

HYBRID ENGINE TECHNOLOGY

easyJet Pilot Matt Wood takes a look at development options for the A320 family.



The much-discussed upgrade of the A320 family has seen some innovative ideas banded around

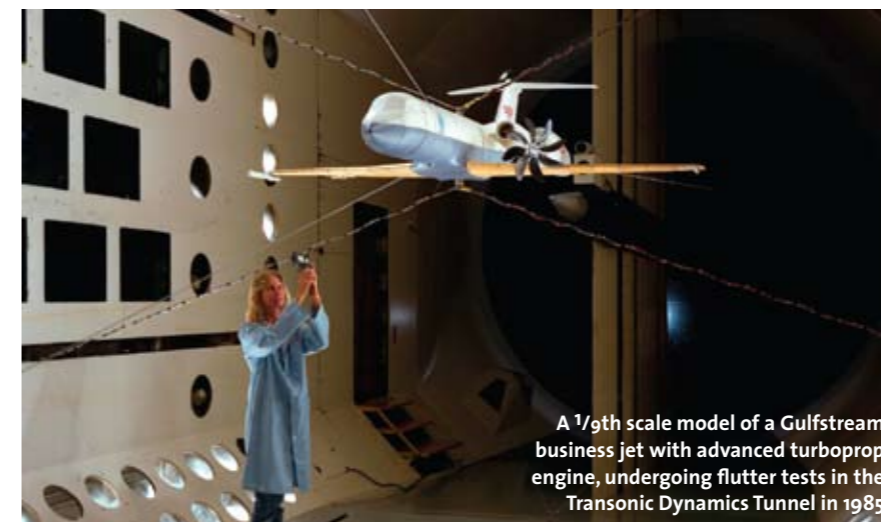
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Throughout 2008 *Flight International* ran several articles on upgrading the A320 family, and among ideas discussed was the use of fuel cells as a means to replace the ram air turbine (RAT) and auxiliary power unit (APU). In July Airbus announced it would evaluate a geared turbofan (GTF) by year end, and believed it could produce a GTF A320 derivative within 24 to 30 months. Rolls-Royce declared an interest in an 'open rotor' solution but was concerned about the effect of propellers on customer reaction and sales. This whole debate reminded me of a project from the 1970s when oil prices had spiked...

NASA Advanced Turboprop Project
The steep rise in fuel costs in the 1970s prompted the US government, airlines, NASA, academic institutions and aerospace manufacturers to develop more fuel efficient engines. The 'Advanced Turboprop Project' ran from 1976 to 1987 and mated gas turbines to various open fan designs that could operate efficiently up to 0.8 mach. The engines known as 'propjets' were flown successfully on test bed aircraft and delivered 20 to 30 per cent better fuel efficiency on short sectors than comparable jet engines. Surprisingly, the project 'failed' although the technology delivered excellent results. 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 turbofans. Other disincentives included engineering risk and cost, and no orders were placed. However, the technology was not entirely lost, some of it appeared in improvements in turbofan engines and Russia maintains an interest in this type of engine.

Hybrid powered Airbus
I had an idea that might avoid the pitfalls of the NASA project and sent it to Rolls-Royce and easyJet when oil prices were \$120 a barrel (having peaked at \$150). The proposal, perhaps naïve, was



A 1/9th scale model of a Gulfstream business jet with advanced turboprop engine, undergoing flutter tests in the Transonic Dynamics Tunnel in 1985

to eliminate the APU and replace it with a small 'propfan' that would carry out normal APU functions while also providing thrust. My logic was that many of the flights I had flown in the Airbus had stayed within a height and speed envelope where an advanced propfan was very efficient. By leaving the existing turbofans in place engineering risk was reduced and customer reaction was likely to be muted by having a rear mounted fan. The concept was not without challenges but I could see the following advantages:

- It is discrete and would negate customer resistance.
- A P-APU would supplement performance at points in the flight envelope where it is more efficient than turbofan engines.
- A P-APU would allow more de-rated take-offs thus reducing noise and engine wear.
- The aircraft can lift greater commercial loads from limiting runways.
- It could also routinely permit steep-angle approaches.

The proposal was based on a Rolls-Royce engine, the AE2100 and assumed:

- That existing fuselage structure could be strengthened to support a propfan.
- That a suitable propeller could be developed.
- No tail/prop scrape issues.
- That an AE 2100 can be semi-recessed into the tailcone area.
- The additional weight of an AE2100 over an APU does not critically affect trim.

Why the AE2100 engine?

I chose the AE2100 because it has an excellent power-to-weight ratio (750kg basic weight versus 4000shp) and full authority digital engine control (FADEC) to control both the engine and propeller.

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Matt Wood, Pilot

Operational and technological advantages of hybrid A320

A propfan APU offers some intriguing ways of improving the way in which we operate:

- It might be possible to 'power back' on just the P-APU.
- It could taxi out on just the P-APU thus saving fuel.
- The 4000shp would improve take-off performance.
- It would climb faster to optimum cruising altitude.
- Better drift-down performance.
- Send speedbrake requests to the FADEC thus changing the propeller pitch angle to generate drag and remove three wing spoilers.
- Steep approaches possible (quieter, greener, shorter separation distances?).
- Less noise and fuel wastage on approach by sending auto thrust requests to the P-APU to correct small changes in speed rather than the main engines which suffer from lag at low rpm.
- Improved stopping performance.
- Taxi in on the P-APU.

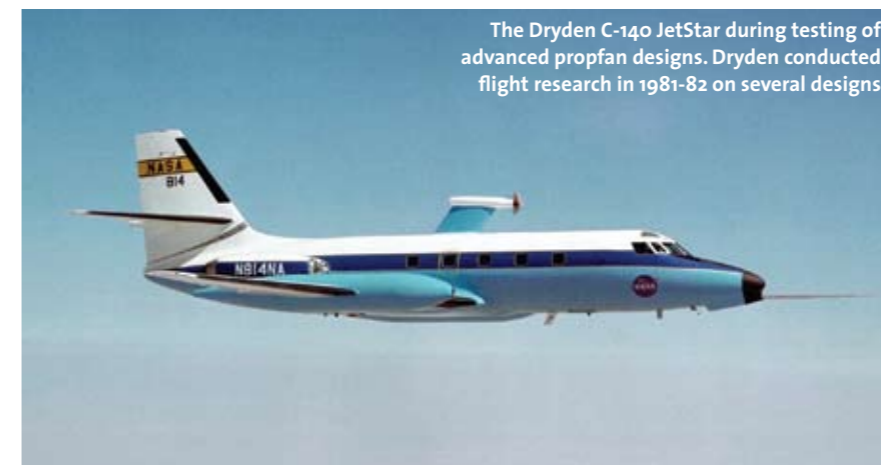
Feedback from Rolls-Royce

Mark King of Rolls-Royce responded to the article and made the following points:

- Designers and engineers have considered thrusting APUs but the economics are rarely viable.
- Elevator and rudder movement would affect airflow over the propeller, noise is a concern and the re-design of the rear fuselage would be costly. They did not consider it viable.

Closing thoughts

A hybrid solution is not viable. But will open rotor technology fly again only to be overtaken by events, engineering risk, costs and customer perception? In my opinion if 'open rotor' is to succeed it will have to be carefully marketed to both airlines and their customers. Something similar did occur in the automotive industry in the 1980s. Back then diesel powered cars were considered noisy, smelly, agricultural and unloved. ■



The Dryden C-140 JetStar during testing of advanced propfan designs. Dryden conducted flight research in 1981-82 on several designs