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Broadcast transponders for low flying unmanned aerial vehicles

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Abstract

Present day unmanned aerial vehicle (UAV) technology in urban mobility applications is severely limited in use due to lack of reliable collision avoidance mechanisms. There are numerous applications for UAVs in urban environments, including information awareness, urban management, on-demand goods deliveries, and even parking assist, but present day legal regulations preclude their use over safety concerns, requiring presence of a pilot and restricting UAV use in urban areas.
Indeed, possibility of midair collision is a significant concern in a densely populated urban area, and will only get worse as UAV use becomes widespread.
Collision avoidance cannot be done effectively using onboard sensors. A transponder system like automatic dependent surveillance-broadcast (ADS-B) could be used to augment airspace awareness of UAVs, greatly reducing collision risks.
SPH Engineering has successfully integrated such transponders with two of the most popular consumer class autopilots. In each case a device by Sagetech was used, the smallest commercially available transponder to date. This is a major step towards commercial UAV integration into regulated airspace.
Unfortunately, ADS-B is ill suited for small low flying UAVs that are navigating unregulated airspace. While weight and power are the more obvious limitations, the use of ADS-B also requires International Civil Aviation Organization (ICAO) certification, which is both expensive and lengthy.
Furthermore, at close range receiver was overwhelmed by transmit power. In a collision avoidance scenario for delivery drones short range is exactly where reliable reception is most needed.
This article presents an approach, which is used to design a collision avoidance system in accordance with safety regulations of manned aviation that would be specific to small, commercial UAVs operating in unregulated airspace.

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1. Introduction

Present day technology makes mass production of remotely piloted aircraft, commonly known as "drones", both feasible and affordable. UAVs can be used to improve urban mobility as part of “smart cities” (Jensen, 2016), providing mobile, real time surveillance for better city management, or be directly involved in a “here and now” application, such as parking assist (Siemens, 2015) or a mobile WiFi hotspot.

There are also attempts to use such craft for cargo deliveries. Especially, for rapid deliveries of small items to people’s homes, such as mail service and internet shopping, like Amzon’s “Prime Air”. Google’s “Project Wing”

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could even be used, among other things, for quick, on-demand delivery of medical supplies, directly to the patient at a press of a button – greatly improving accessibility of services while saving on transportation costs, time and lessening street traffic.

There are, of course, numerous other applications for UAVs in urban areas, which include building and infrastructure inspection, firefighting and rescue operations, 3D reconstruction and photo shoots for real estate presentations, even gas leak detection and atmosphere quality analysis using various sensors. Not only can UAVs be deployed faster than manned aircraft, they are also considerably cheaper to operate and much more environment-friendly.

Nomenclature

ADS-B	automatic dependent surveillance-broadcast
COTS	commercial off the shelf
EU	European Union
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
RF	radio frequency
RPAS	remotely piloted aircraft systems
TCAS	traffic collision avoidance system
UAV	unmanned aerial vehicle
USA	United States of America

At the same time there is still no exhaustive legislation dealing with the status of said systems. For example, EU law does not acknowledge even the possibility of a completely unmanned system, since the term chosen for “drones” in European law is RPAS (European Commission, 2015), not UAV, thus implying presence of a pilot. There are also strict requirements that RPAS operate within direct sight of their pilot. Interesting to note that beyond visual line of sight operations are present in the classification, but not currently permitted.

USA, on the other hand, has a blanket law that classifies any flying object that can be remotely operated as an "aircraft", which also requires compliance with FAA regulations. FAA, however, has banned all commercial use of UAVs (while providing a strict set of regulations for non-commercial use), and is issuing exemptions for commercial use (as of April 2016, this can be done electronically). Either way, both EU and USA do not recognize legally the possibility of such aircraft to be flown completely pilotless (at least, by civilian operators).

There is a technical reason for such a harsh restriction - presently such UAVs do not present the same level of safety that manned aviation enjoys. Manned aviation has specific requirements listed for each type of system, including electronic and software components (Won Keun Youn et al, 2015). Far from it, there is no way to measure safety and reliability of small commercial UAVs, since they weren’t manufactured with these requirements in mind.

As can be seen in Figure 1, UAVs can be operating below regulated airspace, and, in this case, they do not present any danged to aircraft. They do, however, remain dangerous to everything below. A UAV may range in weight from below 1 kg. and up to several (sometimes - dozen) kg. If it falls down, it may injure people or damage property. Such an event may occur due to mechanical or electric failure, as well as software failure. These three, however, are outside the scope of this paper – higher manufacturing standards could satisfy the former requirements.

Another two possibilities are midair collision and collision with a static object (UAVs could be restricted to fly high enough not to run into people). Avoiding stationary objects is a problem for advanced route planning which should include 3D environment maps.

Midair collisions between small UAVs, however, present a challenge – due to their relatively small size, such craft are impractical to detect with onboard sensors. At the same time, the “layer” of unregulated airspace is somewhat thin, and with future proliferation of UAVs could become highly saturated, making such collisions likely.