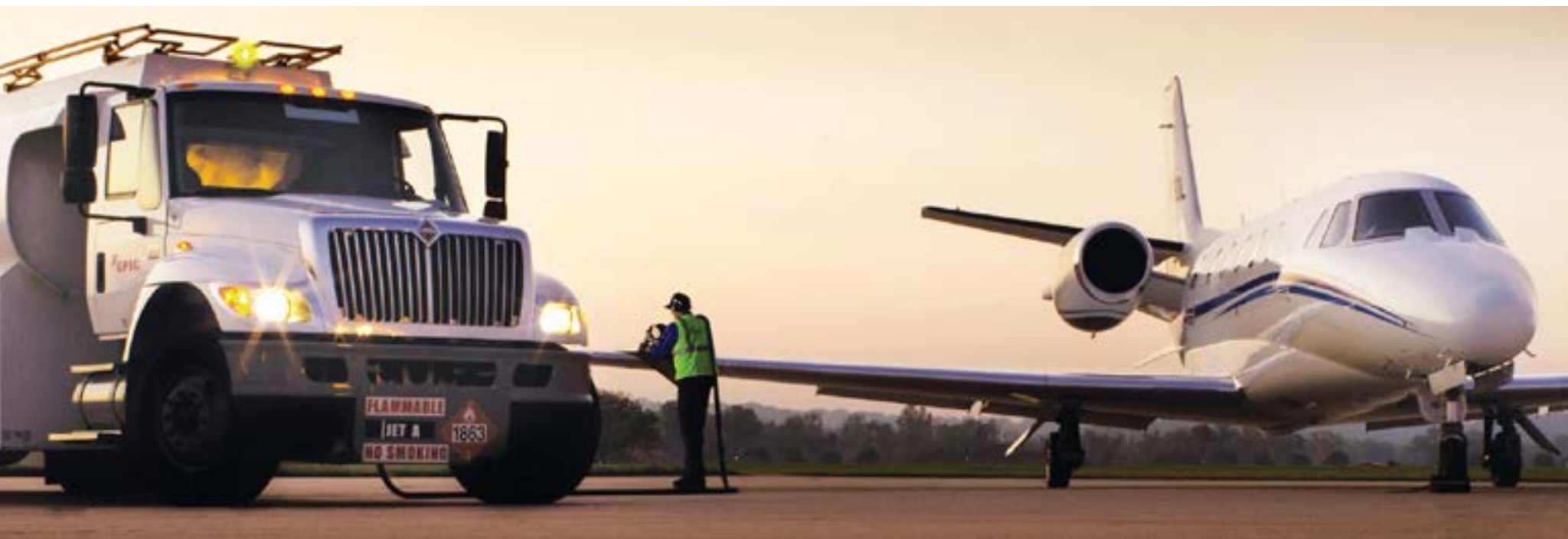


Business Aviation and the Environment

by Kerry Lynch



Industry finds a seat at the table

As government and industry came to a historic agreement last year on the first-ever standard for aviation carbon-dioxide (CO₂) emissions and the associated carbon-offset market-based program, most eyes focused on the airlines. Formally called Carbon Offset and Reduction System for International Aviation (Corsia), the [market-based scheme](#) primarily targets the airlines, exempting all but the largest business aviation operators.

Most of business aviation was afforded this protection because of its de minimis contribution to global emissions; business aviation accounts for 2 percent of all aviation emissions and 0.04 percent of global emissions.

Even so, business aviation has remained sharply focused on its environmental footprint, and as the CO₂ and Corsia agreements came together, the industry insisted on participating. “We fought to be included,” said Ed Smith, senior v-p of international



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and environmental affairs for the General Aviation Manufacturers Association. The global aviation community initially thought that business aviation did not need to be involved.

But business aviation leaders insisted on joining the dialog for two reasons. One was a worry that whatever was decided for air transport would be applied to business aviation without any understanding of the operational and industry differences between the two segments. But second, business aviation leaders recognized that the industry must be a strong advocate on the environmental front.

It's a matter of dollars and sense, business aviation leaders agree. Environmentally friendly operations mean more efficient operations. "We've always had an incentive to be more efficient because it costs us money not to be," Smith said.

NBAA COO Steve Brown agreed. "Two things drive a strong desire to reduce our carbon footprint. The first is self-interest. The lighter you can make the aircraft and the less fuel you burn, the lower the cost of operation and the more universal good."

Second is what Brown refers to as societal culture, which is shaping corporate sustainability goals. "Many companies have environmental elements within their corporate responsibilities," he said.




LONG-TERM VISION

While the global community reached agreement on a CO₂ standard last year, the aviation industry has long been shrinking the footprint made by each flying seat. Both the airlines and business aviation had established their own emissions goals years earlier.

In 2009 GAMA and the International Business Aviation Council, which represents business aviation organizations worldwide, jointly released a document titled Business Aviation Commitment on Climate Change. The document outlined an environmental agreement signed by GAMA president and CEO Pete Bunce and then IBAC director general Donald Spruston. The organizations acknowledged business aviation's accomplishments thus far:

a 40-percent improvement in the efficiency of business aviation products over the past 40 years. But, with that success, the organizations acknowledged the need to accomplish even more. "Our community recognizes that we must do our part to reduce aviation emissions further even as we grow to meet rising demand for transportation," they said.

The three basic goals:

-  Carbon-neutral growth by 2020
-  An improvement in fuel efficiency averaging 2 percent per year until 2020
-  A reduction in total CO₂ emissions of 50 percent by 2050 relative to 2005.

These goals nearly mirrored those already established by international airports, airlines and other organizations. The only difference is that the airlines sought an annual reduction of 1.5 percent per year until 2020, with the goal of reaching carbon-neutral growth from 2020 and beyond. Business aviation leaders conceded that these were aggressive goals, requiring a sustained commitment throughout the industry as well as a strong government/industry partnership.

To achieve the goals, the leaders identified four pillars that must work together to carry the load: technology improvements, infrastructure and operational improvements, alternative fuels and market-based measures.

Technology has been a key driver of efficiency improvements to date. The primary source is engine improvements, but airframe design, avionics, new materials and even retrofits such as winglets play their part too. The leaders predicted that a business aircraft built in 2050 will be 45 percent more fuel efficient than those built in 2005.

Past successes suggest that this is achievable. "The things that have been effective so far have been the things we really know how to do and have been doing for some time, such as continuous improvement in engine technology," Brown said. "Every new engine that gets certified is a couple of percent more efficient than the one that preceded it. That's

been a routine commendable achievement on the part of industry.”

While technology is an important piece, infrastructure and operational improvements promise to bring even greater gains, Smith said. He defines infrastructure improvement as the modernization that moves ATC from a ground-based system to space-based. The industry has less control of this, because it depends on initiatives such as NextGen and Sesar. While they might be rolling out more slowly than everyone would like, these efforts are moving ahead, Smith noted, providing more direct routing, performance-based navigation (PBN) approaches and improved separation management, among other benefits.

The FAA found that flights using PBN approaches cover on average 14 fewer miles and shorten delays by two minutes. “This saves 6.5 million gallons of fuel per year, which in turn reduces carbon dioxide emissions by 62,000 tons,” the agency said in its *U.S. Aviation Gas Greenhouse Gas Emissions Reduction Plan*.

Separation management is estimated to save 1.4 million gallons of fuel per year and reduce CO₂ emissions by 13,000 metric tons. While those estimates are for the entire aviation industry, with airlines accounting for the lion’s share, Brown notes that all apply to business aviation. Business aircraft will follow the same approaches, and properly equipped aircraft can take advantage of some of the more advanced procedures, he said, adding that business aircraft operators tend to be early adopters of technologies.

More specific to business aviation are other operational efforts. Business aircraft operators have looked at multiple means for shrinking their footprint, Brown noted, such as limiting APU run time, cutting down on catering, avoiding carrying excess fuel, flight planning for the most direct routes and preparing better for weather accommodations.


OEMs and industry groups have also held sessions with operators on how to wring the most efficiency

out of their aircraft, Smith said, citing awareness of cg and thrust requirements. “This is not falling on deaf ears or preaching anything, because operators love to save fuel and save money,” Smith said.

Biofuels, the third pillar, offer the single greatest possibilities for gains, industry leaders agree, noting that much has been accomplished technologically in recent years. But this long-term solution is still facing cost and distribution questions.

With biofuels still off in the future and air traffic management initiatives still being implemented, Smith said technology improvements alone may not get the aviation community to carbon-neutral growth by 2020. This is where market-based measures such as Corsia come in, he said, as the “gap filler.” They apply specifically to international aviation, and 65 nations (representing 85 percent of international traffic) have already signed on to the program, which will be phased in from 2021 through 2035. In the short term, both Brown and Smith concede that it is difficult to measure business aviation’s year-to-year progress. Each goal, Smith explained, is designed as a look-back measurement.

Business aviation does not have detailed emissions tracking mechanisms in place that are more readily available to the airlines. Honeywell, however, is among those researching more accurate measurement, said Bill Traxler, director of marketing and product management for Honeywell Aerospace. Asked if the ICAO goals are realistic, Traxler, said “absolutely,” adding that the community has worked closely with regulators to ensure the industry is prepared to meet the goals for the long run. On the basis of “really rough data,” Smith noted, “we are fairly optimistic we are on track.” Brown agreed with that assessment.

“We have put in place the international regulatory structure and framework,” Smith added. “What we don’t have right now are the numbers, but [the business aviation environmental framework] has been designed, it has been agreed, it is going to be put in place and it is going to have an effect.” 



Pratt & Whitney Canada PW800

Engines and airframes drive efficiency gains

Business jet makers are looking at completely new technologies, such as electric and hybrid systems, to make dramatic steps in improving their efficiencies and reducing their environmental footprint. But in the interim, manufacturers are continuing to build on a long tradition of steady improvements through evolving engine and airframe technologies.

“Aviation has always looked to become more efficient, and it has been pretty steady over time,” said Greg Bowles, vice president of global innovation and policy for the General Aviation Manufacturers Association (GAMA), noting that the gains have averaged about a percentage point each year. “An improvement of 1 percent year in and year out adds up. Over 60 years, we are about 60 percent more efficient.”

Walter Di Bartolomeo, v-p of engineering for Pratt & Whitney Canada, said that while environmental regulatory requirements drive these improvements, competition is an even bigger motive. “Being ahead of the game and staying ahead of regulation is a must. But from a competitive perspective there is an advantage to being more fuel efficient and having fewer emissions,” Di Bartolomeo said. “Operationally, fuel costs everyone money. Everyone competes to be more efficient,” Bowles agreed. “It’s a great story because aviation is driven to be more efficient for pretty much every reason. The only thing preventing us is physics. We have to do everything we can to try to figure out how to navigate physics properly.”

Many of the efficiency gains to date center on

the engine. Optimizing engine performance and burning fuel as efficiently as possible is the ultimate goal, Di Bartolomeo said.

To get there, manufacturers look at bypass area, clearances, airflow, core temperatures and improved materials that can handle higher temperature, Bowles said. “We’re looking at even more exotic materials, more exotic ways to cool and better efficiencies.”

At P&WC, “we are always working new technologies on how effectively we burn fuel,” he said. He agreed with Bowles that new materials and the ability to run the engine hot are key factors in these changes. “There is a continuous effort to improve alloys and materials in the turbine end of the engine,” he said. But he also pointed to the aerodynamics side and use of computational fluid dynamics.

Some of these advances are making their way into the Pratt & Whitney Canada PW300 and PW800, and the results are measurable. The PW307, which incorporates the company’s Technology for Advance Low Nox (Talon) combustion technology, is 30 percent ahead of where ICAO standards say it needs to be on emissions. The new PurePower PW800 builds on that, providing a 50-percent improvement in NO_x, along with a 35-percent improvement in carbon monoxide emissions.

The PW800 further has a 10-percent improvement in fuel burn, relative to previous generations in the same class, Di Bartolomeo said. “Ten percent is a big deal. It’s a large step in reducing fuel burn.”

The PW800 also benefits from some of the technology incorporated in Pratt & Whitney’s Geared Turbofan program. Selected for the Gulfstream G500 and G600, the PW800 shares a common core with the PW1500 turbofan. “We worked together to develop that core, compressor technology, combustor technology and turbine technology, leveraging what we’ve learned from both

product lines,” he said.

Long term, P&WC is looking at technologies that the company believes can reduce NO_x by up to 80 percent from both combustion and engine performance improvements.

Honeywell Aerospace also has seen significant strides through its technology research. The TFE731 has a long history of improvements, with each variant offering new capabilities and efficiencies. The introduction of the HTF7000, which powers a number of super-midsize jets, brought a new generation of technology with it, resulting in a 5-percent reduction in fuel burn.

The Phoenix, Ariz. engine maker is now looking forward to its next-generation engine core demonstrator program, with a goal of extending range by 10 to 15 percent, said Bill Traxler, director of marketing and product management for Honeywell Aerospace. “To enable that we need to [develop] an engine that provides more fuel efficiency, more power density and reduced weight,” Traxler said.

Honeywell is looking at targets such as an 8-percent reduction in total specific fuel consumption. This is being weighed against possible constraints on fan diameter that would reduce drag and save weight, but possibly give up SFC gains in return.

“We’re running the equations to figure out how to optimize the aircraft on the SFC side and power-density side,” he added. On the power-density side, the company is looking at a one-piece blisk fan, which he said could save 40 pounds and improve SFC.

The engine maker is adding advanced materials and has made considerable strides in coatings that would allow the core to run hotter. “It’s a combination of better performance and advanced coatings and materials,” Traxler said. Timing and the ultimate design of the engine will be shaped by the customer, he added.

Honeywell is participating in a five-year public/private research effort, the Continuous Lower

Energy, Emissions and Noise (Cleen II) program, which takes a multifaceted approach to introducing much more environmentally friendly technologies to civil aviation by 2026.

The company is testing a Single Annular Combustor for Emissions Reduction (Saber) compact, low-emissions combustor and an advanced turbine blade outer air seal in an effort to cut fuel burn by 27 percent and beat the ICAO NOx emissions standard by 53 percent.

Manufacturers also underscore the role additive manufacturing (3D printing) is beginning to play in these technology improvements. The process allows manufacturers to use more exotic materials, improving heat tolerance, Bowles said. Traxler noted that additive manufacturing allows manufacturers to develop more complex parts that advance technology and shed weight. It enables Honeywell to develop a part much more quickly as a single component, he said.

Beyond the engine, aircraft manufacturers continue to refine their designs, resulting in an overall package that burns less fuel. “You’re seeing efficiency in the airframe design, higher-aspect-ratio wings and higher wing loading,” said Bowles. “The aircraft that can go around the world really take advantage of new understanding in aerodynamics and computational fluid analysis tools.”

Dan Nale, senior v-p of programs, engineering and test for Gulfstream Aerospace, pointed to advanced aerodynamics incorporated to reduce drag and improve fuel efficiency on the G650/650ER, a design that was adapted for the G500 and G600.

AIRFRAME ENHANCEMENTS

Like the engine makers, airframers are placing an emphasis on materials. “Gulfstream has a dedicated team devoted to composites research to look at new ways aircraft can benefit from



Honeywell TFE731

composite structures to cut weight and improve fuel efficiency,” he said, noting that composites are used in the pressure bulkhead, horizontal stabilizer, winglets, floor panels, furnishings, fairing and control surfaces and cabinetry veneers of the G650, G650ER, G500 and G600. Environmental improvements are showing up in nearly every area of the airframe: structural optimization, systems refinements, aerodynamic improvements and flight deck capabilities, he said.

But improvements have also found their way in through retrofits such as winglets, added Walter Desrosier, vice president of engineering and maintenance for GAMA. Aviation Partners (API), which has been in the forefront of winglet technology, has had its winglets forward fit or retrofitted to a host of airliners and Falcons, Hawkers and older Gulfstreams. Some 7,000 aircraft are equipped with API winglets, which are designed to reduce the drag caused by wingtip vortices. API estimates its winglets have saved six billion gallons of fuel, representing a reduction of CO₂ emissions of 64 million metric tons. With its business growing, API believes the fuel savings could jump to 10 billion gallons by 2019.

HYBRID AND ELECTRIC

Looking into the future, manufacturers are eyeing brand-new technologies. “The step change that everyone is focused on right now is hybrid and electric propulsion,” Bowles said. There’s been so much attention on it that GAMA established the Electric Propulsion Innovation Committee (Epic) a year ago, and membership has already swelled to 40 companies. “In a year, we went from zero to 40,” he noted.

“These 40 members don’t come in with hands in their pockets,” added Di Bartolomeo. “They all bring boxes of information and work they’ve been doing independently. They bring their capabilities.”

As it founded Epic, GAMA began accepting new associate members with those areas of expertise.

Bowles noted that it is attracting new companies, among them Siemens, that bring a background in energy and power. Committee members have been busy with numerous individual projects.

Collectively, Epic devised a worldwide standard for measurement of hybrid and electric propulsion in general aviation aircraft. Released on February 3, the standard provides a common set of measurements for hybrid and electric aircraft performance, including a 30-minute reserve for typical flights. “We don’t typically standardize a technology until we feel it’s taking hold,” Bowles said. “This sector is really starting to turn up.” With a number of projects in development, Epic seeks to ensure manufacturers take a similar approach to the measurement of aircraft power and their claims of capabilities.

If one excludes the energy expended by the manufacturing cycle, pure electric propulsion is completely “green” from an operational standpoint, Bowles said. The field is advancing rapidly, he said, noting that this year’s Aero Friedrichshafen will feature the world’s first airshow demonstrating electric-powered aircraft. Bowles expects a handful of aircraft will participate.

Electric propulsion in light aircraft provides insight into what is required to apply it to heavier aircraft.

For the lighter end of general aviation—two- to four-seat aircraft—electric is demonstrating two-hour capability (an hour of flight and an hour in reserve), he said. While possible for smaller aircraft, all-electric propulsion is still in the distance for anything larger. “The challenge is the energy density of the battery,” said Bowles. “Today we are about 60 percent shy of liquid fuel once you make everything common.” Battery energy density has been


improving by 3 percent a year. “We believe that trend will continue. We see nothing stopping it,” he said, noting that “three percent on three percent on three percent starts to really mean something.” Progress made in the light end is “a great proving ground to figure out the infrastructure and logistical needs of electric propulsion” for heavier aircraft.

In the nearer term, a hybrid of electric and traditional fuel-powered propulsion is becoming more of a reality for larger aircraft, particularly turboprops, Bowles said. “People are looking at hybrid-electric designs in the larger size and that’s really exciting...because it is available now.”

With hybrid, energy can be generated on the ground and stored in the airplane battery. The energy is then combined with traditional engine power to optimize the flight from takeoff to

landing. “Instead of having an engine at full capacity at takeoff thrust and pulling it back for cruise, you can run at one design point, raising efficiency. Hybrid designs are looking at that,” Bowles said.

“Where the industry is going is continued aircraft system optimization,” added Di Bartolomeo. “So much energy is used on an aircraft that isn’t optimally produced and/or consumed.” Hybrid systems are proving promising in uniform production and their use of energy in flight, optimizing performance and becoming much more efficient.

He added that he could see this begin to become more prevalent in the next wave of new aircraft over the next five to 10 years. “Hybrid systems are going to be a bigger part of the industry,” Di Bartolomeo predicted. 

Sustainability a key concern for FBO and MRO operations

Decades ago, environmental sustainability was not a central concern for many aviation businesses. Stories have it that some would even use avgas to control weeds around their facilities. But those days are long gone. A culture of sustainability has taken root throughout the industry, for businesses as varied as MROs, FBOs and even manufacturing facilities.

StandardAero, one of the largest MRO chains in business aviation, says that sustainability is a central focus in nearly every aspect of the business, from the facilities to the processes to the management of materials. This philosophy has required a substantial investment and buy-in of employees, but the company has seen returns, said John Teimeyer, director of global environmental, health, safety and security at StandardAero.

Each of the company’s facilities has earned ISO 14000 certification (an environmental management system) from the International Organization for

Standardization, making it one of few in the field to receive such recognition. The approval drives how StandardAero approaches every aspect of the business, from the lifecycle of the materials used in maintenance and repair operations—from the supply chain to the waste management—to how it recycles everyday items such as packing material, Teimeyer said.

“It goes so far as we examine our engine testing fuel from the standpoint of *where does it come from, how far does it have to be transported and what is the blend*. It’s that level of detail,” he said. Waste management is a significant emphasis, he said, noting that the company is able to recycle or “divert” about 50 percent of waste that would normally head to a landfill. “We have only so much room in our landfills. If we can repurpose waste, we will,” he said.

He pointed to one instance where the company’s Associated Air Center facility in Dallas, Texas, had



Rather than scrap a BBJ fuselage, Associated Air Center donated it to a scuba diving park for training.

a surplus Boeing Business Jet fuselage that was going to be scrapped. Instead, the center found a new use for the fuselage, donating it to a local scuba diver park for training. Another example he cited was packing material that was repurposed for padding on floors where mechanics need to kneel. Many of these ideas come from the company's employees, he said.

Like many aviation firms, StandardAero has made a substantial investment in switching to LED lighting. "It is saving us literally millions in kilowatt hours per year," he said. Natural-gas heaters have been replaced with infrared heaters, also saving on energy.

StandardAero further has invested heavily in separating hazardous waste from rinse water. This capability in its Los Angeles facility enables reuse of uncontaminated rinse water. In San Antonio, the company was one of the first to install a closed-loop system that treats hazardous waste contamination in water and recycles the cleansed water. In Springfield, the company has begun to solve a problem that has plagued it for years: how to reduce the use of methylene chloride in paint stripper. The company

tried alternatives from chemical products to walnut shells. The shells work fine, he said, but not on an entire aircraft. "We finally got to the point last year where we have eliminated the majority of its use."

FBOS GO GREEN

FBOs, meanwhile, have long faced a series of state and federal environmental regulations, along with airport lease requirements, particularly in the areas of fuel spills, underground storage tanks and storm-water runoff. This has led to practices such as implementing Storm Water Pollution Prevention Plans that provide a framework to comply with EPA and local rules on storm-water discharge. FBOs also have added spill-kits on their trucks.

Beyond the regulations, though, this environmental focus has expanded to looking at facilities, equipment and lighting. Signature Flight Support reports that it has spent \$100 million over the past five years on "eco-friendly" design, construction and operations, including U.S. Green Building Council Leed-designed facilities in Newark, N.J., and San Jose, Calif. The former Landmark Aviation

pursued Leed certification when it opened a new facility in San Diego. Rectrix and Chattanooga Airport also have pursued such recognitions.

Leed certifications have become a design consideration at many FBOs, added Douglas Wilson, president and senior partner at FBO Partners. Some of those design plans are encouraged by incentives from local authorities, Wilson said, but “when you look at the financial analysis, using proper windows, proper insulation and proper heaters drives down operating costs.”

One of the biggest changes at FBOs is LED lighting, he said. One company that many FBOs use is Every Watt Matters, which offers a program that replaces existing lighting with LEDs, charging a monthly fee based on energy savings over a period of time.

FBOs are moving toward more efficient radiated heat and incorporating simple solutions such as switches that moderate heating and cooling when the hangar doors open. “These are simple changes that cost little, deliver significant savings and are environmentally friendly,” Wilson said. Another common change is the move toward Lektro electric tugs, which he said are now ubiquitous at FBOs.

Aircraft and aircraft suppliers are looking to make manufacturing processes and facilities more environmentally friendly. Gulfstream committed in 2010 to building its new facilities to Leed standards, and this standard has been incorporated in production, distribution, maintenance and research facilities, said Dan Nale, senior v-p of programs, engineering and test for the Savannah, Ga.-based manufacturer. The effort has involved low-emitting construction materials, reflective roofing materials, highly efficient heating and cooling systems, low-emitting construction materials and lighting control centers, among others.

At Pratt & Whitney Canada (P&WC), attention is given to understanding energy expended in every part, from the removal of the raw materials, to the shipping and to the production, said Walter Di Bartolomeo, vice president of engineering. This extends from suppliers, operations and facilities to details such as cleaners and strippers.

“From the president on down, the company has a directive to ensure that everything we design, everything we produce, the way we service them has a reflection on the impact to the world,” he said. □

Biofuels show promise, while market waits

Research into biofuels continues to make great strides, with demonstration programs under way in both airline and business aviation operations. But while business aviation leaders believe a transition to biofuels likely will be necessary to achieve the segment’s long-term environmental goals, they also concede that market forces will ultimately drive any transition.

“Enormous progress” has been made in research and testing of biofuels in recent years, said Ed Smith, senior v-p of international and environmental affairs for the General Aviation Manufacturers Association. The standards-setting agency ASTM

has approved several pathways for the development of drop-in fuels from various feedstocks, and flights aboard airliners and business jets are proving that use of the fuel is technically feasible.

“The technical issues have been solved,” Smith said. “The problem is the commercialization of it, and that is a much more difficult valley to cross because of the current price of oil.”

Walter Di Bartolomeo, vice president of engineering for Pratt & Whitney Canada, agreed. “There is a supply-and-demand issue. With the price of a barrel of oil as low as it is today, the industry is not excited to go out and find alternatives.”



A Dassault Falcon 20 operated by Canada's National Research Council, flew powered exclusively by RediJet biofuel in 2012.

Di Bartolomeo added, however, “eventually the price of a barrel will go up” and said the industry needs to be prepared when it does. Pratt & Whitney Canada, among the manufacturers that have collaborated on biofuels testing for years, has found performance characteristics similar to fossil fuels, he said.

According to Airlines for America, the fuel categories that have been ASTM certified so far are hydrogenated esters and fatty acids; Fischer-Tropsch based on biomass; and renewable Synthesized Iso-Paraffinic fuel. Among the other options the association cites are hydrogenated pyrolysis oils. Bio-jet fuels have been made from oil crops and waste fats, and scientists are evaluating sources such as biomass sugars, algae and halophytes. Whichever source is used, industry leaders agree that it must not be a food source.

United Airlines is the first major carrier to burn biofuels on regular routes. The airline struck an agreement with Paramount, Calif.-based refinery

AltAir Fuels to take up to 15 million gallons of biofuel a year for three years. The airline is using a blend of 30 percent biofuel and 70 percent fossil-based jet fuel for flights out of Los Angeles International Airport. United estimates that 15 million gallons would fuel 12,500 flights from Los Angeles to San Francisco.

BIZAV STAKEHOLDERS

The airlines are a major driver in the research, but business aviation has been involved too. Honeywell made history in June 2011 with the completion of the first transatlantic flight **fueled in part by biofuel** when a Gulfstream G450 made the crossing on a 50/50 blend. A year later, the National Research Council of Canada became the first entity to **fly a jet (a Dassault Falcon 20) fueled by 100 percent biofuel**, called RediJet.

Like United, Gulfstream has become a regular user. In 2015 the OEM signed a three-year agreement with World Fuel Services to supply

300,000 gallons of AltAir biofuel annually. The first shipment arrived in Savannah in April last year, and a month later Gulfstream flew a G450 and G550 from Savannah to Geneva for the European Business Aviation Convention & Exhibition using biofuel. Gulfstream also is using a 30/70 blend of biofuel to traditional jet-A.


“Each gallon of renewable fuel used reduces greenhouse gas emissions by more than half, relative to petroleum-based jet fuel,” said Dan Nale, senior v-p of programs, engineering and test for Gulfstream. “This fuel blend also emits less sulfur and fewer fine-particle pollutants than jet-A.”

Gulfstream uses the renewable fuels in all models of its demonstration, flight-test and Field and Airborne Support Team aircraft. “We consider our efforts a significant step in developing the rapidly growing renewable fuels business,” Nale said, adding that “Gulfstream is committed to

maintaining and using our renewable-fuel supply and helping that industry grow. We continue to look for new opportunities to support renewable fuel efforts by creating demand, promoting sustainable practices, and continuing to monitor advances in next-generation renewable fuels.”

Gulfstream gets its fuel from California, but industry leaders believe that supplies will become available regionally as renewable fuels make more of a mark, thereby reducing cost and alleviating distribution issues. The content of the fuel will vary depending on which feedstock is available locally, Smith said.

The programs remain in the demonstration phase, but NBAA COO Steve Brown emphasized, “Our members have indicated clearly that they want access to it when it becomes available.”

Brown also underscored the importance of a transition: “Biofuels contribute the most toward reaching the industry’s goals to reduce carbon emissions.” 

2018 approval sought for unleaded avgas

A government/industry cooperative and a number of other companies are individually pushing forward to begin a transition to a viable unleaded alternative to aviation gasoline in the next few years, recognizing that such a transition might be necessary to ensure the future vitality of general aviation.

“Going to an unleaded avgas is one of the biggest things we are doing from the environmental perspective for recreational [aircraft] and the light end of general aviation,” said Walter Desrosier, v-p of engineering and maintenance for the General Aviation Manufacturers Association (GAMA). Desrosier noted that this is a critical move for general aviation, because the future of leaded fuel is in doubt as countries move to phase it out. General aviation is the primary user of the additive tetra-ethyl lead.

“It has to be done. For the health and future of general aviation, we have to identify, test and ultimately approve an unleaded fuel that works with the majority of the fleet,” added David Oord, senior director of government affairs for the Aircraft Owners and Pilots Association (AOPA).

But getting the lead out has presented a significant challenge, Desrosier conceded. “All the piston engines and all the airplanes in the last 40-plus years were designed, developed and certified around leaded avgas. Our entire operating history and our maintenance history is around leaded avgas,” he said.

LEADED AVGAS ALTERNATIVE

GAMA and AOPA are among a cross-section of industry organizations that have been working with the FAA on the Piston Aviation Fuels

Initiative (PAFI), launched to develop such an alternative. PAFI seeks approval of at least one drop-in replacement by the end of next year.

Any delays could be costly to the industry. The Environmental Protection Agency (EPA), facing litigation from environmental groups such as the Friends of the Earth, plans to release a finding this year that leaded aviation gasoline is a danger to public health and welfare. Under the schedule proposed before the Trump Administration took office, the EPA would finalize the endangerment finding next year, triggering a requirement for regulation that would either phase out or eliminate leaded aviation gasoline.

Hence the PAFI timeline for a replacement. PAFI has received \$6 million in federal funding for each of the past three fiscal years and is in the middle of a five-year program that evaluated 17 candidate fuels from six groups or companies and whittled the choice to four: one apiece from Shell and Total and two from Swift. These fuel offerings moved to a Phase 1 testing program consisting of basic fit-for-purpose and chemical property laboratory evaluations, six rig tests, materials compatibility testing, engine testing and a toxicity and environmental impact evaluation of the chemical components of the fuels.

In March last year PAFI narrowed the field to two candidate fuels for Phase 2 testing—one by Shell and the other by Swift. This testing, involving engines and propellers, has already begun at several sites. Lycoming and Continental are conducting engine checks and aircraft testing is beginning. Along with Lycoming and Continental, airframers such as Textron Aviation, Piper and Cirrus are engaged, as well as Canada's National Research Council.

The review has to be comprehensive; the fuel has to work in as many aircraft as possible and tested in conditions that could be found from Florida to Alaska, he said. "We are trying to make it as drop-in as possible."



Participants are planning to work with Congress to put language in the next reauthorization bill that will give the FAA the authority to provide a blanket approval that lists as many models as possible.

The initiative is focusing primarily on technical aspects related to the engine and airframe, but PAFI is also researching how to make the transition safe and smooth. This means the fuel or fuels (both candidates ultimately could be approved) must be able to mingle with the current 100LL low-lead avgas.

"Evaluation and assessment of the fuels in the PAFI program considers the entire infrastructure, from development of the fuel to its distribution to general aviation airports," Desrosier said. An unleaded fuel might open up distribution venues currently off limits to the leaded avgas, he added.

Noting that "it is not a flip the switch," Oord said a working group is being stood up involving the American Petroleum Institute, the FAA, PAFI members and other organizations in distribution and production to define what will be necessary for distribution, materials compatibility, education and communications during a transition.

ADDITIONAL EFFORTS

While PAFI has been a cornerstone of the effort, Oord noted that a number of other initiatives are under way outside PAFI.


One such project is from General Aviation Modifications (GAMI), which has been developing its own alternative drop-in replacement candidate. GAMI founder George Braly noted that GAMI elected not to participate in PAFI primarily because it would be required to start over in the certification process.

“We had already conducted our first 150-hour on-aircraft endurance test,” Braly wrote in the January edition of the *American Bonanza Society* magazine. GAMI has demonstrated materials compatibility and is now in final detonation testing required for FAA STC approval.

GAMI reported, “We have one more 150-hour

engine durability test to complete (on a big-bore Continental engine). At that point GAMI will write the final reports and we should then be able to obtain a fleet-wide STC for an unleaded avgas that will function transparently to pilots for all engines in the general aviation fleet,” Braly wrote.

Oord noted other options such as 94-octane unleaded and an automotive fuel that works for a portion of the fleet.

The ultimate replacement(s), he said, must be available for the long haul. When PAFI concludes its work, GA will have a solution for the vast majority that can be used immediately for the long term, Oord concluded. 

ELECTRIC MOBILITY: COMING TO A CROWDED CITY NEAR YOU?

Some forward-looking designers are fielding new electric aerial vehicles that promise to solve the problem of efficient transport in highly congested urban areas. Two of the more significant efforts are the EHang 184 autonomous aerial vehicle (AAV) and the CityAirbus urban vehicle.

Chinese drone maker EHang introduced the EHang 184 AAV in January 2015, and says it has begun flight-testing. The electrically powered four-rotor AAV is designed to carry one passenger safely and reliably point-to-point in urban environments, with the passenger using a smartphone to set the destination before takeoff.

EHang engineers are well aware that there is more to designing a passenger-carrying autonomous vehicle than simply scaling up a smaller drone. According to the company, “As the EHang 184 might be the multi-rotor aircraft with the world’s largest propellers, in order to avoid the problem of ‘control divergence’ in its autonomous flight, we need to do a variety of algorithm optimizations for the flight control system to ensure that such a large multi-rotor aircraft can fly in the air stably.”

All AAV flights will be monitored in real time by the EHang command and control center, which will be able to communicate with passengers, monitor flight data and keep an eye on weather conditions. We are told that in the event of an emergency, the AAV will be able to land by itself.

Airbus Helicopters is serious about exploring the electric VTOL market and plans to begin flight-testing the four-seat, all-electric CityAirbus next year, with manned flights starting in 2019, according to CEO Guillaume Fauray.

To speed the CityAirbus to market, the company is planning for initial operations to be flown by a pilot, followed by autonomous operations as that becomes possible operationally and from a regulatory perspective.

Because it has four seats, the concept for the CityAirbus would be for shared passenger operations. Passengers would book an available seat via a smartphone app then take off from the nearest helipad. “A flight would cost nearly the equivalent of a normal taxi ride for each passenger, but would be faster, more environmentally sustainable and exciting,” according to Airbus. —M.T.

Avionics wring out more efficiency gains

by Matt Thurber

On the afternoon of inauguration day, January 20, when former President Obama and his family winged their way to vacation in Palm Springs, Calif., on their last flight aboard Air Force One, the pilots of the presidential Boeing 747 (VC-25) ended up diverting to March Air Reserve Base, following two missed approaches for weather. The missed approaches and diversions added at least half an hour to the trip, resulting in the unnecessary burning of hundreds of gallons of jet fuel.

There are three instrument approaches to Palm Springs International Airport, two of which are Rnav (RNP) to either end of the airport's 10,000-foot runway. Both of these approaches are "authorization required," which means not only that the aircraft must be equipped with the right kind of avionics but also that the crew must be trained and have received authorization to fly the approaches.

Apparently, either the crew wasn't trained and authorized or Air Force One isn't equipped with modern avionics or both. The result was that after two attempts at shooting the VOR or GPS-B approach, which has much higher minimums and is circling-only, the Air Force One pilots elected to divert to March Air Reserve Base, where there are plenty of ordinary approaches with lower minimums and no special authorization required.

The aviation industry has always pursued efficiency improvements, primarily in response to pressure to keep operating costs as low as possible, but in recent years those efforts have also

targeted reduced emissions. The events of President Obama's last flight on Air Force One illustrate how lack of equipment and training can make a difference, preventing completion of the mission and pumping more emissions into the atmosphere. As more new NextGen instrument procedures and even en route procedures are implemented, this kind of inefficiency event is going to become more common, adding pressure to operators to update their aircraft to meet new requirements and ultimately, benefitting the environment and helping operators cut the cost of flying.

Avionics have grown in importance as a factor in improved efficiency, but now the industry is poised to leap into a future of further improvement, thanks not only to avionics developments but also massive changes to the navigation infrastructure concurrent with new avionics technology.

Where this is affecting business aviation and also airlines is with modern flight management systems (FMS) and avionics equipment that allows operators to take advantage of new performance-based navigation procedures that are part of the FAA's and other regulators' ATC modernization efforts.

HONEYWELL

Since its introduction FMS has "been the tool that has helped operators fly more efficiently," said Marc Herdegen, Honeywell senior director of marketing and product management. Honeywell's latest airliner and business jet FMS—the NG FMS—benefits from years of refinement and is easier to upgrade to future capabilities, he explained. The NG FMS allows efficiency in three main areas: fuel savings through optimizing power, reducing track miles and helping in altitude selection.

The continuous descent approach (CDA) offers large efficiency improvements for NG FMS users, Gulfstream G650 operators among them. The FMS smoothes out the descent using lower power settings, instead of descending, leveling off, then descending again in steps. “The CDA is a significant driver in lowering emissions, probably the biggest one with the most savings,” Herdegen said.

Honeywell’s cost index, available in earlier FMSs and refined in the NG FMS, gives pilots a numerical index to target fuel savings during climbs and descents while optimizing fuel burn and time. The higher the index number, the more fuel is saved, he said, “and those translate into savings on CO₂ emissions.”

The NG FMS also helps pilots select the optimum altitude, taking into account wind models to calculate the most efficient flight level. With airborne connectivity, near real-time wind data is becoming more available via Honeywell’s Weather Information Service, allowing further improvements in altitude optimization.

ROCKWELL COLLINS

“FMS plays a predominant role,” agreed Rockwell Collins principal marketing manager Chuck Wade. Like all FMS, Rockwell Collins products have long provided performance information, but new FAA NextGen capabilities built on satellite navigation will lead to significant efficiency improvements. “The central aspect is Waas-SBAS technologies,” said Wade, “they’re not constrained to ground-based nav aids any more, and this has opened up much more efficient routes. Because of ADS-B and Waas position accuracies, the FAA will be able to start reducing spacing between airplanes. Now we can create a much more efficient terminal area. The key is our Waas and ADS-B technology and keeping our FMS up to date because ADS-B uses that Waas GPS sensor in keeping everybody on the correct path.”

Rockwell Collins is making all of these new capabilities available from its newest flight decks in Bombardier Globals down to older Pro Line 21 and 4 systems.

Business aviation will soon start flying more performance-based navigation (PBN) procedures as air navigation service providers (ANSPs) adopt them more widely. Airlines have been using PBN already, he said, and business aviation is changing to meet the new requirements. In Southern California, the FAA has restructured some 90 arrivals to make them PBN-compliant and improve efficiency, and those equipped to fly those procedures will be the ones to realize the benefits. “If you are not able to sequence into the system,” Wade said, “especially during high-density times in the morning or afternoon, you could be sent into a holding pattern if not properly equipped.”

Further improving efficiency is the ability to take off and land in poor weather, and the FAA’s new [enhanced flight vision system \(EFVS\) regulation](#) makes that possible for properly equipped aircraft. “That’s a keen interest of ours,” said Wade, as Rockwell Collins manufactures head-up displays and sensors that enable EFVS operations. “If you cut the number of diversions by 50 percent a year, that’s a lot of fuel and environmental savings.”

On the operational side, Rockwell Collins Arinc Direct works with both operators and ANSPs to support NextGen technologies that will improve operational efficiency. Datalink technology is a key driver and has already led to significant changes at 56 airports in the U.S. where departure clearances (DCL) are now available. Aircraft equipped for future air navigation system (FANS) operations can take advantage of DCL and not only obtain clearances digitally on their FMSs, but also modify and update clearances, all without using radios for voice calls with controllers. Arinc Direct facilitates use of DCL for equipped aircraft, and these aircraft are often able to depart

before non-DCL-capable aircraft.

The next step is en route datalink communications, and “plans are to start offering en route services, like in Europe,” said Andrew Onken, principal manager program management at Arinc Direct. In Europe Arinc Direct provides aeronautical telecommunications networks to support datalink services. “The FAA effort is ramping up, and I know they’re quite excited about it,” he said. “There is a vision among the industry of making data the primary means of communication, but I think that’s seen as long term. No one is looking to do away with voice. But the goal is to make data your go-to for routine communications.”

UNIVERSAL AVIONICS

FMS is the heart of Universal’s avionics system, said Universal Avionics director of sales Robert Clare. With that in mind, “Over time we have built in functionality and benefits to assist pilots and operators to help them to get better direct routing and LPV approach capability to get into areas they’re not normally able to get into,” he said. “We’re constantly getting feedback that using our FMS with LPV has really saved operators money. They can see the return on investment on the installation in as short as a couple of years.” Universal equipment also facilitates FMS operations and the new DCL system.

Even older aircraft equipped with Universal FMSs can be upgraded to modern units. “There are thousands of those Citations and Learjets flying with our FMS,” he said, and they can easily be upgraded to the latest version with LPV approach capability and ADS-B OUT. Once equipped with ADS-B OUT, there are efficiencies as a result of the ability to depart and arrive in areas where radar coverage is unavailable, he explained.

Universal has long offered fuel management functions on its FMSs. “It uses inputs from various fuel flow and quantity sensors and provides real-time fuel management, extensive fuel



Universal Avionics

information and calculations in the fuel management section of the FMS,” Clare said. “This can help eliminate unnecessary fuel stops and hone specific range and endurance.” The FMS also helps pilots evaluate alternatives when weather changes en route.

In the PBN arena, Universal is enabling operators to fly new procedures, he explained, “not only approaches but en route like PRnav in Europe and RNP [required navigation performance], which is part of the PBN initiative. Every major software change we’ve had increased the capability and support for the latest PBN requirements.” This enables those aircraft properly equipped for the new capabilities to realize, he said, “a vast improvement in how they fly their aircraft and the overall efficiency and capability of what they can do.”

GARMIN

Pilots flying with Garmin integrated flight decks, especially the G3000/G5000 systems in many late-model jets, have access to graphical



displays of efficiency. For example, range rings give an instant view of available range at current power settings. And the vertical situation display shows wind information delivered via Sirius XM, Garmin Connex via Iridium satcom or ADS-B in, helping pilots pick the best altitude while en route.

Garmin-equipped aircraft can also take advantage of PBN RNP procedures, according to avionics product manager Bill Stone. “PBN is much more accurate than ground-based navigation,” he said, “and it allows more efficient sequencing and fewer holds. This directly addresses the efficiency issue and reduces emissions, track miles and fuel burn.”

ADS-B IN capabilities, while not mandated, will become ubiquitous as the world’s ANSPs incorporate ADS-B. “This lets ATC reduce separation,” Stone said. “There is technology coming, especially in larger aircraft, such as interval management and in-trail procedures. We’re doing research on that. For both ADS-B and PBN, the real efficiencies are realized when the majority of operators are appropriately equipped.”

ESTERLINE CMC

Esterline CMC’s FMS products are targeted primarily at the air transport market, although the company is seeking opportunities in business aviation. CMC FMSs feature a performance-Vnav function that offers operators an index of the

optimal path for fuel efficiency or speed. In the next few years, more aircraft will employ the time-based element to allow ATC to manage reduced traffic separation and time-based traffic flow. “It really helps with planning,” said Tarek Savanekh, production marketing manager for navigation and integrated systems. “If you know a bunch of aircraft can enter the airway at this particular time, it helps.”

The Sukhoi Superjet is already equipped with a CMC FMS with PBN functionality, and CMC is upgrading Air Transat A310s with the same capability, as well as Canadian military Airbuses.

In the business aviation market, the opportunity is for upgrading older airplanes with CMC’s FMS. “Our FMS is federated,” he said, meaning it can be more easily installed in older jets without highly integrated flight decks.

GE AVIATION

Some 12,000 GE Aviation FMSs are flying, primarily in Boeing and Airbus airliners but also in military aircraft. To help its customers improve efficiency, GE, in conjunction with its work with the FAA on the Continuous Lower Energy Emissions and Noise (Cleen) program, is developing ways to extract the best performance from a specific aircraft. “If you look at the way we’ve typically managed performance,” said Gary Thelen, FMS software product manager, “it’s around establishing fixed models for aircraft and putting in fixed factors in the FMS to simplify it. But this leads to making assumptions for the total fleet of that aircraft and how it’s going to operate. If we can come up with a way to dynamically change the performance of an individual aircraft, we can get significant savings from the standpoint of fuel and operating cost.”

Because GE also makes turbine engines, it is able to connect the FMS and engines and monitor inputs from airframe sensors, then make adjustments to improve efficiency. “If we can detect and measure



GE Aviation

those changes and reflect them in the performance of the FMS, that's where we get real performance benefits," he said. "We're trying to get a performance model for that aircraft in real time, by incorporating weather and adjusting the aircraft model."

So far GE has done this in simulation by modeling real flight profiles, then using algorithms to see how the aircraft performs. "We're currently trying to get it onto an aircraft and validate it through flight-testing," Thelen said. The simulation shows that there will be significant efficiency benefits, such as flying defined routes with smaller

fuel reserves, greater range and lower maintenance costs.

In the business aviation market, GE's data concentrator network (DCN) is a key part of the avionics and electronics installation on the Gulfstream G500 and G600 fly-by-wire jets. Derived from its work on the 787 and upcoming 777X, the DCN consists of 10 data concentrators networked together. The DCN significantly reduces wiring between electronic components, saving weight and allowing inputs from a variety of devices that simply hook into the network. 