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Autonomous Navigation and Control of Unmanned Aerial Systems in the National Airspace

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Introduction
Pilotless aircraft known as Unmanned Aerial Vehicles (UAVs) have been used extensively for military and intelligence purposes. This includes situations where the mission area is too dangerous for a pilot to fly, the length of the mission is longer than a pilot could stay awake or aircraft are used as cruise missiles that crash into their target. With the decreasing cost and miniaturization of computers, it has become possible to build UAVs that are small and inexpensive making them accessible to businesses, law enforcement, hobbyists and the general public.

Current FAA UAV Regulations
Current relevant regulations [1]
- UAVs must be within line of sight of the operator
- Fly below 400 feet above ground level (AGL)
- Under 55 lbs
- Commercial use with special permission

FAA NextGen Technologies
NextGen technologies being rolled out by the FAA make integrating UAVs into the national airspace possible. With NextGen, air traffic control communicates with aircraft digitally rather than voice. [3] All aircraft will be equipped with ADS-B transmitters allowing UAVs to locate nearby aircraft easily. ADS-B transmitters at air traffic control also distribute NOTAMS, TFR's and weather data. [2]

Avoid Nearby Obstacles
A LIDAR system can be used to create a map of nearby objects. LIDAR uses reflected laser light to measure how far away objects are and their relative speed. This system has an advantage over cameras in that it is not obstructed by clouds and other atmospheric conditions that a person wouldn’t be able to see through.

Detect Nearby Aircraft
ADS-B transmitters will be installed on all aircraft by 2025 giving better special awareness to pilots and enabling UAV's to accurately track and avoid other aircraft. [2]

Avoid Bad Weather
The system will check ADS-B In for local weather and add any weather flight constraints based on the limitations of the aircraft. [2]

Obey NOTAMS and TFR’s
NOTAMs and TFRs will be gathered via ADS-B or the internet if it has access. It will also load unexpired restrictions from memory. [2]

Navigating the airspace
Each piece of data is given a cost and a path is calculated using an A* algorithm. A* analyses the expense of each path to find a clear path through the airspace. If a safe route can not be found, A* will find the least dangerous path based on cost or the nearest place to land if possible.

References

Figure 1. Diagram of Aircraft Avoiding Obstacles [4].

Figure 2. Diagram of System Components [4].

Figure 3. Diagram of System Operations [4].