Passenger air traffic continues to grow in the U.S. and around the world and shows no signs of slowing down. More than 815 million people flew domestically on U.S. carriers in 2012, up 1.3 percent from 2011. Worldwide, forecasts predict 3.6 billion passengers will fly in 2016, of which almost 500 million will originate in the U.S.

Accommodating such growth will require new aircraft and more flights, plus new runways and airports. Without intervention, the likely consequences are a significant escalation in harmful jet engine emissions, unprecedented traffic jams in the sky, nonstop noise near airports, and more citizens unhappy about the effects on their health and their quality of life.

In order to eliminate as much potential harm to the environment as possible and make air travel as efficient and economical as it can be, NASA is working closely with its government, industry and university partners on a number of environmentally beneficial, or “green,” aviation initiatives.

Within the Environmentally Responsible Aviation Project, research toward achieving the simultaneous goals described earlier is organized into three main areas:

1. **Airframe Technology:** Addresses areas such as lightweight structures, flight dynamics and control, and drag, all with the goals of reducing noise and fuel burn.

2. **Propulsion Technology:** Focuses primarily on high-pressure engine-core components and propulsion technologies, with the goals of lowering harmful emissions and fuel burn.

3. **Vehicle Systems Integration:** Addresses the integration of airframe and propulsion technologies, including vehicles configured to shield engine noise with the airframe.

ERA researchers from those areas are currently collaborating on eight large-scale integrated technology demonstrations to advance some of the more mature concepts and technologies. The demonstrations focus on five areas: aircraft drag reduction through innovative flow control concepts, weight reduction from advanced composite materials, fuel and noise reduction from advanced engines, emissions reductions from improved engine combustors, and fuel consumption and community noise reduction through innovative airframe and engine integration designs.

NASA’s goal is to reduce aircraft fuel consumption, emissions and noise simultaneously. Image credit: NASA
Goals for Green Aviation

NASA has a set of research goals that can be described as “green” because they relate to mitigating environmental impacts of aviation. NASA’s goal is to reduce aircraft fuel consumption, emissions and noise simultaneously, which is a much more difficult challenge than working to reduce them individually.

Fuel Efficiency

The challenge: In 2012, U.S. commercial air carriers burned 10.6 billion gallons of jet fuel at a total cost of $31.6 billion, while international carriers spent another $18.8 billion on 6.5 billion gallons of jet fuel. The Department of Defense in FY2011 used more than 3 billion gallons of aviation and jet fuel, costing another $10 billion.

The goal: Develop aircraft technology capable of reducing fuel burn significantly. This technology should enable the design of new aircraft that burn 33 percent less fuel than today’s airplanes by 2015, 50 percent less by 2020 and at least 60 percent less by 2025.1

Emissions

The challenge: Fuel consumed by the U.S. commercial air carriers and the military releases more than 250 million tons of carbon dioxide (CO2) into the atmosphere each year. CO2 is a greenhouse gas and a contributor to global warming. Other major emissions are nitrous oxide (NOx) and nitrogen oxide (NOx), which together are called NOx and contribute to ozone creation; sulfur oxides (SOx) and particulates (often referred to as soot). Forty of the top 50 U.S. airports are in areas that do not meet Environmental Protection Agency local air quality standards for particulate matter and ozone. Reducing NOx emissions also reduces SOx emissions. Reducing the amount of fuel burned reduces CO2 emissions.

The goal: Develop aircraft technology and air traffic management tools capable of cutting NOx emissions at landing/takeoff (LTO) 60 percent by 2015 when compared with today’s best engines, 75 percent by 2020 and 80 percent by 2025; cutting NOx emissions during cruise 55 percent by 2015, 70 percent by 2020 and 80 percent by 2025; and transfer those technologies to industry.2

Noise

The challenge: Aircraft noise continues to be regarded as the most significant hindrance to increasing the capacity of the National Airspace System, largely because of nuisance noise near major metropolitan airports. Although the Federal Aviation Administration has invested more than $5 billion in airport noise reduction programs since 1980, the problem persists.

The goal: Develop aircraft technology and airspace system operations to shrink the nuisance noise footprint around each airport until it is about one-third of its current size by 2015, about one-sixth its size by 2020, and contained within the airport property boundaries by 2025.3

Solutions for Green Aviation

NASA is working on concepts to deal with the environmental issues of fuel burn, emissions and noise. Some ideas have to do with improvements in technology; others have to do with using new technology in new ways. Here are some examples:

• Changes in the way an airline’s transit through the national air traffic control system is managed, by allowing pilots to take off and climb directly to their cruising altitude or descend directly to touchdown, without leveling off periodically to check in with air traffic control along the way.

Data from the top 27 airports in the U.S. indicate this operational improvement could reduce the amount of fuel burned each year by 188 million gallons with direct climbs, and 218 million with continuous descents. Similarly, by integrating new satellite-based air traffic information and communication systems into existing cockpit instrumentation and displays, new procedures for managing the flow of air traffic may allow airlines to fly more efficient, direct routes to their destinations. This could save 200 million gallons of fuel each year.

• Changes in aircraft design, such as the use of lightweight composite structures and means to increase laminar, or smooth, air flow over aircraft surfaces, can increase overflight lift and reduce drag.

These improvements require less engine power for an aircraft to fly at the same speed and altitude, and thus represent important contributions to achieving the goal of reducing fuel burn rates by as much as 50 percent over current rates. An example of a “green” design change can be seen in the blended wing and body of the subscale, flying X-48B aircraft prototype.

The work is managed by the Aeronautics Research Mission Directorate at NASA Headquarters in Washington, which is organized into five programs that oversee a number of projects. The programs are the Fundamental Aeronautics Program, Airspace Systems Program, Aviation Safety Program, Aeronautics Test Program, and the Integrated Systems Research Program.

Research into green aviation technology begins at an elementary level in elementary school laboratory. For example, a new air traffic management or aircraft vehicle concept is first identified and matured within the Airspace Systems Program or Fundamental Aeronautics Program. The overarching goal of the Fundamental Aeronautics Program is to achieve technological capabilities necessary to overcome national challenges in air transportation including reduced noise, emissions and fuel consumption, and increased mobility through a faster means of transportation. The Airspace Systems Program is responsible for developing concepts, capabilities, and technologies for high-capacity, efficient, and safe airspace and air portal systems.

ShOULD a particular concept or technology demonstrate potential for success, it may be matured further within the Integrated Systems Research Program, where research is designed to test more mature concepts with others as a system in real-world environments. This higher level research is clustered in the Environmentally Responsible Aviation Project, which is part of the Integrated Systems Research Program.

Noise reduction of 50 percent. Source: Federal Aviation Administration. Adapted with permission.

Looking to the future, the ultimate goal is to confine any objectionable noise within the boundaries of an airport. Source: NASA

Future aircraft designs that generate dramatic reductions in noise, emissions and fuel consumption could look like this hybrid wing body. Image credit: NASA

Other concepts may include capitalizing on the potential of advanced electrical power technologies such as batteries or fuel cells to reduce the amount of fuel needed.

Green Aviation Research Begins with Fundamentals

NASA’s green aviation research takes place at all four of the agency’s aeronautical field centers, including the Ames Research Center at Moffett Field, Calif., Neil A. Armstrong Flight Research Center at Edwards Air Force Base, Calif., Glenn Research Center in Cleveland, and Langley Research Center in Hampton, Va.

To further reduce fuel burn, the reference aircraft for the NASA’s fuel efficiency goal is a 300-passenger, long-range transport with GE 90 engines, manufactured in 1997 or 1998. The goal represents a technological readiness level of 6, which is the point at which NASA traditionally transfers a new technology to industry for further development toward operational readiness and certification by governing authorities such as the Federal Aviation Administration.

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