Fuel efficiency improvements escalate

IT IS 2050. NEARLY 90% OF THE WORLD'S airliners have algae-derived fuel in their open-rotor engines. A new generation of blended-wing aircraft is about to enter service, powered by a global network of directed energy beams and flown, of course, without pilots on board. The airspace system is working at 98% efficiency. Every aircraft—at least, those subsonic aircraft that operate within the Earth's atmosphere—can fly the most fuel-efficient route possible, changing height and direction automatically to optimize the prevailing weather and traffic conditions.

Meanwhile at the world's busiest airport, in the Persian Gulf, aircraft land and take off every 20 sec. Their final descent paths vary between 3 deg and 7 deg, to offset the wake vortex problems caused by a 20-seat aircraft following 1 n.mi. behind a 2,000-seater. Once on the ground, planes taxi automatically at high speed to their gates. Fatal airliner accidents have been reduced to just one or two a year.

Short-term focus

For many in the aerospace sector, the burning issue is how the industry will survive the next few months, rather than how it will deliver an ideal air transport system in the next 40 years. Over the past year, manufacturers have come under intense pressure to concentrate on making the current aircraft fleet more affordable.

For example, Airbus and Boeing both have developed some fuel efficiency improvements to their current short/medium-haul models. In April Airbus announced that its A320 family would benefit from new aerodynamic improvements—a redesign of the surge tank inlet, a redesign of upper belly fairing, and a reshaped engine pylon—that together will produce a 1% cruise drag reduction. In the same month Boeing also announced an efficiency improvement package to its Boeing 737 NG range, targeting a 2% reduction in fuel consumption by 2011 through a combination of airframe drag reduction and CFM-56 engine improvements.

Reality check

To meet the targets manufacturers and research agencies have set for 2020, there will need to be some major "step-change" improvements in engine and airframe design, along with the year-on-year incremental fuel efficiency developments. For example, Europe's "Clean Sky" consortium of aerospace industries has pledged €1.6 billion over the next five years to develop technologies that will deliver a 50% reduction in CO_2 emissions through drastic reduction of fuel consumption.

But how realistic is this?

Historic trends in improving efficiency levels show that aircraft entering today's fleets are 70% more fuel efficient than they were 40 years ago, which suggests aircraft fuel efficiency is improving at a rate of 17.5% every 10 years. These efficiency levels have been achieved with one or two step changes in design—such as the introduction of high-bypass engines—coupled with year-on-year "tactical" improvements. The pace of these incremental, or short-term, improvements in fuel efficiency has been stepped up in recent years—IATA's efficiency goal of 10% fuel improvements between 2000 and 2010 was reached before the end of 2006.

Pressure to reduce the environmental impact of aviation and escalating fuel costs over the past few years has led to several initiatives for finding new ways to remove weight from aircraft, increase fuel efficiency, and provide the most direct—or the most efficient—routes from airport to airport. For example, CFM International's Tech Insertion, International Aero Engines' SelectOne, and Rolls-Royce's Extended Performance

Winglets can offer a 5-7% improvement in fuel burn.

upgrade for the Trent 700 all promise fuel burn improvements of at least 1% for engines currently in service.

Recent turbulent economic times have added further urgency to this process, creating even more pressure to deliver fuel-saving initiatives now, rather than in the next five years.

For manufacturers, there are four major areas where a current aircraft's economic performance can be improved—better aerodynamics, more efficient engines, lighter interiors, and innovative support packages to keep down maintenance, repair, overhaul, and ownership costs.

In Europe, where the costs of airline operations are higher than anywhere else in the world, recent months have seen the launch of several new weight-saving/efficiency-improving initiatives in current aircraft operations.

INTERNATIONAL AIRLINE FUEL COSTS (IATA)

Year	Percentage of Operating Costs	Average Price per Barrel of Crude, $	Breakeven Price per Barrel, $	Total Fuel Cost, $ billions
2003	14	28.8	23.2	44
2004	17	38.3	34.5	65
2005	22	54.5	51.8	91
2006	24	65.1	65.0	107
2007	28	73.0	81.1	136
2008*	32	99.0	93.6	168
2009*	25	50.0	46.8	116

*Forecast.

Another look at winglets

Around 85% of all new Boeing 737s are fitted with winglets, which can deliver a 5-7% improvement in fuel burn, according to winglet manufacturers Aviation Partners (API). Over 3,000 aircraft currently in service have saved an estimated 1.6 billion gal of fuel, according to API, but none of these are Airbus aircraft. In May, Airbus announced it was reconsidering its winglet policy and had recently completed a flight test campaign to identify both the performance and economic benefits that these devices could offer. According to Stuart Mann, director of product marketing for the Airbus A320 family, "The analysis of the winglet testing results is under way at the moment, but that is certainly one of the elements that we are looking at for the future to ensure that the A320 family stays competitive."

The cost-benefit analysis revolves around the tradeoff between increased aerodynamic efficiency and greater weight and cost. According to API:

"Winglets cost about $725,000 and take about one week to install, which costs an extra $25,000-$80,000. Once fitted, they add 170-235 kg (375-518 lb) to the weight of the aircraft, depending upon whether they were installed at production or a retrofit. The fuel cost of carrying this extra weight will take some flying time each sector to recover, although this is offset by the need to carry less fuel because of the increased range. In simple terms, if your average sector length is short (less than 1 hr), you won't get much benefit from winglets—unless you need any of the other benefits, such as reduced noise, or you regularly operate from obstacle-limited runways."

Losing weight

Decreasing weight of aircraft in service has been another feature of recent research. Airbus has created a new galley concept: SPICE, or Space Innovative Catering Equipment. "Instead of putting ATLAS trays in heavy trolleys, we put them in lightweight boxes," said Bob Lange, Head of Aircraft Interiors Marketing. "Foldable carts transport the boxes during service, bringing huge benefits in weight and space savings on board aircraft, assessed to be over one tonne on an A380 and potentially 10 more economy seats."

Meanwhile seat manufacturers are also developing new lightweight concepts. At the Hamburg Aircraft Interiors Exhibition in March, seat manufacturer Recaro showed a prototype Stingray economy class concept seat which, at 6 kg, is 4 kg lighter than the average economy seat. Weight savings have also resulted from integrating intelligent new designs and combining lightweight materials in new ways: In the concept seat a new aluminum alloy was used along with titanium and additional CFRP materials.

Other approaches

These new lightweight materials and interior structures are also bringing down the cost of ownership. But many believe the real savings are to be made outside the aircraft cabin.

According to IATA, each 1% improvement in fuel efficiency across the industry can lower fuel costs by $700 million a year. Its "save a minute" campaign is aimed at saving one minute per flight through better airspace design, procedures, and management, to reduce total industry operating costs by over $1 billion per year.

A key to this is opening new, more direct flight routes and realigning others to reduce fuel requirements. In April a new initiative was launched by European airport, airline, and air navigation service provider trade associations (ACI Europe, CANSO, Eurocontrol, and IATA) to implement continuous descent approaches (CDAs) at up to 100 airports across Europe by the end of 2013, saving airlines 150,000 tonnes of fuel and €100 million a year. In a CDA, an aircraft flies a smooth approach into an airport rather than the traditional stepped approach, reducing fuel burn by 50-150 kg for a short- to medium-haul aircraft.

As part of this initiative, Italy's air navigation service provider ENAV has launched a flight efficiency plan. During 2008-2009 the plan will save 67,300 tons of fuel for airlines flying into and out of Italy and will shorten routes by 2,588,000 km.

Step changes

But to reach the fuel efficiency targets set by researchers, manufacturers, and intergovernment bodies such as the European Commission, new step-changing technologies will be needed. In the medium

term, aircraft operators can look forward to a new generation of more fuel-efficient engines pioneered by the Pratt & Whitney PW1000G geared turbofan engine. This engine has already achieved near double-digit improvements in fuel burn over current models and will make its appearance on the new Mitsubishi Regional Jet and Bombardier C-Series airliner.

Meanwhile, CFM International's advanced LEAP-X demonstrator engine is due to start tests in 2012 with possible certification in 2016. It reduces fuel burn by up to 16% over current CFM56 Tech Insertion models. Even greater savings will be possible with new open-rotor engines currently being researched; all these engines should be mature by the time the Airbus A320 and Boeing 737 replacement aircraft appear.

Also, the successful completion of the Single European Sky program by 2025—allowing for more direct routings in Europe's airspace and reduced delays on the ground—could in theory deliver reduced fuel burn by a further 6-12%. Operational improvements can bring an additional 2-6% fuel saving.

According to a March 2007 statement by Philippe de Saint-Aulaire, Airbus vice president for environmental affairs, Airbus is serious about targeting a 50% reduction in aircraft fuel consumption by 2020: Airframe improvements would provide about 25% of the reduction, engine improvements 10-15%, and improved air traffic management 10%. The 25% improvement is based on research by Airbus into drag reduction.

According to a paper given by Géza Schrauf of Airbus at the Fifth Community Aeronautics Days conference held in Vienna in June 2006, Airbus identified three major areas of drag reduction potential: a 15% improvement in the area of viscous drag (through the introduction of laminar flow technology, turbulence, and separation control technologies), a 7% improvement in lift-induced drag (through shape optimization, adaptive wing devices, wing-tip devices, and load control technologies), and a 3% improvement in other drag areas such as wave drag and interference drag (through the development of new shock control technologies and novel configurations).

A further step-change in aerodynamics would be the advent of blended and advanced swept-wing aircraft designs. The VELA project, part of the European Commission's sixth framework program (2000-2006), has already researched blended wing concepts that would deliver fuel consumption improvements of up to 30% over current aircraft designs. Led by Airbus, with a team of 17 partners, the program investigated the benefits, potential, and problems of a flying wing transport aircraft; two configurations were built for wind tunnel testing by the Institute of Aerodynamics and Flow Technology, DLR, Germany.

The net result

Taken together, these incremental and step-change improvements in fuel efficiency suggest that the long-term targets are indeed possible, though some aspects will be more challenging than others.

"Yes, the Single European Sky would reduce unnecessary flying by 12%, so it would reduce emissions by 12%, and costs by 12%. If you listened to the promises, anything seemed possible," according to Andrew Charlton of Geneva-based ATM consultants Aviation Advocacy. "Sadly, the figures do not support it. Particularly when you consider that air traffic is expected to double, does anyone actually believe that there is a 24% improvement just sitting out there? There is likely to be a 4% improvement in ATC to 2020, assuming that everything else works."

But with engine manufacturers advanced in their plans to turn next-generation concept powerplants into working models—and airframe manufacturers developing ever lighter interiors and subsystems—perhaps the highly ambitious targets of 50% fuel efficiency improvement in the next 10-15 years may not be so fanciful after all.

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UAV worldwide roundup—2009 (April, page 30) was enjoyable but not the "rest of the story." I'm not sure if the whole truth matters but the factual content regarding deployment of Pioneer in Desert Storm is in part misleading. I was a Navy lieutenant Pioneer mission commander and the assistant OIC of VC-6 Det 2 on board the USS Missouri. The first deployment of Pioneer against hostiles was from the Missouri just off Al Khafji in early February. For three days we pounded the southern KTO bunker, artillery sites, and targets of opportunity to help discourage any more Iraqi excursions into Saudi Arabia.

The Missouri was given the combat action citation for actual engagement and exchange of fire with enemy. The Wisconsin took the second mission, followed by a third Missouri mission. Both then moved into the northern KTO.

The Wisconsin took the northern gun line several hours prior to the cease-fire. This was her limited opportunity only after the Missouri expending all five Pioneer assets during the ground war (one was lost to hostile fire, the rest fatigue); having lost the last one in the wee hours on Monday (the last day). Capt. Kaise of the Missouri then decided to pull out and give the Wisconsin the closing rounds because he concluded that without his UAVs he was blind.

This was the real turning point, prior to the actual first engagement in early February and the first use of Pioneer in combat. All of the Pioneer units (two Navy, three Marine, and one Army) were instrumental in leading the aware-

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ness of UAVs, but the Missouri-UAV tactical mission successes were overshadowed by the historically sensational but tactically minor event on Failaka Island.

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I just read the commentary **Addressing Climate Change with help from abroad** (April, page 3) by Jerry Grey. I apologize if I appear critical and I am not specifically criticizing Grey's commentary, but I grow weary of all these articles where AA is promoting the very questionable theory of climate change. Climate change appears to be more of a business and power grab, not any real environmental problem. There are no consequences of climate change that are going to affect the entire world. Climate research is interesting and informative, but way too much money has been spent on this.

Those who edit *Aerospace America* ought to be aware that most aerospace scientists and engineers with technical training and experience are very, very skeptical of the idea of man-made global warming being a genuine concern. That has been my experience with a high percentage of colleagues I've worked with. Just because politicians and journalists keep repeating this stuff over and over does not make it true. In fact, ABC-News polls leading up to last year's election showed that less than 1% of the respondents thought global warming was a major issue. No wonder no one I work with thinks much of it.

Frankly, I believe the theory of anthropogenic global warming is a farce and not anything close to being worthy of the aerospace industry, or Western countries for that matter, sacrificing what may amount to trillions of dollars of cost and economic growth in the coming decades for something that very likely is a nonissue, just like the ozone hole in the '90s and the global cooling scare in the '70s. In fact an ice age was predicted in the 1920s, and a global warming scare in the 1930s, always fueled by some people's eagerness to proliferate panic.

What many people don't realize is that the current theory of global warming, in which planet warming will accelerate monotonically unless we drastically reduce our CO_2 output, is based entirely on computer models. Temperature data does not support it. Global average temperatures are lower now than the last 10 years. The data shows we are at about the same global average temperatures as the early '90s and even at times in the '80s. And the temperature data does not track closely with atmospheric CO_2.

The computer models haven't accounted for actual fluctuations in the data (which means they are not accurate enough to start crafting policy to limit CO_2). Charts showing CO_2 and temperature tracking together show temperature leading CO_2 if examined closely. How then can CO_2 cause warming? Climate researchers themselves do not show a great deal of confidence in their models (also shown in the survey mentioned below).

Here are highlights of some climate change news you won't see on the evening news: The Japan Science Advisory board to their government has stated that the idea that the Earth's temperatures are going to monotonically increase is an improvable hypothesis; they compared the UN's IPCC report to ancient astrology. A British court found 11 inaccurate assertions in Al Gore's documentary *An Inconvenient Truth*. Two successful conferences on climate change have been held in the last two years dedicated to global warming skepticism. In 2008 Russian climate scientists predicted a coming global cooling because of a change in solar activity. Harvard astrophysicist Willie Soon recently has also stated that changes in the Sun's activity is a major driving force of the Earth's climate. In addition, a survey of climate scientists by Bray, Dennis and Hans von Storch (as condensed by Joseph Bast) found that 55% agree climate change has mostly anthropogenic causes, 35% agree climate models can accurately predict future climate conditions, 32% agree the current state of scientific knowledge can provide reasonable climatic predictions on time scales of 10 years, 27% agree reasonable predictions can be made on time scales of 100 years, 69% agree climate change might have some positive effects for some societies, and 45% agree that climate scientists have enough evidence to recommend policy makers enact climate change policies.

I skimmed through the IPCC report myself and found the word uncertainty many times in the body of the report with regard to their conclusions, but the 'Summary for Decision Makers' had a much different tone, one of certainty of the coming worldwide catastrophe. Maybe it would be a lot cheaper for the aerospace industry to conduct a public education campaign.

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Reply by author: As I pointed out in my response to the letter from Joseph Sheeley in the May issue, in my commentary I do *not* "…imply that it is mankind's generation of greenhouse gases (or aerosols) that is causing the observed global warming trend, although that conclusion has been drawn, not without opposition, by most climate scientists. Mr. Sheeley is correct in his contention that the link between man-made CO_2 and global warming is based on climate models that still require significant improvement, but nowhere do I imply that those models 'prove' such a connection."

Mr. Cento expresses a view that is strongly held by some climate scientists, but as I implied in the above response to Mr. Sheeley, I believe they represent a small minority of the entire qualified climate-science community.

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In the editorial **Lost in space** (May, page 3) you note that some see "jobs and funds flowing to Russia—at a time when both are critically needed at home."

I believe that I read in a recent article that the Russians will charge the U.S. $51 million per trip to the ISS. If this is for an entire crew change, it is a bargain—less than 10% of the cost of a shuttle mission. Even per passenger, it is not a bad price, but, perhaps we can bargain them down to the space tourism price of around $30 million.

I, as you, decry the loss of U.S. capabilities and prestige in this area, but from the taxpayer perspective using the Soyuz is not a bad idea, and cost should not be the main point of the discussion. Perhaps the money saved on shuttle flights could be used to support NASA's sorely underfunded science missions.

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