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Building Evidence the Federal Aviation Administration's UAS Safety Strategy Needs Improvement

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In the first known incident of its kind, the Federal Aviation Administration (FAA) received reports that a small unmanned aircraft system (sUAS) caused the crash of an aircraft. According to Yee (2018), a flight instructor and student aboard an R22 helicopter performing maneuvers near Daniel Island in Charleston, South Carolina, reported spotting a DJI Phantom approaching their airspace. The instructor assumed control of the helicopter and attempted to perform an evasive maneuver to avoid the sUAS (Yee, 2018). The maneuver, presumably performed at low altitude, caused the helicopter's aft rotor to strike a tree, careening out of control and impacting the ground (Yee, 2018). While the instructor and student did not sustain any injuries, the helicopter was determined to be a complete loss (Yee, 2018). According to news sources, the operator of the unmanned aircraft had not yet been identified (Yee, 2018). If proven credible, this report would be ground-shaking to the aviation industry and have a detrimental impact on UAS operations in the United States. This news comes in the very same week the FAA opened yet another investigation into a February 9, 2018, incident in which an unmanned aircraft allegedly struck a tour helicopter near the Hawaiian island of Kauai (Bernardo, 2018).

To experts, such occurrences should come as no surprise—several 'red flags' served as stark indicators suggesting UAS integration problems were getting worse, not better. These conditions underscore the applicability of Heinrich's Law presented in Figure 1. Heinrich's Law states that serious incidents or accidents are preceded by several minor incidents and a more substantial number of near-misses (Ward, n.d.; Johnson, 2011). Based on the theory, reducing the number of near-misses and minor incidents should invariably decrease the likelihood of a serious incident or accident (Ward, n.d.; Johnson, 2011). Conversely, several near-miss incidents or minor accidents may suggest underlying conditions are ripe for a major accident.

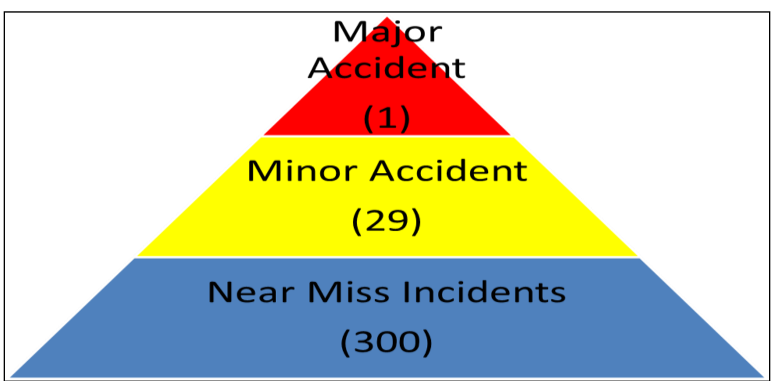

Figure 1. Visual depiction of Heinrich's Triangle.

Recent of Minor Accident Events

Reports of encounters or outright collisions between unmanned aircraft and manned platforms are becoming increasingly common. The Daniel Island incident is in some ways reflective of a similar UAS encounter over New York. In mid-2014, the New York Police Department alleged that a police helicopter encountered not one, but two small unmanned aircraft flying at 2,000 feet over the George Washington Bridge shortly after midnight on July 8 ("Two Drones," 2014). Reportedly, the helicopter "had to swerve to avoid a collision" ("Two Drones," 2014, p. 1). In this case, however, the helicopter successfully evaded both unmanned aircraft.

Perhaps the most notable incident occurred on September 21, 2017, when a United States Army UH-60M Black Hawk helicopter was struck by an unmanned aircraft while performing a routine, low-altitude formation flight near Staten Island, New York (National Transportation Safety Board [NTSB], 2017). The midair collision caused damage to the helicopter's main rotor blade (see Figure 2), as well as lodging several fragments of the sUAS in the helicopter's fuselage (NTSB, 2017). Recovery of an electrical motor component from the destroyed sUAS allowed investigators to corroborate the collision and aided in identifying the sUAS operator by correlating the unique serial number stamped on the recovered wreckage with manufacturer sales records (NTSB, 2017). The NTSB (2017) determined the sUAS operator's failure to "see and avoid the helicopter," and intentional violation of visual line of sight rules caused the incident (p. 1).

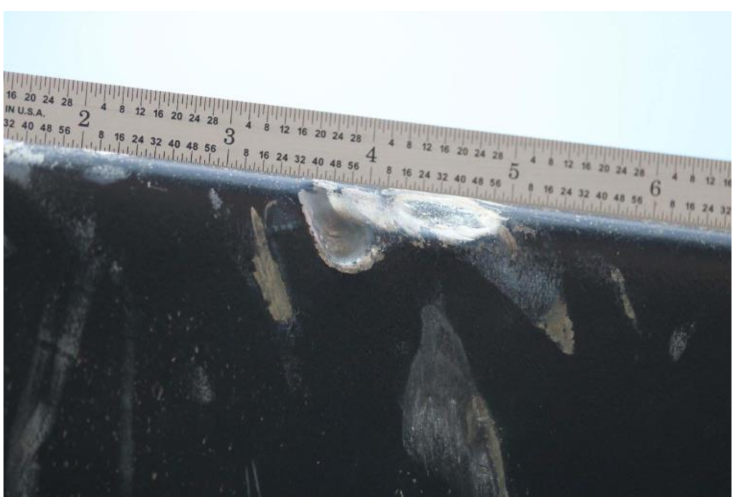

Figure 2. Main rotor damage to UH-60M Black Hawk helicopter, September 21, 2017. (Public domain image retrieved from https://dms.ntsb.gov/public/60500-60999/60650/610458.pdf)

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The Black Hawk accident follows on the heels of several similar, but less severe encounters. On September 13, 2017, Fire Spotter Bradley Goldman suspected an unmanned aircraft struck his Rockwell Twin Commander while operating at low altitude near Newport, Oregon (Mortimer, 2017). The incident, which is presumably still under investigation, caused minor damage to the leading edge of one of the aircraft's airfoils (Mortimer, 2017). The presence of plastic leads to the suspicion that the impact was not the result of a bird strike, but rather a strike from a UAS (Mortimer, 2017).

According to the Flight Safety Foundation's Aviation Safety Network (2018) database, unmanned aircraft--including RC aircraft--are suspected or have been confirmed to have been involved in 14 midair collisions around the world since 2015. Eight of those incidents occurred within the United States.

Serious UAS accidents are not limited solely to the United States. On October 12, 2017, a Canadian SkyJet King Air-100 turboprop flying from Rouyn-Noranda Airport struck an unmanned aircraft while enroute to Jean-Lesage Airport, Quebec (Transportation Safety Board of Canada [TSB], 2017). On final approach to the destination airport, the Sky Jet crew reported spotting a small oncoming drone “about the size of a dinner plate” (TSB, 2017, p. 1). The UAS struck the top leading edge of the left wing, destroying the drone and leaving a dent and several minor scratches on the wing surface (TSB, 2017). Investigators did not find any UAS wreckage and were unable to identify the UAS operator (TSB, 2017). Unmanned aircraft are also suspected to be involved in several other midair collisions, including a Linhas Aereas de Mozambique (LAM) Boeing 737-700 in January 2017 near Tete Mozambique (Jansen, 2017).

Rising UAS Close Encounters & Sightings

The alarming rise in UAS midair collisions and incidents are paralleled by an increasing number of UAS sightings by manned aircraft crewmembers. It should be noted that not every sighting is necessarily a hazardous event--many sightings likely involve UAS operators that are following established regulations. Unfortunately, a portion of those sighting incidents involves near-midair collisions or close encounters, UAS incursions into protected airspace around airports, or otherwise present hazards for manned aircraft. In 2016, the FAA received 1,762 reports of UAS sightings by aircrew members, an average of nearly 147 incidents each month (FAA, 2017). Initially-released figures from 2017 reveal a substantial climb in the number of UAS sighting reports to 1,696 in first nine months of the year—an average of 188 UAS sightings per month (FAA, 2017). Based on the results presented in Figure 3, it is relatively easy to see a steadily-increasing, annual climb in the number of reported UAS sightings. Generally, UAS sightings peak during the April to September months and diminish between October and March, likely due to favorable seasonal weather conditions.

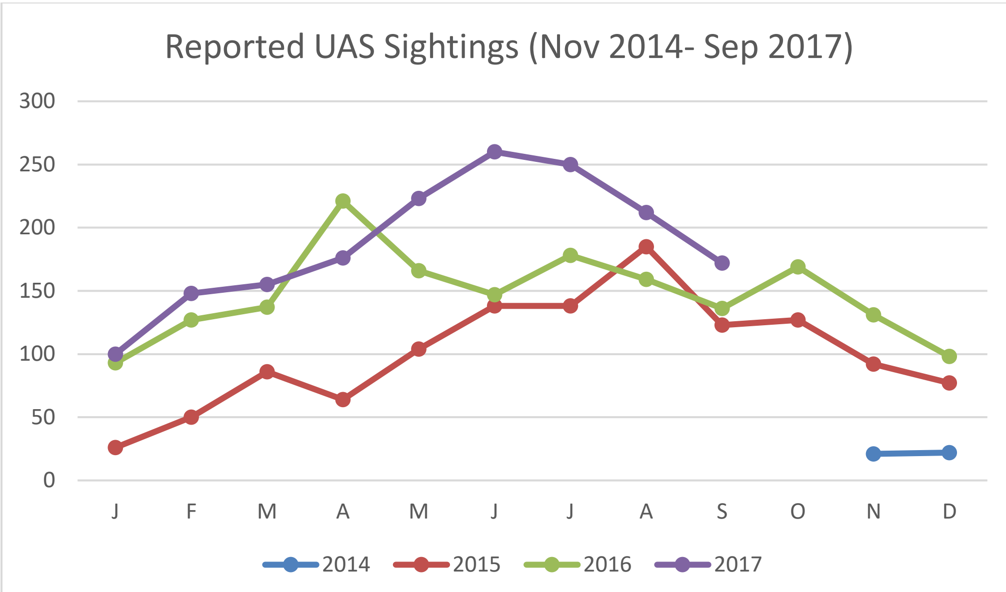

Figure 3. Reported UAS Sightings by month, November 2014-September 2017. Adapted from https://www.faa.gov/uas/resources/uas_sightings_report/.

The aforementioned safety implications are exacerbated by recently completed research into UAS collision severity. In a report commissioned by the FAA through the Alliance for System Safety of UAS through Research Excellence (ASSURE) initiative, researchers assessed aircraft damage potential caused by an airborne collision with a small unmanned aircraft system (2017a). During the study, researchers evaluated potential damage caused by a small 2.7 lb UAS impacting the structural components of typical commercial transport and business jet aircraft at a speed of 250 knots (ASSURE, 2017a). Researchers concluded that "Quadcopter UAS impacts are likely to cause more damage than bird strikes with an equivalent initial kinetic energy" (ASSURE, 2017a, p. 215). Researchers cited the density and structural rigidity of UAS components as the primary reason for this conclusion, stating "impact and consequent perforations exacerbated subsequent impact damage as other high-density UAS components (i.e., battery) impacted the underlying aircraft structure causing progressively more structural damage" (ASSURE, 2017a, p. 215). In a parallel study of aircraft collision potential with fixed-wing UAS platforms, researchers reached similar conclusions, remarking that unmanned aircraft strikes caused more severe damage than bird strikes of equivalent energy due in large part to their rigid composition (ASSURE, 2017b).

Discussion

To accurately assess these indicators, one must evaluate them within the context of UAS integration policy. According to the FAA Modernization and Reform Act of 2012 (FMRA)(PL 112-95), Congress charged the Department of Transportation with developing a “phased-in approach to the integration of civil unmanned aircraft systems into the national airspace system” as well as “safely designate airspace for integrated manned and unmanned flight operations in the national airspace system” (FMRA, 2012, Sec 332).

Congressional emphasis on integration is a key framework, prominently featured throughout the legislative language throughout the FMRA. To integrate means “to combine into one unified system or desegregate” (“Integrate,” n.d.). In other words, Congress specifically intended for unmanned aircraft operators to become equal and full users of the National Airspace System—to the same extent, degree, and privilege as those flying manned aircraft. In the sixth year following the passage of PL 112-95, unmanned aircraft are still largely segregated from vast swaths of airspace. Perhaps more frustrating is that even in areas where integration has proceeded, policies have still favored segregation tactics. When establishing the Small Unmanned Aircraft Rule later codified into 14 CFR §107, the FAA established a vertical limit of 400 feet AGL because “most manned aircraft operations take place higher than 500 feet” (Operation and Certification of Small Unmanned Aircraft Systems [sUAS], 2016, p. 42116). In response to altitude limitation, the agency stated (Operation and Certification of sUAS, 2016):

> Allowing unrestricted small unmanned aircraft to operate at high altitude without the benefit of additional equipment (for example transponders and altimeters) and the provision of air traffic services introduces a significant threat of collision to manned aircraft operating in the NAS. (p. 42116)

Perhaps not surprisingly, stakeholders representing low altitude aircraft operations, such as helicopters and agricultural applicators advocated in favor of the restriction, with some pushing for even lower altitude limits for sUAS, although these recommendations were not adopted into the final rulemaking (Operation and Certification of sUAS, 2016).

When employed in concert with rules derived from 14 CFR § 91.119, Minimum Safe Altitudes, one can see why such policies were initially implemented. According to 14 CFR § 91.119, except takeoff or landing, pilots are limited to operating aircraft no closer than 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet over congested areas such as towns, settlements or open congregations of people. Over uncongested areas, pilots are limited to operating no closer than 500 feet to people, vessels, vehicles, or structures. One should admire the logic of this design. As presented in Figure 4, one can easily see vertical and lateral buffers that have been engineered to protect sUAS from manned aircraft.

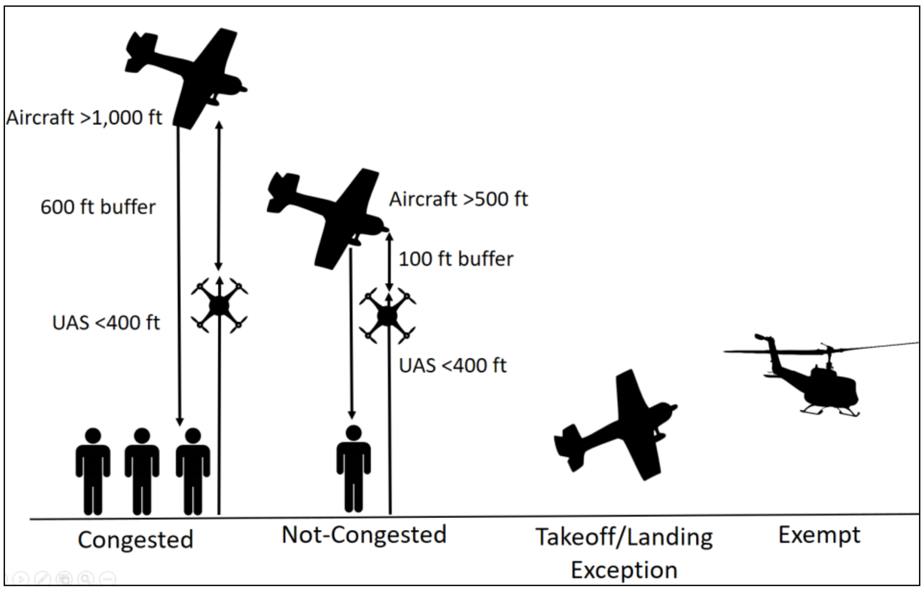

Figure 4. Minimum Safe Altitudes (14 CFR § 91.119) and sUAS Operating Limitations (14 CFR § 107.51). Note: diagram does not take into account additional sUAS flight restrictions imposed by airspace class (14 CFR § 107.41), operations in the vicinity of airports (14 CFR § 107.43), or other prohibited or restricted areas (14 CFR § 107.45).

It should come as very little surprise that helicopters and other low-flying aircraft have borne the brunt of recent collisions or near-misses with unmanned aircraft—such events are occurring in the only airspace that has genuinely been integrated.

Conclusions

UAS operations in surface and low-altitude class B, C, D, and E airspaces have mainly been segregated from other manned aircraft operations. The issuance of Certificates of Authorization or Waivers under FMRA Section 333 and 334, as well as airspace waivers granted under 14 CFR § 107.205(h), have largely segregated sUAS operations from manned aircraft operations. Indeed, this approach is probably appropriate in the short term considering the lack of infrastructure development for identification and tracking of small unmanned aircraft. Within areas of airspace integration, however, the aforementioned safety indicators suggest that the progression of successful, safe sUAS integration policies has not yet been achieved. The careful balance of existing operations in the National Airspace System seems much more fragile than originally suspected, which may suggest further sUAS policy adjustment may be in order. Furthermore, additional 14 CFR § 91 modifications may be appropriate to address the evolving nature of shared airspace between manned and unmanned aircraft.

Hopefully, new efforts such as the Low Altitude Authorization and Notification Capability (LAANC) and UAS Detection Initiative will yield fruitful results in aiding the FAA in safely progressing UAS integration (FAA, 2018; FAA, 2016). Perhaps most importantly, the agency cannot ignore trending safety indicators, which seem to suggest that as unmanned aircraft operations within the NAS increase, so too are the number of safety hazards. Left unmitigated, such hazards will yield inevitably predictable results.

While the UAS industry clamors for more operational autonomy, it is essential to consider that UAS integration is not on schedule—as an industry, we still have much to learn about how to safely and effectively entwine UAS within the complex system of systems that make up the NAS.

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