Piloting Unmanned Aircraft with a Computer Mouse

Challenges to Point-and-Click Flying

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Flying an aircraft using a keyboard and mouse has its advantages, but it has its challenges too! Having grown up at the controls of the nimble F-16, I have had to fundamentally adjust my mindset while flying the modern RQ-4D Phoenix, a Global Hawk derivative. While flying the F-16, I certainly never worried about going "lost-link." Relying on a vulnerable data link introduces challenges to safe and effective flight operations.

Additionally, unmanned aircraft incorporate unprecedented levels of automation. In most circumstances, the automation reduces pilot workload and improves effectiveness, but in some instances, the pilot must override the automation to maximize safety or mission effectiveness. As militaries expand applications of unmanned technologies, several lessons learned here at the NATO Alliance Ground Surveillance Force may prove instructive.

Data-link interruptions. The first edict of operating any unmanned aircraft is that the data link will be interrupted (normally at the most inopportune time); consequently, the pilot must always anticipate the aircraft's immediate actions. Typically, this is called the lost-link profile or flight plan. In this situation, the aircraft may be programmed to turn, descend, or change airspeed but often will proceed to a predesignated holding area to wait for restored communications. Challenges in this scenario include weather events in the holding area or the introduction of a new surface-to-air threat.

Pilots must therefore remain vigilant, constantly updating lost-link flight plans to preclude the aircraft from performing actions that jeopardize safety or survivability. Once communications are interrupted, the aircraft will only perform those actions for which it was programmed. If the aircraft was programmed to hold for three hours and then return to base but only had two hours of fuel remaining, it will diligently maintain its holding pattern until it impacts the ground due to engine failure and fuel starvation. Maintaining updated lost-link flight plans is essential to flying unmanned aircraft safely.

Delays in executing the lost-link plan can also cause the aircraft to fly in an unintentional manner. During near-border operations, mitigating this issue becomes a priority. In my F-16, maps, GPS, and, as a last resort, an aggressive, 90-degree, 4-to-5g pull on the stick kept me from accidentally venturing into prohibited airspace—I have avoided a North Korean or Pakistani airspace incursion using this reliable maneuver. But the RQ-4D, operating at altitudes over 50,000 feet and bank angles under 20 degrees, moves differently, often requiring a turn radii of more than 5 miles. When intelligence, surveillance, and reconnaissance collection requirements force near-border operations, the possibility of accidental airspace incursion is real.

Although manually maneuvering the aircraft via mouse clicks and waypoints is intuitively easy, severed communication links create heightened tension when every mile counts. The RQ-4D has multiple redundant links. Normally redundancy improves reliability, but transition to alternative links is not seamless. Precious time may elapse before the aircraft successfully receives the command from the pilot—a less-than-ideal process during near-border operations. As the aircraft attempts to regain communications with the pilot through alternative links, it is flying at 350 knots on a flight plan based on the pilot's last input, making an unintentional incursion into a foreign country a very real possibility.

One mitigation technique involves manually shutting off all backup data links thus making it clear the aircraft is either receiving immediate input on the primary link or taking action by performing its lost-link profile (which in this case would be an immediate turn away from the border), thus minimizing the chance of a border incursion.

Pilot overrides. Like any unmanned system, the RQ-4D computer bases its decisions on information collected through onboard aircraft sensors (pilot-static system) or information provided through data links. The two most important data links in this case are GPS and the primary aircraft control link to the pilot. The aircraft sensors permit the machine to remain safely airborne with little assistance from the pilot—basic aircraft control, airspeed, turns, climbs, and descents are easily accomplished without additional input.

Yet aside from basic aircraft control, pilot input is necessary. Border awareness, threat awareness, fuel awareness, and aircraft system degradation—these are areas where the aircraft lacks automated awareness. The machine relies on human input (and thus a data link to the pilot) to maximize safety and effectiveness. For example, the RQ-4D lands itself. When crosswinds are high or visibility low, this auto-land feature is ideal. As the landing phase is the most critical, the aircraft will ensure its systems are optimized for a safe touchdown. If it suspects a nonoptimum inertial navigational system navigation solution, approach angle, or fuel imbalance, it will execute an automated go-around.

In some instances, however, this logic is deliberately overridden by the pilot. If icing is encountered during decent, the pilot inhibits the auto-go-around function. This action precludes an auto-go-around and subsequent climb and/or holding pattern within dangerous icing conditions. The pilot always maintains a "manual" go-around command if the aircraft ever appears to be in an unsafe position to land.

Looking ahead. Certainly, through additional sensors, links to external databases, and a real-time interface with other machines, the RQ-4D *could* greatly reduce its dependence on human input. But in my experience, the cost quickly becomes prohibitive. Each additional set of automatic inputs, new sensors, or machine-to-machine connections requires millions of dollars of investment to ensure the capability and then to certify the capability as "airworthy." Unlike ground unmanned systems, airborne systems require airworthiness certification, thus incurring additional costs.

Two challenges to operating and developing unmanned aircraft are worth noting. First, the importance of data-link assurance during the employment of any unmanned system cannot be overstated. Mission effectiveness will be degraded whenever communications are interrupted. War fighters must commit to improving link reliability across the battlespace. The *2020 Department of Defense Electromagnetic Spectrum Superiority Strategy* raises several important issues, but much more work is required. Second, what processes are worth automating? Technology exists to automate more—the aircraft could certainly be engineered to stay within assigned borders or avoid surface threats—but the war fighter must determine which processes are worth the money to automate. Keeping a human in the loop is often less expensive.

The operational success of unmanned systems hinges on a fundamental criterion, namely, how to provide an aircraft's mission computer sufficient information to make proper decisions within a dynamic environment. As demonstrated by the RQ-4D, unmanned aircraft rely on information provided by onboard sensors and data links—critically, those with GPS and with the pilot.

When data links are denied, the aircraft must be programmed to perform in a safe, effective, but most of all, predictable manner. Future systems tasked with more complex mission sets (the use of lethal force) will rely on an increased amount of information exchanged across an even greater number of data links—the location of friendly forces, enemy forces, threats, and weather. As the number of data links increase and mission complexity increases, the challenge to ensuring safe and effective operations, regardless of link status, becomes ever more difficult.

For the foreseeable future, the successful use of unmanned systems in combat operations necessitates careful integration of computer-driven processes and human oversight. Ultimately, data-link vulnerability and aircraft logic management (manipulating aircraft decision calculi to maximize overall effectiveness) are growing challenges that remain fundamental to mission effectiveness when physically separating the war fighter from the machine. ✪

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