

Abstract

Understanding the role of autonomy in aviation – why do planes need to fly themselves?

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The rise of innovative air mobility over the past decade and a half has been driven by significant leaps in two main areas of development – sustainable aviation and autonomous aviation. While sustainable aviation attempts to combat the challenges of climate change by innovating novel forms of propulsion with a focus on distributed electric powertrains, autonomous aviation offers a pathway to reduce the workload, training and qualification requirements of the flight crew on board the aircraft. Moreover, autonomous aviation offers an opportunity for newer forms of aviation to have a viable business case, e.g. cargo delivery drones or air taxis. However, the promise of autonomy in aviation is neither new nor unexplored.

Today, commercial transport aircraft ferry millions of passengers every day across the world but the pilots in command of these aircraft are only involved in critical phases of flight. Indeed, large portions of the flight are conducted by the flight computers onboard the aircraft. However, the human pilot in the cockpit is not only a source of confidence for passengers (although few ever see the pilots ferrying them), they also serve as the last line of defense in case a complex and thankfully improbable chain of failures should necessitate a manual intervention. However, as systems grow increasingly complex, so do the training and qualification requirements for the pilots supervising them. At the same time, there is a global shortage of pilots which does not seem to get better. Still, a future with an empty cockpit may be distant in commercial aviation as autonomous agents need to prove their robustness and resilience in challenging scenarios – for example similar to the Hudson River landing by Capt. Sullenberger and his copilot after a bird strike incapacitated both their engines.

An avenue with more potential for the introduction of autonomy may instead be in the realm of unmanned aircraft systems, where the lack of a pilot onboard the aircraft is not only acceptable but a premise to the operation and a technical (as well as regulatory) challenge to be solved. Already, drones deliver medical supplies to remote areas in different parts of the world and are being considered for such deliveries in densely populated urban centers of the world. The promise of delivery drones transporting our workday lunch or an urgently required spare part can only be fulfilled at scale if the need for human intervention from remote pilots can be eliminated. As regulatory advances allow for increasingly complex operations, the safety criticality of the autonomous systems flying these drones will also increase, particularly at the large scale these drones are expected to operate. For example, Roland Berger predicts that 160,000 commercial passenger drones will ply the skies by 2050 [1].

Drones play not only a useful role in the civilian sector, but they are also being increasingly deployed as a capable tool in military operations as evidenced by recent major conflicts in Europe and the Middle East. Ever more militaries and governments across the world are looking to drones to replace their aging aircraft fleets due to their promise of cost-effectiveness, rapid capability deployment as well as their ability to overwhelm enemy air defenses. Moreover, drones remove the risk to personnel on both sides, who would instead have to be deployed to these conflict zones.

Finally, the trickle-down effects of the successful development and integration of autonomous systems in aviation could mean that the dream of personal flight could come true. Hobbyists may be able to realize their pursuit of flight like birds without having to amass the high degree of skills needed to safely pilot an airplane. On the other hand, even experienced private pilots could benefit massively from the safety net potentially provided by autonomous systems in their general aviation aircraft, a domain where the safety record is orders of magnitude worse than that of commercial aviation.

The motivation to introduce autonomy in aviation is therefore quite clear. It is therefore important to understand its impact on aviation especially with regard to innovative air mobility. This paper attempts to address this topic by taking a holistic look at the history of autonomous systems development in aviation. It aims to also provide a classification of the different types of autonomous systems that have been introduced by domain and by level of functional responsibility, and identifies where there is still a significant need for development. It looks at concrete examples in industry and discusses potential challenges and opportunities for further development. A discussion of the technical aspects of autonomy would not be complete without a regulatory discussion. Therefore, this paper also looks at the key certification challenges and discusses potential regulatory pathways for the different technologies involved. While the discussion revolves around onboard autonomous systems, ground-based infrastructure elements are key to the success of autonomy in aviation and are also discussed to the extent possible. Through this contribution, the domain of autonomous aviation with its technical and regulatory challenges can be better understood and developers working in the field may have a bigger picture for where they could be headed. This enhanced technical comprehension, in turn, could accelerate the development of new regulations, and foster an informed discussion of the challenges and opportunities associated with autonomy in aviation.

References:

[1] Hader, M. et.al. “Urban Air Mobility | USD 90 billion of potential: How to capture a share of the passenger drone market”, Roland Berger GmbH, November 2020.

Biography

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Pranav Nagarajan is a Research Scientist at the Institute of Flight Systems of the German Aerospace Center (DLR) in Braunschweig. There, he works in the Department of Unmanned Aircraft towards the development of safe autonomous systems for drones primarily in the EASA specific and certified categories.