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Unmanned cargo transportation systems

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TMAL02, Linköping University, 2018

1 Introduction

A UAV is defined as an aircraft that is capable to fly without pilots present in the aircraft itself. It can either be remote controlled or fly autonomously and it is possible to reuse it.

UAVs are making their way into our modern society and have great potential to contribute to the future of transportation. The transport UAVs are now at the very beginning of their development, especially in the integration into our current infrastructure, which is not adapted to UAVs. To successfully implement them into our society we need a common understanding of the possibilities and limitations of a UAV in order to adapt our current infrastructure.

2 Concepts

2.1 Rotary winged UAVs - Drones

One of the most practical and innovative way to transport goods through the air from one point to another is without doubt the drone. The propulsion of this cargo transportation system is based on at least 4 lifting rotors designed to achieve a vertical takeoff and landing (VTOL) and, at the same time, to provide a forward flight mode in order to achieve a more efficient travel. With respect to the power system, it is frequently purely electric and uses rechargeable batteries for energy storage.

In general its weight and dimensions vary according to the payload they are designed for, but so far they usually weight less than 25 Kg. In this regard, an essential parameter to take into account is payload. In order to be used for every kind of transportation, the internal cargo bay needs to host at least 3 Kg of goods and, at the same time, it has to ensure that products are fixed and can not move during the flight despite different weather conditions.[1]

In recent years, a true example of a real cargo drone prototype has been given by Boeing. With a weight of around 340 Kg, length and width of 4.5 m and 5.5 m respectively, it represents the biggest drone ever made so far. Thanks to eight counter-rotating engines equipped with six-foot-long blades, it can reach a top speed of 110 Km/h and carries a payload of almost 230 Kg.[2]

2.2 Fixed wing UAVs

Fixed wing concepts generally neglect the vertical take off capability in order to provide a maximum operational range and higher speeds.

In order to still be as independent as possible from other ground infrastructure, fixed wing UAVs are often launched by a catapult and have to be recovered on their launch site. In flight they are usually driven by one or more propellers and operate on a battery powered engine setup with the possibility of swapping out batteries after each delivery to reduce turn around times.

Since fixed wing aircraft can't hover, but are meant to be able to stay airborne throughout their entire trip, individual deliveries can only be made by dropping a parachuted parcel. This delivery method is not very accurate and therefore can't operate in urban areas but is sufficient in rural areas or other place with suitably large open spaces.

An already operating example by the company "zipline" is able to do up to 160km long multi-delivery runs with a payload of up to 1.75kg and has a top speed of up to 128km/h.

This concept wont be a solution to urban deliveries, but its properties enable it to make high priority deliveries to rural or otherwise hard to reach areas. Therefore it is presently used for medical supplies in Rwanda.[3]

2.3 Comparison

When it comes to choose between these two typologies, a lot of factors play a significant role. Most importantly there will always be a trade off between the three main properties, which are maneuverability, range and payload capacity.

In a scenario where high maneuverability is required and can be traded for a shorter range, a drone would be the superior choice. Vice versa a fixed wing UAV would perform better if the requirements are the opposite. Due to desired design limitations in size, there is not too big of a difference in payload capabilities.

2.4 Integration of UAVs into the existing airspace

UAVs with either rotary or fixed wings are already quite good developed, but integrating them into our existing airspace infrastructure will be quite challenging. A UAV can be controlled remotely or can even fly completely autonomous.

The first challenge will be to integrate and certify remotely controlled aircraft systems. The "European RPAS (Remotely-Piloted Aircraft Systems) Steering Group" developed in their final report [4] a roadmap for integrating RPAS into the European airspace. According to the roadmap the following activities will have the largest effort to implement: the communication and separation between IFR and VFR flights, the access to the airspace, Airport operations and emergency situations.

To address the first two problems researchers from the DLR therefore suggest in [5] to introduce a new class of airspace. This would require new standards and new Air Traffic Management (ATM) procedures. Also the certification regulations would need to be adapted for UAVs. There are also still some technical issues that need to be solved: like the redundancy and precision of the flight navigation system [5]. But small niche applications with uncrowded airspace can already benefit from unmanned cargo flights like emergency supply after natural disasters or medicine supply in developing countries [6].

3 Users and application

UAV can be utilized when delivery of payload has to be accomplished in "hard to reach" areas or in locations where most of the transport is relying on ground-based vehicles. Since UAV's are currently limited in payload weight and size, they are suitable for lighter and smaller payload, such as letters, small packages or take away food. Companies such as Amazon, Walmart and Dominos are researching the possibilities of delivering their payload with UAVs in the future and have already made some deliveries.[7]

The military has been using UAVs for transporting payload e.g modified K-Max helicopters are used as UAVs in Afghanistan. The fact that UAVs can operate for a longer time than an aircraft with crew makes the UAV and its development interesting for the military. There are ongoing projects with the goal to create a UAV with long range capabilities and establish a network of routes that can haul cargo over long distances without having to transfer the cargo between different instances or hubs in order to make the delivery directly to where it is needed. [8]

Due to their current limit in range, using UAVs for longer transportation is currently unfeasible. In the area of last mile deliveries however, UAVs have the capability to replace current methods which relays on mostly trucks or cars. Replacing trucks will result in lower costs, less environmental impact and shorter delivery times. One application for UAV delivery is in citys where most of the deliveries are made by trucks. An armada of UAVs could replace the trucks and thus less traffic has to travel on an already overloaded road network. If a UAV delivery system were to be established in a city, problems such as noise, integration and legal issues should be solved. Current models of UAVs are very noisy and require additional infrastructure to function properly in a city environment. [9] [10]

To compensate for the UAVs weakness in range, UAVs can also be used in conjunction of trucks to extend their range. A single truck with a number of UAVs can be used to deliver packages to multiple destinations in a shorter time, such in suburbs. This configuration can also be used to reach rural areas where roads are in poor conditions or even non-existing.

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