Look before you LEAP

An Indigo A320 coming in to land at Delhi.

The Airbus/Boeing re-engining Saga

Much has been said about the prospects of Airbus re-engining its A320 family and Boeing doing the same to its 737 family.

There have been predictions that the re-engining process will cost too much, weigh too much, be less reliable, and will depress present aircraft values.

However, we think re-engining is all but inevitable!

Given that Airbus and Boeing would really rather keep on selling the models they have, but on the other hand they really don't want to have to introduce all new models to replace the A320 and 737 until the emerging new technologies have had a chance to mature, about ten years from now.

It is one thing to break new ground on some large aircraft with composite airframes, all-electric systems and bleedless engines, as will be the case with the new 787 and to a degree with the even newer A350XWB. These large widebody aircraft are of a scale to benefit easily from composite structure, and are a natural developing ground for new systems and new 'but not quite so radical' engines.

It is quite another thing to take even bigger risks on even more radical engines with the smaller, more difficult design cases of the 150 – 200 seat narrowbody domestic aircraft that are far more economically important to the big airframers.

Airlines have been clamoring for some time for better narrowbody aircraft, and the only way to at least partially satisfy them and still not take huge technological risks before new engines and systems have time to prove themselves is to offer re-engined variants of the present airframes, making use of the latest developments of the turbofan engine that will become available in the next 3 to 4 years. The target is an operating cost reduction on the order of 10 to 15 percent.

The leading engines are the GE/Snecma CFM56 LEAP engine with a fan diameter of 70 to 75 inches and a bypass ratio of about 10, using integral blade/discs and a composite fan to reduce weight, and the Pratt & Whitney geared fan, the PW1000 or variant, which uses a reduction gearbox to better match the optimum higher engine speeds with the slower speeds best for the fan. The Pratt fan is supposed to be 75 inches diameter or more, with more being better in this case.

Airbus flight tested a pre-production model of the P&W geared fan and have been unusually non-committal on the results, but are working like beavers to be able to offer a re-engined version of the A320-200 later this year. That seems like a lot of effort if results were less than very good; we think they are just holding their cards close to their vest.

They also have announced they want at least two engines to offer; they are pressuring Rolls and Pratt to join forces again under the IAE banner to offer the Pratt designed geared fan. The second engine will probably be a version of the CFM LEAP.

Rolls Royce has other directions in mind, but has been remarkably silent on any new 20,000 pound thrust category twin shaft or three shaft engine development. Rolls has made no secret of their dislike for geared fans, and indeed earlier geared fans were not successful, to say the least.

But it is a bit late for Rolls to enter a new engine to the re-engine competition, and it would be strange indeed for Pratt to shelve its geared fan to join Rolls in a new IAE V engine a la LEAP or even an all new three shaft design.

The way to go

So the betting is that either RR caves and joins Pratt in an IAE geared fan offer, or Pratt goes it alone, regardless of Airbus's

preference to stick with the present engine vendors. If it is to be the latter, that would leave Rolls in a very exposed position, offering new engines only suitable for widebody aircraft.

As it is, we think Airbus will commit, first to satisfy the near term desires of its customers, second to buy time before they have to offer an all new design, and third because re-engining for the A320 is relatively inexpensive, and they think they have an advantage over a Boeing re-engined 737.

Even a re-engined A320 variant needs at least a 7 to 10 year production run to be economically viable. Boeing doesn't want to rush into an all new 737 replacement either, but they cannot allow a re-engined A320 to dominate the all-important narrowbody market for that long.

So Boeing will have to follow with its own 737 re-engining programme. And indeed, the Boeing 737 has some 7 to 8 inches less room to work with under wing than does the Airbus A320 and thus, all things equal, cannot accommodate as big an engine fan without some really fancy pylon work that puts the engine way out in front of the wing and looks nasty from the standpoint of weight and structural efficiency.

But, the largest fan may not be the best solution for Boeing anyway. Matching an engine to an existing airframe is always a complex compromise. Thrust, weight, fuel efficiency, drag, frontal area, noise, emissions, all must be placed in balance. And then there are the considerations of cost and reliability.

Take the present 737 Next Generation family, for example. It competes quite well with its 60.5 inch diameter fan engine, the CFM56-7B series, against the 68.5 inch diameter fan of the CFM56-5 series on the A320 family. In fact, the smaller 63.5 inch fan of the IAE V2725-A5 competes well with the larger CFM engine on the same A320 airframe.

And Airbus may not enjoy the advantage they think they have over Boeing. Remember that the 737 has a smaller fuselage diameter than the A320, and for the same capacity the 737 empty weight tends to be less. That means less drag, more aerodynamic efficiency; not by much, but it is there.

You will also note that Airbus has had a difficult time putting large efficient winglets on the A320. This appears to be due to the margins of safety in the outer wing; they did not initially design in enough strength to handle the extra loads imposed by the optimum large winglet and the process of adding that strength incurs a weight penalty that offsets a significant part of the advantage the winglet offers.

This suggests that Airbus may face some difficult wing strengthening issues with a new engine as well, and may be one reason they have been less than informative about the potential of re-engining. But, as said, we think Airbus will overcome the obstacles and offer a re-engined A320 that will be significantly better than the present models of either manufacturer.

Boeing certainly has its share of re-engining problems too. There have been disturbing reports of some rather extreme pylon designs being considered to place the largest fan possible under the 737 wing – or rather, way out in front of it. That will raise all sorts of other issues such as weight, rigidity, vibration and just simply keeping the fan exhaust away from under side of the wing.

We think Boeing will find simpler practical solutions; probably not trying to match Airbus in fan diameter, and probably electing to stay with CFM and install a version of the new LEAP engine which should have lower weight and less technological risk compared to the PW geared fan.

Technological risks

Speaking of technological risk, that bears on another vital issue in the re-engining story: reliability. Today's newest narrowbody airliner engines are providing superb reliability, now routinely staying on wing for over 10,000 cycles. No airline will accept any decline in that level of reliability, but it is well to consider that it has taken the engine manufacturers over 20 years to achieve it with the present engines.

To take a radically new engine such as the PW geared fan or even the highly advanced CFM56-LEAP engine, and have it deliver at the start the same reliability as the present engines represents at least as large a challenge as attaining the fuel efficiency, noise and emissions goals that have been set for these new engines.

But, at the end of the day, we expect Airbus to offer PW geared fan and CFM56 LEAP re-engined versions of the A320 and Boeing to offer a slightly smaller fan CFM56 LEAP engine on the 737. We'd be very surprised if both airplanes are not very competitive, just as they are today.

And, yes, for the pessimists out there, the re-engined aircraft will indeed depress values of the present models – but what is new about that?

It should not be an economic disaster, any more than was the introduction of the 737 Next Generation to the 737 Classic, or the Classic to the 737-200.

The facts are that both the A320 and the 737 NG are in about their last five or six years of production run, which will be ended either by the re-engine programmes, or by a perhaps premature introduction of all new replacement aircraft. We think re-engining is a better alternative for the manufacturers, the airlines and even the lessors, and the impact on present aircraft values will be less.

Aircraft produced in the last five years of a production run always lose their value much

Artist rendering of the LEAP-X.

faster than earlier aircraft, but the re-engined aircraft will still be derivatives, and we would expect the effect on present aircraft values to be only slightly more than the effect on the 737 Classics values when the 737 NG was introduced.

Historically as operating aircraft first become technologically obsolete and lose value, they begin to trade off the advantage of reduced capital costs with the disadvantage of higher operating costs, and the trade-offs sustain the older aircraft in the marketplace for quite some time. Besides, it will take several years of high new aircraft production rates to permit the replacement of a significant part of the existing fleet under any circumstances.

CFM's Open Rotor concept.

Finally, we know nothing yet about the price of the re-engined variants. Their real offering price cannot be at much of a premium to the present models, based on a 10% to at best 15% operating cost improvement, especially in view of the likelihood that the re-engined aircraft will have at best a very short 10-year production run before they themselves are challenged by all new replacement designs, and their values decline.

It is looking like those all new replacement aircraft will not appear before the middle of the next decade, or almost 15 years from now, and they will have to offer at least another 15% improvement in operating costs, noise, and emissions while sustaining advantages in reliability and price.

That is going to be quite a challenge, and we not have heard that anyone can see the way clear for that to happen yet, which is the compelling reason not to try to do it prematurely, but to follow the alternative path of re-engining.

Unducted Fans

Some engine manufacturers are suggesting that unducted fans (we used to call them propellers) are the answer for the future. We hope not. Having survived the era of propeller driven aircraft, we do not want to return to it.

Propellers have an annoying habit of disengaging from the body of the engine and hitting various parts of the airframe, causing very nasty accidents. Thus airframe designers tend to want to put the unducted fans far at the rear of the fuselage, separated widely apart and high above the wing, where errant propellers are less likely to pierce the pressure vessel, take out another engine, or destroy control surfaces.

The trouble is that is also a very dirty place full of damage causing foreign objects, it causes centre of gravity problems and in general it requires a large pylon and probably some heavy shielding. It is not the optimum place to put an engine from the airframer's perspective.

The unducted fan also has a preference to run at aircraft cruise speeds slower than that of a turbofan engine, which means loss of productivity. Noise is also an issue with unducted fans, and if you are concerned about the reliability of one gearbox on the geared fan engine, be prepared to worry about some 15 to 20 propeller pitch change gearboxes on the unducted fan.

Fortunately for me, I guess, these will be problems for the next generation to face and solve and I would be quite happy to see the problems delayed until some time in the middle of the next decade.

CFM56 is an aviation industry benchmark

Once in a while engineers and designers come up with something so innovative and ahead of its time that it creates an industry benchmark to which other major manufacturers in the industry aspire for years to come.

Despite the fact that the CFM56 engine has been powering a majority of the world's Boeing 737 and Airbus A320 family narrow-body fleets for around 30 years, it is still the 'state-of-the-art power-plant of choice' for airlines around the globe (many, like those in India, hurting due to the global recession) thanks to its rugged reliability, compelling overall cost of ownership, eco-friendliness and fuel economy.

Building on this solid foundation – and determined to create yet another benchmark - CFM is developing its all new LEAP-X engine (of which more later) that will propel the company towards the end of the 21st century.

It is the CFM56 in its two major guises (CFM56-7BE for Boeing's New Generation 737s and the CFM56-5B for Airbus' A320 family of airliners) that will be selected by the world's airlines – until the major western airframers decide on their next moves. And interestingly, CFM is currently talking to Airbus about further enhancing today's -5B in a similar way to the recently-announced -7BE engine that will generate even greater fuel savings.

So what do the operators of more than 320 CFM56 engines in India have to say about their engines? Paris-based CFM customer support manager Vincent Forest explains that either he - or one of his senior colleagues - meets face-to-face around ten times each year with airlines and operators like Air India, Air India Express, Jet Airways, JetLite, Go Air and Spice Jet.

"We have a very friendly relationship with them all," he says, "even when there are issues in the process of being resolved through each operator's dedicated CFM field service engineer."

India can be a very harsh environment for aircraft engines, with abrasive dust and chemical atmospheric pollution creating some unique maintenance challenges.

However, all the operators of CFM56 engines in the sub-continent say that they are pleased with the reliability of their engines.

Forrest continues: "I'm convinced that this is thanks to two main things: Firstly to the ongoing support that we provide through our rapid response engineering teams and subsequent technical review meetings and secondly because of the innate reliability and cost-effectiveness of our engines."

These are exciting times for the world's major engine makers, with new technologies, breakthrough materials and manufacturing techniques all featuring strongly.

In many ways, the current situation is analogous with the motor car industry. Although everyone knows that hybrid engines, sophisticated battery packs, bio fuels and possibly hydrogen power will be on offer in time, it's today's ultra-reliable and fuel-efficient petroleum and diesel powered vehicles that we will all be buying, driving and enjoying well into the current century.

The world's major commercial aircraft engine suppliers are all developing – or likely to develop – new powerplants. An example of this is Pratt & Whitney's geared turbofan engine. And although this is currently only an option on smaller regional aircraft, the day could come when larger versions of the engine will be produced to compete with today's kit.

Over the past 30 years, CFM has delivered more than 20,300 CFM56 engines and today's are made with the same basic architecture as was envisaged back in the late 1970s. But constant research and development by both GE and Snecma has resulted in an engine that is considerably more reliable, less-polluting, more fuel-efficient, produces vastly more thrust and is far cheaper to maintain than its forebears.

Way back then, two primarily military engine suppliers – the USA's GE Aviation and French company Snecma–were looking for an entrée into the commercial arena. They shared a joint vision that newly invented high-bypass technology, which offered dramatically lower noise and much better fuel consumption, was the right bet for the future. Consequently, in 1974, they joined together in a 50/50 relationship (a partnership now extended until at least 2040) to create CFM International as the umbrella under which the CFM56 product line could be developed, marketed, and supported. This is now the most successful JV in aviation history and CFM has become the world's leading commercial engine maker.

Having achieved that successful status, CFM didn't stand still. Constant improvement and innovation resulted in more power and even more reliability, taking today's CFM56-5B and -7B engines to an engine-related despatch reliability rating of 99.97% - a figure undreamed of only a few short years ago.

And operators of older fleets/engines were not ignored either as parts and modules were largely capable of being retrofitted during planned shop visits, considerably improving operating economics for customers…and the environment for everyone.

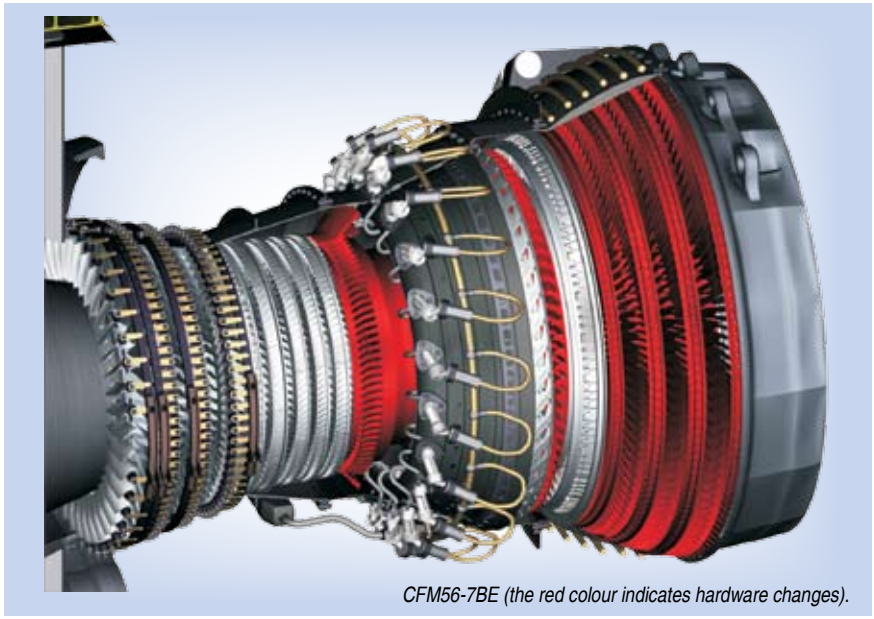
Thanks largely to its super-sophisticated compressor and turbine blades – utilising 3D aerodynamic flow technology – and advanced combustor technology, today's CFM56 Tech Insertion engines are already providing up to 10 percent better fuel-efficiency than their 1980s forebears.

But it's not only about reduced fuel burn. Other significant advantage as much as 12% lower maintenance costs due to more durable part and longer time on wing, in addition to 25% fewer NOx (oxides of nitrogen) emissions.

In December 2009, the Commercial Aircraft Corporation of China (COMAC) and CFM jointly announced that the advanced new LEAP-X1C engine had been selected as the sole Western power-plant to launch the new C919 single-aisle aircraft that is scheduled to enter commercial service in 2016, following its first flight late in 2014.

COMAC predicts a global market of more than 2,000 C919 aircraft over the 20 years following entry into service.

LEAP-X, which was formally launched in 2008, is a totally new CFM centerline engine and the development programme has been progressing steadily since it was launched in mid-2008. The first core in the development programme, eCore 1, successfully completed the first phase of testing during 2009 and the second phase will begin in the first quarter of 2010. All of the data gathered during eCore 1 testing will be fed into the design of eCore 2, which is scheduled to begin ground testing in mid-2011. This core incorporates includes advanced aerodynamic designs in the 10-stage compressor; a lean-burning, low-emissions combustor; a two-stage high-pressure turbine; and advanced materials in both the high- and low-pressure turbines.



CFM56-7BE (the red colour indicates hardware changes).

CFM has also been testing the revolutionary 3-D Woven Resin Transfer Molding (RTM) composite fan that will be a feature of all LEAP-X engines. The new fan will includes18 blades, 25% fewer than the CFM56-7B.

The LEAP-X1C will be the most fuel-efficient engine in its thrust class when it enters service, providing double-digit fuel burn improvements over current CFM56-7B and -5B Tech Insertion engines.

Fred Bearden
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