Market review: **turboprops punch above their weight**

Angus von Schoenberg, industry officer, TrueNoord, and aviation journalist Michael Doran put the case for turboprop aircraft.

In September 2021, the global commercial airline fleet numbers about 35,500 aircraft, with some 5,750 of those being turboprops. About 40% of those turboprops come from two manufacturers, ATR and De Havilland Aircraft of Canada Limited, and operate in the large turboprop market of 46- to 90-seat aircraft.

ATR, a partnership between Airbus and Leonardo, produces the most popular current-generation turboprop with about 1,200 aircraft in operation. The aircraft is considered a workhorse of the fleet and was first launched in the late 1980s as the ATR72-200. The -200 was superseded by the -500 series in 1995, followed by the current ATR-600 series from 2011.

The ATR42-600 can be configured with up to 50 seats, and the first ATR42-600S, a short take-off and landing aircraft that can be used on airstrips as short as 800 metres, will be delivered over the coming years.

The ATR42 has also been successfully converted to use as a freighter and, more recently, the first ATR72-600F, a purpose-built freighter, was delivered to launch customer Fedex.

De Havilland Canada took over the Dash 8 type certificate and manufacture in 2019 when Bombardier exited the market and made a solid start by delivering 11 Dash 8-400 aircraft in 2020. However, when Bombardier left the business, it sold the plant where the Dash 8 is currently produced so De Havilland needed to find a new facility at a time when fresh orders were stalling.

In February, De Havilland announced it would not produce new Dash 8-400 aircraft at the existing site beyond currently confirmed orders in what it called a "production pause". The company says it is committed to the Dash 8-400 programme and will be ready to meet new aircraft demand as the industry recovers but will not rush into a decision on a future production location.

On the aircraft side, the Dash 8-400 is a high-speed turboprop (360 knots high-speed cruise compared with 270 knots for the ATR72-500/-660). It also has about a 35% range advantage over the ATR72-600. The Dash 8-400 can carry up to 90 passengers and is an impressive performer, flying faster and further with 12 more passengers than the equivalent highest density ATR72-600.

Turboprops are used for all manner of regular passenger transport and freight operations, starting from the world's shortest flight of 1.7 miles between two Scottish islands, although more generally on trips of up to 90 minutes. In terms of range, the sweet spot is about 250 to 350 nautical miles (nm) because the faster speed of a jet has a marginal impact on sectors of this size, shortening the journey by 10 to 15 minutes at best.

It is not uncommon to see large turboprops at major airports on every continent, but an area in which they come into their own is in regional and remote locations, often where the existing infrastructure is limited or virtually non-existent. An ATR is a truly self-contained aircraft that can land on a gravel airstrip, turn around, go into hotel mode with the right-side engine instead of an APU to keep power running on the non-boarding side, load and unload passengers and take-off.

Turboprops also perform many public service obligations to keep communities connected where no viable air service would otherwise be available and have played a major role in getting medical personnel and supplies out to distant communities during the Covid-19 crisis.

In these times of "flygskam" (flight shame) and banning of short flights, although two-and-a-half hours is hardly a short flight, having green credentials is important, and on this aspect the current-generation turboprops have plenty to talk about.

Flight shame is still predominantly a European consumer sentiment. However, because of their lower fuel burn, and emissions, any effect is likely to influence positively the balance between jets and turboprops in Europe where the proportion has skewed in favour of jets in recent years. But the turboprops will only gain where no high-speed rail connections are feasible.

On the back of environmental arguments, turboprops also have good prospects of regaining territory in the USA that was previously lost to 50-seat aircraft. Major airlines are considering the replacement of at least some of the sizeable 50-seat aircraft population in the country with turboprops.

Although only feasible for shorter sectors, it still leaves a sizeable replacement market in which Embraer has also set its sights. Turboprops use less fuel and, therefore, have less emissions than jets, with ATR claiming the 72-600 consumes up to 40% less fuel per trip than similar capacity regional jets and emits 40% less CO_2 than a regional jet on an average route of 550 kilometres.

Many readers would be aware of the 2019 Perfect Flight when sustainable aviation fuel was used to power a Braathens Regional Airlines ATR72-600 carrying 72 passengers on a one-hour flight between Halmstad and Stockholm in Sweden. The fuel was produced by Neste from non-palm renewable and sustainable raw materials and is claimed to reduce emissions by up to 80%.

Turboprop manufacturers and operators have a good story to tell about their efforts to reach carbon-neutrality but they need to educate lawmakers, media and the broader community on what they are achieving today. This is particularly pertinent as alternative sources such as electric and hydrogen power engines have many years of development ahead before they find their way onto a large commercial aircraft.

Global footprint

Turboprops represent a relatively small proportion of the world's commercial aviation landscape. Of the aircraft in the global commercial fleet, the split is distributed between 53% narrowbody, 18% widebody, 16% turboprop and 13% regional aircraft.

Turboprops of all sizes total about 5,750 aircraft, with more than 1,200 ATRs and nearly 1,050 Dash 8s. These two have a combined market share of 40%, the balance being made up of multiple types and sizes of aircraft.

Narrowbody, widebody and new-generation regional aircraft have all been going through a step-change in both airframe and engine technology, in particular, producing a surge of new aircraft such as the Airbus A220, A320neo, A350, Boeing 737 Max, 787 and Embraer E2 onto the market.

By contrast, there has not been similar development in turboprops and, while cabin interiors have benefitted greatly from makeovers, the airframes and engines show little near-term signs of development.

While step changes in air transport efficiency have primarily been driven by engine technology rather than airframe changes, the present turboprop engines (Pratt & Whitney Canada PW100 and PW150 series) have been in production since the 1980s and late 1990s, respectively.

Both ATR42/72 and Dash 8-300/-400 aircraft have an average age of more than 13 years, which increases when the out-of-production, smaller 30-seat variants are considered. In the case of the Dash 8, this pushes its overall average age up to 18 years. This compares with an average age of 10 years for the A319/A320/A321 and 12 for the 737NG and Max aircraft.

This lack of new technology in turboprops can in part be attributed to their efficient engines and the overall fit-for-purpose nature of the turboprop fleet, where their construction and performance characteristics suit the more remote environments in which they often find themselves. It also reflects the lack of incentive for engine original equipment manufacturers (OEMs) to bring new, conventionally powered turboprops to a market that is currently served by one established player and a second whose future is uncertain.

To date, this market has seemingly been satisfied with the economics and capabilities of its current aircraft, irrespective of age.

With aviation under increasing environmental scrutiny and regulation, such as the move in France to ban flights that can be made by train in less than two-and-a-half hours, the push for hybrid, electric, hydrogen or other sustainably powered regional aircraft is accelerating. However, the current state of technology will not allow for the application of these in 50-plus-seat turboprop aircraft until the next decade.

The ageing nature of the turboprop fleet is at odds with the preferences of those lessors and financiers which trade primarily in new or young aircraft, but for those that look

Figure 1: Global commercial aircraft fleet

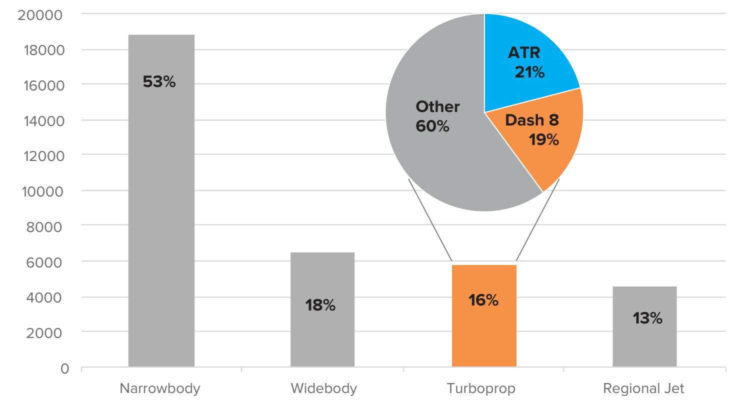
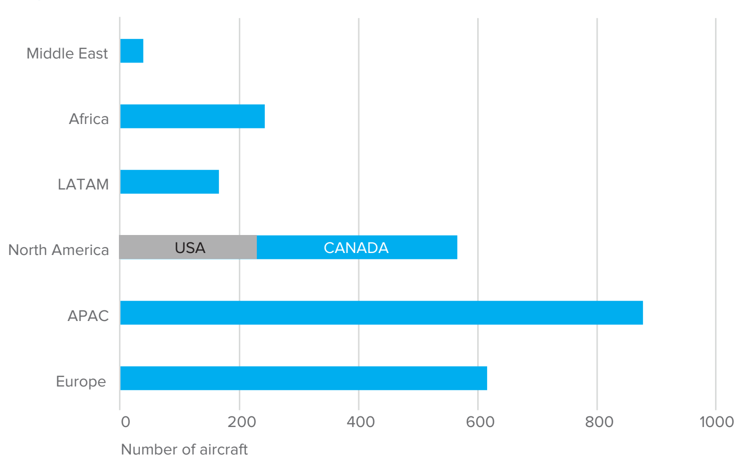


Figure 2: Distribution of 50-plus-seat turboprops



beyond age, there is still the promise of productive operational life in these aircraft.

Looking at turboprops with greater than 50 seats, the most popular region for these types is in Asia-Pacific (APAC) where 35% of the fleet is located, followed by Europe with 24%, North America 22%, Africa 10%, Latin America (LATAM) 7% and the Middle East 2%.

APAC is by far the greatest market for large turboprops with more than 850 aircraft in the region. This is unsurprising given the need to connect remote and island communities, challenging operating conditions and the demand for domestic services from rapidly growing populations.

It is the largest market for ATR with about 550 aircraft and almost 60 operators in the region, compared with the Dash 8, which has more than 250 aircraft in use by 25 operators. By country, Indonesia has the largest combined fleet with 115 aircraft, followed by Australia 96 and India with 90.

While North America makes up 22% of the fleet, the figures are skewed heavily in Canada's favour with more than 350 large turboprops located there compared with just 210 in the USA. Consequently, the USA currently has the smallest proportion of turboprops of any large domestic market.

While there are concerns in the USA about customer acceptance and some older ATRs having only rear-door entry and therefore no airbridge connection, there appears to be an opportunity to replace a portion of the ageing US fleet of 50-seater jets, such as the Bombardier CRJ100/200 and Embraer ERJ135/140/145, with the more fuel-efficient and therefore more environmentally friendly turboprops.

That process gained some ground when Silver Airways introduced the 46-seat ATR42-600 series in 2019, almost 25 years since a passenger ATR had last flown in the USA. The initial order of 20 aircraft is replacing Silver's SAAB 340 fleet with a mix of ATR72/42 aircraft now operating routes in the southeastern United States, the Bahamas and the Caribbean.

ATR is also increasing its visibility with logistics giant Fedex using a fleet of about 40 ATR aircraft on its Fedex Feeder network. The Fedex fleet is made up of ATR42-300F, ATR72-200F and ATR72-300F aircraft and has a substantial order for dedicated ATR72-600 freighters, of which two have been delivered.

In the rest of the world, the fleet is more fragmented, with Europe having only three turboprop operators with more than 20 aircraft – these being Widerøe 40 (Dash 8), Binter Canarias 24 (ATR) and Swiftair 22.

Africa is a region where Dash 8 aircraft dominate with more than 60% of the market, driven by their superior hot and high performance compared with ATR aircraft. Ethiopian Airlines is the largest Dash 8 operator with 23 aircraft, followed by Air Algerie's 15 (ATR), with the balance of the market made up of smaller operators with less than 10 aircraft. In LATAM, more than 30% of the fleet is concentrated in just two ATR operators: Azul Brazilian Airlines with 33 and Colombia's Easyfly with 17.

Challenges for financiers

Irrespective of the current pandemic or any previous crises, there are a range of market characteristics or risks that need to be considered, some of which have been discussed at length elsewhere in this article:

- owning or financing turboprops is a niche business within aviation finance, requiring a specific skill set different to mainstream aircraft at all levels, including technical management, oversight, counterparty risk and specialised aircraft remarketing;
- the value of the assets involved are lower than mainstream aircraft but managing those assets is just as onerous as that required for more highly valued aircraft;
- turboprops are often used by smaller, niche operators which can entail greater counterparty risk, unless they are a subsidiary of a major airline;
- overall, this a relatively small market niche with less liquidity;
- any change in the competitive landscape including, for example, the launch of a large new turboprop by Embraer, could similarly impact the market for existing types;
- any technological step change, particularly with reference to propulsion systems, could impact the attractiveness of used large turboprops. However, there is a wide industry consensus that such technology will not become available for 30- to 50-seat aircraft for at least 10 to 15 years with the impact on large turboprops likely to be even further away; and
- any major disposal programme by a large operator could leave significant fleets on the market for a short period, which would increase supply and thereby lower values and lease rates.

Notwithstanding these risks, the financing of turboprops also offers a number of advantages compared with mainstream aircraft. While no aircraft type is totally immune from external shocks, the turboprop sector, with its lower capital and operating costs, high reliability and focus on domestic connectivity, appears better equipped than most to absorb them and bounce back strongly. In many smaller markets, the turboprop is the only aircraft that can operate viably on routes that are shunned or flown infrequently by airlines with larger aircraft.

A testament to the resilience of turboprops is that in the devastated 2020 market, ATR added nine new operators, launched services in another three countries and saw 84 new routes opened with its aircraft. This is also shown by the relatively high utilisation rates of turboprops in some regions as shown in Figure 5. This would suggest that operating cash flows are better protected.

Turboprops also benefit by serving many routes that are inherently loss making but subsidised by governments, such as the EU Public Service Obligation (PSO) and the US Essential Air Service (EAS) programmes. These routes are typically tendered for by governments, with the selected operator gaining a monopoly on routes not viable without subsidy.

Communities that benefit from these programmes change depending on their circumstances but are usually remote, low-population areas with no other way of connecting to regional hubs.

In the USA, there are about 160 EAS airports with around one-third located in Alaska, while in Europe PSO routes include some connecting France, Italy, Scotland and Greece to their islands and remote regions within Scandinavia. Similar programmes exist in all parts of the world with turboprops figuring largely in their operation, including many significant developing markets such as Indonesia.

Such monopolistic protection also occurs naturally in most regions. In many cases, the typical low-density routes flown by turboprops are only serviced by a single operator because competition would generate too much capacity.

Furthermore, although distances travelled are usually short, and therefore could compete with other transport modes, the reality is that such alternatives are more often than not very slow because either geographical constraints preclude them, or ground-based transport infrastructure is underdeveloped. Indeed, there are few city pairs connected by turboprops where fast road or rail options exist even in some of the world's richest nations such as Norway. Such natural monopoly protects the demand and revenues of turboprop operators to serve their obligations to financiers, among others.

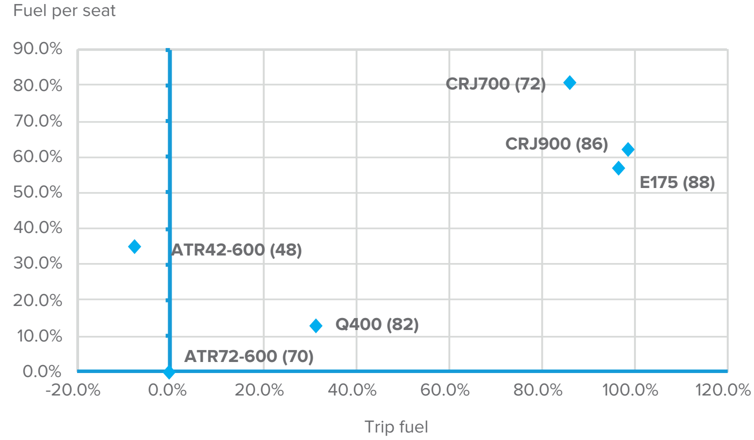
Economic comparison

The elements of operating costs, apart from the aircraft capital portion, are often referred to as cash operating costs and the elements that are driven by the aircraft itself are reviewed in the chart below.

Fuel burn

The ATR72-500/600 has generally been considered to have lower operating costs than any of its competitor aircraft in a similar seat capacity. In the example shown in Figure 3, the ATR72-600 burns some 850kg compared with 1,100kg for the Dash 8-400, which represents a substantial 30% difference in the trip cost.

Figure 3: Block fuel relative to ATR72-600 (300nm at $0.79/kg fuel)



While De Havilland agrees that the ATR72-600's fuel consumption for a 300nm trip is in the region of 850-900kgs, it now claims the Dash 8-400 consumption to be about 980kg, or a more modest 10% to 12% difference.

Nevertheless, the ATR72-600 still has the lowest fuel burn of any regional aircraft on both a cost per trip and a per seat basis at this sector length. As the trip length increases (not shown), the faster speed of both the Dash 8-400 and the regional jets begin to erode the fuel efficiency of the ATR72-600 so that the fuel burn advantage against the Dash 8-400 reduces to below 20% on a per seat basis, and under 50% for the regional jets.

Maintenance

As the ATR72-600 and Dash 8-400 are both mature aircraft there is a strong base of real maintenance data available. While maintenance intervals differ between types, there are similarities in the costs, although these will vary considerably according to how the aircraft are operated and the environments in which they fly.

For example, although scheduled maintenance costs for the Dash 8 are generally a little higher principally in relation to engines, in harsh climatic environments, the ATR72-600 is often less robust than Dash 8-400 aircraft and additional findings at major events can often increase the maintenance costs significantly.

The maintenance cost estimates are based on fixed intervals, except for engines, which are maintained on condition. With regard to engines, there is considerable disparity between benign and inhospitable climates with several historical examples of engine removals below 5,000 flight cycles in harsh environments.

Performance and economic comparison points

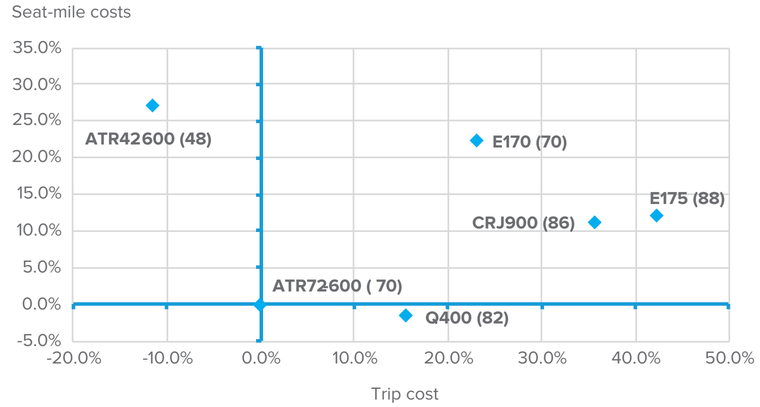
The ATR72-600 has a number of benefits over its principal competitor the Dash 8-400, but the latter also has some advantages, which does mean that both types are not entirely head-to-head competitors in the same way as typical mainstream aircraft.

Despite its smaller size, the ATR has best-in-class operating economics, particularly in relation to fuel burn, weight-based airport charges and, to some extent, maintenance costs.

Figure 4 shows the direct operating costs, which include capital costs for the aircraft, and confirms that the ATR72-600 remains marginally the most attractive turboprop for most markets. The exceptions are those areas where superior performance characteristics, mainly in terms of climb and operational ceiling, are needed where the Dash 8 is stronger. This is important for those carriers operating at inner city obstacle restricted airports, mountainous regions, or hot and high climates.

The Dash 8-400 also has a faster cruise speed that enables it to compete with, or more effectively

Figure 4: Direct operating costs relative to ATR72-600
(300nm at $0.79/Kg fuel)



complement, regional jets. In regions where sector lengths can be long, such as certain North American markets, this can be beneficial and provide greater operational flexibility.

ATR has developed a high-capacity 78-seat variant, which is particularly well adapted to competitive Asian regional markets and has contributed it to being the undisputed leader across Asia. However, now that the 90-seat EC version of the Dash 8-400 is in service with 12 additional seats compared with the ATR72-600, the seat costs of both have converged, although the trip costs still favour the ATR.

Covid-19 impact and recovery

Before 2020, any discussion on risk factors for aviation would most likely have centred on five major events: the 1990 Gulf war; the 1997 Asian financial crisis; the 2001 9/11 terrorist attack; the outbreak of Sars in 2002; and the global financial crisis of 2008. As difficult as these times were for aviation, the industry was able to bounce back strongly relatively quickly after each event and continue its long-term growth path to recover from the shocks.

Covid-19 is different in so many ways in that after each of the above events world passenger traffic stalled or dipped slightly whereas with the coronavirus, traffic fell by more than 60% in 2020, leaving an unprecedented hole from which to climb.

When the pandemic struck in early 2020, thousands of perfectly good aircraft were parked, stored or retired and headed for the desert. With international borders slammed shut, widebody aircraft, such as the 747 and A380, were immediate casualties, while the impact on single-aisle aircraft was shared across all types.

However, the impact on turboprops was less dramatic. Focusing on monthly flights in Europe and the CIS as an example, Figure 5 shows a generally similar picture for both jets and turboprops, surfing the same wave generated by new Covid-19 variants and the arrival of colder weather in the winter low season. This illustrates that ATR utilisation did not fall to the same extent as other types and it has managed to hold onto and then accelerate that gap over the past 12 months. It is now closer to flying at prepandemic levels.

The ATR has also performed consistently better than other narrowbody aircraft, which also reinforces the role turboprops play in connecting people and freight on routes where jets are not commercially viable.

For the Dash 8, the picture is skewed by the demise of some major users and planned aircraft retirements being brought forward because of the Covid-19-induced lower demand and flight activity.

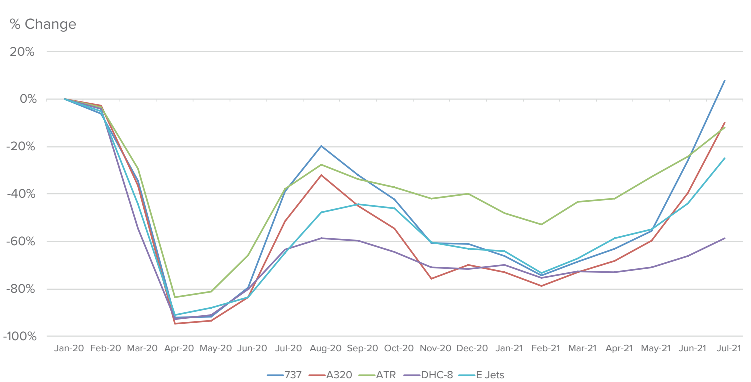
UK airline Flybe operated almost 40% of the UK domestic market. When it collapsed in early 2020, it took 55 Dash 8 aircraft out of the European market permanently, reducing the global Dash 8 fleet by more than 10%.

About 10 more Dash 8s disappeared when German airline LGW folded, to be followed by the 12 at Air Baltic that went into early retirement. This loss of more than 70 aircraft, more than half the European fleet of Dash 8s, accounts for a large part of the gap between it and ATR, with the fleets at Widerøe (40), Luxair (11), LOT (12), Olympic Air (10) and Croatia Airlines (4) doing comparatively well and following a similar trajectory to the ATRs.

In June, Greek airline Sky Express took delivery of the first of six ATR72-600s with the balance to join the fleet by the end of 2021. Sky Express is an existing ATR operator, with 42-500 and 72-500 aircraft serving a blend of domestic and international destinations.

With many international borders closed or constrained by red, amber

Figure 5: Monthly flights in Europe and CIS region



Maintaining connections

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or green lights, countries with large domestic aviation markets have rebounded the quickest, although sudden closures can change that in the blink of an eye.

Australia's domestic market, where turboprops play an important role in connecting remote communities, reached prepandemic levels mid-year only to have state borders instantly closed when the Delta variant arrived.

In April, China continued to be the world's largest domestic market, about 20% larger than in 2019, while the USA, previously the largest, shrank by 27% in the same period. Out of the top 10 domestic markets, only Indonesia and Japan were smaller in April than a year ago, with South Korea and Vietnam growing strongly.

With domestic markets growing, and more people looking to travel internally, similar opportunities exist for turboprops to be the right-size aircraft on thinner routes, be it to connect communities or transfer to central hubs.

While gaining access to the China market is problematic, the sheer size of the opportunity demands attention from turboprop OEMs, be they the existing ones or perhaps those which are developing the emission-free technology discussed later.

In China only about 3% of its fleet comprises aircraft with 100 seats or less compared to the global average of 25%, and, although the country has about 238 airports, some 83% of all traffic is concentrated through just 39 of them.

ATR says that the 164 regional airports in China handle just 7% of total passenger traffic and the ATR42-600, in a 30-seat configuration, would be the ideal solution to provide essential connectivity and grow local economies.

The pandemic has also heightened the need to move medical personnel, supplies and equipment quickly and often into remote environments where road access may not be possible. Turboprops are the ideal platform for such operations.

An aircraft with a distinct role to play in these situations is the ATR42-600S (STOL) with its capability to take off and land on runways as short as 800 metres carrying 40 passengers. The STOL aircraft moved from design to industrialisation in June, meaning all critical reviews have been passed, the design architecture frozen and parts manufacturing can commence.

The launch customer is PNG Air of Papua New Guinea, which will be replacing its current fleet of 30-seat STOL aircraft with the new ATRs.

PNG Air has been an ATR72-600 operator since 2015 and uses STOL aircraft to connect communities and access mining operations using remote airstrips across the mountainous country.

The ATR72-600F freighter is also gaining traction with launch customer Fedex inducting its second aircraft, from its order of 30, with an option for 20 more in May. Before the launch of the ATR72-600F, Fedex was already operating about 40 ATRs in a mix of 42/72 aircraft converted for cargo operations.

The way ahead

On the surface, it seems that current turboprop technology is in a state of suspended animation. With few new engine or airframe projects under way, other than the GE Catalyst engine for smaller aircraft and the Deutsche Aircraft D328eco, OEMs are waiting to see which way the sustainable aviation debate impacts their businesses.

From a technology perspective, the main movement looks to be on new propulsion technologies that could still be a decade or so away from reaching large turboprop aircraft, although Universal Hydrogen suggests hydrogen fuel cells could be possible in a 30- to 50-seater-category Dash 8 or ATR by 2025.

What is concrete is that the large but ageing US fleet of CRJ and ERJ regional jets will come under more environmental scrutiny and their higher operating costs will present an opportunity for ATR and De Havilland to increase their market share. Both OEMs have invested considerably in upgrading their cabins to a high standard, and with Covid-19 making direct flights more desirable but less available, the opportunity for turboprops to capture some of the regional jet replacement market is real.

Although Universal Hydrogen is targeting Dash 8s and ATRs, and has commitments from Icelandair, Air Nostrum and Ravn, most projects on zero-emission aircraft are targeting the nine- to 19-seat market. While there are still many hurdles to be overcome, particularly in battery technology, power distribution and hydrogen storage, test flights are happening and lessons being learnt that will encourage more players into this market.

With the push for aviation to become more sustainable unlikely to diminish any time soon, the developments that will ultimately find their way into large commercial aircraft are already happening in the turboprop sector.

Supporting the view that turboprops have a viable place in the commercial aviation ecosystem, Embraer is considering a clean-sheet design 70- to 90-seat aircraft with rear-mounted engines. This will be targeted at the operators of the ageing ERJ and CRJ 50-seat regional aircraft.

While the aircraft still remains a concept at this stage, Embraer says it will have a similar cross-section to the E-jets and a quieter cabin because of the rear-mounted engines. Embraer suggests the engine would be a jet-like prototype that will use 20% to 40% less fuel and emit up to 40% less carbon than regional jet equivalents.

Separately, Embraer has already committed to 100% compatibility with sustainable aircraft fuels by 2030 and has commenced flight tests of its electric propulsion EMB203 Ipanema demonstrator. When the electric tests are completed, Embraer plans to convert the EMB203 into a hydrogen fuel-cell propulsion demonstrator to be ready for flight in 2025.

Taking its future into its own hands, De Havilland is working with Pratt & Whitney Canada (P&WC) to integrate hybrid-electric technology into a Dash 8-100 flight demonstrator, with ground testing to start in 2022 leading to flight testing in 2024. De Havilland will install the propulsion technology, which includes an electric motor and controller from Collins Aerospace, within the Dash 8-100 airframe by designing a modified nacelle structure to house the hybrid-electric technology.

They will also be responsible for the cockpit interfaces needed safely to monitor and control the system, conducting the flight tests and demonstration programme and working with Transport Canada for the experimental flight permit.

P&WC estimates the hybrid-electric technology will target a 30% reduction in fuel burn and CO_2 emissions, compared with a modern regional turboprop airliner, by optimising performance across the different phases of flight. However, it remains to be seen whether this will be sufficiently attractive if Universal Hydrogen or others succeed with cleaner options within a similar timeframe.

In addition to the Universal Hydrogen projects, the Dornier Do328, first flown in 1991, may also be in the vanguard of clean and green aviation in 2021. Now under new ownership as Deutsche Aircraft (DA), and with the aircraft relaunched as the D328eco, it is heading in the right direction. The D328eco will be stretched by two metres, increasing capacity to 40 seats in a standard configuration. With new Garmin avionics, it is being designed for future single-pilot operation. Power will come from PW127S engines capable of running on 100% sustainable airline fuel or jet-A fuel. DA says the aircraft will have the lowest cash operating cost per trip in its class and will have the highest cruise speed of any 30- to 50-seat turboprop. The D328eco is planned to come to the market by 2025.

While DA has also partnered with Universal Hydrogen to evaluate how its system could be applied, in July, DA signed a memorandum of understanding with H2FLY, a German start-up developing hydrogen fuel cell systems for aircraft, to work together on the research and development of hydrogen fuel cell technology for commercial regional aircraft.

The smaller RUAG-owned Dornier aircraft are becoming popular test-beds with two twin-engine 19-seat Do228 aircraft procured in June 2021 by Zeroavia for its hydrogen-electric aviation programme. The aircraft came from Aurigny and AMC Aviation and were previously in-service for regional flights in the UK and US, respectively.

Zeroavia has operations in the UK and US and has already secured experimental certificates for two prototype aircraft from the CAA and FAA. After passing significant flight-test milestones, Zeroavia is planning to commence commercial operations in 2024 with its initial focus on a 500-mile range with nine- to 19-seat aircraft used for commercial passenger transport, cargo and agricultural operations.

In 2020, it successfully completed the UK's first electric-powered flight in a commercial-scale aircraft using a Piper M-class six-seater and followed that later in the year with the Piper aircraft completing taxi, takeoff, a full pattern circuit and landing powered by a hydrogen fuel cell.

The 19-seat programme is Zeroavia's second project to be backed by the UK government to target the development of a hydrogen fuel cell powertrain and is based on a 600kW powerplant, significantly larger than the 250kW one in the Piper aircraft. Initial ground tests in the US were successfully completed in August paving the way for flight-testing later this year.

The ultimate aim for Zeroavia is to develop a zero-emission engine for a 50-plus-seat aircraft that will be built from the learnings of its six- and 19-seat hydrogen-electric powerplants.

The march to emissions-free aviation may have started with electric systems and batteries, but a clear signal that hydrogen is becoming the fuel of choice came when Cranfield Aerospace Solutions' Project Fresson changed course this year. Cranfield Aerospace Solutions is leading the Project Fresson consortium (which includes Britten Norman) which is seeking to deliver the world's first truly green passenger carrying airline services using hydrogen fuel cell technology.

The project started in 2019 aiming to develop an electric propulsion system for Britten-Norman BN-2 Islander aircraft, but, in 2021, the power source was switched from hybrid-electric to hydrogen fuel cells with wing-mounted fuel tanks. In simple terms, the project realised a pure battery electric solution would not give it a useable range and that a hybrid-electric range extender system with its weight implications and charging needs was not feasible either for fulfilling range or green targets.

With new partners in fuel-cell systems, and hydrogen storage on board, the consortium is planning on a hydrogen-fuel cell demonstrator to be flying by September 2022. There are some 230 operators of the nine-seat Islander around the world, mostly tiny airlines and public sector-run utilities, and Britten-Norman says the simply engineered aircraft is ideal for pioneering future technology, while longer-range aircraft will benefit from the work being done now.

Based on the above selection of projects, real progress is being made and, in the next few years, it is entirely possible a nine-seat, hydrogen-powered aircraft will be flying, with the 19-seat versions coming after. However, the systems under development are a step change in technology and certification challenges are very real so that projected programme timescales may yet prove challenging.

The 50-plus-seat turboprop will be around for many years in its present form but it remains to be seen if ATR and De Havilland can protect their market dominance with either their own developments, or those of Universal Hydrogen, or lose their places to some of the start-ups discussed previously.

The implications for lessors and financiers for either or a combination of both outcomes are potential game changers. While the opportunities and risks are substantial, it is clear that those with an interest or appetite for current-generation turboprops will for better or worse experience these developments before those that focus exclusively on larger aircraft.

Turboprop conclusions

Although the financing of turboprops has been a challenge for many years (for operating lessors and other financial institutions primarily because of the smaller scale of the market in terms of absolute numbers, which impacts liquidity, and the value of each individual aircraft), this segment also offers strong opportunities.

Turboprops operate predominantly in short-haul domestic and neighbouring country markets on low-density routes with little competition from either other carriers or suitable alternative surface transport modes. Often this natural monopoly is reinforced by public service obligation contracts. This combination creates a level of demand and therefore revenue stability greater than for large aircraft fleets.

Historically, the impact of economic shocks had a smaller effect on turboprops because they operated in distinct local markets so that a local or regional economic downturn was often matched by growth elsewhere. Although the economic impact of Covid-19 has been felt globally for all aircraft including turboprops, the negative impacts, despite being worse than previous crises, have been less than for other aircraft types.

Despite the relative recent lack of engine technology innovation, turboprops remain highly fuel-efficient aircraft. To date, reducing fuel burn has been about lowering operating costs, but in the current age of ESG, this second and arguably more important motivation is now dominating the minds of airline fleet planning departments. Modern existing turboprops meet carbon reduction targets effectively.

The next generation of emissions-friendly aircraft will be small and gradually creep towards 50- and then 70-seat capacity propeller driven aircraft many years before a mainstream-sized aircraft with hydrogen or electric propulsion becomes commercially viable.

If Universal Hydrogen's ambitions become a reality, such technology could be retrofitted to existing turboprop platforms, thereby generating the next step change in aircraft technology. In turn, this will impact not only the demand for aircraft and the manufacturers, but also downstream suppliers, maintenance organisations and the leasing and finance community.

However, on a final note of caution and without wishing to spoil the party, the certification of any new aircraft takes years even for one that is conventionally powered. Rightly so, the aviation industry's paramount concern is safety. The push for carbon neutrality cannot be allowed to compromise safety even if this means delayed service entry. Among the other technology challenges remaining, we believe that certification time alone is likely to preclude full electric or hydrogen propulsion in this decade. ⋀

Strengths

- best operating economics of any sub-150-seat aircraft on sectors up to 300 nautical miles with insignificant speed penalty on short routes;
- optimised for performance-driven missions – eg, short runways and climb capability;
- increasingly well diversified global operator base;
- class leader for low emissions footprint;
- relatively resilient to economic shocks including Covid-19 with greater proportion of turboprops returned to commercial service; and
- significant protection offered by both essential public service contracts and natural monopolistic route structures.

Weaknesses

- turboprops often operated by smaller and financially weaker carriers;
- lower value aircraft for financiers that require the same asset management input;
- average fleet age is higher than mainstream aircraft;
- lower appeal to network carriers compared with regional aircraft for hub-and-spoke operations particularly in US market;
- much smaller and less commoditised market compared with larger aircraft; and
- lack of significant technological advancement in this century, particularly in relation to powerplant.

Opportunities

- significantly underserved markets ideal for turboprops remain in Asia, Latin America and Africa;
- above-average fleet age for both turboprops and smaller regional aircraft creates substantial fleet-replacement opportunity for lessors of turboprops, in particular;
- any continued fuel price increases or new taxes on aviation fuel imposed at national or supra-national level will increase the attractiveness of turboprops relative to other types because of their lower fuel burn; and
- electrification or hybridisation of existing airframes.

Threats

- continued technological and economic improvement of regional aircraft could erode benefits of large turboprops;
- introduction of a new 90- to 100-seat turboprop by Embraer could reduce the appeal of current-generation 70- to 90-seaters; and
- future hybrid and electric-powered aircraft will probably affect existing turboprop fleets and small aircraft before any other larger aircraft types thereby increasing obsolescence risk.