The next-generation turbofan engine—more efficient, cleaner burning and weighing less—is arriving now on an aircraft near you. It isn't that engine manufacturers haven't been working toward building engines that its been low fuel, emit fewer greenhouse gases, weigh less and cost less. They have been doing just that for more than 25 years, according to Pratt & Whitney Canada vp of engineering and productivity Walter Di Bartolomeo. He should know, because that's how much time he's had for the engine manufacturer.

Until the past decade, this effort was driven primarily by the competitive market of demand. More recently, with the exception in new regulations and in the usual pressure from public advocacy groups, has 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 (turbofan engines that were approved by the United Nations' International Civil Aviation Organization). Engine manufacturers are meeting these standards and are now producing aircraft with small drops in total NOx emissions, as approved by the Tier 8 standards.

At the same time, research continues in the European Commission's Clean Sky initiative. The goal of this research program is to develop engines that meet future emissions standards, which are expected to come into effect in 2020.

In the United States, the U.S. government has awarded $290 million in Clean Sky research grants. The program aims to develop engines that can meet future emissions standards and can be manufactured in the United States.

Engine manufacturers are also working on reducing the amount of carbon dioxide emissions from aircraft engines. This is important because carbon dioxide is a greenhouse gas that contributes to global warming. To reduce the amount of carbon dioxide emissions, engine manufacturers are developing new technologies that use alternative fuels, such as biofuels, and are improving the efficiency of existing engines.

The technology for biofuels is still in the early stages of development, and it is not yet clear how effective it will be in reducing greenhouse gas emissions. However, some biofuels, such as bio-derived jet fuel, have the potential to reduce greenhouse gas emissions by up to 80% compared to conventional jet fuel.

In conclusion, while there is progress being made in reducing the greenhouse gas emissions from aircraft engines, more research and development is needed to make these technologies more effective and widespread. It is important for the aviation industry to continue working towards reducing greenhouse gas emissions in order to mitigate the effects of climate change.
Efficient next-gen turbofans reduce greenhouse gases

Continued from preceding page

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 percent more thrust, the take-off 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 50 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 scaldoped engine exhaust nozzle design, improving 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 the CFM56-7B8E, 50 percent below the NOx emissions limit set by CAEP/6E, and 75 percent quieter for the aircraft’s noise footprint.

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 was the V2500 for the Airbus A330 and the B777.

Cairn (clean air) engine is MTU’s “technology roadmap for the eco-efficiency 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 fans 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...
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 CO2 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 hydrotreated esters and fatty acids (HEFA) that are identical to the hydrocarbons found in jet fuel. The process, also referred to as hydrotreated (or hydrotreated) renewable jet fuel (HRJ) or bio-derived synthetic paraffinic kerosene (Bio-SK), uses naturally occurring oils from sources such as non-food crop seeds, algae, 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 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 tons 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 CO2 emissions by more than 1,400 tonnes.

In another test program currently being conducted by Canada’s National Research Council (NRC) a Dassault 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/convventional 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-A.”

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.

LanzaTech uses a microbe to convert carbon monoxide into ethanol.

**Aviation Biofuels**

Continued from page 20

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**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 sizzles 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 we would have said we’d have [a deal] in the next six months, said Jan Roske, 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.”

Roske 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 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, Roske 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 companies begin to seek technology licensing, agreements and large-scale production of aviation biofuels vary by the billions of dollars, but for Roske 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

and 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 greenhouse emissions, as well as engine noise and weight, some of them stretching way 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 such 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 off-take agreements from airlines (including several from consortia of carriers) that could reassure lenders. The consortia 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 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.”

**Waiting In the Wings**

Despite the slow start for production of alternative aviation fuel, other processes currently under development are 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 cellulose sugars derived from wood waste and energy grasses as it examines potential geographically distributed feedstocks.

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 250,000 metric tons of biocarbon material 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 CO₂. 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 CAAFT’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 microbial strain from the corn plant, the company produced almost 90 percent of jet fuel from 100 percent available and distributes that as a livestock feed. The company is also exploring the use of cellulose sugars derived from wood waste and energy grasses as it examines potential geographically distributed feedstocks.

**To address 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 fuel, or a 50-50 blend of biofuels.**

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 CAAFT’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 that 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 produces high-purity isobutanol that can be used as jet fuel without the traditional perception of jet fuel. Aviation biofuels are used in the manufacture of 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 several 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 producing their own fuels 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

What one expert calls an “overhang of unsold aircraft” is afflict ing 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.

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 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 2,300 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 GHI 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 GHI and GHI, so the types may yet have some life left. Conversely, GIVs selling for around $5 million could swiftly kill off the GHI/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 IIIs, Falcon 10s and Westwinds as examples of types that are dying in the marketplace. “A lot of the problem for these owners is that...”

Source: JetNet

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Airframers consider end-of-life details as early as design phase
by Thierry Dubois

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 forming 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 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 toxics in manufacturing.

Dassault is endeavoring to waste fewer composite materials during Falcon manufacturing, and it says offsets 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
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 founded Norm Hill’s company has partout 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.

**End-of-life considerations begin at design stage**

Continued from page 30

Continued from page 28

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 CO2 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 head. 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. Factory logistics are the main impediment to more recycling, but another limiting factor is the 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 techniques for alloys, production technologies 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 reduction of the alloy’s density and the new design possibilities it offers.

**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 a variance from bronze to silver rating in the Environmental Leadership Program. —T.D.

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

banning non-hushkitted GIIIs and GIIIs from flying in the U.S., Hill expects to see as many as 85 older Gulfstreams part 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 planes 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.”

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 $100,000 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 GIIIs and two GIIIs in California and one GII 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 partout 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 owner of the GII thought he was getting a great deal when he purchased the airplane—SN 10, one of the last GIIIs 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 dig 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.