www.pipelinepub.com
Volume 21, Issue 9

Drones, GenAI and the Need for Collision Avoidance Communications Protocol

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It looks like delivery drones and air taxis are coming fast. As their numbers increase, low-altitude airspace is going to get congested. We need to find a way to avoid collisions. GenAI will likely play a key role in autonomous operation. But, it is not sufficient by itself to prevent collisions. We need a protocol for collision avoidance. Research on this topic has not created a solution. Things are happening too fast to wait for a 6G solution. The best way forward may be for those building the equipment and those planning to use the equipment to come together and develop such a protocol.

Increasing Drone Deployments

Drone delivery has been talked about for years. What is different now is that it is beginning to happen in a way that could produce an explosion in traffic. Some recent US examples include:

Zipline is launching its airborne delivery service in the Dallas-Fort Worth suburb of Mesquite and will spread to Seattle before the end of the year. Zipline has already flown over 1.4 million deliveries and covered over 100 million miles.

Wing has completed more than 75,000 deliveries in the Dallas area. Flown more than 315,000 miles with an average flight time (from takeoff to delivery) of 3 minutes and 27 seconds.

Amazon is starting a drone delivery in a Phoenix suburb.

Walmart is starting a drone delivery in a Dallas suburb

Deployment is also happening in other parts of the world. Recent examples include:

Home delivery in Bengaluru, India.

Prompted by Zipline's success in delivering medical supplies in Ghana, the UK National Health Service has started drone delivery Service has started drone delivery of medical supplies in the UK.

Congestion Problem

It appears that drone delivery is well on its way, with average delivery times of three and a half minutes. If congestion problems are avoided, drone delivery may become ubiquitous. All major retailers may have to offer it.

One problem that could impede success is some highly publicized collisions. The coverage of the recent collision between a helicopter and an airliner in Washington, D.C., is an example of how much negative attention a collision can create. As long as there is a very low density of activity in low air space, the probability of collision appears relatively low. But, of course, successful drone businesses will generate lots of traffic, dramatically increasing the likelihood of collisions.

Delivery drones are not the only things using low airspace. In addition to conventional aircraft, there will be air taxis. The first will be piloted ones, like the electric piloted air taxi service from and to all three New York City airports or connecting the major cities in the San Francisco Bay Area. Autonomous air taxis are being produced. Examples include those in the US and China. Examples of services outside the US include ones in India.

The Zipline-style drone adds another form of congestion. In delivery mode, the main aircraft hovers and drops a smaller powered craft tethered by a cable. This smaller craft goes to the ground and drops off the package. One craft becomes two. The space between the two crafts is obstructed or occupied by the cable connecting them.

Given all this, it can be seen that low-altitude airspace will soon get congested.

Possible Collision Avoidance Solutions

The traditional way of avoiding collisions is using manual air traffic controllers. The growth of commercial airliner service is already stretching such manual systems to and beyond their limits. Commercial aircraft have collision avoidance systems that warn the pilot of an impending collision. When such a warning occurs, the pilot only has time for an extreme maneuver. In low-altitude airspace at climbing or landing speed, the plane may not be able to make such a maneuver.

In the short term, it is neither politically nor economically viable to try to replace legacy air traffic control systems. What is needed is a way for conventional legacy air traffic control systems to continue while providing a way for an explosion in drone and air taxi traffic.

One approach that appears to have some support in the US is to treat drones and air taxis the same way as autonomous automobiles. Use GenAI and just keep them away from the areas surrounding airports. That approach doesn’t seem to scale. The largest customer bases will be in the areas used for the takeoff and landing of commercial airliners in major metropolitan areas.

Also, the problem of collision avoidance in low altitudes is different and much more difficult than for automobiles. Surface vehicles operate in 2D (two-dimensional) spaces that are well-defined by streets, roads, lane lines, stop signs, traffic lights, well-established required behaviors, no or very few obstacles, etc. Low-altitude vehicles operate in 3D spaces with obstacles such as tall buildings, no roads, lanes, stop signs, traffic lights, etc. Thus, it is hard to predict, even with the fastest and most effective GenAI, what another vehicle is going to do.

Academics in China are studying centralized, automated control systems. In their proposals, vehicles would be equipped with sensors and wireless communication systems that connected them to a central site(s). Connection to the central site would be centrally controlled through a modified cellular network. Everything would file a flight plan and be under complete automated central control. Such a centralized approach is consistent with the current cultural, political, and economic situation in China. Unfortunately, this approach has serious problems. The proposed cellular modification is to reorient base station antennas to point up. Even with this change, there are problems with cellular coverage, power consumption, security and reliability. Flight plans may not accurately predict actual flight. Things like wind, weather, children flying kites, etc., plus consumer or vendor changes will make pre-filed flight plans only estimates of what will actually transpire. Not reliable predictions. Getting feedback from sensors on the aircraft may help. But all of this is subject to delays - processing, round-trip propagation, etc. Also, capacity problems with cellular systems shared by consumers, public safety, etc., as well as air traffic control will have difficulty scaling.

There are also fundamental problems with centralized control systems. The recent experience at Newark International Airport with outages of the air traffic control system show the possibility of failure. Centralized systems can be designed and maintained to avoid these kinds of failures. But not eliminate them. There is a more fundamental problem with centralized systems in times of natural disasters. Centralized systems depend on the underlying infrastructure. In hurricanes, floods, wildfires, etc., the underlying infrastructure is often knocked out. Without infrastructure, central site systems can become ineffective or inoperable. During and immediately after such natural disasters, drone delivery and air taxi services may be critical. Demands and resulting traffic could peak, creating both more need and more risk of collision.

What seems to be the most promising approach is to develop a protocol that intelligent agents in each aircraft can use to communicate directly with their neighbors, supported by sensors in each aircraft. Here, GenAI can provide effective help. This kind of distributed control can be seen as analogous to the distributed control found in Ethernet and Wi-Fi. It could also rely on unlicensed frequency in a similar fashion to Wi-Fi.

Such a protocol can take advantage of another historical development that has and is, working well. When motorized sea-going vessels first appeared, they had to co-exist with many legacy sail-powered vessels. The simple rule of the sea that was developed was that a sail-vessel always had the right away over a motorized vessel. The logic was that motorized vessels had more ability to maneuver. This rule of the sea worked well and is still in use today. An analogous run of the air would be that all legacy aircraft have the right away over drones, air taxis, and other types that might emerge. This rule of the air could be part of the new low-altitude collision avoidance protocol.

Protocol Implementation

Some propose that this all be worked out in existing cellular standards groups, such as 3GPP's 6G efforts. There are two problems with this approach: time and knowledge.

The development of a new cellular standard takes a long time. Then, there is further delay while the new standards are designed into equipment, the equipment is purchased by cellular operators, the new equipment is fielded, and resulting networks are debugged, etc. To make matters worse, there is not support for a new cellular standard amongst the operator community. It seems highly unlikely that a new standard would be in full operation in time to meet the needs of this rapidly growing industry segment.

The needs of the drone and air taxi industries are not well represented in cellular standards groups. These groups are dominated by the largest cellular manufacturers and network operators. They know quite a bit about what is needed to make cellular networks operate with economics that support their existing business. However, they do not have extensive knowledge of autonomous aircraft and their operational and business needs.

What worked well in the development of LANs was for a group with deep knowledge and strong economic interests in a good solution to join together to create such a protocol. In this case, those with the deepest knowledge and the strongest economic interests are the autonomous aircraft equipment and service providers.

Conclusion - Find a Way

In summary, delivery drones and air taxis are coming fast. Low-altitude airspace is going to get congested. We need to find a way to avoid collisions. GenAI will likely play a key role in autonomous operations. But, it is not sufficient by itself to prevent collisions. We need a protocol for collision avoidance. Things are happening too fast to wait for a 6G solution. The best way forward is for those building the equipment and those planning to use the equipment to come together and develop such a protocol.