BUSINESS AVIATION and the ENVIRONMENT

> Biofuel > Engines > Fractional vs airlines
> Aging fleet > Recycling effort

With the debate over Europe's emissions trading scheme heating up faster than you can say "illegal carbon tax," aviation quietly continues the efficiency and emissions-reduction gains that have been under way for decades. Engine manufacturers are turning their ingenuity to building lighter engines that get more out of every drop of fuel and emit less greenhouse gas. If biofuel developers meet expectations, fossil fuel could go the way of the dinosaur, but nobody wants to be the trailblazer who risks stumbling and falling hard. Aviation's green initiative extends to figuring out what to do with aircraft at the end of their life, and for business aviation this task is suddenly significant: in the next 10 years, more business aircraft will be chopped than were decommissioned in the first 50 years of business aviation.

Technology proven and fuel tested, why is biofuel still scarce for aviation?

by Curt Epstein

TERRY ISBELL/USDA/AGRICULTURAL RESEARCH SERVICE

While many of the feedstocks currently under study can be used on a rotational basis, such as pennycress (above), there are other options. Lanzatech plans to convert carbon monoxide into ethanol at one of its factories, left. The result is the same...green energy to power aircraft, such as a recent Azul flight.

In the middle of July, as part of its participation in Rimpac 2012, the world's largest multinational naval training exercise, the U.S. Navy made a bold statement on the future potential of biofuels. With the exception of its nuclear-powered vessels, the other ships and aircraft in its "Great Green Fleet" demonstration group were powered by biofuel blends. During the course of the exercise, Navy aircraft burned 100,000 gallons of hydroprocessed renewable jet fuel derived from algae and animal fats blended with conventional jet fuel in a 50-50 mix, while the non-nuclear ships consumed 700,000 gallons of biofuel blend. The fuel order last year from producers Solazyme and Dynamic Fuels represented the U.S. government's single largest biofuel purchase in history.

The demonstration was a success as the equipment performed as safely and effectively as if it were run on conventional fuels, but some congressional leaders lambasted the exercise as a waste of money based on the price paid for the fuel, which has not yet achieved large-scale production. Some media reported a price tag of more than $26 a gallon, and a total fuel outlay of approximately $12 million. Yet with the military's nearly unslakable thirst making it the world's largest consumer of oil, the event seemed to underscore the U.S. government's commitment to spurring commercial development of biofuels to reduce its dependence on foreign fuels. "Absolutely it was worthwhile to show that biofuels can compete and can be used in every single thing that we do in the Navy," said Navy secretary Ray Mabus.

In stark contrast to this "green" achievement, and provoking widespread ire in the civil aviation community, a U.S. senate committee had voted just a month earlier to prohibit the U.S. military from buying biofuels that cost more per gallon than hydrocarbon-derived jet fuel and to prohibit it from participating in biofuel research and infrastructure development.

While the development of "home grown" alternative fuel supplies is one of the driving forces behind the U.S. government's interest, other factors take a front seat for the airline industry. "Basically what we're looking for is a biofuel that addresses environment concerns and economics as well as security-of-supply issues," said Richard Altman, executive director of the Commercial Aviation Alternative Fuel Initiative (CAAFI), an initiative sponsored by the FAA, along with trade organizations such as the Aerospace Industries Association, Airlines for America and the Airports Council International-North America. In the face of increasing carbon emissions regulations such as the embattled European emissions trading scheme (ETS), biofuels promise lower carbon dioxide emissions than conventional fossil fuels, and the feedstocks are renewable. To underscore this potential, in March, Airbus, Boeing and Embraer signed an agreement to work

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Next-gen turbofans combine efficiency with lower CO_2 emissions

by Kirby J. Harrison

The next-generation turbofan engine–more efficient, cleaner burning, quieter and weighing less–is arriving now on an airplane near you.

It isn't that engine manufacturers haven't been working toward building engines that burn less fuel, emit fewer greenhouse gases, weigh less and create less noise. They have been doing just that for more than 25 years, according to Pratt & Whitney Canada v-p of engineering and productivity Walter Di Bartolomeo. He should know, because that's about how long he has been working for the engine manufacturer.

Until the past decade, this effort was driven primarily by the competitive juices of market demand. More recently, new regulations in the U.S. and abroad, along with pressure from public advocacy groups, have spurred the industry to even greater efforts.

In the U.S., the Environmental Protection Agency (EPA) is adopting the NOx (nitrogen oxide) emission standards for aircraft turbine engines that were approved by the United Nations' International Civil Aviation Organization (ICAO). Specifically, the EPA is adopting two new tiers of more stringent emissions standards for NOx: the Tier 6 (or CAEP/6) standards and the Tier 8 (CAEP/8) standards.

At the same time, research continues into the European Commission's seven-year, $29.82 billion Clean Sky research program. The aim is development of technologies to meet the goals the European aviation industry has set for itself: a 50-percent reduction in carbon dioxide (CO_2) emissions with the year 2000 as the baseline. Clean Sky 2 has as its goal a 75-percent reduction by 2050.

U.S. government data shows the U.S. aviation industry has cut greenhouse emissions by 13 percent since 2000. But environmental watchdog groups such as The Intergovernmental Panel on Climate Change have only increased their clamor, asserting that by 2050 "emissions from aircraft could be responsible for 15 percent of total global warming produced by human activities." Current data places aviation's share of man-made greenhouse emissions at approximately 2 percent.

The EPA points to a number of greenhouse gases as primary offenders in contributing to global warming: CO_2, methane, nitrous oxide (NOx) and fluorinated gases, of which CO_2 and NOx make up the majority of jet engine emissions. The EPA has designated CO_2 as a dangerous pollutant.

Faced with such growing demand, engine manufacturers are spending billions on research and rapidly developing new engines that will meet or exceed current and future emissions standards. For the most part, explains Honeywell senior director of technical sales Mike Bevans, most of the engine improvements have come as a result of new designs, such as the company's "rich, quench, lean" research into a more advanced combustor.

The technology includes improved fan, core and exhaust nozzle designs and composite materials in engines from the 70,000-pound-thrust Rolls-Royce Trent 1000 on an executive variant of Boeing's 787 to the FJ44-3AP that will produce 3,052 pounds of thrust for the Nextant 400XT.

Some manufacturers produce engines primarily for larger business and private jets, but they also have models appropriate to the market for smaller private and business jets. Initially, new technology appears on larger engines meant for a much larger and more lucrative market in the airline industry.

One example is Rolls-Royce, with a 45-percent share of the propulsion market for the Boeing 787, a program that offers the customer a choice of engines. As of March this year, twenty-six of the 787 customers had not made an engine choice, prompting Rolls-Royce to expect orders for roughly another 300 Trent 1000s.

The improved Trent 1000, branded the Trent 1000-Ten, from Rolls-Royce will provide a modest but welcome one-percent increase in efficiency.

It should be noted there is not always enough "real estate" in a small engine to scale down a new technology pioneered on a large engine.

Rolls-Royce Pushing Beyond 2020

At the Farnborough International airshow this summer, Rolls-Royce offered visitors a look into the coming decade with a composite fan blade, the aforementioned Trent 1000 high-bypass turbofan and a model of the Trent XWB being developed for the Airbus ACJ350 and A350 XWB. Rolls-Royce calls it "a relentless pursuit of technology."

Part of that pursuit includes the Advance3 program based on the Trent 1000-derived environmentally friendly engine (EFE) technology demonstrator core. The goal is two- and three-shaft (Advance 2 and Advance 3) engines incorporating "lean-burn" combustion and technology from the advanced low-pressure system (ALPS) project.

Among elements of the EFE technology is active blade-tip clearance-control that increases efficiency by reducing leakage around the blade tips, according to R-R strategic marketing v-p Robert Nuttall.

Meanwhile, in July Rolls-Royce unveiled the follow-on Trent 1000-Ten, which the company says leverages new technologies from the in-development XWB, an engine being developed for the Airbus A350 XWB. Rolls-Royce expects to see a 3-percent efficiency gain over the "package B" Trent 1000s now being delivered.

Saying the -Ten variant will "ensure the lowest 'real-life' fuel burn for every model of the Boeing 787 Dreamliner," Rolls adds that it will also provide "the lowest net fuel cost and carbon emissions."

A key element in the Rolls-Royce philosophy is its three-phase

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CFM is using a new 3-D woven composites process for its aero-acoustic geometry fan blades, fan case and several other parts of its Leap engine.

NetJets Europe Is Greener than Airlines with Carbon Neutrality for 2012

NetJets Europe is on track to achieve something this year that no European airline has yet managed: 100-percent carbon neutrality for its flying. The fractional ownership group expects to have covered all its carbon emissions for this year either by offsetting them through approved programs or by buying sufficient carbon credits.

In 2007, NetJets launched its Real Difference program as an ambitious incremental campaign to reduce the carbon footprint of private aviation that attacked the problem from multiple angles. As of late July, it had offset more than 62,000 flights amounting to 687,343 metric tons of carbon.

The most public aspect of Real Difference was the introduction of mandatory carbon offsetting charges for NetJets Europe customers, even though this was optional for NetJets clients in North America. According to NetJets Europe chairman and CEO Eric Connor, almost without exception, customers accepted the case for offset charges, which are itemized clearly on monthly bills. In fact, with the start of Europe's cap-and-trade emissions trading scheme (ETS) this past January, NetJets Europe has made offsetting voluntary to take account of the extra carbon credit costs to which clients will be exposed.

But NetJets has also been challenging its employees to be part of the carbon-neutral solution. In late 2008, the company established a "Fuel Team" through which a group of its pilots have focused on ways to drive down jet-A consumption. This has resulted in the following initiatives:

- A fuel handbook to promote awareness of fuel efficiency.
- Great accuracy in calculating fuel needs for pre-flight APU use and taxiing, as well as for the cruise phase of flight.
- Changing alternate flight plan profiles to more accurately reflect real-time operations.
- Standardization to 30 minutes for how much "standard allocated extra fuel" to carry beyond the legal minimum requirement.
- Ground recurrent training on a fuel awareness simulator has now been completed for 80 percent of flight crew.
- Reducing cruise speed for positioning flights.

Over the past two years, this work has cut fuel consumption by an average of 4 percent and emissions by approximately 2 percent. This approach is set to continue, with smaller average incremental reductions anticipated for this year and next.

Further fuel-burn reductions are expected to result from the approval NetJets has received to operate extended-range operations under commercial rules. This applies for twin-engine aircraft and will allow more direct routes that do not put the aircraft more than 180 minutes from an airport, instead of the previous 120 minutes.

Waste management initiatives, such as the introduction of recyclable catering boxes, have also contributed to a smaller carbon footprint for NetJets. These are made from sustainable bamboo with reusable porcelain inserts. –C.A.

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Efficient next-gen turbofans reduce greenhouse gases

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Vision program. Vision 5 describes available off-the-shelf technologies that could be incorporated into new products or used to update existing engines. Developments at the validation stage and due to be commercially available in the medium term (up to 10 years ahead) are dubbed Vision 10, while technologies at the emerging (or unimproved) strategic research stage are aimed at future generations up to two decades hence classed as Vision 20.

The Rolls-Royce and Gulfstream relationship is one of the longest in the industry, dating back 54 years to the Gulfstream I and its Dart turboprop. Now, Gulfstream's new G650 will be delivered with twin BR725 engines each producing 16,100 pounds of thrust. While producing 4.6-percent more takeoff thrust than the BR710 from which it is derived, the engine generates 20 percent lower NOx emissions, is 33 percent quieter than and is 16 dB below Stage 4 noise limits, according to Rolls-Royce..

GE Engines 'Cleanest, Quietest'

GE Engines is a major competitor for the Trent 1000 in the Dreamliner market with its GEnx, an engine that GE claims is the "cleanest, quietest, most passenger-friendly engine ever produced."

The company claims a 15-percent improvement in specific fuel consumption over comparably sized engines, with emissions "95 percent below current regulatory standards." In fact, the company claims its twin-annular pre-swirl (Taps) combustor will reduce NOx gases by as much as 56 percent below today's regulatory limits.

Its claim of "quietest" is based on the ratio of perceived decibels to pounds of thrust for engines for medium-size, long-range airliners.

Thanks to a new scalloped engine exhaust nozzle fairing, advanced engine acoustic linings and new fans with larger, slower-turning blades, GE claims the 787 registers 85dB in the airport environment, a level that Boeing says represents a noise footprint 60 percent smaller than that of comparable airliners.

At this point, GE Engines and Rolls-Royce are preparing a future collaboration on new technology for the ACJ320neo from Airbus and a BBJ variant of Boeing's 737 Max. GE has been quiet on the subject, and Rolls too is declining to comment.

More focused on the business aviation market is GE Aviation's new GE Passport 20, a 16,500-pound-thrust turbofan destined for Bombardier's Global 7000 and Global 8000. A key feature is the 52-inch fan bladed disk (blisk), which eliminates leaks, reduces wear and vibration and allows greater airflow

GE Aviation expects to have the Passport 20 running on the ground next spring.

within the same fan outer diameter.

GE expects the engine to offer "at least eight percent improved specific fuel consumption compared to current engines in the field." Plans are to certify the Passport 20 to CAEP/8 environmental standards. As for noise, GE believes it will meet ICAO Stage 4 limits. In addition, the one-piece flow structure will further reduce vibration and result in lower noise levels on the ground and inside the cabin.

Also part of GE's future is its partnership with Honda Aircraft, branded as GE Honda Aero Engines. The integrated technologies have produced the HF120 turbofan that will initially power the HondaJet.

Gulfstream's new G280 is powered by Honeywell's HTF7250G, which the engine manufacturer claims will meet or exceed requirements for more power and lower emissions.

It features an uncooled, single-stage high-pressure turbine, the latest blisk technologies, a low-emissions combustor and high-flow, wide-chord fan blades. According to GE Aviation, the engine is expected to offer reduced fuel burn and a high thrust-to-weight ratio. Lightweight at just 368 pounds, it will exceed Stage 4 noise requirements but nevertheless provide 2,095 pounds of thrust.

Biofuels and New Technology

Honeywell is hard at work on the latest variants of its HTF7000 engine series, including the HTF7500E and HTF7250G. Incorporated in the newer variants is Honeywell's new "green combustor" technology. According to Bevans, it is called the singular annular combustor for emissions reduction, or Saber for short, and is designed to reduce carbon dioxide, nitrous oxide and other unburned hydrocarbon emissions, while at the same time lowering operating costs.

Saber, said Bevans, cuts emissions to 25 percent below current requirements, and the combustor is retrofittable during schedule maintenance intervals to engines already in service.

The HTF7000 is the sole engine available on Bombardier's Challenger 300 and Honeywell claims that retrofitting Saber to that airplane will cut its emissions by 25 percent.

Gulfstream's new G280, powered by the HTF7250G. It is the second aircraft after the Challenger 300 to meet or exceed requirements for more power and lower emissions using the HTF7250G.

Embraer selected the HTF7500E for its new Legacy 500 and Legacy 450, and preliminary tests demonstrate better fuel efficiency and lower emissions with the new combustor. It also weighs less than earlier versions of the engine.

Silvercrest Is Over Here!

After a long development period, Snecma's first business jet engine, the Silvercrest, has found a home with Cessna on the Wichita OEM's Longitude super-midsize jet. The deal assures Cessna of a turbofan that will burn 14 percent less fuel, emit 50 percent less NOx than the CAEP/6 standard, and cut the noise footprint by half "compared to existing engines in the 10,000- to 12,000-pound class," according to Snecma.

Flight testing of the engine will begin in next year's first half, using a Gulfstream II testbed. Certification is expected in 2015, well before the Longitude's 2017 expected entry into service.

The cold section of the Silvercrest consists of a 42.5-inch fan, a four-stage booster and a five-stage compressor, followed by a single-stage, high-pressure turbine featuring single-crystal blades and a four-stage low-pressure turbine. The high- and low-pressure spools are contra-rotating "for better fuel efficiency."

Snecma, part of Safran, describes the Silvercrest as a "true on-condition engine," with no fixed overhaul interval and no requirement for hot-section inspection.

Seeing the Value of Biofuel and Engine Technology

Pratt & Whitney Canada is also looking forward to the growing use of biofuels and taking their use into consideration as it develops the PW800, a turbofan that had been intended for Cessna's cancelled Citation Columbus large-cabin business jet. P&WC now envisions the PurePower PW800 as "part of a family of engines for the next generation of business jets."

"Pratt & Whitney Canada [also] is moving forward with its research into alternative fuels, with the goal of making all of its engines biofuel compatible, including the PW800," said a spokesman.

The company continues to develop its Talon low-emissions combustor technology and points to its energy efficiency and low environmental impact as "a step change." For the PW800, the combustor technology means a 50-percent reduction in NOx emissions and a 35-percent reduction in CO_2, both of which put the engine well below ICAO limits. Combined with its GARDN (Green Aviation Research & Development Network) biofuels program with Bombardier and the Canadian government, P&WC expects to further reduce emissions, and eventually customers will be able to operate all its engines on either conventional jet fuel or biofuel.

P&WC is also "investing significant resources into reducing the amount of noise produced by its engines and has a goal of reducing cumulative noise levels of its next-generation engines by 10 dB over the next decade."

P&WC has also begun wind tunnel tests on the next-generation geared turbofan that will allow a 50-percent-higher bypass ratio. The first-generation geared turbofan has a 12:1 bypass ratio but the next is expected to be somewhere between 15:1 and 18:1. The geared turbofan architecture allows the fan to spin more slowly, reducing the noise footprint.

Leap X Challenges PurePower

The CFM line of engines is the product of a 50-50 collaboration between GE and French engine-maker Snecma, and the company claims "there are more CFM56 engines in service than any other commercial turbofan in the world." Building on that legacy, the next generation is the Leap series, already selected by Airbus, Boeing and Comac to power their respective new single-aisle airliners, from which the Airbus Corporate Jet (ACJ) and the Boeing Business Jet lines are derived.

CFM claims Leap is 10- to 12 percent more fuel efficient than the CFM56-7BE, 50 percent below the NOx emissions limit set by CAEP/6, and 75 percent quieter for the aircraft's noise footprint. CFM is already fielding orders for the Leap-1B variant.

When Claire Means Clean

MTU Aero Engines in Germany recently announced as part of its first-half 2012 earnings that "new engines were the major revenue driver." Among those new engines mentioned was the V2500 for the Airbus ACJ320 and the BBJ.

Claire (clean air engine) is MTU's "technology roadmap for the eco-efficient engines" and the company is looking forward to a fuel-burn reduction of 15 percent for its geared turbofan by 2015, a 20-percent drop by 2025 and 30-percent reduction by 2035. The technology is being developed in partnership with Pratt & Whitney.

MTU claims that any further increase in propulsion efficiency of an engine requires a higher bypass ratio, and the next step toward this is the second-generation geared turbofan MTU is developing.

Crisp, or "counter-rotating, integrated, shrouded propfan," is one of the alternatives being investigated. In this derivative of the geared turbofan, two contra-rotating fan rotors are arranged one behind the other on coaxial shafts, allowing a boost in propulsive efficiency with the fan diameter remaining unchanged. This permits bypass ratios as high as 20 to 25.

Stage three of the Claire program is

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together to promote the development of drop-in affordable biofuels. “The production and use of sustainable quantities of aviation biofuels is key to meeting our industry’s ambitious CO_2 reduction targets,” said then Airbus CEO Thomas Enders.

In July last year the biofuel industry achieved certification of a new fuel process when ASTM International approved the use of a drop-in blend of jet fuel and up to 50 percent of hydroprocessed esters and fatty acids (HEFA) that are identical to the hydrocarbons found in jet fuel. The process, also referred to as hydrotreated (or hydroprocessed) renewable jet fuel (HRJ) or bio-derived synthetic paraffinic kerosene (Bio-SPK), uses naturally occurring oils from sources such as non-food crop seeds, algaes and even used cooking oils and animal fats.

The ASTM approval followed a nearly three-year certification program that included demonstration flights by airlines testing the new fuel blend. More than 30 carriers have now used the product, many on revenue-generating flights. Earlier this year, Lufthansa concluded a six-month trial titled “burnFair” (Future Aircraft Research), partially funded by the German government’s Ministry of Economics

Gevo, the company that provided ATJ for an Air Force demonstration, commissioned a facility that can convert 10,000 gallons of isobutanol feedstock into approximately 8,000 gallons of bio-jet fuel.

and Technology. The carrier earmarked one of its new Airbus A321s to explore the use of biofuels in passenger service. The aircraft, which made nearly 1,200 short flights on the Hamburg-Frankfurt route, operated with one of its engines powered solely by a 50-50 biofuel blend.

As a finale, Lufthansa flew one of its 747-400s from Frankfurt to Washington, D.C., in January, using 40 tonnes of a biofuel blend. “Our burnFair project went off smoothly and to our fullest satisfaction,” said Joachim Buse, the airline’s v-p of aviation biofuel. “As expected, biofuel proved its worth in daily flight operations.” During the trial, the aircraft burned 1,556 tonnes of the blend, reducing CO_2 emissions by more than 1,400 tonnes.

In another test program currently being conducted by Canada’s National Research Council (NRC) a Dassault

LanzaTech uses a microbe to convert carbon monoxide into ethanol.

Falcon 20 is being flown on a HEFA-process fuel blend produced by Honeywell’s UOP subsidiary. The fuel is derived from Brassica carinata, a type of hardy nonfood mustard plant that produces an oil-rich seed. The NRC is flying with an even biofuel/conventional fuel ratio as well as with a nonstandard 60/40 mix and sampling the biofuel exhaust plume in flight using a specially outfitted T-33 chase airplane. Preliminary results of the tests have shown that “particulate emissions, including aerosols of black carbon, sulphates and by-products of the combustion of aromatic compounds, are significantly lower from biofuels than from jet-A1.”

Engine maker Pratt & Whitney Canada is partnering with Bombardier on an alternative-fuel initiative designed to help reduce the aviation industry’s overall environmental footprint. The first biofuel-powered (camelina blend) revenue flight in Canada was flown in April on a Porter Airlines Q400 turboprop. The project partners–including Green Aviation Research and Development Network (GARDN) and Sustainable Development Technology Canada (SDTC)–intend to demonstrate the use of camelina oilseed as a renewable jet fuel.

Obstacles To Overcome

HEFA was the second of the alternative aviation fuel processes to receive the ASTM nod. In 2009 the organization, the governing body that signs off on the specifications to which fuels must conform, approved the use of a 50/50 blend of jet fuel and synthetic paraffinic kerosene created using the Fischer-Tropsch process, from gasified coal, natural gas and/or biomass.

Despite the buzz surrounding the approval of the HEFA process last year, the aviation biofuels market still simmers only slowly. Honeywell’s UOP subsidiary was a driving force in the development, testing and certification of the HEFA production process and it supplied much of the biofuel used in demonstration flights by the airlines and the military. The company never intended to be a major fuel provider and was banking on licensing its technology to producers after proving its ability. Yet more than a year after the fuel was certified for use, UOP has not yet signed a single licensing deal.

“This time last year I would have said we’d have [a deal] in the next six months,” said Jim Rekoske, vice president and general manager of UOP’s renewable energy and chemicals business unit. “All of the people that I was talking to then, we’re still talking to and more.”

Rekoske sees several interconnected hurdles that must be scaled before companies begin to seek technology licensing agreements and large-scale production of aviation biofuels becomes a reality. One of the most prominent concerns is the feedstock for biofuels. “Airlines are among the pickiest customers when it comes to sustainability of the feedstock and there’s good reason for that,” he told **AIN**. “They are going to take the brunt of any customer flak from environmental groups if the feedstock that they choose to source is not sustainable.”

Organizations such as the Sustainable Aviation Fuel Users Group (SAFUG) have created a list of criteria for optimal feedstocks: minimal impact on biodiversity; sustainability with respect to land, water and energy use; no displacement of or competition with food crops; positive socioeconomic impact; and no special fuel handling equipment, distribution systems or changes to engine design. The wish list is there, but as yet there is no international consensus on what feedstocks are considered sustainable. The inherent international nature of aviation makes international agreement crucial. There’s been a big push to agree on a definition of sustainability, Rekoske said. “No one can really say with certainty what a sustainable feedstock is, and that’s created a bit of paralysis in the decision making.”

Generally most of the current feedstocks under investigation are so-called “energy crops” (such as jatropha and camelina) that thrive in areas unsuitable for food-crop production or can be used as an interim or rotational crop on current farmland (pennycress, carinata and sweet sorghum). Other feedstock options include grasses, algae, municipal solid waste or even sewage sludge.

Money Makes the World Go Round

Another weighty factor in the development of large-scale production is cash. Estimates of how much financing will be required to mass-produce alternative aviation fuels vary by the billions of dollars, but for Rekoske the hardest money for small companies to acquire is the approximately $10 million needed to establish an initial business plan. Known in industry parlance as “walking-around money,” it covers many of the costs required to convince potential investors of the company’s feasibility such as engineering studies, site planning, logistics and distribution studies and construction bids. “It’s the hardest money

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the recuperated propfan engine, a long-term program. Elements include a high-speed/low-pressure turbine with an intercooler between the compressors and a recuperator in the exhaust gas stream. “Intercooling and recuperating energy from the exhaust gas stream markedly increase the engine’s thermal efficiency,” maintains MTU.

Point of Diminishing Returns?

Williams International’s FJ44-3AP is now certified by the FAA and EASA. Compared with the FJ44-3, the -3AP has 8 percent more takeoff thrust and 13 percent more cruise thrust, while weight was reduced 3 percent and cruise specific fuel consumption improved by 1.5 percent.

Every jet engine manufacturer has active programs to reduce fuel burn and

The GE/Snecma partnership’s Leap 1A and 1C are destined for the Airbus ACJ320 and the Chinese Comac C919.

greenhouse emissions, as well as engine noise and weight, some of them stretching well into the next two decades.

Bevans of Honeywell notes that the basic workings of a jet engine are relatively simple, based on the time-honored explanation that “they suck, squeeze, bang and blow.” Even with the most advanced jet engine, something is going to be burned in the middle, which means gas will come out the back. As Bevans puts it, you can run the engine cooler and get one type of emission, or run it hotter and get another. But you are always going to get something.

Bevans believes the aviation industry is approaching asymptote, a mathematical term he uses to describe the peak of a curve, or a point of diminishing returns. “I don’t want to discredit the work being done by some brilliant people, but we’re reaching that point.

“That’s why we’re looking at biofuels, because that’s where the next big gains are going to come,” he explains. “There isn’t much in terms of combustor design, for example, that remains to be improved. So future gains in fuel burn and emissions reduction are not much more than two to five percent, but we could realize a 20- to 30-percent reduction through a combination of advanced biofuels and improved ATC.” ❑

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to get these days because after the most recent financial crisis, everybody ran away from risk,” said Rekoske. “That money is the riskiest because you’ve got to spend that first $10 million to know if you even have a project.”

To assist biofuel startups, the Department of Defense has issued a series of grants through the Defense Production Act, on the order of $4 million to $6 million to help companies put together credible project proposals that they can take to lenders as they attempt to secure project financing. The grants must be matched by private investment.

Many of the would-be players in the industry remain constrained by the lack of venture capital in an investor market wary of deeper European debt woes and a lackluster U.S. economy. “Early-stage companies and new technologies are a tough sell right now, so that’s a factor,” said Jim Lane, editor and publisher of industry observer *Biofuels Digest*. “As investor confidence returns to the market and investors start to take on more risk, these are excellent projects lined up for them; but it remains to be seen when that’s going to happen.”

Despite the financing logjams, there have been many offtake agreements from airlines (including several from consortia of carriers) that could reassure lenders. The consortium contracts are especially valuable as they guarantee that a sizable group will purchase a specified amount of fuel.

Many in the industry believe that once a solid company commits to using the technology to establish a successful biofuel production plant, the floodgates will open. “I really think what the industry needs is for a couple of these technologies to go through the Valley of Death,” said Jennifer Holmgren, CEO of Chicago-based LanzaTech. “A couple of these technologies need to get past the demonstration phase so that people would be willing to start building commercial units. Building the first one is the hard one.”

“I suspect there are a lot of people out there who are waiting to be first to be second,” said UOP’s Rekoske, who is anticipating the first commercial license for his company’s production technology. “They don’t want to be the trailblazer, but they want to be right behind the trailblazer. That means we just have to find that one trailblazing individual who wants to be the first mover, and we’ll go from there.”


U.S. NAVY/SEAMAN CHRIS BROWN

Above, a fuel distribution system operator secures a fueling hose during a biofuels transfer to the Military Sealift Command fleet replenishment oiler USNS Henry J. Kaiser. The oiler took on 900,000 gallons of a 50-50 blend of advanced biofuels before delivering the upload to machinery participating in the Great Green Fleet demonstration, to fuel aircraft such as the Hornet.

Waiting In the Wings

Despite the slow start for production of alternative aviation fuel, other processes currently under development are awaiting their shot at spurring a growth in volume. Alcohol-to-jet (ATJ) does exactly what its name implies, converting alcohol into jet fuel. At the end of June, the U.S. Air Force flew an A-10C Thunderbolt II on the first flight of an aircraft powered with an ATJ blend. The fuel, supplied by Colorado-based Gevo, was derived from cornstarch and was part of an 11,000-gallon test order placed by the Department of Defense. Last December Gevo commissioned a demonstration-scale facility in Silsbee, Texas, that can convert 10,000 gallons of isobutanol feedstock into approximately 8,000 gallons of bio-jet fuel each month. The company has also recently completed the world’s first commercial-scale isobutanol plant in Luverne, Minn. That facility is undergoing testing and the company is working on another in Redfield, S.D. Both facilities were converted from corn ethanol plants.

The track record from previous processes suggests ASTM certification for AJT by 2014, and by that time Gevo expects to have scaled up to produce more than 18 million gallons per year at Luverne and 38 million gallons per year at Redfield. The company uses a strain of yeast to convert starch from animal feed-grade corn into the alcohol. As a co-product, it retains the protein content of the corn and distributes that as a livestock feed. The company is also exploring the use of cellulosic sugars derived from wood waste and energy grasses as it examines potential geographically distributed feedstock sources.

Another company has an even more esoteric idea for a feedstock. LanzaTech has developed a microbe that can turn the toxic pollutant carbon monoxide (CO) into ethanol. The company has established a joint venture with Bao Steel to produce a demonstration facility at its mill in Shanghai. “Steel mills and other industrial sites create quite a bit of carbon monoxide, but they usually flare it and it goes right out the stack as CO_2. We capture that and convert it to ethanol,” said LanzaTech’s Holmgren.

The facility, which began operation in April, is anticipated to produce 100,000 gallons of ethanol feedstock a year. “It’s just a drop in the bucket,” Holmgren told **AIN**, but once the demonstration unit has proved the technology, LanzaTech will build commercial-scale plants in Shanghai and Beijing each capable of producing 30 million gallons of ethanol a year. The company hopes to use one of the locations solely to synthesize up to 15 million gallons of jet fuel a year. Virgin Atlantic plans to use that fuel to make a demonstration flight using one of its Boeing 747s.

“Based on what we understand today, recent surveys show that if we could convert all the waste gases coming off steel mills worldwide, using current technology we could make 30 billion gallons of alcohol and approximately 15 billion gallons of jet fuel,” said *Biofuels Digest*’s Lane. “That’s just to illustrate that these sources can produce a tremendous amount of fuel without the traditional perception that you have to take land from people growing their vital food crops.”

Pyrolysis-to-jet is another process currently being explored. It breaks down biomass under extreme heat to produce a low-quality oil that can be further upgraded for processing into jet fuel. “Both of those hold significant promise, so there’s a hope that pyrolysis oil and alcohol-to-jet will come in at sufficiently lower [cost] levels and really build up our supply potential,” said CAAFI’s Altman.

In June Brazil’s Azul Airlines conducted a test flight of a fuel derived from a process known as direct sugar-to-hydrocarbon (DSHC) or fermentation. Using a biofuel blend produced by California-based Amyris from Brazilian sugar cane, the airline flew an Embraer E195 over Rio de Janeiro, which at the time was hosting the U.N. Conference for Sustainable Development (Rio+20). The process uses microorganisms that can directly metabolize sugars into hydrocarbon fuels that can be used as jet fuel with little or no additional chemical processing.

According to CAAFI’s Altman, “The real goal of the airline industry–and it’s universally accepted–is to achieve carbon neutrality in terms of growth by 2020 and then halve the fuel carbon footprint by 2050. I think that is a realistic goal.” To achieve that would require approximately 5 percent of the fuel the industry uses in 2020 to be derived from bio sources, Altman told **AIN**. Given today’s total industry fuel use of approximately 70 billion gallons annually, that would require a supply of 3.5 billion gallons of a 50-50 biofuel blend to achieve CAAFI’s 2020 goals with a similar fuel use.

Aviation fuels currently account for approximately one percent of the total worldwide production of finished biofuel, which stands at approximately 28 billion gallons a year. *Biofuels Digest* predicts six billion gallons more capacity will be added by 2017. Achieving CAAFI’s goal would certainly be technically possible, according to Lane. “If price were not an issue, 90 percent of all aviation fuel [based on the ATJ specification being approved] used worldwide by 2015 could be in the form of a 50-50 fossil-biofuel blend,” he said.

In fact, Lane noted, today’s entire global biofuel capacity (28 billion gallons) could be upgraded using currently available technologies to produce jet fuels that are either currently or soon to be certified, if the price was right. “It really comes down to price,” said Lane. “These are not capacity or technology issues; these are market issues.”

The end-user per-gallon price factors heavily into the equation, and airline users are understandably reluctant to pay more than the current price of conventional jet fuel. Aviation biofuels are but one of the end products that can be made from the intermediate products of the various processes. The chemicals also have other uses, many of which are considered high value, and the basic laws of supply and demand would dictate that those applications would have to be saturated with product before producers would make their intermediate supplies available for lower-margin products such as aviation fuel. As examples, Gevo provides its isobutanol for use in solvents and paints, while Solazyme, which provided feedstock for fuel in the recent U.S. Navy test, makes an algae-based skin cream from byproducts of the same process.

Feedstock production costs will also determine whether the price of biofuel is palatable for users. “There’s energy intensity in the aggregation or growing of [crops such as] switchgrass,” said Lane. “You need tractors planting seed and fertilizing, and when oil prices swing up and down, as they do so violently these days, that creates a lot of uncertainty.”

While some airlines have already signed supply contracts or offtake agreements guaranteeing the purchase of a certain quantity of fuel, to help ease that uncertainty, some carriers have taken the first tentative steps into providing their own biofuels capacity. British Airways has partnered with Solena on GreenSky London, a project that uses the Fischer-Tropsch process to convert municipal solid waste into up to 30 million gallons of renewable jet fuel a year at a plant in London, and Qantas and SAS are reportedly investigating similar deals. ❑

Growing fleet of aging bizjets sits idle

by Matt Thurber

Dodson International's 120 acres in Rantoul, Kan., stores approximately 1,000 airplane carcasses and five million parts.

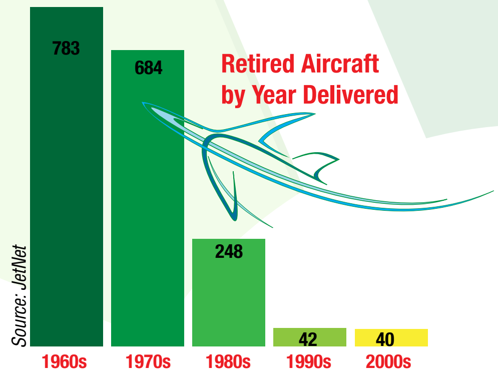
What one expert calls an "overhang of unsold aircraft" is afflicting the business jet ecosystem. "These old business jets are not going to sell," says Rollie Vincent, president of Rolland Vincent Associates. "Take a Hawker 700 with mega hours…There appears to be no market for it and it's time to say goodbye." This overhang, he adds, "is like a freight train coming."

The glut of old jets is a problem for many reasons, according to Vincent. At some point these jets have zero trade-in value. As jets age, the supply chain that formed to manufacture all the parts, avionics and complex components is gone. Another factor is the jets' engines: "If the engines are getting close to overhaul, you're looking at very little value," says Vincent. "I've seen Falcon 20s with no engines. Those aircraft will never fly again, and at some point they get scrapped."

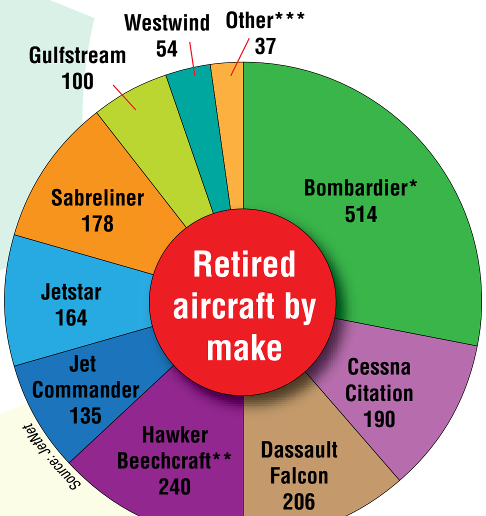
It used to be that third-world countries welcomed old business jets, but that is no longer the case. Many countries now limit the age of imported used jets. And, says Vincent, "emerging markets bring in new aircraft; they've been able to afford it." Financing is elusive for buyers of older jets. "Most bankers won't touch them anymore," says Vincent. It's also getting harder to find maintainers who know how to troubleshoot and repair old jets and who have the necessary equipment and parts. Vincent expects to see about 2,200 business jets taken out of service in the next 10 years.

This Gulfstream GII (S/N 10) is virtually worthless and it is headed for the scrap heap, unless a school or museum could use it.

MATT THURBER



One aircraft was retired in 1957 (not shown).
*International aircraft accounted for 20 of the total.



* Includes Challenger, Global and Learjet
**Includes Beechjet, Hawker and Premier
***Includes Adam, Astra, Eclipse, Embraer and Emivest

Never Selling

JetNet pulled some statistics on older business jets from its database for **AIN**. (*See pie chart at right.*) Some models, stubbornly remaining unsold, are headed for the scrap heap. Lear 24s, for example, have no pulse, languishing on the market for an average of 2,605 average days–more than seven years.

According to JetNet, 1,818 business jets have been retired from service since 1957. (These numbers include some aircraft that were likely registered with the FAA as preproduction prototypes, such as three Adam A700s–an airplane was never certified.)

Logically enough, the majority of retired jets hail from earlier eras (*see bar chart at right*). Many aircraft delivered in the 1960s have been retired, as well as 1970s-delivered jets. Retirements of jets delivered in the 1980s taper down, and aircraft delivered in the 1990s have seen few retirements, according to JetNet. The bottom line is that in the next 10 years, if Vincent's prediction is correct, the aviation industry will see about 2,200 business jets retiring from the fleet, which is 400 more than the number that retired during the first five decades of business jet manufacturing. Two thousand two hundred is a lot of jets to dispose of, especially when compressed into a period of 10 years rather than 50.

Where Do They Go?

The high number of soon-to-be-retired and already-retired jets poses a challenge for manufacturers of new jets. A Gulfstream III, for example, could be gold-plated with new avionics, paint, interior and a digital-age entertainment system, for less than the cost of a used GIV and far less than the cost of a new Gulfstream. The GIII is a perfectly good airplane, other than the fact that it faces a Stage III noise ban beginning Dec. 31, 2015. Two Stage III noise-reduction kits–from Hubbard Aviation and Quiet Technology Aerospace–are available for the GII and GIII, so the types may yet have some life left. Conversely, GIVs selling for around $5 million could swiftly kill off the GII/III market.

Would it make sense for manufacturers simply to buy old jets and recycle them? Vincent doesn't expect this to happen: "They have other fish to fry, including active research and development plans and new product development. They're going to wait for somebody else to do it."

As for what owners should do with jets that no longer have any value, Vincent advises, "People need to know what they're looking at. They're looking at nothing. Just write it off."

Broker Action

Jeff Carrithers used to be an aircraft broker, but in 1995 the brand-new World Wide Web beckoned and he launched Globalair.com, an aircraft sales listing service that includes airport and fuel pricing information and a proprietary system for aircraft brokers called BrokerNet. From his perspective, many older jets linger on the market because the owner can't afford to sell at today's lower prices and because there simply isn't any demand. He sees Citation IIs, Falcon 10s and Westwinds as examples of types that are dying in the marketplace. "A lot of the problem for these owners is that

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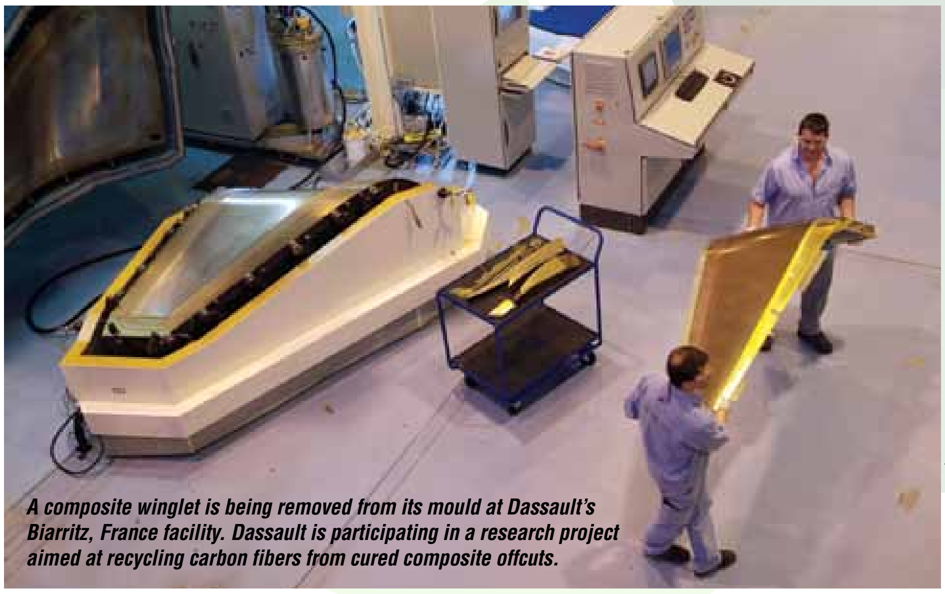
Airframers consider end-of-life details as early as design phase

by Thierry Dubois

Gulfstream's sustainability office is devising a process to eliminate more "materials of concern" in manufacturing its aircraft, including the flagship G650.



A composite winglet is being removed from its mould at Dassault's Biarritz, France facility. Dassault is participating in a research project aimed at recycling carbon fibers from cured composite offcuts.

DASSAULT/S. RANDÉ

Like many other creations of man, a business aircraft makes its mark on the environment not only when it is functioning (in this case, flying), but also before and after its useful life. Manufacturing and dismantling/disposal have an impact too, necessitating that companies choose the right materials and processes for each stage in the aircraft's life cycle. Manufacturers are striving to address the sometimes conflicting criteria of design strength, performance, longevity and recyclability. Their factories must become greener, and the graveyards that dispose of retired aircraft are tasked with recycling more of their structure.

When it comes to the manufacturing phase, Gulfstream tries to do "more than simply pick a particular material for the application." It looks at "materials of concern" (MOCs) but also factors in energy consumption and its "lean Six-Sigma continuous improvement culture," according to a spokesman.

The company aims to keep the broad picture, or life-cycle analysis, in sight. "A component that has half the manufacturing impact is not a good choice if it has to be replaced four times as often," the spokesperson pointed out.

MOCs can be found in coating or painting processes. For example, the company is looking for ways to eliminate the use of hexavalent chromium, among others. Gulfstream's "sustainability office" is now formalizing an MOC process for both mandatory and voluntary efforts, and expects to have it in place this summer.

To improve energy consumption, Gulfstream wants to address employee behavior and factory infrastructure. "The sustainability office has an annual budget to foster improvements," the spokesperson said. Employees partly own the effort through their "green teams." A new painting process, for example, promises to reduce consumption of both energy and water. Gulfstream has taken it upon itself to use its "Lean Six-Sigma" approach to adopt new definitions of "green wastes," and employees are involved in adding them to the company definitions of "lean waste."

Embraer does not see aircraft production as having a heavy environmental impact. "The consumption of water and energy in this phase of the lifecycle is relatively discrete," an Embraer spokesman said, and waste materials have "a suitable environmental destination that prioritizes reuse and recycle."

The Brazilian OEM's environmental impact research focuses on reducing the use of hazardous materials, typically heavy metals such as chromium, cadmium and lead used in surface treatment and soldering. Some of these materials were selected long ago to enhance the properties of structural components and they are indirectly essential to safety, a spokesman pointed out. Under its own initiative, Embraer has been studying alternatives and expects some solutions to be ready for certification shortly.

Gulfstream, Bombardier and Embraer seem to agree that Europe's Reach regulation is the strictest and most influential framework for the mandatory reduction of toxins in manufacturing.

Dassault is endeavoring to waste fewer composite materials during Falcon manufacturing, and it says offcuts in composite manufacturing now represent only 5 to 15 percent of the fibers it buys. In the case of metal machining, approximately 90 percent of the metal becomes turnings.

Until last year, unused dry composite fabrics (before curing) were just sent to a landfill and pre-preg fibers were burned. Both processes used energy. Now, all these dry offcuts find a second life: Dassault sells them to a company that transforms them into fabric used in car component manufacturing.

Offcuts left over from manufacturing after curing are not currently recycled. However, "They will be recovered as soon as resin-free carbon fibers can be extracted economically," a Dassault expert explained. Dassault hopes to see this fiber recovery process mature from research to production, and since 2007 it has been participating in a $3 million project named Aerdeco (a French acronym for aeronautical composite waste) with universities and companies specializing in composites. The players think they might well have found the right process to recover carbon fibers. It involves dissolving resin in water at high temperature (about 400 degrees C, 750 degrees F) and high pressure (about 200 bar). The process is now at the small-scale demonstrator stage, but Dassault and its partners expect a production facility will be built in France at some unspecified time.

Bombardier is concerned about the inconsistency of environmental regulations around the world that seek to ensure greener manufacturing. With that in mind, the Quebec-based manufacturer has helped establish the International Aerospace Environmental Group (IAEG), a consortium of aerospace manufacturers, to help the industry's supply chain understand these complex and variable rules.

From there, the IAEG wants to promote the development of "voluntary consensus standards" to address all environmental concerns, such as chemical use reporting. For Bombardier, the idea is to "standardize the response of the supply chain."

End-of-Life Concerns

Fast-forward to the aircraft's end of life. How much of a business aircraft is recyclable today? The answer is elusive, with no official statistics or definition, according to Embraer. This is especially true for aircraft manufactured at least 20 years ago that are now nearing the end of their life.

"For in-production aircraft, some aerospace companies have estimated that about 90 percent of the aircraft could be recycled, but the difficulties found in recycling operations already carried out led our company to revise that number to about 70 percent," Embraer said. The other 30 percent are materials with "no commercially viable solution." Bombardier agrees with the 70-percent assessment.

Gulfstream asserts that 75 to 85 percent, by weight, of its current production aircraft can be recycled into some other aircraft component. The remaining materials are foams, plastics and commingled materials that are difficult to separate, difficult to recycle or have no market demand. Finally, some retired aircraft find a second life on the ground as a training device for maintenance or fire safety.

Progress made today in design and manufacturing should bear fruit in the dismantling process 25 years from now. For example, Gulfstream's MOC program aims to eliminate during the design phases those components that inhibit or interfere with recycling processes. Those MOCs that must remain can, at least, be identified and isolated to avoid contaminating end-of-life processes.

Embraer is a member of the Aircraft Fleet Recycling Association (Afra), a partnership of "OEMs, aircraft disassemblers and parts distributors, aircraft insurers and appraisers, materials recyclers and technology developers." They seek "an industry-developed solution to manage the world's aging aircraft fleet."

Afra suggests that manufacturers use materials that are in demand for recycling and blend fewer different types of material. Here, however, there can be conflict between the quest for economical reuse and the need for specific component attributes such as strength, lightness, durability, resistance to temperature extremes and so on. Embraer emphasizes that labor costs pose a challenge to the economic viability of the recycling process. Aircraft disassembly requires skilled labor and is a time-consuming process.

Despite the obstacles, many different materials are being recycled already, even from the cabin, according to Gulfstream. For example, cabinets, made mostly of aluminum honeycomb, can be fed directly into a smelter. Carpets are recyclable: natural fibers such as silk or wool can have second lives as jute, rags or feedstock for paper mills; synthetics such as nylon and polyester are sought after by

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Fleet of aging bizjets sits idle

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they bought aircraft in the 2007-2008 heyday, and we'll never see that kind of activity ever again. With the economic conditions today, operators will just park the aircraft."

Parked Airplanes

Most of the airports in the Southwest U.S. that store unneeded and obsolete airplanes are repositories for airliners. At Kingman Airport in Arizona, Kingman Airline Services has just one business jet, a GII that will soon be dismantled, according to a spokesman. The company is currently storing 50 EMB-135s, forty 727s, 20 MD-80s, eight DC-8s and 20 CRJ200s. Some of these airplanes are headed for recycling, while others will fly again, and Kingman Airline Services can handle either destiny. Airplanes that will fly again are kept on life support–the required storage maintenance processes outlined by manufacturers. For airplanes that will never again charge down a runway, some parts are still worth salvaging, especially the engines. The remaining airframe is then dismantled by another company, which hauls away the metal for recycling.

Norm Hill Aviation at California City Airport in the Mojave Desert opened in 2008, and since then founder Norm Hill's company has parted out 21 Gulfstreams. He thinks there is still plenty of life left in old Gulfstream airframes and thus a steady demand for parts that he can supply.

With the upcoming Stage III deadline banning non-hushkitted GIIs and GIIIs from flying in the U.S., Hill expects to see as many as 85 older Gulfstreams parted out in the next few years. But there are also plenty of airframes with relatively low hours and cycles that can keep flying, if hushkitted. "What I'm doing is going to be good for quite a while," says Hill, adding that his technicians dismantle the airplanes carefully, not with a chainsaw but rivet by rivet when necessary, to preserve as many good components as possible. "We're stocking all those parts with traceability data all the way back to birth."

MATT THURBER

Norm Hill Aviation specializes in dismantling old Gulfstream GIIs and GIIIs and reselling usable parts and components.

One factor that accelerates the decision for owners to give up on their older jets is the cost of upcoming heavy maintenance events. This includes older Gulfstreams that are due for a 72-month inspection and a 5,000-landing event. "That's $500,000 to $600,000," according to Hill. Add to that the cost of overhauling the Rolls-Royce Spey engines, and that's another $400,000 for the midlife service and $800,000 for overhaul, for each engine. "This perfect storm is there and people are falling into it," he said.

Hill currently has eight GIIs and two GIIIs in California and one GIII being dismantled in Opa-Locka, Fla. Hill says his company is providing a service to the used airplane community, because, he says, an owner can get more from selling a decent jet to Hill than from dumping it on the used market. And if Hill can extract more value by selling good parts, he says he shares that with the seller.

Companies like Dodson International Aircraft Parts have long specialized in what CEO JR Dodson calls "demanufacturing" of obsolete aircraft. "The last three years we've been buying a lot of older business jets," he said. Most of these are jets coming up on major maintenance events or overhauls and some are bank repossessions that can't be sold. "There's more supply than demand right now." Dodson International also carefully removes valuable parts, and the leftover carcass is either stored at the company's 120 acres in Rantoul, Kan., or sent to the smelter for recycling. The company has parted out more than 3,000 aircraft since opening in 1980. There are currently about 1,000 gutted airframes at the facility, which parts out about 100 aircraft every year, ranging from turbine helicopters to business turboprops and jets to Boeing 747s.

Serial Number 10

And then there are the hopeless cases, such as a GII and Hawker 700 parked on the Western Jet ramp at Van Nuys Airport in Southern California. The buyer of the GII thought he was getting a great deal when he purchased the airplane–S/N 10, one of the last GIIs built at the Grumman facilities in Long Island, N.Y. He bought the airplane in Panama, and the seller promised to send the logbooks, but they never arrived. Western Jet founder Jim Hansen finally told the owner that to bring the GII up to safe and legal standards would take about $5 million, because all components would need overhauling, given the lack of documentation. "I'll have to chop it up," Hansen said sadly. "It's not worth the parts."

A Hawker 700 parked next to the GII is also in a sorry state. The owner, perhaps unknowingly, let the jet sit at another maintenance facility for more than two years without covers on the engines or application of any preservation processes. "There is no value," Hansen said. ❑

End-of-life considerations begin at design stage

Continued from page 30

carpet mills to use as feedstock.

Since the under-development Learjet 85 makes extensive use of composite materials, Bombardier has conducted a feasibility study for composites recycling. So far, it does not envision using any recycled composites in primary structure because it says recycled fibers, often shorter than the original ones, are not long enough for the required strength. However, they could still be useful in secondary structure such as a bracket for an interior panel.

Dassault is more optimistic. The aforementioned research and development to recover carbon fibers from cured composites will apply, too, at end of life, and Dassault suggested it expects that recovered fibers could be reused in aircraft primary structure.

To help improve end-of-life aircraft dismantling, Bombardier has joined a project led by Quebec's aerospace research and innovation consortium (CRIAQ). The company has given the project an old CRJ200 as a test platform for dismantling. The $1.4 million effort was launched in November last year. The partners also believe that this work will allow them to create greener designs and improve on today's recyclability rate. The economics of recycling in the CRIAQ project are all the more important as the cost of discarding materials in a landfill continues to climb. The companies and universities involved in the project want to make sure they will find ways to reuse materials, perhaps in non-aerospace products such as cars and razor blades.

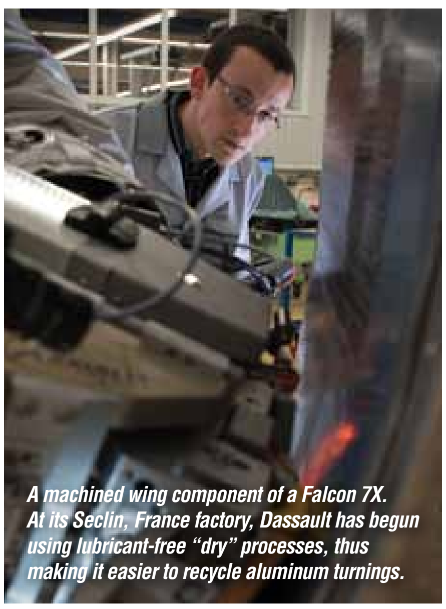
Asked about recycling aluminum, the Bombardier expert points out that melting and cooling degrades the metal's qualities, making recycling high-grade aluminum alloys into aerospace applications an unlikely proposition for Bombardier.

This may change, however. Aluminum product developer Constellium is endeavoring to increase the percentage of recycled metal in its aerospace-grade production. "Last year, 77 percent of the aluminum alloys we produced for aerospace applications came from recycling," Bruno Chenal, Constellium's director of technology and innovation, said recently. This figure is targeted to reach 80 percent by 2015.

From an environmental standpoint, said Chenal, "recycling one pound of aluminum avoids 11.4 pounds of CO_2 emissions." Measured in energy consumption, recycling one pound of aluminum uses just 5 percent of the energy needed to produce one pound of "new" metal. This is where the frequently conflicting logics of environmental concern and economics take up the same heading. Energy accounts for one third of the cost of producing new aluminum.

To gather aluminum for recycling more efficiently, Constellium involves customers in most of its efforts. They are encouraged to include every machining process in a "closed loop" that Constellium can comb for offcuts.

In addition, more and more components are pre-machined at the aluminum supplier's facilities, ensuring that most of the turnings stay at the aluminum production facility.



DASSAULT FALCON/S. RANDÉ

A machined wing component of a Falcon 7X. At its Seclin, France factory, Dassault has begun using lubricant-free "dry" processes, thus making it easier to recycle aluminum turnings.

Recycling at the Maintenance Stage

Maintenance operations are part of an aircraft's life cycle and therefore appear in its environmental big picture. East Alton, Ill.-based repair and modification specialist West Star Aviation is thus endeavoring to recycle, just as other players do at the production and dismantling phases. Among the company's initiatives is recycling all metals on site. All paint thinners are recycled in on-site distiller towers. West Star Aviation recently applied to advance from bronze to silver rating in the Environmental Leadership Program. *–T.D.*

Factory logistics are the main impediment to more recycling, but another limiting factor is the possible presence of lubricant in the offcuts, which presents a risk of oxides in the recycled metal if the offcuts are not dried effectively. Some aircraft manufacturers, such as Dassault at its factory in Seclin, France, are implementing "dry" (lubricant free) machining processes.

Constellium's latest technology has been dubbed Airware. It is a collection of patented recipes for alloys, production techniques and recycling processes. Even the turnings recycling methods are proprietary.

One key to the success of Airware's recycling is its recently acquired ability to preserve lithium–a highly reactive metal that used to be lost in the recycling process. A recycled Airware alloy can be reused in an airframe, according to Constellium. Airware's first applications are airliners, but Constellium regular customer Dassault might be close to following suit.

Constellium also claims that its Airware technology provides a weight advantage of up to 25 percent, thanks to the combination of the alloy's reduced density and the new design possibilities it offers. ❑