Drone's Shared Knowledge for Product Delivery Service

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***Abstract*—The technological progress of Unmanned Aerial Vehicles (UAV) and the rise of drones on a massive scale suggest that the time has come to start solving everyday problems (like product delivery) with them. A common property to most UAVs is that they are either monitored, or have had their routes pre-defined by humans A delivery drone in a urban environment has limited aerial space, either by buildings, weather conditions, grown trees, scaffolding,etc. This situation makes it necessary for the drones to have their routes redefined. Because of this, operating multiple drones simultaneously can become way too expensive and even unmanageable. Our proposal is to develop an AI for the drones that will allow them to calculate and manage their own routes, taking inputs from the world around them and sharing that knowledge among them in order to improve the overall knowledge of the available aerial space.**

***Index Terms*—Unmanned Aerial Vehicles, UAV, drone, delivery, IA, shared knowledge.**

I. Introduction

The origin of drones can be traced back to middle of the 19th century when the Austrian military attacked the enemy Italian city of Venice using balloons laden with explosives, but being entirely at the whim of the wind, a dangerously unpredictable flight-path saw many explode over Austrian territory. In 1898, inventor Nikola Tesla displayed a small unmanned boat that appears to change direction on verbal command. He used RF to change the course of the boat. In 1915, he gave a dissertation on using armed pilotless aircraft capable of defending US.

Drones similar to the one's used today started showing during the WW II. In **2005**, drones started entering the **consumer market space** and the FAA came up with a memorandum of interim policy, which approved the use of domestic drones and helped drone operators fly at the same standard as pilots. In the following years the FAA restricted that policy and made it a requirement to have a certificate of authorization by FAA to fly drones. This applied to companies, government agencies and universities. This slowed down the commercial applications as very few authorizations were issued. In 2012, Congress enacted FMRA (FAA Modernization and Reform Act), which requires FAA to devise a plan to accelerate and successfully integrate drone usage in the airspace by Fall 2015.

One of the most widely talked about commercial drones is for freight transport or package deliveries. **Amazon** made a big splash when they announced Amazon Prime Air in December 2013 with the stated goal of reducing shipment times to 30 minutes from nearby distribution centers. **DHL** initiated a pilot program in Sept 2014 to perform parcel deliveries in Germany to reach remote locations near the North Sea. **Google's** "Project Wing" has been testing delivery drones in Australia. **UPS** is also researching delivery drones, and according to articles, they are considering using drones to move packages between distribution centers and airports to distribution center.

Although, drone delivery technology is being developed by a few companies, we will focus in one in particular: **Amazon**.

II. State of the art

Amazon is the pioneer in drone delivery technologies, and security is one major issue. A drone falling from the sky is actually a really serious problem for people's safety and measures have to be taken. It's not the same if a drone flies in a high density area like a city or if a drone flies in a country area. They will also need to minimize interaction with lesser-equipped small unmanned aerial vehicles, as well as the occasional manned aircraft flying at low altitude. To ensure the safety and integrity of the overall system, it is paramount that all UAS operators understand where they can and cannot safely operate.

Aviation authorities, manufacturers and operators around the world have created high standards for equipment, operations, reliability, and safety. In order to maintain and enhance the level of safety achieved in aviation today for sUAS, aviation authorities should adopt performance-based equipage and operating standards.

It is with this in mind that **Amazon** envisions four separate sUAS equipage classes: **Basic, Good, Better, and Best**, as we see in *"Determining Safe Access with a Best-Equipped, Best-Served Model for Small Unmanned Aircraft Systems"*. These classes optimize for safe and efficient airspace operations by creating categories of access based on capability. For example, a vehicle with an equipage classification of 'Good' does not meet the vehicle capability requirements, such as automated collaborative deconfliction and non-collaborative SAA, that are needed to perform a complex mission in an urban environment. On the other end of the spectrum, operators requesting access to execute missions with high complexity

Fig. 1. Amazon Prime Drone

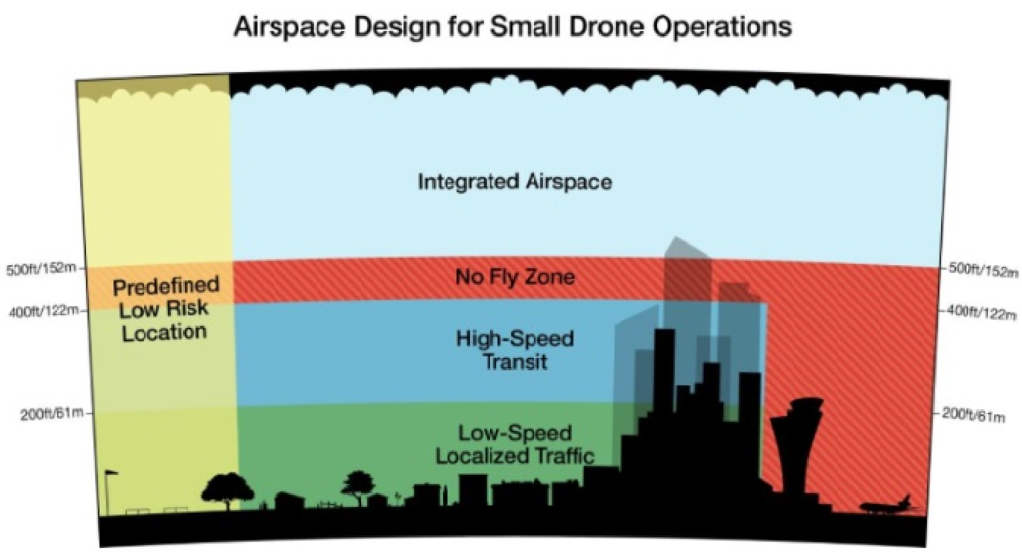

Fig. 2. Airspace Drone Operations

must equip in the ‘Best’ class and possess five equipage elements: (1) geospatial data for safe separation from known hazards, (2) online flight planning and management, (3) reliable Internet connection, (4) collaborative V2V SAA, and (5) non-collaborative sensor-based SAA. It is Amazon’s position that these five ‘Best’ equipage elements are essential for safe, highly-automated operations.

Of course, this classification is not enough. Another thing to keep in mind is airspace division.

The majority of airspace integration efforts over the past decade have focused on integrating medium or large unmanned aircraft systems into non-segregated civil airspace, i.e. airspace above 500 feet where most civil and military aviation activities occur. However, given the rapidly growing small unmanned aircraft industry, Amazon believes the safest and most efficient environment for sUAS operations—from basic recreational users to sophisticated BLOS fleets—is in segregated civil airspace1 below 500 feet ”. Segregating the airspace will buffer sUAS operations from current aviation operations. It will also buffer lesser-equipped vehicles from highly-equipped vehicles able to safely perform BLOS missions.

In the proposed model ("Revising the Airspace Model for the Safe Integration of Small Unmanned Aircraft Systems") below 200 feet, or the 'Low-Speed Localized Traffic' area, will be reserved for terminal non-transit operations such as surveying, videography and inspection, and operations for lesser-equipped vehicles, e.g. ones without sophisticated sense-and-avoid (SAA) technology. Those lesser-equipped vehicles will not have access to certain airspace in this zone, such as over heavily-populated areas. A 'High-Speed Transit' space, between 200 and 400 feet, will be designated for well-equipped vehicles as determined by the relevant performance standards and rules. The airspace between 400 and 500 feet will serve as a permanent 'No Fly Zone' in which sUAS operators will not be permitted to fly, except in emergencies. Finally, this airspace model will also encompass 'Predefined Low Risk Locations'. Altitude and equipage restrictions in these locations will be established in advance by aviation authorities. These Predefined Low Risk Locations will include areas like designated Academy of Model Aeronautics airfields, where members will meet pre-established parameters for altitude and equipage. **Amazon** believes this segregated airspace model will enable safer overall operations by providing a framework where airspace access is tied to vehicle capability, and by buffering sUAS operations from current aviation operations.

Other aspect to keep in mind is finding the best paths and drone's battery life. As a drone's movement is not limited to existing transportation network, path planning needs to be conducted in continuous space with **taking into account obstacles for flight**. However, due to limited flight range of battery-powered drones, **multiple recharging stations are required to complete delivery without running out of the power in large urban area**. As we see in *"Deviation flow refueling location model for continuous space: commercial drone delivery system for urban area"*, it is possible to create a coverage model that can optimize location of **recharging stations** for delivery drones, as well as ensure construction of a feasible delivery network that connects the stations and covered demands based on continuous space shortest paths. A heuristic solution technique is utilized for the optimization of station location. Application results show the effectiveness of this model for construction of drone delivery network that covers large urban area.

III. Shared knowledge

As we said, our proposal is to develop an AI for the drones that will allow them to calculate and manage their own routes, taking inputs from the world around them and sharing that knowledge among them in order to improve the overall knowledge of the available aerial space. **Shared knowledge is the ability to learn information known by other drones and devices connected to the network.** For example, if a drone is in an area with high drone density, he may inform to other drones to avoid that area to reduce collision risk. A drone can tell another one to carry packages for him if they go to the same destination. Drone to drone communication is just one of many, as it can be extended to all kind of devices. For example, a **weather channel** on the internet can inform drones to avoid certain areas due to bad weather conditions. This is only one example of an online service to assist drones, but it can be extended to a lot of different types of them. On the other hand drones can also provide data to users and services, for example **timing in package distribution, real time street information via photographies**.

Physical devices can also communicate with drones. For instance, in the case of **battery replacement and charging**. As we all know, drones need to be charged regularly. But if drones share info about their battery life, plus the model we saw early in the state of the art section, they can share their payload, accordingly to their size, type of drone and weight, drones that are running low on battery can just stop and reload while other take their package and send them to the specified destination.

Other crucial information is the position and trajectory of nearby drones for **collision detection and avoidance**. Finding optimal paths will not only prevent accidents, but also will reduce delivery times and save fuel.

IV. Conclusion

Drone are here to stay. They are not only the future, but the present as well. Governments of the world should regulate accordingly, not prohibit, their use. Drones will help the economy, increase competition, increase customer satisfaction,and allow e-commerce to flourish even more.

Communication is the key to success in every organization and in every team so, why would be expect it to be any different in drone's product delivery?