The Renaissance of the Turboprop Airliner Market

AirInsight

Analysts: Erkan Pinar, Addison Schonland

June 2010

Contents

Conclusions

- We expect the turboprop passenger airplane to experience a renaissance.
- Within the United States airline consolidation is in full swing. Fewer airlines mean fewer choices and higher fares. This movement is likely to be mimicked elsewhere.
- As eloquently put forward by our colleague Doug Abbey in his report “Air Service to Small and Medium-Sized American Airports: Preparing for the Inevitable”:
    - Between 2006 and 2010, 10 U.S. airports lost important scheduled air service links when their last small-jet flights were determined to be uneconomical by major carriers.
    - Nearly 200 U.S. airports have lost all scheduled air service since airline schedules reached their peak in the mid-1980’s.
    - We anticipate that at least 30 other U.S. airports face a similar risk. A majority of the local communities are simply too small or located too near alternative gateways to sustain small jet flying in the long-term. With relatively few 30 to 50-seat turboprop aircraft flying today which could theoretically be used to replace them - and larger capacity (70-plus seat) regional jets too financially risky to deploy in small markets – more local communities remain at-risk at losing their air service than ever.
- With shrinking jet service, smaller communities can expect that air service to hubs will increasingly depend on turboprops.
- Fast turboprops have performance characteristics that make them competitive with jets, particularly on routes of 500-600 miles, but are significantly cheaper to operate.
- The next generation of turboprops is expected to offer up to 100 seat capacity, and further reduce the airline industry interest in jets under 100 seats.
- Finally, the recent spike in fuel costs made turboprops much more attractive and put off major airlines from small jet operations, giving a boost to regional feeder airlines. Regionals, as these airlines are called in the US, are being squeezed to take on more financial risk by the majors. We expect this increased risk to favor the acquisition of fewer small jets but boost interest in next generation turboprops.

Background

The commercial turboprop airliner market has seen significant fluctuations over the past decade. Initially there was great interest as regional airlines started to grow; the need for airlines to feed network airline hubs meant lots of opportunities. What had been essentially a 19-seat market rapidly grew into a 30-seat aircraft market and then into today’s ~70 seaters.

There were a number of oldline, established players offering aircraft. Many of these companies ended up leaving the business as regional jets usurped the market, driving the turboprop market more or less into the doldrums. SAAB, BAE, Fokker, deHavilland and Dornier are names that evoke powerful memories of firms that produced outstanding aircraft - now they are gone.

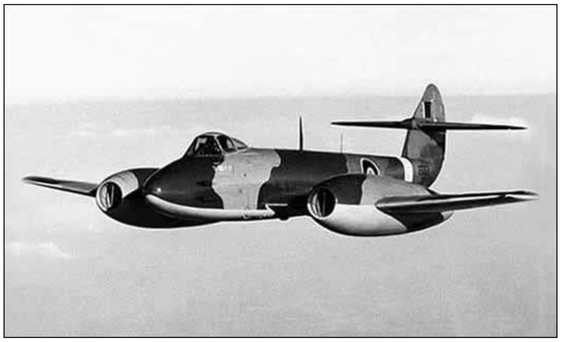
Through all the turmoil a few Western firms stayed the course. Brazil's Embraer went into the regional jet market, leaving the turboprop behind. Canada's Bombardier kept making its turboprop, while building its regional jet program. Turboprops remained popular with airlines, but by 2007 there were only two Western sources of these types of aircraft; Bombardier and ATR. Principally these aircraft remained popular because they had grown to be so much more efficient, particularly in the case of the Bombardier Q400, which operates at near jet speeds while costing 30% less per seat mile.

Three years on, airlines have seen their business evolve and business models based on pure jet fleets have changed. Clearly as turboprops have evolved into "greener" options; these aircraft have once again grown popular. Moreover, with substantially lower fuel burn, turboprop airplanes are big cost savers when fuel prices spike as they have in the recent twenty four months. Further, turboprops offer a flexibility in that they breakeven at substantially lower load factors. This is a crucial factor considering the paucity in traffic (especially the premium paying variety) at present. Consequently we have seen turboprops replace regional jets, that once replaced them.

The rise in interest in Turboprops is catching on in odd places. *The Weekly of Business Aviation* reports South Korea is proposing to build a 90-seat turboprop under an industry development plan that also seeks to press ahead with the KF-X fighter and KAH attack helicopter programs. The 2010-19 plan aims to raise South Korean aerospace turnover tenfold, making the country one of the top seven in the global industry, up from 16th now. It may be that aerospace is once again at a tipping point; after years of consolidation which saw brands disappear, its seems new brands are about to emerge. Even the Israelis have mentioned an interest in developing a small airliner, likely a turboprop. India is also talking about developing a “high speed turboprop” in the 90+ seat category.

A Long History

This report is about the a renaissance in the turboprop market. An interesting fact is that this is not the first time turboprops have made a comeback. The first turbine engines were pure jets that started flying in 1945. The first image is of a British Meteor fighter as a pure jet. But within a year, the second picture shows the same aircraft was being tested with a



turboprop engine! This experiment was not a success, but the turboprop version of the aircraft caught the attention of the Royal Navy, though it ordered none.

The first turboprop engine was the Rolls-Royce RB.50 Trent, a converted Derwent II fitted with a reduction gearbox and a Rotol 7-ft 11-in five-bladed propeller. Two RB.50 Trents were fitted to Gloster Meteor EE227 - the sole 'Trent Meteor' - which thus became the world's first turboprop powered aircraft; a test-bed not intended for production. It first flew on 20th September 1945. From their experience with the Trent, Rolls-Royce developed the Dart, which became one of the most reliable turboprop engines ever built. The Dart-powered Vickers Viscount was the first turboprop aircraft of any kind to go into series production and was also the first four-engined turboprop. This same engine powered the long serving Fokker F27. The F27 is thought by many to be the original turboprop regional airliner.

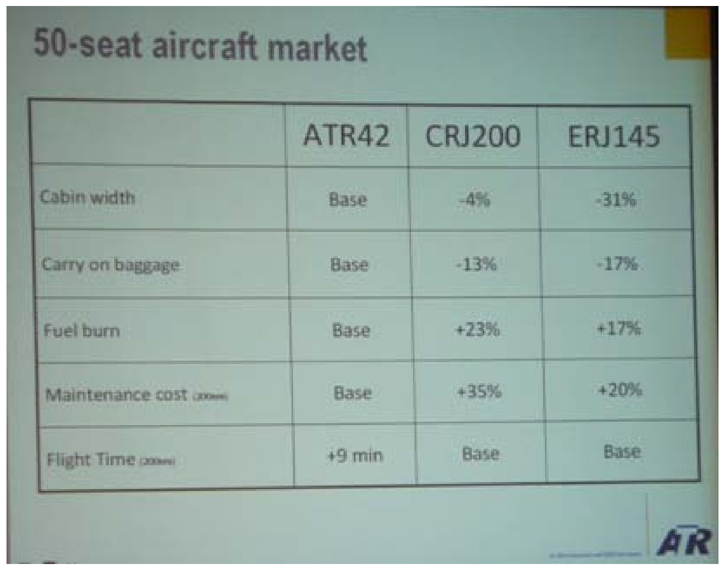
The Dart engine was built for fifty years. Another important piece of turboprop lore is that the Tupolev TU-95 bomber, a four-engined turboprop now named the TU-142 (picture), still holds the world record as the fastest propeller powered aircraft at 575 miles per hour. It features four Kuznetsov coupled turboprops fitted with eight-bladed contra-rotating propellers, producing a nominal 12,000SHP. By comparison to the TU-95 which first flew in 1952, the new Airbus A400M military freighter which just started its test flights is equipped with four 11,000SHP turboprop engines. Clearly these extremely powerful turboprop engines demonstrate where the technology can go. By comparison the turboprop engine used in Bombardier’s Q400 has 5,000SHP.

Resilience

As part of our primary research for this report we spoke with many people in the industry. One standout data point that came up is that looking into the future of the turboprop engine, the biggest technology leap is seen as biofuel use. It was made clear that actual basic engine design has not changed much and is not expected to change much. In terms of a “next generation” turboprop engine, the top items getting attention are thermodynamic cycles which will impact material selection. Certainly for the next engine to be accepted into service, manufacturers need to offer double digit improvements in fuel burn. Therefore focus will be on ever lighter materials to extract more power from lighter engines burning the same exotic blends envisaged for turbofans.

Turboprop technology has been dismissed before and has been resurrected again because it turns out this technology has features that continue to make it very useful. Aircraft that use propellers are able to fly into small airports that jets cannot serve easily. The ability to fly much more slowly make turboprops more flexible in marginal conditions - even with the concerns about flying at lower altitudes and in icing conditions.

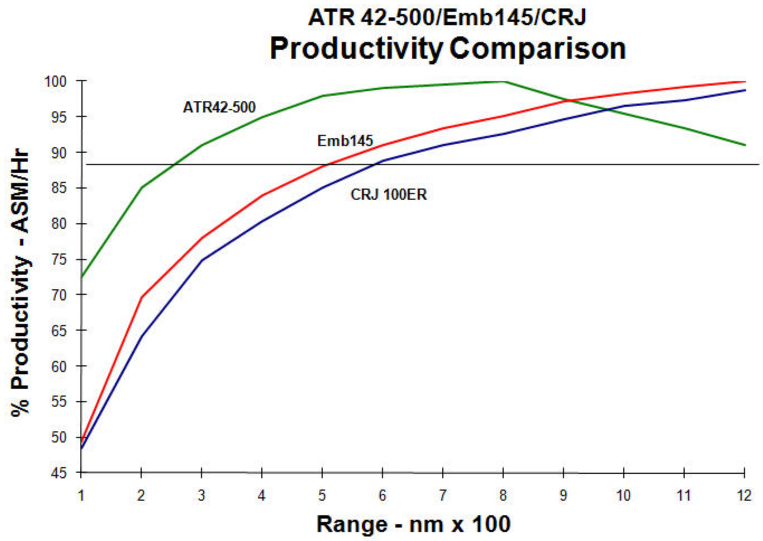
As the picture to the right illustrates turboprops are competitive with regional jets today. Since regional jets have abandoned the 50 seat market, next generation turboprops will likely be even more competitive. Hence we do not expect to see turbofan engined regional jets come back into this size category.



	ATR42	CRJ200	ERJ145
Cabin width	Base	-4%	-31%
Carry on baggage	Base	-13%	-17%
Fuel burn	Base	+23%	+17%
Maintenance cost	Base	+35%	+20%
Flight Time	+9 min	Base	Base

But turboprops do not have an easy future. For example, speaking with Ted Vallas, an aviation pioneer who at 89 is staring his second airline in Carlsbad, California, USA (flycpair.com), he explained that they decided on Embraer 170s. Their second choice was the Bombardier Q400 turboprop. The Embraer offered “pure jet” service – which illustrates the apparent view – particularly in the USA that turboprops are not good enough in terms of passenger appeal. Though Mr Vallas conceded the Q400 is a superb airplane; interestingly they also decided against the Bombardier CRJ because its landing speed was deemed too high for the short runway at Carlsbad.

The following chart illustrates the relative performance tradeoff between comparable turboprop and regional jets. The classic industry thinking is that turboprops are best in the under 500 nautical mile range. Indeed for a short haul airline, the tradeoff tends to be a combination of operating speed, capacity and range. The speed issue is driven by the need to connect passengers to pure jet service as many of the turboprops act as feeders to major airlines.



Lower operating costs and the smaller ecological footprint of turboprops ensures that we are likely to see a resurgence in use of these aircraft. Engine technology has provided enough power to operate at near jet speeds, at substantially lower fuel burn and with less pollution. Indeed a turboprop typically burns just under two thirds of the fuel needed to fly a passenger compared to a pure jet. It is generally accepted that for routes between 300 to 500 miles a turboprop is faster and more economical than a pure jet. Turboprops do not have to climb as high and therefore reach cruise faster and descend quicker.

High-Speed Rail

The biggest competition to turboprop aircraft is probably no longer the pure jet, but the high-speed train. Turboprops operate best on shorter routes. This chart from UK turboprop operator Flybe was coined on an EU-wide household appliances efficiency sticker.

It explains just how efficient its Q400 aircraft are when compared to other transportation types over the same distance. That said, the competition from rail is not critical for all turboprop operators. Flybe is one such example, being based in the UK and flying across the English Channel and North Sea, where it also competes with ferries.

Rail is fixed-base and therefore inherently less flexible. So for turboprop operators, not only are they as fast as any train, they can serve more places. However, on certain routes, such as London-Paris or London-Brussels Flybe has to compete with high speed rail that is less affected by weather (though Eurostar had numerous cold-weather-related problems in winter 2009/10) or truly exogenous factors such as volcanoes. Moreover, Chinese airline executives have complained about that country's rapid growth in its high speed rail program. The success of these trains is seen as a direct threat to China's airlines.

Turboprop Engine Technology

As will be seen much of the analysis as to whether turboprop aircraft can better serve a particular airline and/or route than a pure jet or turbofan equipped aircraft comes down to the limitations or challenges of turboprop technology. When looking at how this turboprop technology could be evolved in the future it is necessary to understand some of the fundamental differences between turboprops and turbofan engines.

The process of developing an aircraft engine is one of compromises between multiple and often conflicting design requirements. An aircraft engine must be:

- *Reliable*, as loosing power is a substantially greater problem in an aircraft than in any ground based transport. Aircraft engines operate at temperature, pressure and speed extremes and need to perform reliably and safely under all expected conditions.
- *Lightweight*, as a heavy engine increases the MEW (Manufacturer's Empty Weight) of the aircraft and therefore reduces the aircraft's payload.
- *Powerful*, to overcome the weight and drag of the aircraft.
- *Small and easily streamlined*; large engines with substantial surface area when installed create excess drag.
- *Fuel efficient*, to give the aircraft the required design range.

Aircraft engines are often operated at high power settings for extended periods of time. In general, the engine runs at maximum power for a few minutes during take-off, then power is slightly reduced for climb, and then spends the majority of its time at a cruise setting - typically 65 percent to 75 percent of full power. As a result the design of aircraft engines tends to favour reliability over performance.

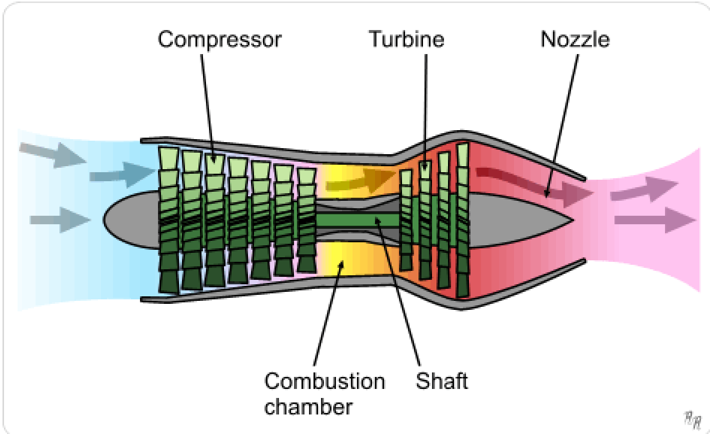
Crucially, smaller airliners like regional jets and turboprops operate higher number of cycles (flights) each day than widebody, long haul aircraft. This type of operation puts these airplanes through much more stress – meaning these small airplanes wear out faster. Consequently their engines are expected to have very high reliability.

Turboprops, Turbojets and Turbofans

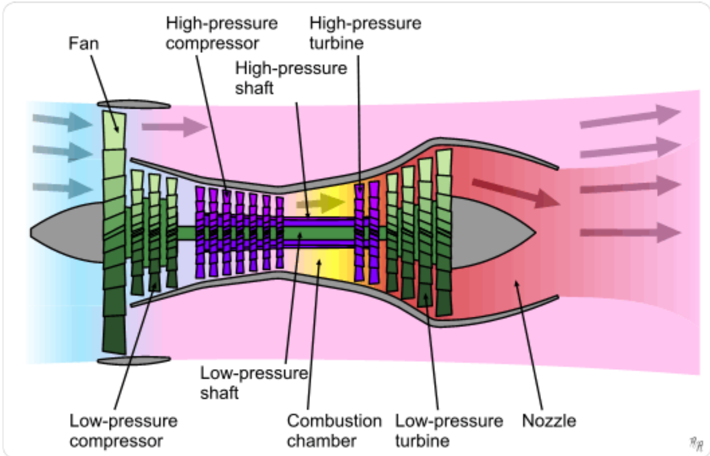
Turboprops came about because aircraft designers wanted to benefit from the high power and low maintenance that a gas turbine engine offers. Because gas turbines optimally spin at high speed, a turboprop features a gearbox to lower the speed of the shaft so that propeller tips don't reach supersonic speeds.

A turboprop is very efficient when operated within the realm of cruise speeds it was first designed for, typically below 450 mph. As aircraft speed is increased beyond this threshold, the flight path of the propeller blade becomes increasingly straight ahead and less sideways. Consequently the 'lift' generated by the blade turns into rotational resistance and less into thrust. In other words, the thrust generated by the propeller falls off the faster it flies.

This means reaching a point of diminishing returns where the engine is no longer imparting any useful power into the air and its thrust drops. The turboprop's engine exhaust gases contain little energy compared to a turbofan and play only a minor role (typically less than 10%) in the propulsion of the aircraft.



A turbojet is a type of gas turbine engine that was originally developed for fighters during World War II. A turbojet is the simplest form of all aircraft gas turbines. It features a compressor to draw air and compress it, a combustion section which adds fuel and ignites it, one or more turbines that extract power from the expanding gases to drive a compressor, and an exhaust nozzle which accelerates the exhaust out the back of the engine to create thrust.



A turbofan engine is much the same as a turbojet, but with an enlarged fan at the front which provides thrust in much the same way as a propeller. A turbofan has extra turbine stages to turn the fan. Thus, more power is extracted from the exhaust gases before they leave the engine. Although the fan creates thrust like a propeller, the surrounding duct frees it from many of the restrictions that limit propeller performance.

Turbofans are more efficient than propellers in the trans-sonic range of aircraft speeds, and can operate in the supersonic realm. Turbofans are split into low-bypass and high-bypass categories. Bypass air flows through the fan, but around the jet core, not mixing with fuel and burning. The ratio of this air to the amount of air flowing through the engine core is called the "bypass ratio".

Low by-pass engines are preferred for military applications such as fighters due to high thrust-to-weight ratio, while high-bypass engines are preferred for civil use for good fuel efficiency and low noise. High-bypass turbofans are usually most efficient when the aircraft is travelling at 500 to 550 mph, the cruise speed of most large airliners.

SaM 146 **PurePower**

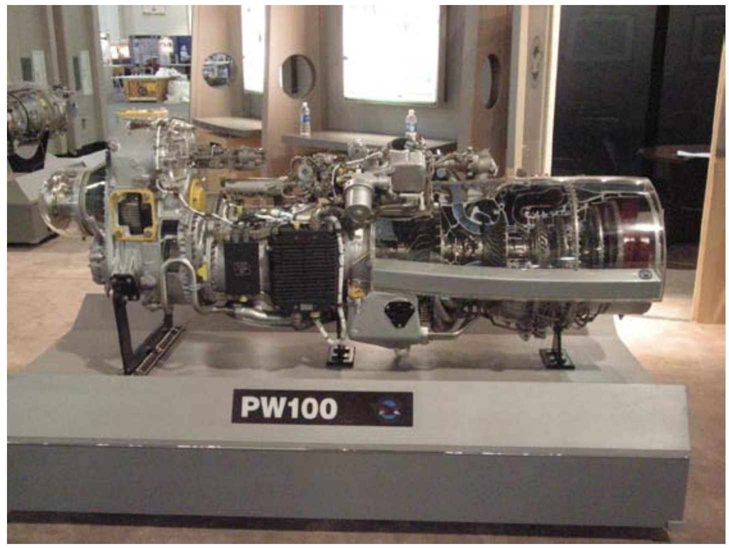
The latest generation of turbofan engines have by-pass ratios of between 4.4 (SaM146 on SuperJet) to as high as 12 (Pratt & Whitney PurePower on CSeries).

Comparing Turboprops and Turbofans

Ultimately what matters to an aircraft is thrust, not power. The need is to accelerate the aircraft at take-off and overcome air resistance at cruise. Turboprops and turbofans are rated differently because their power is measured differently. A turboprop engine is rated in horsepower because that's what you can measure at the shaft (power=torque*RPM). But that's only loosely related to what it's really doing for the aircraft because the amount of thrust the propeller can translate that power into greatly depends on the aircraft's speed.

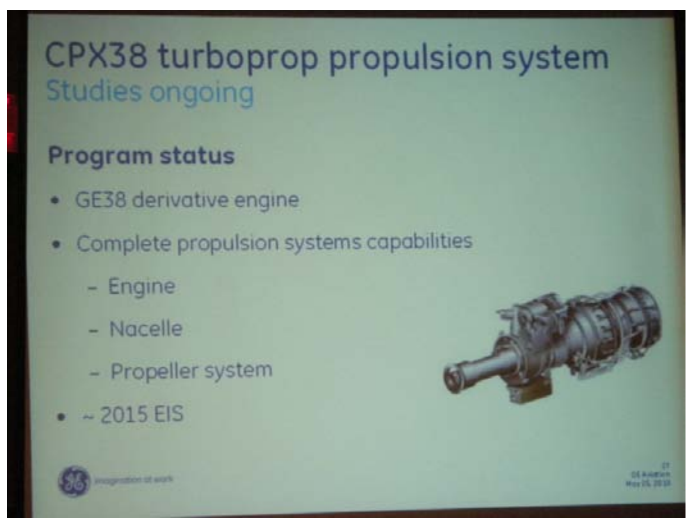
From an energy conservation point of view, turboprops are more efficient at low speeds than turbofans because all the energy goes into accelerating the air. A lot of the turbofan's energy goes into heat and that part of the energy is effectively lost. The downside of turboprops is that approaching Mach 1 at the blade tips, they do not accelerate the air anymore. In addition from the energy conservation point of view, a turbofan typically generates a lot more total power than a turboprop engine. However, at low speeds a greater proportion of that power is wasted heating air and accelerating it to very high velocities. At higher speeds, more of that power is actually imparted to thrusting the aircraft.

Engine Sources



There are a number of engine sources one could consider, but the industry leaders unquestionably are Pratt & Whitney (P&W) and General Electric (GE) in the USA and Rolls-Royce (RR) in the UK. Of these three firms, P&W is the far more prolific in terms of turboprop-powered programs. P&W engines are found on both Bombardier's Q400 and the ATR airplanes, as well as on some smaller Turboprop airplanes.

The picture to the right is the ubiquitous PW100 engine which powers both ATR and Q400. The engine is also found on the Chinese turboprops.



GE's engines are found on SAAB's 340, but are not in use on any current in production turboprop airliners, especially not on any of the larger turboprop aircraft. However, GE is a serious competitor. The slide on the right was shown at the 2010 Regional Airline Association convention and describes GE's next commercial turboprop engine. This engine is based on the military engine GE is producing for the United States Marine CH-53K heavy lift helicopter.

This engine will be in the 5,000SHP class and could be used to power the expected next generation turboprop airliners with seating capacity up to 100. GE is arguably the world's top turbofan producer and consequently has access to the very best in design, testing and engine production facilities. Therefore its interest in this market is a manifest threat to P&W's dominance.

Pre-Owned and Out Of Production Turboprops

The market for "almost new" turboprops is quite active. The market has a lot to offer - Dornier, Fokker, SAAB and BAe aircraft are available. These aircraft have typically been maintained by an airline and are therefore in good condition due to national airline safety regulations. Clearly for corporations seeking an aerial commuter solution, these aircraft are a tremendous opportunity to acquire reasonably recent equipment at low cost, some of which are modern and still setting standards in the industry today.

BAe - Jetstream & ATP

The Jetstream is one of the oldest designs in the modern turboprop era, which is why the aircraft have notoriously limited comfort. These airplanes served in the days when turboprops operated as air taxis and commuter planes from rural airstrips.

The Jetstream 31 was the first of these and it originated its life as the Handley Page HP137 Jetstream 1 in summer 1967, two years after its inception. Critically for those days, it offered a pressurized cabin, allowing for higher altitude flying and therefore faster speeds than other aircraft in its day. The Jetstream 31, and its improved version, the Jetstream 32, introduced in the 1980s marked the first stepping stone into the world of modern turboprop aircraft. At this time British Aerospace (BAe) was created by combining various British aerospace firms and the new company worked on improving the aircraft for the growing feeder and regional aviation sectors.

A stretched airplane, the Jetstream 41, grew out of the experience of the Jetstream 31/32 and this development increased the passenger count from 18 to 29 - a marked improvement for an airframe stretch in those days. Crucially, BAe made the smart decision to incorporate an early version of an EFIS flightdeck into the Jetstream 41, in order to improve the efficiency of the aircraft's operation and to make it compatible in large airline use. About 486 examples of the Jetstream family were built up to the late 1990s and many remain in service today, particularly the Jetstream 41.

The BAe ATP was an airliner produced by British Aerospace, designed as an evolution of the Hawker Siddeley HS 748. The fuel crisis and increasing worries about aircraft noise led business planners at British Aerospace to believe that there was a market for a short-range, low-noise, fuel-efficient turboprop aircraft. By the time it entered the market, the segment was already well represented by designs such as the de Havilland Canada Dash 8 and ATR 42, and production was ended after only 64 examples.

The British Aerospace Jetstream 61 was an improved derivative of the ATP. It featured an interior based on the Jetstream 41 with innovative cabin wall armrests and an increase in capacity from 64-70 seats. In addition the airframe incorporated more powerful PW127 engines and increased weights and range.

With the exception of the Jetstream 31/32, most of which flew in the USA like the sistership Jetstream 41, BAe failed to capture the Turboprop market despite its innovative ideas and aircraft.

Dornier Luftfahrt

The German synonym for aerospace innovation has always been Claude Dornier and his floatplanes, the largest being the Do-X of the late 1920s. After 1945, Dornier developed a range of aircraft - jets and turboprops. Most notable in the turboprop sector were the Do24 and Do26 of the late 1930s that became the platforms of later aircraft.

In conjunction with the Do335 Arrow, the fastest piston engined aircraft ever built with a maximum speed of over 475 mph and also the first aircraft ever with an ejector seat, Dornier amassed a knowledge of reliable and fast aircraft construction that led to the very successful

Do27 (picture) of which over 600 were built between 1956 and 1965 - some in Spain by CASA as the C127.

This was followed by the Do28 (picture) SkyServant and its derivative as the first true Dornier turboprop aircraft the Do128, which was the predecessor to the Do228. Several hundred of the Do28 and Do128 were built in the 1970s and early 1980s, until the end of the line when the Do228 (picture) production started. The Do228 incorporated the new technology TNT wing and built on the experience with the Do28/128 in heavy duty operations and short and uneven runways in Africa and Southern America.

About 270 Do228s in all variants were built, some 150 by Hindustan Aeronautics in India, which was the result of successful demonstrations of operating in difficult terrain in the Himalayas, which the Do228 mastered even under OEI conditions. No other aircraft came close to the sturdiness, reliability and STOL-abilities of a Do228. Production of the last 228-212 ended in 1997, but a new 228NG is already undergoing flight testing at Dornier successor RUAG's facilities in Oberpfaffenhofen just outside Munich. The Do228NG has much improved engines with an all new composite 5-blade prop, a glass cockpit and other enhanced features. The renowned ability of the Do228 as the best and most reliable turboprop aircraft for difficult terrain and sturdy operations made it possible to develop a new version of this aircraft, however RUAG should be careful not to price it out of its core niche market.

The most advanced turboprop aircraft that Dornier ever built was the Do328 (picture), a pressurised circular widebody cabin (2,08m) for up to 33 passengers. With the famous TNT wing, P&W Canada PW119 engines. The combination of the new wing ensured the Do328 was capable of flying at much higher altitudes than its competitors, ATR and the Dash 8-100 and -200, typically cruising at 31,000 feet.

Another innovative feature of the 1988 developed aircraft was the incorporation of the then-latest EFIS technology with the Honeywell Primus 2000 avionics that were also used in the A320. Unfortunately, Dornier with its military background, never had the wisdom of having more than one aircraft program run alongside another, as well as lack of foresight of family planning. The Do228 was sort of forgotten, when Do328 production ramped up and a stretched family member of this advanced turboprop was too long in coming.

Transition from Do328 (TP and Jet) to A320 is an easy stepping stone for pilots. Sadly for Dornier, mismanagement reigned; one of its poorest decisons was to stop development of the stretched version Do428 (44 seats), which was almost completed at the time.

Another mistake was to stop Do328TP production in favour of the Do328 Jet, with a mere 107 Do328TPs built and most of these are still flying today as regional airliners, corporate shuttles or air ambulances and SAR aircraft. The Do328TP remains popular today due to its widebody cabin feel and its high speed of 387 mph combined with low fuel consumption as it can fly in altitudes that are far beyond of any competitor, with the exception of the Q-400. The technology of the Do328 series is still the milestone for the entire industry - often copied, never beaten.

Fokker

Another famous aerospace name from Europe is Antony Fokker. And his story is somewhat similar to that of Dornier. Both companies built advanced aircraft in their respective niches and even created and defined niches that others couldn't see nor envisage.

Fokker was an early pioneer for the modern turboprop aircraft with its F27 (picture), some of which still operate today. Succeeded in the 1980s by the Fokker 50, the first 50-seater turboprop for modern air transport.

But Fokker didn't stop there: it was also the pioneer of small regional jets with its F28, which it built in various versions and which served regional and commuter airlines around the globe very successfully.

So much so that Fokker redesigned the wing of the aircraft and updated the avionics and systems and fitted new Rolls-Royce Tay engines to a stretched version known as F100 (picture) and F70.

At a time when regional air transport were on the rise, this was the right aircraft, since turboprops then were slow and noisy. Unfortunately, and similar to Dornier, Fokker's incompetent managment led to the demise of the airframer in the 1990s.

Interestingly, Daimler Benz Aerospace owned both Fokker and Dornier and should have integrated the two, tidied up management and created a powerful European regional airframer. Unfortunately, Daimler's management was as blind and incompetent as some of Fokker's and Dornier's managers and they all lacked vision. It was also completely focused on its interests in EADS and Airbus.

While it falls outside the ambit of this report, a company called Rekkof (Fokker spelled backwards) is working on resuscitating the F70 and F100, having secured some funding from the Dutch government.

SAAB

In the turboprop market, the most notable Swedish addition was of course the SAAB 340 series of aircraft, with 459 built between 1983 and 1998. Most of these flew in the US market as commuter and feeder aircraft. Some work packages were covered by Fairchild Industries at an initial stage, but when it became apparent that technology transfer was the key interest of Fairchild, the Swedes ceased cooperation and swiftly making it an all Swedish aircraft by 1995.

When the aircraft first flew in 1983, the 30-40 seater market was open and SAAB had a winner on its hands. With better reliability than the Jetstream 41 and lower operational costs, the SAAB 340A (the first 159 units) and the improved 340B (200 units) were a runaway success in the growing regional feeder systems of the US and Europe, where most of these aircraft were flying in the late 1980s and most of the 1990s.

The aircraft lives on today as a low cost package freighter and enables low cost start up contractors for such parcel and post flights an easy entry into the market. The high dispatch reliability of the 340 series aircraft make this a still much sought after commuter flier today and more than 400 are still flying. Interestingly, this was also the most successful turboprop aircraft that uses the GE CT7 engine series.

On the basis of a family concept that BAe followed and that Dornier wanted to, SAAB forged ahead with a stretch version, the SAAB 2000. Having missed out on EFIS introduction on the 340 series (apart from the final batch), SAAB introduced the Collins ProLine 4 EFIS system in its SAAB 2000 and also went for a new engine; the Allison AE2100 engine with mighty 6-blade Dowty props promising jet-like speed of around 425 mph.

Unfortunately for SAAB, the speed came with a higher than expected fuel burn and a much lower dispatch reliability in the early stages of the aircraft's commercial service with Crossair. After five years of production and a mere 64 built, the programm ceased in 1999. This 50-seater was a victim of the manufacturer's aim to compete with the upcoming regional jets. Reliability has now improved and about 54 remain in commercial service today. Many are being converted to military use as maritime patrol or AWACS-type work.

New Build Turboprops

Today's market offers few choices for new build turboprops. There are essentially two primary players in the west while smaller programs are being conducted in Ukraine and China.

The former are ATR in France/Italy and Bombardier in Canada. These firms have managed to survive the turboprop market decline and now are the two most significant players. The Chinese program is established and clearly evolving without any apparent resource constraints. The Chinese government has determined that the nation will be a global player in aerospace and consequently Xi'an Aircraft Industry Company is a name the industry will rapidly come familiar with. In the Ukraine an old stalwart, Antonov, soldiers on under tough times and resource constraints. We believe this company cannot yet be counted out as it has the innate ability to design and build new and innovative aircraft in this category. Moreover recently Antonov agreed to enter into a joint venture with Russia's UAC, potentially becoming a force again.

ATR builds three variants of its (~1,000 sold in total) turboprop ATR-42/-72, with a backlog at December 2009 totaling 156, or approximately three years' production at current rates. Bombardier sold ~1,040 turboprops and has a backlog today of ~90. Production rates of the Q400NG are at ~50 per year. In 2009 ATR delivered 54 aircraft at a list price of $25m while Bombardier delivered over 60 aircraft at $28m list prices.

ATR and Bombardier both see a strong growth in the 60-99 seat turboprop market sector over the next 20 years. This bullish view that is the reason we believe the turboprop market is headed into a new phase of growth.

ATR

ATR (Avions de Transport Régional or Aerei da Trasporto Regionale) is a French-Italian aircraft manufacturer. It was formed in 1981 by Aérospatiale of France (now EADS) and Aeritalia (now Alenia Aeronautica) of Italy. Alenia Aeronautica's manufacturing facilities in Pomigliano d'Arco, near Naples, Italy produce the aircraft fuselage and tail sections. Aircraft wings are assembled at EADS Sogerma in Bordeaux in western France for Airbus France. Final assembly, flight-testing, certification and deliveries are the responsibility of ATR in Toulouse, France.

The company produces two models; the ATR42 and ATR72. The ATR42 comes in six variants but of these there are really two primary versions. The -300 was the standard, powered by twin 1,800SHP P&W engines. The -320 version came with an extra 100SHP for hot and high conditions. There is a -400 which uses the -300 engines but has a six blade propeller. The new standard is a -500 which is a substantial improvement; it was redesigned and uses 2,400SHP engines, six blade propellers and with the greater power, this aircraft has a range of 1,500 miles and greater payload.

The following table illustrates key differences between the ATR42 and ATR72.

	ATR42-500	**ATR72-500**
Flight Deck	2	2
Cabin Crew	1	1
Passenger Capacity (Single Class)	44-50	68-74
Length	22.67m	27.16m
Wingspan	24.57m	27.05m
Height	7.59m	7.65m
Maximum takeoff (kg)	18,600	22,500 (Basic) 22,800 (Optional)
MTOW Takeoff Run	1,165m	1,290m
Powerplants	P&W Canada PW127E	P&W Canada PW127F/M
Maximum speed	300 kts	276 kts
Range	1,611 km	1,500 km
Service ceiling	25,000ft (7,600m)	25,000ft (7,600m)

The difference between the two aircraft illustrate that the larger model does not offer an operator substantial benefits over greater payload. The larger aircraft has a shorter range and operates somewhat slower, despite its higher power.

Recently the company announced a -600 model. This aircraft will have a 5% greater power output, but crucially, it finally has a glass flightdeck, which provides ATR with CAT III capability. It is important to note that ATR will only be introducing advanced flightdeck technologies to the aircraft late in 2010. This is considerably later (over a decade) than its competitors. It almost certainly explains why its products are substantially less expensive.

At the 2010 RAA convention, ATR made it clear that by the end of the year it is likely to announce plans for a next generation turboprop of 90 seats. ATR went on to say it was in discussions with P&W and GE for engines. GE also made mention of this, saying that its GE38 engine to be used in the new Marine CH-53K helicopter would be the core for a new 5,000SHP class turboprop engine for airliners. Such an engine would clearly be available to various manufacturers in the soon to be busy 90-seat category. P&W would not speak at the RAA convention about this, but subsequently described its vision for this category as engine not exceeding 7,000SHP.

When looking at the market's acceptance of ATR's products, the following table illustrates orders and deliveries.

	Orders	**Deliveries**
ATR 42	418	410
ATR 72	584	472
	1002	882

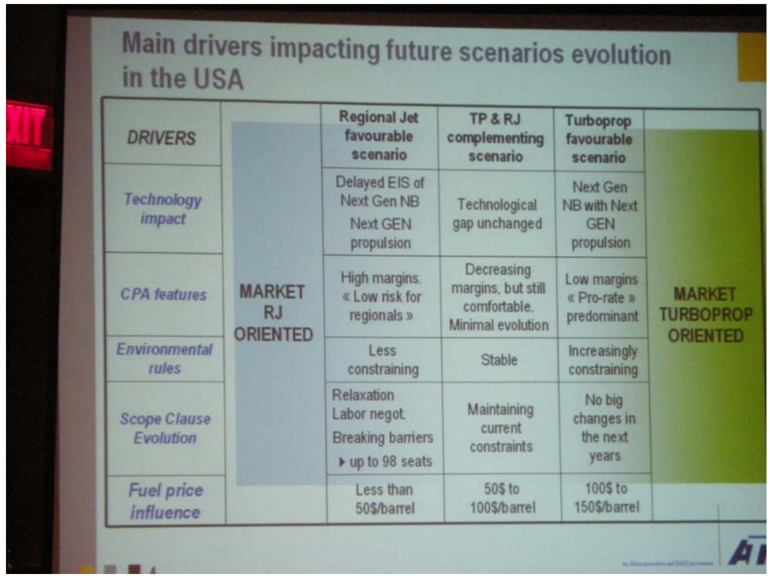
Compared with Bombardier, ATR has a far broader customer base and consequently a lot less concentration. The table below shows the top 50% of ATR's deliveries to date.

AIRLINE	Orders	Deliveries	Concentration
Continental Express	53	53	6%
American Eagle Airlines	45	36	10%
AMR Simmons	24	29	13%
Transasia Airways	27	27	16%
Air Tahiti	30	25	19%
Air Dolomiti	23	23	22%
Air Littoral	21	21	24%
Binter Canarias	19	19	26%
Eurowings	16	19	28%
Kingfisher	56	18	30%
Mount Cook Airlines - ANZ	18	18	32%
Vietnam Airlines	20	17	34%
Bangkok Airways	13	15	36%
Jet Airways	15	15	38%
CSA - czech airlines	13	13	39%
Nurnberger Flug	13	13	41%
Aeromar	12	12	42%
Atlantic Southeast Airlines	12	12	43%
Cimber Air	12	12	45%
Finncomm Airlines	16	12	46%
Brit Air	8	11	47%
CCM Airlines	11	11	49%
Finnair	11	11	50%

To be fair, it has to be said that the ATR aircraft are by far the cheapest Western aircraft an operator can buy and thus they present the cheapest seats in the industry. In the 1990s when the regional jets were up and coming, ATR offered its aircraft especially to cash-weak operators often foregoing the downpayments that are usually needed.

There was thus never a real need for the company to upgrade their aircraft technically since being cheap is a key factor when it comes to deciding which aircraft to buy in the commuter and regional market. The fact that the aircraft are under-powered and technologically obsolete did not play a major point. For example, whereas Bombardier uses a 5,000SHP P&W engine, ATR uses a 2,750SHP P&W engine. In addition, being allied to EADS means that ATR has deep pockets to reach for when needed.

Finally, ATR remains committed to the future of the turboprop market and is likely to announce its own 90 seat design before the end of 2010.



DRIVERS		Regional Jet favourable scenario	TP & RJ complementing scenario	Turboprop favourable scenario	
Technology impact	MARKET RJ ORIENTED	Delayed EIS of Next Gen NB Next GEN propulsion	Technological gap unchanged	Next Gen NB with Next GEN propulsion	MARKET TURBOPROP ORIENTED
CPA features		High margins. « Low risk for regionals »	Decreasing margins, but still comfortable. Minimal evolution	Low margins « Pro-rate » predominant	
Environmental rules		Less constraining	Stable	Increasingly constraining	
Scope Clause Evolution		Relaxation Labor negot. Breaking barriers ▸ up to 98 seats	Maintaining current constraints	No big changes in the next years	
Fuel price influence		Less than 50$/barrel	50$ to 100$/barrel	100$ to 150$/barrel	

Indeed, as ATR sees it, the market conditions over the immediate future favor turboprops. So much so they believe that by 2029 we are going to see turboprop deliveries rise from 15% in 2000 to 40% in its size segment.

Given such a bullish view we expect ATR to invest in new programs to keep its product line on the cusp of technologies and a credible force in the market. And they will try to remain the cheapest seat regional airlines can buy.

Bombardier

The story of Bombardier's entry into this business starts with another legendary name in aerospace - De Havilland. De Havilland built an excellent name in creating robust airplanes that could serve any sort of air service in the northern wilds of Canada. De Havilland created a remarkable twin engine airplane in the DHC-6 "Twin Otter" (picture).

Powered by two small turboprop engines this aircraft has impressive STOL capabilities. The success of this aircraft led De Havilland to grow the design into the four engined DHC-7, or "dash seven". The design has proven so compelling that a new build program has been started by Viking Air on Vancouver Island, incorporating the newest flight deck technologies. Viking is now the type certificate holder for the DHC-2 Beaver, DHC-2T Turbo Beaver, DHC-3 Otter, DHC-6 Twin Otter, DHC-4 Caribou, DHC-5 Buffalo and DHC-7 aircraft.

De Havilland used medium power engines but large propellers and created a relatively quiet airplane that could serve inner city airports efficiently. Unfortunately its STOL performance was not attractive to airlines. While the airplane found itself truly appreciated by communities living in the Rockies, too few airlines bought the airplane. De Havilland went back to the design and decided on a twin rather than a four engined offering. Using more powerful engines, the new design (known as the dash eight) proved much more popular with airlines. This was principally due to the fact the airplane offered the lowest seat mile costs of any turboprop. While not a STOL design, the wing was efficient enough to allow the dash eight to only use 36% more runway length than the Dash Seven.

As described above, the arrival of the regional jet took much of the blossoming opportunity for turboprops away. But Bombardier kept at it, protected by its own burgeoning regional jet sales. Bombardier is thus the only aerospace firm with substantial skin in both the RJ and turboprop games. The company stayed with its Dash Eight, and the aircraft became the benchmark turboprop airliner. The demise of BAe, Dornier, Fokker and SAAB certainly helped Bombardier to play a role by replacing these aircraft as and when airlines sought newer turboprops.

In 2008, De Havilland was part of Bombardier (the company had been owned briefly by Boeing which sold it in 1992) and the early dash eight designs (-100, -200, -300) were curtailed in favor of the current -400 model. This design has been tweaked in the tried and trusted Bombardier formula. Currently in a "next generation" form, as it is now called, the aircraft has noise suppression to make it even quieter inside.

The Q400 is so efficient, that depending on configuration, it can breakeven with load factors between 25% to 33%. There is no pure jet that can compete with such economics. Which is one of the reasons we believe the turboprop is about experience its next renaissance.

Bombardier has a fine reputation as the aerospace industry's quintessential stretcher of airframes. It has managed to stretch its original business jet design into a frame holding nearly 100 seats. Therefore it is no surprise that Bombardier is considering a stretched Q400, for now known as the Q400X, which could seat up to 90 passengers. At the 2010 RAA convention Bombardier would not be drawn into a discussion of this airplane. But clearly if ATR makes a move and new competitors on the horizon step up, Bombardier can be expected to protect its franchise.

In a briefing Bombardier provided to our analysts, the company described the encouragement its customers are providing for a larger turboprop. Even as the company is reluctant to discuss a bigger airplane, take a look at its view of the market. It views the future as bigger airplanes – it views the future as a world with 60-seaters or bigger. Clearly the 60-90 seat market is the sweet spot for turboprops. We are reasonable that a combination of industry entrants and ATR’s move to the 90 seat market will tip Bombardier’s hand. Indeed, just as this company has upset the Airbus/Boeing duopoly with its CSeries, it would be incredibly myopic not to expect the same moves developing below its own Q400.

Another point to note about this aircraft is the design of its landing gear; the decision to design landing gear integrated into the engine nacelle was something Fokker used successfully, and it gives the Q400 a sturdiness that is unmatched in the industry. Thus even rugged airfields can be served by a Q400, where its main competitor, ATR, would fail.

	Orders	Deliveries
Series 100	299	299
Series 200	105	105
Series 300	267	266
Series 400	362	257

When looking at Bombardier’s customer base, we selected the Q-400 major customers to create this table. Note that program is somewhat concentrated – the top six customers account for over 50% of deliveries to date. Note that SAS experienced difficulties with the landing gear on its Q-400s and are retiring the entire fleet – replacing these planes with CRJs. The following table shows Bombardier's top 50% of Q400 deliveries to date.

	Q400		
Customer	Ordered	Delivered	Concentration
Flybe	56	52	14.8%
Horizon Air	46	38	27.0%
Colgan Air/Pinnacle	30	15	34.9%
SAS Commuter	28	28	42.3%
Qantas Airways	21	21	47.9%
Porter Airlines	20	20	53.2%

Comparing the ATR 72 and Q400

Using the 2009 data from the United States Department of Transportation's financial reporting by airlines operating these aircraft we have assembled the following comparisons.

Hourly Cost	Fuel Ops	Total Direct Maint.	Total Flight Ops	Total Air Ops
ATR 72	$565	$1,072	$ 1,513	$2,845
Q400	$680	$639	$1,421	$2,529

The ATR has fuel costs ~17% lower than the Q400. But the ATR costs over 6% more per hour to operate. Indeed when comparing the direct maintenance costs, the ATR is just over 40% more expensive to operate per hour. The Q400 costs 11% less in terms of total air operations per hour.

During 2009 the ATRs utilized 44.4% less fuel than the Q400s to accomplish their missions. This no doubt is a function of the ATR using a much smaller version of the PW100 engine – the Q400 engine is roughly twice as powerful. However in terms of airframe repair costs, the Q400 cost nearly 63% less than the ATR.

The data suggests that industry rumor mill is supported by the data. The ATR may be the least expensive airliner in class to buy, but it is not the lowest cost to operate. The Q400, despite burning more fuel, seems to be robust, requiring substantially less maintenance. Given that these airplanes operate in high cycle environments, being a robust airplane is a critical factor. Bombardier has a truly deep experience base upon which to build from the original de Havilland designs, which were tough airplanes first and foremost.

Chinese Programs

China has made its aerospace ambitions plain - it plans to be a first tier global aerospace supplier. The country has long been a developer of aircraft, but typically this has been licensed production of Antonov designs. More recently indigenous designs have been forthcoming - but there are manifestly copied aircraft being seen as well. China has earned a reputation is being quite liberal with the intellectual property of others, most notably Russian aerospace technology.

In terms of the turboprop market, China started off with the 50 seat MA-60 (picture). Only 122 were built and these were primarily exported to African and Asian airlines. The design "borrows" extensively from the AN-24/28. The MA-60 employs P&W engines, making it somewhat comparable in performance to ATR and Bombardier aircraft. Sales of this aircraft are likely to have been made at exceptional prices in order to give the manufacturer experience necessary to become a better source of aircraft. Profits being defined by Chinese in non-financial terms; political influence and technology experience being far more important.

The follow on to the MA-60 is the MA600 (picture), a 60 seat turboprop. This design is a stretch of the MA-60. The Xi'an Aircraft Industry Company, maker of both aircraft, learned its lessons from the MA-60 and built an aircraft that has a larger payload, yet is 300kg lighter and, if Xi'an is to be believed, 40 percent more fuel efficient than turbofan aircraft of equivalent size. China's Aerospace Industry Research Center forecasts that 5,300 to 5,500 regional aircraft would be needed in the next 20 years, of which 1,900 would be turboprops. Indeed, Xi'an has announced plans for another turboprop to be called the MA700, which should seat 70.

The MA700 is reported to be quite a different design from the earlier aircraft. This could mean an entirely domestic Chinese design, but to date even the Comac 919, which supposed to be an entirely China design, looks remarkably like the Airbus 320. Similarly, the ARJ21 is essentially an updated DC-9. Reports from China state that the MA700 will make significant use of composites. The MA700 will compete directly with the ATR 72 and Q400. This means the aircraft will face the west's latest turboprops and consequently have to offer at least similar performance.

Rather than dismiss Chinese designs as not compelling, it should be noted that Airbus' China plant has delivered 11 A320 aircraft within its planned schedule. Airbus proudly noted this effort and, importantly, made a point of describing the output as "Airbus-quality". The message is clear, China is a rising force in commercial aviation. Though its current designs may borrow heavily from other programs, China has the ability to develop its own designs. The nation's aerospace industry has a rich heritage of building aircraft under license or building unlicensed copies. Each program's lessons have led to a rising knowledge base consequently we expect to see China play a significant role in the turboprop market within a decade. This means not only seeing many of these aircraft flying within China, but also at customer airlines in southeast Asia and Africa.

Antonov

A once famous name in big turboprops is Ukraine-based Antonov. Maker of the large Soviet era transports, Antonov is famous for the AN-225, the largest commercial aircraft in the world. Antonov shrank after the breakup of the Soviet Union and disappearance of the Soviet air force as its principal client. Also gone were orders from Aeroflot.

But the firm's designs are clear to see in the Chinese aircraft. The image shows an An-32 configured for fire fighting. The Chinese aircraft heritage is manifestly based on Antonov's designs. Without capital to invest in significantly updated programs, Antonov continues to find new uses for its old and trusted designs. Clearly, though the firm once had the technical ability, without customers and short of resources (cash and engineers) it is a shadow of its former self. It is doubtful Antonov gets any fees from its IP in use by China.

We mention this firm as it has the potential to once again be a player in the market - under very specific circumstances. Its aircraft are seen in use across Africa. In Africa Antonov aircraft have proven their reliability in the most testing of circumstances. The primary work of many Antonov aircraft in Africa is flying aid for the UN food program. Invariably this means operating in hostile environments that would destroy most airplanes.

An important reason not to count out Antonov is that the firm has been resilient and continued to develop programs. A key example is the An-148. It is a pure jet and seats 70-80 passengers.

The list price for the An-148-100 is between $18–20 million and Antonov claims direct operating costs will be 25-30 percent lower than an Embraer 170. Clearly Antonov has the capability, even with significant resource constraints, to produce compelling airplanes, even if they often do resemble Western aircraft to a T. The An-148 (picture) looks clearly like the child of a BAe 146/Avro and a Dornier 328 Jet. But Antonov is right to follow that thinking; both Western designs were visionary and had compelling arguments in their respective markets, so why not take up the idea and built on it?

If Antonov were to identify the turboprop as a market that it could compete in and win, the firm should be expected to offer robust and low cost designs. Therefore Antonov should be at minimum be considered a potential supplier. The latest news prior to publication of this report is that Antonov and Russia's United Aerospace Company were developing a joint venture. Such a deal will certainly provide Antonov with a much more stable resource base to work from.

Emerging Programs

There are a number of programs being spoken of. One is in South Korea, where a turboprop airlines of ~90 seats is being planned. Another new program recently announced comes from India.

South Korea

South Korea is another nation with grand aerospace ambitions. It is uncertain whether the nation's parliament will favor a 90-seat airliner project as it will need government funding. The South Korean Knowledge Economy Ministry, which drafted an aerospace development plan, described the project as a "strategic program". This is always useful language to attract state support. Few details of the design are available - its configuration and design are to be determined later. What we do know is that it will be a turboprop. The project apparently replaced the 60-seat regional jet that Korea Aerospace was working on in 2008.

This project would create a turboprop airliner larger than and a competitor to China's MA700, the ATR 72 and the Bombardier Q400. There can be no doubt that these emerging programs are spurring on ATR and Bombardier to move ahead with their own programs to raise capacity to nearly 100 seats in next generation programs.

South Korean would likely need a partner to execute such a project; just as it relied on Lockheed Martin for its T-50 project. However, the only partners it might find would the GE and P&W for engines as these firms have stepped in to assist other emerging turboprop projects.

India

According to available information, the Indian program is known as the RTA-70. The program is thought to be focused on 50-70 seats; it is also reported that Hindustan Aeronautics Limited (HAL) and the National Aerospace Laboratories (NAL) are planning to jointly design and develop this aircraft. Its development cost could exceed $4 billion and will roll out for certification in six to seven years.

The aircraft is planned to cater to regional Indian routes. It is to have a range of between 600km-800km. HAL and the NAL had not decided on work share and funding; NAL has held discussions with P&W and GE for an engine.

However, India's plans might remain concepts for a while yet. In October 2008 the Comptroller and Auditor General of India (CAG), which audits and assists state and central institutions on accounts and accountability, advised the NAL to defer its plans to build the 70-seater on account of delays on its 15-seater Saras aircraft. "Keeping in view the problems faced by NAL in HANSA (a two-seater trainer flown at flying clubs) and SARAS (a 14-seater project in the works for two decades, which has is suspended until an inquiry is completed into the crash of a prototype that killed its two pilots) projects relating to marketing of the aircraft, difficulties in finding an industrial partner and lack of specialised manpower, NAL may review initiation of the new project for development of a 70 seater aircraft." India has had trouble with its local helicopter program as well.

Perhaps with an eye on India's rather clumsy attempts in aerospace to date, G. Madhavan Nair, chairman of NAL and the former head of the Indian Space Research Organization (ISRO), said the plane project would be run by an independent commercial body, with public and private partners, including an overseas aerospace firm. It should be noted that in the late 1990s, HAL and ATR dropped a plan to build turboprops jointly in Kanpur.

However, hope springs eternal in aerospace and the RTA-70 is expected to have a ~30% lower fuel burn than existing 70-100-seater passenger aircraft, and have half their maintenance costs through the use of special sensors and coatings. The RTA-70 will be designed to enable it to land and take off on small runways and use satellite navigation. There are even reports as detailed as this: advanced technologies should give the aircraft 25% lower acquisition costs, 25% lower operating costs and 50% lower maintenance costs than existing turboprop regional aircraft according to NAL. NAL talks of a composite airframe and plans.

Power will come from two "next-generation turboprop engines" - but it is not clear what this means or where these will come from. The RTA-70 will have a fly-by-wire control system, open distributed modular avionics, automatic dependence surveillance, broadcast navigation capabilities, and advanced displays. All very high-tech and probably beyond anything India can handle domestically.

Perhaps the greatest case for the airplane is India's state of airport infrastructure. A STOL aircraft would be useful as many airports are small. That said, in the tried and tested Indian fashion, complexity will be piled on - competing agencies and budgets will create the usual havoc and delays. Particularly when one thinks that by the time this airplane starts flying the world will have moved to 90 seat turboprops. What might be a very useful programe could fail for lack of focus and simplicity. Hubris never created a successful program.

About the Authors

Addison Schonland heads Innovation Analysis Group, an aviation focused market-research and consultancy based in the United States, and has worked with aircraft manufacturers, engine manufacturers, airlines and the air travel sector. Dr. Schonland has been an innovator in new media, and publishes a successful aviation blog and on-line information resources.

He holds degrees in Sociology, Economics and Finance for the University of Cape Town, South Africa and a doctorate in business administration from Rushmore University. He was previously with PA Consulting Group and has been involved with commercial aviation for over twenty years. Additional information can be found at www.iag-inc.com

Erkan Pinar is owner and principal at www.airlinestrategy.com based near Munich, Germany. He has worked with aviation consultancies in various locations in Europe and the Far East. Having done stints in the IT and F&B sectors, Erkan has also done research for Airbus and worked with Dornier and Fairchild Dornier until the final demise of the company in 2003.

The network around Erkan includes MRO companies, for which he signs responsible in commercial functions, general aviation and test pilots, engineering companies and interior specialists.

Erkan holds a degree in Law by the University of Buckingham, England /UK, as well as an MSc in Air Transport Management by the famous College of Aeronautics of the Cranfield University, England / UK. He is a regular contributor to IAG and coordinates the continental European information resources.

Other Publications Offered by Air Insight

http://www.iag-inc.com/store1.html