Hybrid-electric aircraft concept

MIT design could reduce aviation's emissions problem - Jennifer Chu, MIT News Office

At cruising altitude, airplanes emit a steady stream of nitrogen oxides into the atmosphere, where the chemicals can linger to produce ozone and fine particulates. Nitrogen oxides (NOx) are a major source of air pollution and have been associated with asthma, respiratory disease and cardiovascular disorders. Previous research has shown that the generation of these chemicals due to global aviation results in 16,000 premature deaths each year.

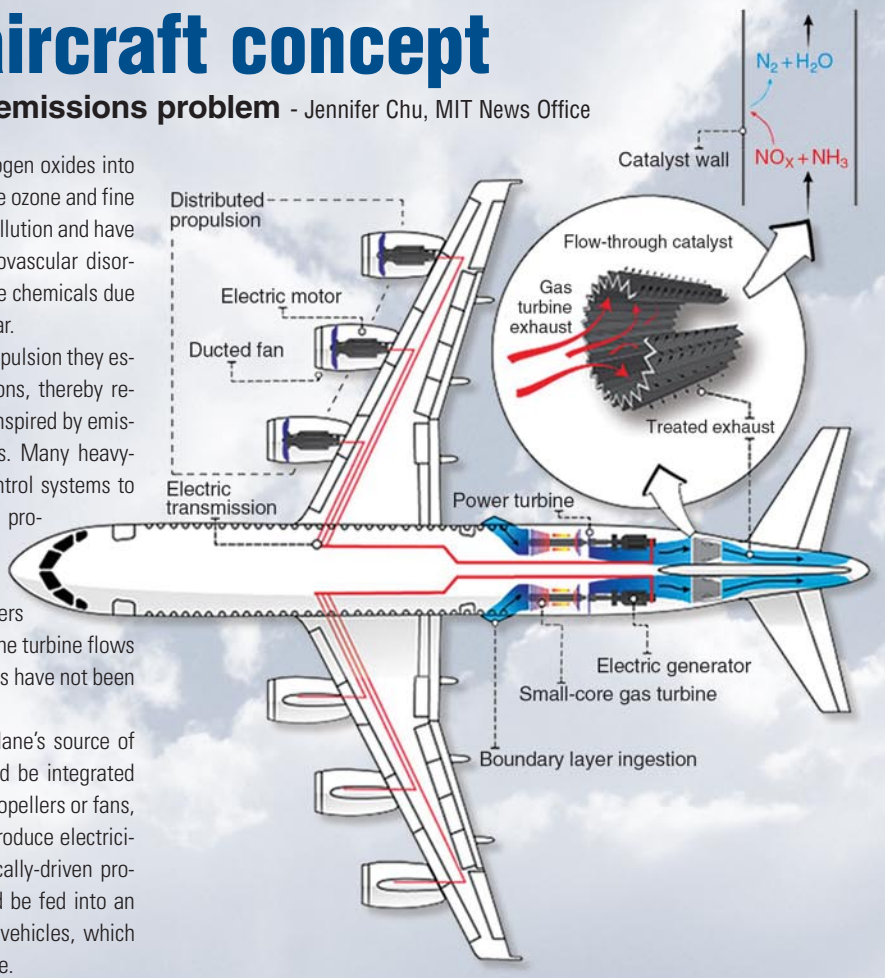
MIT engineers have come up with a concept for airplane propulsion they estimate would eliminate 95 percent of aviation's NOx emissions, thereby reducing associated early deaths by 92 percent. The concept is inspired by emissions-control systems used in ground transportation vehicles. Many heavy-duty diesel trucks today house postcombustion emissions-control systems to reduce the NOx generated by engines. The researchers now propose a similar design for aviation, with an electric twist.

Today's planes are propelled by jet engines anchored beneath each wing. Each engine houses a gas turbine that powers a propeller to move the plane through the air as exhaust from the turbine flows out the back. With this configuration, emissions-control devices have not been feasible, as they would interfere with the engines' thrust.

In the new hybrid-electric (or "turbo-electric") design, a plane's source of power would still be a conventional gas turbine, but it would be integrated within the plane's cargo hold. Rather than directly powering propellers or fans, the gas turbine would drive a generator, also in the hold, to produce electricity that would then power the plane's wing-mounted, electrically-driven propellers or fans. Emissions produced by the gas turbine would be fed into an emissions-control system, broadly similar to those in diesel vehicles, which would clean the exhaust before ejecting it into the atmosphere.

Details of the design, including analyses of potential fuel cost and health impacts, have been published in the journal *Energy and Environmental Science*. Co-authors are Prakash Prashanth, Raymond Speth, Sebastian Eastham and Jayant Sabnins, all members of MIT's Laboratory for Aviation and the Environment. This team's hybrid-electric plane grew out of work by Steven Barrett, professor of aeronautics and astronautics at MIT, and his team in investigating the 2015 Volkswagen diesel emissions scandal, in which environmental regulators had determined that diesel engines had been manipulated to activate onboard emissions-control systems only during lab testing, such that they appeared to meet NOx emissions standards, but in fact emitted up to 40 times more NOx in real-world driving conditions. As he looked into the health impacts, Barrett also became familiar with diesel vehicles' emissions-control systems in general. Around the same time, he was also looking into the possibility of engineering large, all-electric aircraft.

"(Research) shows you could probably electrify smaller aircraft, but for big aircraft, it won't happen anytime soon without pretty major breakthroughs in battery technology," Barrett says, "(but) maybe we can take the electric propulsion part from electric aircraft, and the gas turbines that have been around for a long time and are super reliable and very efficient, and combine that with the emissions-control technology that's used in automotive and ground power, to at least enable semi-electrified planes." But its impact on thrust would effectively ground the design.



Barrett's concept gets around this limitation by separating power generation from thrust production, with exhaust from the gas turbine power unit fed into an emissions-control system, which could be folded up, accordion-style, in the plane's cargo hold. He envisions the bulk of the hybrid-electric system—gas turbine, electric generator and emissions control system—would fit in the belly of a plane, where there can be ample space in many commercial aircraft. .

The new research paper calculates that the extra weight of such a hybrid-electric system, if implemented on a Boeing 737 or Airbus A320-like aircraft, would require about 0.6 percent more fuel. "This would be many, many times more feasible than what has been proposed for all-electric aircraft," Barrett says. "This design would add some hundreds of kilograms to a plane, as opposed to adding many tons of batteries, which would be over a magnitude of extra weight."

The team also calculated emissions that would be produced by a large aircraft with or without an emissions control system, and found that the hybrid-electric design would eliminate 95 percent of NOx emissions. If this system were rolled out across all aircraft around the world, they further estimate that 92 percent of pollution-related deaths due to aviation would be avoided, based on a global model mapping the flow of aviation emissions through the atmosphere, and calculating exposure of various populations around the world.

The team is now working on designs for a "zero-impact" airplane that emits no NOx *or* climate-altering chemicals such as carbon dioxide. ■