Rottnest, a popular overwater WA tourist destination.

MurrayField airport is an excellent site for close to workshop non controlled airspace trials. It is a short flight away from Rottnest Island (Wadgemup) and our home base in Jandakot airport. We are currently working on a roll out of world first AAM demonstration technology to attract industry to this beautiful part of the world for their flight test operations.

Gateways to the regions

We believe that a ring of AAM centric airports around cities will become gateways to regional electric aircraft connectivity. In Perth for example we think sites in Joondalup, Dwellingup and at Murrayfield airport are all perfect locations for northern, eastern and southern gateways to regional locations. If we initiate strong 100% renewable energy sites here, then a staged expansion into the regions becomes a low risk roll out strategy. Initially aircraft charging tech will go through technical challenges and it is important that they are easily serviceable until proven robust and reliable in Australian conditions.

Test Centres of Excellence (Murrayfield, Oxford Airport, Perdue University

As well as focusing on the once in a generation opportunity to transform Murrayfield airport to an off grid renewable energy AAM hub, Electro.Aero is also setting up projects in Perdue University and Oxford Airport with collaborative partners there keen to see Australian charging technology implemented with their unique aviation environments.

Our Global Partners

Electro.Aero is working with leading companies Ampaire (hybrid fixed wing flight) and Archer (eVTOL aircraft) as well as about a dozen other leading electric aviation companies in the US and UK. By working with so many developers of electric aircraft we have gained unique and unrivalled experience working with a variety of new aircraft designs. This has helped us develop charging and energy storage infrastructure bespoke to electric aviation. With adequate investment at home, we

can demonstrate and further export these solutions to other regions, especially in the Asia pacific region close to us where 40% of the AAM market is expected to be located.

SAF (Sustainable Aviation Fuel) and Hydrogen

It is very unlikely hydrogen will be used significantly in aviation. The earliest we are likely to see any hydrogen aircraft at scale is 2035 at the earliest as completely new aircraft designs are required. There are significant questions about whether authorities will accept these aircraft and any green hydrogen will have to be generated at airports requiring surplus green energy and water. If 40 grams of hydrogen has the explosive potential of 1 kg of TNT, would passengers fly in an aircraft located in such close proximity of this fuel? Green hydrogen is far better used in industries where there is no alternative if our decarbonisation efforts are co-ordinated across all industry. With over 98% of the world's hydrogen coming from fossil fuels, there is no real value in using hydrogen over jet fuel, and in fact the transition could easily increase whole of supply chain emissions considerably. This video explains very clearly the very limited application of hydrogen in aviation:

https://youtu.be/fLWJQzcVg44

some big airline companies are backing away from hydrogen projects in aviation:
https://www.bloomberg.com/news/articles/2023-11-28/rolls-royce-backs-away-from-electric-hydrogen-powered-airplanes
"Erginbilgic said he believes sustainable aviation fuel, or SAF, will be the sole pathway for large jets to achieve net zero climate targets."

SAF will be required for long haul flights. Several investigations have pointed to a likely cost of ten times that of jet fuel making long haul flights considerably more expensive. SAF can be produced in many ways and it is critical its production does not displace food crops. We are exploring partnerships investigating the use of desert hardy crops that require little watering, do not displace agricultural land and sequester carbon whilst providing a source of SAF. This may be one of the best paths forward for long haul flight, especially if hybrid systems with electric propulsion are prioritised.

Conclusion

We look forward to seeing the Australian federal and state governments enter this existing era of aviation and strongly support the innovative community that is already thriving. Our experience and potential is unrivalled around the world and with the right policy and support we believe Australia could become renowned for state of the art AAM development and technology which can be shared around the world whilst also bringing visitors to this beautiful country returning home with a low carbon footprint.