Green Development Options for the A320 Family

Introduction.

Flight Magazine recently ran two articles on the A320 family. They speculated that total production might reach 8,000 aircraft and briefly discussed the use of fuel cells as a means to replace the Ram Air Turbine (RAT) and APU.

It appeared that Airbus would offer some small improvements but no replacement aircraft was yet in sight.

Is this is an acceptable position given the current and future costs of jet fuel?

The aim of this article is to offer to some ideas that would improve the fuel efficiency of the A320 family in the hope of stimulating further debate.

Hybrid Power Options.

The Airbus related articles in Flight and questions that had arisen from my brief time in easyJet prompted some blue sky thinking.

Why has Toyota enjoyed commercial success with hybrid powered cars?

Why has aviation persisted with installing an APU into the tail sections of airliners?

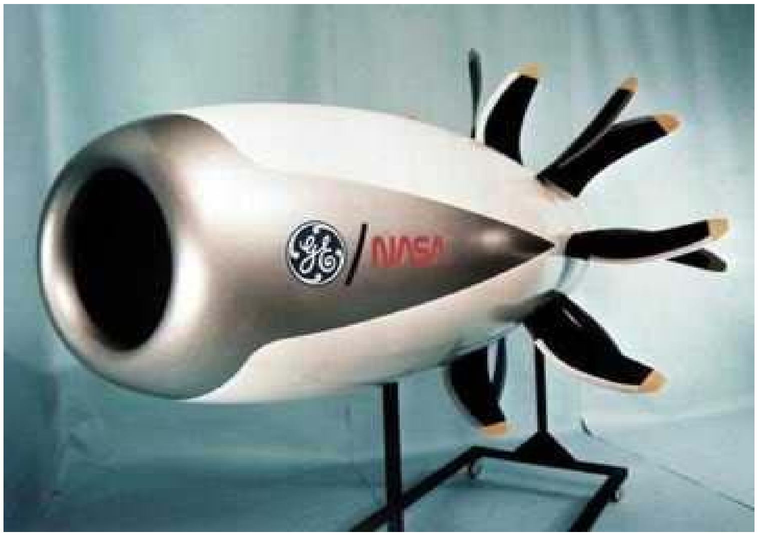
After all, during normal operation the APU becomes ballast from just after engine start to shortly after landing.

The APU has other supportive functions but it contributes next to nothing to aircraft performance.

Should it be replaced with fuel cells in the hope of saving weight or do we look to something else?

My proposal is that Airbus should revisit the NASA Advanced Turbo Prop Project (REF1) and replace the APU on the A320 family with a turbo prop driving a pusher propeller.

For discussion purposes the article will refer to this device as a Prop-APU.



Why?

Primarily to develop a Hybrid A320 that combines the best of Turbo Prop and Turbo Fan technology such that the new aircraft offers better performance and 10% lower fuel consumption pa.

How?

During the oil price shocks of the 1970s the US government, Airlines, NASA, academic institutions and aerospace manufacturers looked at developing "Prop Jets".

The "Advanced Turbo Prop Project" ran from 1976 to 1987 and developed an advanced propeller and gas turbine power plant that could operate at up to .8 Mach.

The power plant was built, flown successfully on a test bed aircraft and delivered 20% to 30% better fuel efficiency on short sectors than comparable jet engines (Ref 2).

What the NASA project proved was that this performance advantage could be sustained up to quite high altitudes and cruising Mach Numbers.

What Happened to the Advanced Prop Fan?

Having read the research it became apparent to me that the Airbus spends most of a flight in a regime where an Advanced Turbo Prop would be more fuel efficient.

So why did the original project fail commercially when the technology appeared to deliver all that had been asked of it?

NASA concluded that the prime cause was socio economic.

Passengers were resistant to aircraft with propellers (cabin noise and perception) and as fuel became cheaper in the 1980s the industry swung back to turbo fans.

Secondary issues included engineering risk and cost. Although the technology worked, to replace the main engines with prop fans did pose a higher engineering risk and cost.

Antonov have produced an aircraft powered by a Prop Fan and there is some technology spill off into turbo fans from firms in the West. Periodically the industry reviews the prop fan and recently easyJet published a concept airliner driven by propellers.

Proposal.

1. To anticipate customer perception and reduce engineering risk by modifying the A320 into a Hybrid powered aircraft.

2. To install a P-APU to supplement Airbus performance at points in the flight envelope where it is more fuel efficient than its turbo fan engines.

3. To remove the APU, re design the tail cone so that a semi recessed engine can be mounted in that area with the gearbox and propeller sited in roughly the same place as the APU exhaust.

What Engine?

The engines developed from the original NASA programme are now in museums and could be best described as archived knowledge and hardware.

I would suggest using a modified AE 2100 which produces around 4,000shp. To quote Rolls Royce the AE 2100 is "the most efficient, environmentally friendly engine in its class".

It has a basic weight of 750kg and is unusual (and essential for this application) in having Full Authority Digital Engine Control (FADEC) to control both the engine and propeller.

What Propeller?

Much useful work was carried out under the original project on propellers (Ref 3) and I would envisage a tailored approach.

Use the research to select a propeller that works at up to 0.8 Mach, is probably contra rotating for efficiency and of low diameter thus eliminating ground clearance issues.

Additional Advantages of Hybrid A320

The P-APU is not just a means to save fuel it offers some intriguing ways of improving the Airbus and changing the way we operate.

In chronological order:

It might be able to "power back" on just the P-APU.

It could taxi out on just the P-APU thus saving fuel.

The 4,000shp would improve take off performance, obstacle clearance and allow derated take offs at higher weights.

It would climb faster to get the turbo fans into their optimum operating environment or on short sectors provide more fuel efficient propulsion at lower altitudes.

Better drift down performance.

Perhaps 3 of the 5 wing spoilers could be replaced if the speedbrake function was delegated to the propeller on the P-APU (via its FADEC). In brief, a speedbrake request results in a propeller pitch change not spoiler deployment.

Steep Approaches possible (quieter, greener, shorter separation distances?).

Less noise and fuel wastage on final approach as the P-APU is used to correct small changes in speed. The existing system suffers from lag as the turbo fans are usually close to idle and take time to respond to speed changes.

Improved stopping performance.

Taxi in on the P-APU.

Approximate Business Case

Assumptions: That fuel remains above $100 barrel and that 10% (800) of total A318/9/20/21 produced are equipped with a P-APU.

Development Costs:

Rear Fuselage re-designs $20m.

Wing simplification $15m.

Fly-by-wire and auto thrust modifications $20m.

AE2100 modification $20m.

Propeller development $15m.

Test flying and re certification $30m.

Grand Total $120 million or $150,000 per aircraft.

Production Costs:

Additional cost of AE2100 over APU $2.5m.

Propeller $1.5m.

Rear fuselage strengthening $1m.

Total $5m

Grand Total about $5.15m per aircraft

Payback Period

I have ignored all other benefits including operational flexibility, additional maintenance costs of the AE2100 and propeller and improved residual value.

Assuming an aircraft consumes 6,500 tonnes pa, at $1,000/tonne, equals $6.5m pa.

A 10% saving on fuel produces $650,000 pa and this equates to pay back in 7.9 years.

I think this needs to be closer to 4 years and might be achievable with development grants from government agencies, possible economies of scale and a power by the hour deal for the P-APU.

Proportionality and other applications?

The A350

Flight Int. (17th June) reported that the A350 XWB empty weight will be 2.2t greater than target resulting in a fuel burn penalty of 1%.

Would it make sense to replace the A350 APU with a Prop APU and if so what engine?

Example, the TP400 from the A400M produces 11,000shp and weighs 1,860kg.

Could the TP400 be re-designed to drive a pusher propeller tailored to work efficiently at A350 cruising speeds?

I believe it could but would have to admit that the economics of advanced prop fans look much better for short sectors and higher production numbers.

Freighters

If Airbus is going to convert A340 200 and 300 series aircraft into freighters then a P-APU might be a very useful performance booster and development costs could be adsorbed into the freighter conversion.

London City and British Airways

British Airways is planning to start an all business service to New York from London City using the A318 and is also looking at a replacement for the RJ currently used by BA CityFlyer.

The New York service will use an A318 with just 32 seats/beds.

Could a P-APU variant of the A319 could safely operate from LCY with 50 seats/beds?

CityFlyer RJ100s are limited to 60 passengers on longer European routes when temperatures are high at LCY and replacing them with the RJ85 will raise this to 84. None the less both are painfully slow in comparison to the Airbus on longer routes like Madrid.

A P-APU variant of the A319 would not only offer a better performance package but would allow fleet commonality for BA at LCY.

Closing Thoughts

Hybrid power in automobiles has produced significant fuel economy for urban journeys and I believe the same could be achieved for the Airbus.

Has Toyota succeeded with customers because the Prius looks like a small family car and not like a Sinclair C5?

Perhaps a lesson from the original NASA project was not that the technology did not deliver but that it looked far too radical?

I believe we could do something to improve the performance of the Airbus without greatly changing its appearance.

The AE 2100 mated to a new propeller is a relatively low risk option and the potential fuel savings makes it worth a feasibility study.

The concept of the Prop APU might also work in larger long range aircraft if a propeller can be made to operate efficiently at .80 Mach but development costs would have to be balanced against production numbers.

Hybrid power for the Airbus is not just a Green Solution it's a smart solution.

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Ref. 1 "The advanced Turboprop Project: Radical Innovation in a Conservative Environment" by M Bowles and V Dawson.

Ref. 2 "Fuel Savings potential of the NASA Advanced turboprop programme" by Whitlow and Sievers from the Energy Citations Database.

Ref. 3 "Wind Tunnel Performance of Four Energy Efficient propellers designed for Mach .8 Cruise" NASA Technical Memorandum 79124 (Multiple Authors).