Overcoming barriers to successful use of autonomous unmanned aircraft

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While civil aviation is on the threshold of potentially revolutionary changes with the emergence of increasingly autonomous unmanned aircraft, these new systems pose serious questions about how they will be safely and efficiently integrated into the existing civil aviation structure, says a new report from the National Research Council. The report identifies key barriers and provides a research agenda to aid the orderly incorporation of unmanned and autonomous aircraft into public airspace.

"There is little doubt that over the long run the potential benefits of advanced unmanned aircraft and other increasingly autonomous systems to civil aviation will indeed be great, but there should be equally little doubt that getting there while maintaining the safety and efficiency of the nation's civil aviation system will be no easy matter," said John-Paul Clarke, co-chair of the committee that wrote the report and associate professor of aerospace engineering at the Georgia Institute of Technology.

The report uses the term "increasingly autonomous" systems to describe a spectrum of technologies, from unmanned aircraft that are piloted remotely – which describes most such aircraft currently in use—to advanced autonomous systems for unmanned aircraft that would adapt to changing conditions and require little or no human intervention. Increasingly autonomous systems could also be used in crewed aircraft and air traffic management systems to lessen the need for human monitoring and control.

Development of such systems is accelerating, prompted by the promise of a range of applications, such as unmanned aircraft that could be used to dust crops, monitor traffic, or execute dangerous missions currently undertaken by crewed planes, such as fighting forest fires. The FAA currently prohibits commercial use of unmanned aircraft without a waiver or special authorization.

NASA's Aeronautics Research Mission Directorate requested that the Research Council convene a committee to develop a national research agenda for autonomy in civil aviation.

One critical, crosscutting goal that must be achieved before increasingly autonomous aircraft and other systems can reach their full potential is ensuring that they will perform with the high level of safety and reliability expected of civil aviation systems, says the report. It identifies specific technological, regulatory, and other barriers that must be overcome in order to reach that goal.

- Technological barriers include the inherent difficulty associated with characterizing and predicting the behavior of systems that can adapt to changing conditions. This poses a particular challenge in engineering increasingly autonomous unmanned aircraft to be compatible with already-existing air traffic management systems and other elements of the national airspace system. Also, the ability of systems to operate independently of human operators is currently limited by the capabilities of machine sensory, perceptual, and cognitive systems.
- Regulation and certification barriers include the fact that existing processes, criteria, and approaches for certifying aircraft do not adequately address the special characteristics of advanced autonomous systems. In addition, many existing safety standards and requirements, which are focused on ensuring the safety of aircraft passengers and crew, are not well-suited to ensure the safety of unmanned aircraft operations, where the main concern is the safety of people in other aircraft and on the ground.
- Other barriers include social issues, such as

public concerns about privacy and safety, and legal hurdles, such as public policy, reflected in law and regulation.

To help surmount these and other barriers, the report recommends a national research agenda that would involve government agencies, industry, and academia. The committee described eight research projects, considering the following four to be the most urgent and difficult:

Behavior of adaptive/nondeterministic systems. Technologies that enable aircraft to adapt to uncertain environments and to learn based on experience will be integral to many advanced autonomous aircraft. As autonomous systems take over more functions traditionally performed by humans, there will be a growing need to incorporate autonomous monitoring and other safeguards to ensure that appropriate operational behavior continues. Research is needed to develop new methods and tools to address the inherent uncertainties in airspace system operations due to factors such as weather and conflicting air traffic and thereby enable advanced autonomous systems to improve their performance and provide greater assurance of safety.

Operation without continuous human oversight. Enabling unmanned aircraft to operate for extended periods of time without real-time human oversight will require that the autonomous systems be able to perform certain critical functions currently provided by humans, such as "detect and avoid" and contingency decision-making. Successful development of these systems and technologies depends on understanding how humans perform their roles currently and how to translate these roles to the autonomous system, particularly for high-risk situations.

Modeling and simulation. Modeling and simulation capabilities will play an important role in the development of increasingly autonomous systems because they enable researchers, designers, regulators, and operators to get information about how an aircraft—or one of its systems or components—performs without actually testing it in real life. For example, computer simulations may be able to test the performance of an autonomous aircraft in millions of scenarios in a short timeframe to produce a statistical basis for determining safety risks. The committee recommended the creation of a distributed suite of modeling and simulation modules developed by disparate organizations with the ability to be interconnected or networked; monolithic modeling efforts that are intended to "do it all" and answer all questions posed tend not to be effective.

Verification, validation, and certification. The national airspace system's high levels of safety largely reflect the formal requirements imposed by the FAA for verification, validation, and certification of hardware and software and the certification of people as a condition for entry into the system. Extension of these concepts and principles to highly autonomous aircraft and systems is not a simple matter and will require the development of new approaches and tools.

"The barriers we identify and the research agenda we propose to overcome them is a vital next step as we venture into this new era of flight," said committee co-chair John Lauber, a consultant and former senior vice president and chief product safety officer at Airbus.

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