Helicopter Safety Enhancement (H-SE) 90 Formal Report

Identifying How UAS/OPA Can Reduce Fatal Accidents in High Risk Manned Helicopter Operations

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H-SE-90's Intended Purpose

The drafters of Helicopter Safety Enhancement (H-SE) 90 (Attachment 2) intend to encourage the increased use of Unmanned Aircraft Systems (UAS) and continue the development and integration of Optionally Piloted Aircraft (OPA), or autonomy-enabled helicopters, to supplement and support manned operations in high-risk operations or environments. The goal is to save lives and mitigate risk whenever manned flights could put individuals in harm's way. Mitigation is possible when suitable unmanned or autonomously assisted options exist to support or supplement high risk operations. H-SE 90 is supported by fatal accident analysis data. Advancements in technology will supplement the implementation of this H-SE. A recent Congressional bill (initially as H.R. 302, then in October 2018, Public Law 115-254) will drive policy and regulation changes. Congress, through P.L. 115-254, has instructed the FAA to adopt self-certification and performance-based standards as a guide to the ultimate integration of UAS into the National Airspace System (NAS).

The following conditions should be met for UAS or OPAs to be a reasonable compliment to existing, conventional manned helicopter flight in higher-risk operations:

1) Easy to obtain; commercial off the shelf technologies.
2) Compliant with security requirements of various customer needs.
3) Cost-efficient for operators to utilize in performing a specific operation.
4) Does not result in any additional risk (to the safety pilot or remote pilot, support personnel, or bystanders) that would not have otherwise been present with the current manned operation.

Applications that can be performed by UAS or an OPA continue to grow. Given the continued expansion of UAS and OPA (both in sensor and performance) capabilities, their use to supplement and support operations is logical when manned operations are at a particularly high risk, such as in low level situations, rapidly changing terrain and weather, and especially near manmade obstacles (poles, towers, wires, etc.).

The implementation of this H-SE is already underway within different industry segments and/or under research and development, test and evaluations as this technology continues to rapidly advance. This document thus serves to highlight and support the continued progress and contribution to safety in addressing how UAS/OPA can reduce fatal accidents in high risk manned helicopter operations.

Implementation Path

H-SE 90 was initiated in June 2018. Within one year of the start of implementation, Output #1 of this enhancement requires a small team of USHST Subject Matter Experts (SME) to research operations and environments that are more susceptible to high-risk conditions for manned helicopter operations, and for which use of a UAS or OPA could be viable to support or supplement operations. Also, the SME team is to conduct a basic review or analysis of the fatal accidents that spurred the creation of this safety enhancement. This SME Team revisited the USHST's (2017) analysis of National Transportation Safety Board (NTSB) data from fatal helicopter accidents that occurred between 2009 and 2013. The 10 fatal accidents from this dataset that spurred this enhancement are in H-SE 90's *Statement of Work* section.

A USHST working group in early 2018 also performed a high-level analysis of fatal U.S. accidents from 2014 to 2017 to identify any changes or evolution from the data discovered in the 2009 to 2013 dataset. The results of this analysis are strikingly similar to the 2009 to 2013 dataset. Nonetheless, the SME team conducted an extensive re-review of the working group's unpublished analysis of these fatal accidents.

The H-SE 90 SME Team organized the helicopter accident analysis required in Output #1 into this report. The team also researched, and summarizes, the current status of UAS integration into the NAS. Potential issues that could hinder or delay UAS integration are identified and recommendations offered. The report will be submitted to the USHST Outreach Team and pushed out to industry and the expected implementers of H-SE 90, such that any issues involving proposed new use of UASs or OPA can be clearly communicated and resolved.

Identifying High Risk Operations and Environments for Manned Helicopter Operations

Essentially, any operation that requires a helicopter to operate close to the ground, such as aerial application of chemicals or retardants, transmission and distribution line (T&D) patrol, construction or maintenance, firefighting, or any other low-level, dirty, or potentially complacent job is full of risk. Ever changing environmental conditions, unforecasted weather, birds, manmade obstacles, and many other outside factors increases the risk exponentially. In order to identify the operations that pose the most risk to helicopter operations, we must refer to the data. Since the creation of the International Helicopter Safety Team (IHST) in 2005, and the USHST in 2013, the team has painstakingly spent thousands of man-hours analyzing 1116 United States commercial helicopter accidents to identify, quantify and explain how and why helicopters crash. In the first ten years, the team analyzed accidents and created accident prevention initiatives. The IHST's efforts helped the U.S. helicopter industry realize a 53% reduction in total accidents. Although it was short of the 80% goal the team had hoped for, it is clear the team's initiatives were, and still are, having an impact. However, the team felt they could do more to reduce accidents, especially fatal accidents.

In 2016, the overall focus of the USHST shifted to reducing fatal accidents and established a goal of reducing the fatal helicopter accident rate by 20% by the year 2020. It was out of this initiative that this safety enhancement movement grew. After attention shifted to fatal accident reduction, the USHST's Safety Analysis Team (SAT) performed a comprehensive analysis of fatal helicopter accidents that occurred from 2009 to 2013 (USHST, 2017). The SAT adopted the data-driven, consensus-based approach of the General Aviation – Joint Steering Committee (GA-JSC) to analyzing accident reports, and developed intervention strategies intended to mitigate the root causes of fatal accidents. Out of the 104 fatal accidents that took place during this five-year span (2009-2013), 52% of them stemmed from three "occurrence" categories:

- Loss of Control Inflight (LOC-I) - 19 fatal accidents
- Unintended Flight into Instrument Meteorological Conditions (UIMC)-18 fatal accidents
- Low-Altitude Operations (LALT) - 15 fatal accidents

A similar high-level analysis of 74 fatal U.S. helicopter accidents that occurred between 2014 to 2017 was conducted by the SAT. The results of that analysis are strikingly similar to the 2009 to 2013 dataset.

The USHST's approach to fatal accident analysis work is a radical methodology departure from the team's previous efforts (USHST, 2017). Over the ten-year period between 2006 and 2016 the IHST's Joint Helicopter Safety Analysis Team (JHSAT) and Joint Helicopter Implementation Measurement Data Analysis Team (JHIMDAT) analyzed 938 helicopter accidents using the Commercial Aviation Safety Team (CAST) method of assigning *Standard Problem Statements* (SPS) to describe the specific problems underlying the accident and any contributing factors. For each SPS, the team assigned a corresponding *Intervention Strategy* (IS), or multiple ISs. The IHST compiled over a half-dozen reports outlining this analysis. They are available at www.ihst.org.

The IHST's JHSAT and JHIMDAT teams worked from a standardized list of SPSs and ISs (JHSAT, 2011). Although the CAST/ICAO Common Taxonomy Team (CICTT) list (updated continually for helicopter specific issues because of IHST's work) provided a great framework to create accident prevention strategies, it began to limit the new SAT's effectiveness and creativity. For the fatal accident analysis portion, the SAT was no longer constrained to a set list of possible interventions. Team members, thinking outside-the-box, devised some clever and common-sense interventions to address the problem statements. After the analysis was complete, the Team discovered it had selected or created a total of 117 Interventions. The safety enhancements for each targeted accident category were created from these 117 Interventions. This safety enhancement was a prime example of the type of "outside-the-box" type of creativity that was encouraged and needed.

The USHST (2017) partnered with the General Aviation Joint Steering Committee (GA-JSC) and added a scoring feature to evaluate the importance and applicability for each chosen intervention. Interventions were scored for their effectiveness in a "perfect" and "real" world, and also scored for their feasibility across six factors (technical, financial, operational, schedule, regulatory, and sociological). The 117 interventions were then scored from highest to lowest and a "Mendoza Line" (baseball expression for a cut-off point) was drawn to prioritize the list. If the intervention was above the Mendoza Line, it was pursued as a safety enhancement. Twenty-five were initially accepted, and some were combined, leaving a list of 22 safety enhancements that required development. Individuals or teams within the USHST then volunteered to author an enhancement or create a path to implementation. Each safety enhancement was then initiated in order of their importance on how they could reduce the overall fatal helicopter accident rate. The H-SE 90 Safety Enhancement is available at: http://ushst.org/Portals/0/PDF/hse90.pdf

The Analysis

In the identification of operations and environments with the most risk exposure to manned helicopter operations, the USHST data (2017) regarding LOC-I, UIMC, and LALT Strikes offers insight on potential mitigations with UAS. To do this, we must start with the hazard, and then detail helicopter operations or activities where these fatal accidents occur and establish alternative actions using UAS. Currently, UAS below 55 lbs. are identified as small UAS (sUAS), and those over 55 lbs., just UAS.

In 10 of the 52 LOC-I, UIMC, and LALT fatal accidents from USHST's 2009-2013 dataset (USHST, 2017), the working group concluded that integrating either UAS or an OPA could have mitigated some of the risks, and subsequent deaths, during those flight operations.

Low-Altitude (LALT) Strikes

Four (4) out of the ten (10) accident helicopters that spurred this H-SE struck a wire while engaging in low-level activities (USHST, 2017). This included: photo documentation of the condition of transmission and distribution lines (T&D) and their supporting structures, conducting T&D surveys or patrol, or pipeline patrol.

In the unpublished 2014 to 2017 fatal accident dataset selected by the USHST for this analysis, five (5) out of thirteen (13) low altitude operations fatal accidents were the result of a wire strike while engaged in T&D patrol or maintenance. During a T&D maintenance flight, two workers fell off a long-line, and two helicopters, while performing line inspection duties struck wires for unknown reasons, but poor visibility was suspected. One helicopter with a highly experienced and respected pilot struck crossing wires while surveying another T&D, and another helicopter struck a transmission tower while threading line.

Transmission and Distribution Line (T&D) Inspection and Maintenance

In the literature, employing UAS in T&D, construction, inspection, and maintenance is not a new concept. In a report from the Oak Ridge National Laboratory (ORNL) (Lusk & Monday, 2017), electric industry use of UAS for inspections is an introductory review of best practices. The integration of UAS for T&D is clearly moving forward in the industry; "For many electric utility industry observers, it's not a matter of whether UASs will be integrated into the operational landscape, but when." (Lusk & Monday, 2017). Over one and a half years later, this statement is quickly coming to fruition. The FAA recently granted several beyond visual line-of-sight (BVLOS) waivers to several power transmission companies across the U.S. (Lillian, 2018).

The ORNL report (Lusk & Monday, 2017) claims UAS technology innovation is transforming the electric utility industry. It states that, as a tool, UASs can be used to: "(1) conduct efficient electric T&D infrastructure inspections, (2) effectively detect problems with electric equipment, (3) access equipment in difficult terrain, and (4) provide direct support for electric utility vegetation management". In the future, OPA, or autonomy enabled helicopters may be able to perform construction (line threading), and T&D maintenance without putting a manned pilot at risk should a malfunction, mistake, or other catastrophe occur.

When it comes to monitoring of transmission and distribution lines, the ORNL report indicates that technology advancements enable UAS to provide a higher quality inspection product for a myriad of infrastructure needs, specifically for "power lines, oil and gas pipelines, transmission towers, buildings and bridges, and wind turbines," which further enhances safety with operators conducting the flight from a standoff position. The use of sUAS in this flight activity is possible in shorter segments than capabilities of UAS currently employed by DoD that are capable of commercial application once regulations evolve. Continuous assessments of infrastructure are more effective, are cost efficient, and data collection with ever-improving sensors is used to gather usable intelligence for timely decision making. ORNL believes a cost savings of upwards of 500% per hour is very achievable, with safety to operators enhanced exponentially.

As the ORNL report was being written, insurance underwriters were just beginning to offer full UAS insurance (personal communication, April 2016). UAS insurance coverage options have recently expanded and UAS pilots can purchase reasonable insurance coverage for a flight operation via smart device application for instant or scheduled coverage (i.e., SkyWatch, AI, and Verifly). UAS or drone insurance typically covers personal, and insurance for manufacturers, military, law enforcement, film production, search and rescue, agricultural and other aerial work uses. Clearly, insurance companies now take the UAS industry seriously, and have not dismissed the UAS revolution as just another passing fad.

Regulatory Environment; Beyond Visual Line of Site (BVLOS)

Small UASs currently have limited operational capability (by design and regulation) to conduct T&D operations over manned helicopters. Until just recently, major obstacles to UAS and OPA use for these types of flights are the FAA's restriction of flying Beyond Visual Line of Sight (BVLOS) and obtaining airspace waivers. Many developments are being forwarded by the FAA (2018) instructing potential operators when and how to apply for a BVLOS waiver. Also, the FAA just released a draft Advisory Circular outlining a "well clear" definition for sUAS operating beyond visual line of sight. (AC # 90-WLCLR, 2018). "Well clear" is defined as a "hockey puck" shaped volume of airspace 2,000' horizontal by 250' vertical. sUAS must maintain these distances horizontally and vertically (but not necessarily both at the same time) from manned aircraft or ultralight vehicles. The information in the AC according to the FAA may support development of sUAS Detect and Avoid (DAA) systems as well as industry consensus standards for those systems.

The FAA recently (2018) instructed pilots how to apply for a Part 107 waiver to fly above the current 400' AGL altitude restriction. Congress, through P.L. 115-254 (2018), directed the FAA to develop ways to streamline the waiver process, both for commercial and public safety operators. The U.S. Department of Transportation's Office of Inspector General (OIG) also released a report on November 7, 2018 (Lillian, 2018) highly critical of the FAA's waivers process. The OIG audit found room for improvement, especially regarding the timeliness in approving waivers. The OIG report made eight (8) recommendations to the FAA. The FAA agreed with all but one and told the OIG that all other recommendations could be completed by August 2019. Also, President Trump's Integration Pilot Program (IPP) (FAA) initiative started in November 2017 and has initiated a great deal of testing and R&D in this area. Power companies, if not doing it already, could soon routinely be flying BVLOS in rural areas.

The FAA's approval of airspace waivers has been slow because of backlogs, contributed by an understaffed, onerous process, but potentially, with the full implementation of the Low Altitude Authorization Notification Capability (LAANC) in August 2018 (FAA, 2018), airspace waivers will be somewhat instantaneous in many locations. Wide-scale use of UAS for power or rail line patrol is now feasible upon airspace resolution through BVLOS flight and will continuously improve as sensor technology is advanced (Knight, 2015). The integration of OPA is a potentially challenging but relevant issue. Technology is advancing rapidly, and the industry could benefit from enhanced safety should a successful completion of an IPP be applied to OPA platforms.

Sense and avoid technologies are becoming more available, enhanced, and widely implemented on commercial off the shelf sUAS to prevent collision with obstacles. This technology could also have an immediate effect on reducing fatal accidents in manned operations. The integration of sense and avoid technologies into new and existing helicopters is the next logical step in the evolution of helicopter flight. This technology should not be stressed as a replacement for human pilots, but to assist in lightening pilot workload for higher risk flights, thus enhancing safety. However, costs of implementation of these systems may be a challenge for many operators.

The H-SE's listed below are also being implemented with several (H-SE-70 and H-SE-82) that dovetail nicely with H-SE 90:

- H-SE-70: Stability Augmentation Systems (SAS)
- H-SE-82: Helicopter Flight Data Monitoring
- H-SE-91: Enhanced Helicopter Vision Systems
- H-SE-100: Digital Cockpit

Aerial Application of Chemicals

UAS and OPA may also be able to save lives in the aerial application industry segment. In addition to the 2009 to 2013 dataset fatal wire strike accidents listed above, one helicopter struck a wire while engaged in an aerial spraying operation (USHST, 2017). However, in the 2014 to 2017 fatal accident dataset, three (3) of the thirteen (13) fatal accidents were the result of wire strikes in this segment. Two additional fatal accidents (for a total of five) occurred while on aerial application flights. One helicopter departed from a staging site and crashed for unknown reasons, and another is suspected to have encountered reduced visibility conditions and crashed due to spatial disorientation. In this particular case, the pilot was also under the influence of drugs, which also may have contributed to the accident.

The Japanese have used sUAS to spray crops for over 20 years. It is currently economical in Japan to service small parcels of farmland with UASs instead of a helicopter or airplane. The concept is catching on in the United States, also. The 200-pound Yamaha RMAX carries about four gallons of applicant. With a 10 to 15 minute endurance, it can cover 4 to 12 acres an hour. (Colborn, 2015). In May 2015, the RMAX received authorization to begin agricultural use under a Section 333 waiver in the United States. In December 2015, it was the first UAS to receive a Part 137 certification by the FAA. (Yamaha RMAX, 2016). In October 2018, Homeland Surveillance & Electronics LLC (HSE) – a full-service UAV company – together with UASolutions Group, Inc. – an aviation consulting firm – received approval from the FAA to begin operating an over 55-pound UAS for commercial operations. The AG-V6A+ is a fully autonomous, unmanned & remotely piloted multirotor designed for, the companies quote; "ultra-efficient spraying operations in agriculture, public safety, invasive species management, etc." (sUAS News, 2018). The UAS fully loaded with chemical weighs 75.3 pounds. The UAS is equipped with terrain following capabilities with up to 1-centimeter accuracy, and beyond average coverage rate. The companies claim that it's built for precision spraying and is already being used in other countries around the world.

Harold Summers, Director of Flight Operations for the Helicopter Association International recently commented on the emerging drone industry at the 2018 FAA Rotorcraft Safety Seminar in Hurst, Texas. Mr. Summers stated; "UAS's are coming, whether we in the industry like it or not…it's a fact." He further stated that existing operators are in the best position to get into the UAS business…and do it safely.

Low Level, Dirty, Potentially Complacent Flying Jobs

UAS and OPA could also help reduce the number of fatal accidents in other low level, dirty and potentially complacent flying jobs where fatigue and boredom can become significant risk factors. In the 2009 to 2013 dataset five additional fatal accidents occurred because of; cattle mustering, frost protection, cherry orchard drying (2 accidents), and low altitude law enforcement search operation. In the 2014 to 2017 dataset, one pilot was fatally injured herding cattle, one private operator was fatally injured after striking 35' poles in a canyon, and another private operator perished after striking a powerline while flying low level (80') over a river.

The technique of using helicopters to prevent frost is not a new one, but there is a tremendous amount of risk involved. On December 8, 2010, temperatures dipped into the freezing mark, causing green bean and sweet corn farmers in central Florida to jump into action to save their crops. Just days from harvest, farmers in desperation hastily contracted with dozens of helicopter operators from around the state to stir up the air above the crops to keep them from freezing. Three helicopters crashed during that cold night near Pahokee over or near prime cropland just southeast of Lake Okeechobee (NTSB. 2011). The next morning, after the sun came up, three company managers were dealing with one pilot in the hospital, and one substantially damaged, and two destroyed helicopters. One very high-time pilot stated he woke up in a crashed helicopter. He admitted he simply fell asleep. Another high-time pilot stated he was tired, and that there were no mechanical problems with the helicopter. The pilot stated had been awake for 18 hours and 30 minutes and had slept two hours prior to the accident. He further stated he had five hours and 30 minutes sleep in the previous 24 hours, and 14 hours sleep in the previous 72 hours. The helicopter was substantially damaged, coming to rest on its side with the skids ripped off. The pilot was evacuated by air ambulance to a trauma hospital. The third helicopter was damaged during refueling operations after striking a pole mounted fire extinguisher. In all three accidents, fatigue was a major contributing factor. (Colborn, 2016).

"Hot-dogging," or errant behavior by pilots is hard to prevent, as in the case of our two low-level private operators in the 2014 to 2017 dataset. A change in mindset and safety culture is required in these cases. But in the case of low level, dirty, and potentially complacent flights, such as frost protection and cherry drying where boredom and fatigue can lead to catastrophe, these jobs could be performed by optionally piloted helicopters that are capable of hovering around fields in most weather conditions. Until UAS develop to a size that can support flight requirements for frost protection and cherry orchard drying, likely UAS will not assume these types of jobs. However, OPAs, with extremely low human factor threats, could.

GPS Augmented Flight Logic Controllers and other Technology

OPA technology exists today and has been implemented in DoD since 2011 with use of the K-Max with the USMC in Afghanistan (Freedburg, 2014). In cooperation with the Defense Advanced Research Projects Agency (DARPA), Sikorsky is developing and testing an optionally piloted helicopter system called the Aircrew Labor In-Cockpit Automation System (ALIAS). Installed in a S-76B, the system according to company sources will change the way pilots fly, prevent CFIT accidents, and improve safety (Parsons, 2018). Sikorsky plans to begin flying a Blackhawk equipped with the ALIAS/Matrix Technology system soon. The company is also working with the FAA to gain certification for the system, so it can be made available for current and future commercial and military aircraft.

Installing a GPS augmented flight logic controller system with actuators into a manned helicopter has one immediate benefit – it reduces pilot workload. The aircraft can be piloted into hover mode so the pilot can concentrate on placing a payload depending on the operation profile. Perfect grid patterns can be flown on a search and rescue operation, and for topographic and magnetometer surveys. Sensors and systems enable target tracking. Police aircraft operations will benefit from this technology by maintaining observation while safely orbiting over a scene – pilot workload is reduced, and safety is enhanced. An aerial application pilot could set up a flight pattern and allow the flight controller to fly a grid over the target crop. Pilot workload in these types of low-level operations is substantial and autonomous capability to land the OPA through pre-determined conditions to a safe landing point mitigates risk. This technology helps reduce potential risk when fog or reduced visibility conditions are suddenly encountered. Current sUAS have this technology with a "GO-HOME" feature. In this scenario, the OPA could automatically level, climb to a safe altitude to clear any obstructions, and fly to a predetermined takeoff or landing point, and land itself without any intervention from the pilot. If self-leveling, hover-hold, return to home, and autonomous pre-planned flight regimes can be incorporated into "off-the-shelf" $1,000.00 consumer sUAS, it can certainly be incorporated into newly certified OPAs and helicopters, or even existing helicopters. With the new self-certification and performance-based standards for UAS and OPA recently mandated by Congress in P.L. 115-254 (2018), the FAA can now allow it to be done more efficiently and effectively than previously expected.

Currently available technologies in the UA marketplace are:

1. First person forward and multidirectional simultaneous view.
2. Automatic take-off and landing.
3. Self-levelling in flight or at hover.
4. Altitude hold.
5. Hover/position hold.
6. Autonomous and semi-autonomous flight with simultaneous data capture in 360 degrees relevant to the flight path.
7. Headless mode: Pitch control relative to the position of the pilot rather than relative to the vehicle's axes.
8. *Omni-directional collision avoidance: forward, rearward, sideward and downward.
9. Terrain following: maintaining constant AGL.
10. Automatic roll and yaw control.
11. GPS Waypoint navigation with mapping.
12. Geotagging of collected data
13. Georeferenced orthomosaics
14. 3-Dimensional point clouds
15. 3-Dimensional models
16. Digital Surface Modeling
17. Multi-spectral and Hyperspectral imagery
18. LiDAR Imagery
19. Infra-Red Imagery
20. Normalized Difference Vegetative Index (NDVI) imagery
21. Automatic logging of all flight data parameters.
22. Failsafe: automatic landing or return-to-home.

*This feature, using any of the following or a combination of all (cameras, lasers, and short- and long-range radar) are nearly standard equipment on many production automobiles today. The feature goes by many different names (forward obstruction warning, smart city brake support, collision mitigation, forward collision alert/warning, intelligent brake assist, Distronic Plus, pre-safe brake, Eyesight, etc.) but is essentially an anti-collision system.

Unmanned Traffic Management (UTM)

UTM is the major key to the integration of all types of UAS into the NAS. Multiple versions of UTM will be rolling out, each delivering differing types of capabilities for specific types of UAS operations. No one solution can fulfill all UAS operational needs (B. Marcus, personal communication, November 7, 2018). Mariah Scott, President of Skyward, a Verizon Company, testified on this subject before the House Subcommittee on Aviation on September 6, 2018 stating:

> We see UTM as a system of systems, a decentralized network like a wireless network or the Internet, for coordinating all types of aircraft. We believe this will be the most efficient, cost effective, scalable, and safest method for managing the national airspace.

Scott prefers to refer to UTM as Universal Traffic Management (Scott, 2018) rather than UAS Traffic Management as defined by the FAA and NASA. For a complete UTM system to work, NASA envisions a system or systems that would enable safe and efficient low-altitude airspace operations by providing services such as airspace design, corridors, dynamic geofencing, congestion management, severe weather and wind avoidance, route planning and re-routing, separation services, sequencing and spacing, and the ability to handle contingencies and emergencies. The system(s) would need to be automated also, and not require a human operator to monitor every UAS operation (NASA Ames, 2018).

The aircraft industry has operated for decades under a three-bucket certification method; 1) aircraft certification, 2) operator certifications, and 3) ATC certifications. The UAS industry concludes that it can no longer look at each of these certification methods in isolation…rather, addressing each at the same time. (B. Marcus, personal communications, November 7, 2018). Congress agrees and acted.

The 115th Congress, in P.L. 115-254 (2018), gave the FAA 270-days from enactment to update the Comprehensive Plan first outlined in the FAA Modernization and Reform Act of 2012, or P.L. 112-95 (2012). The Comprehensive Plan is a timetable for the integration of UAS into the NAS. P.L. 115-254 repealed previous processes created in P.L. 112-95 for acceptance and authorization that allowed, exigent of an actual airworthiness certificate (Section 333 for commercial operations and Section 334 for Public Safety operators), sUAS to fly in the NAS. The bill modified the methods used to adopt sUAS safety standards and mandated the FAA accept risk-based consensus safety standards related to items such as the design, production, and modification of sUASs. Also, manufacturers can self-certify if they meet the conditions of these consensus safety standards.

Before accepting the new Comprehensive Plan's (P.L. 115-254, 2018) mandated consensus safety and self-certification standards, the FAA must evaluate the following:

1. Technologies or standards related to geographic limitations, altitude limitations, and sense and avoid capabilities.
2. Using performance-based requirements.
3. Assessing varying levels of risk posed by different small unmanned aircraft systems and their operation and tailoring performance-based requirements to appropriately mitigate risk.
4. Predetermined action to maintain safety in the event that a communications link between a small unmanned aircraft and its operator is lost or compromised.
5. Detectability and identifiability to pilots, the Federal Aviation Administration, and air traffic controllers, as appropriate.
6. Means to prevent tampering with or modification of any system, limitation, or other safety mechanism or standard under this section or any other provision of law, including a means to identify any tampering or modification that has been made.

All prospective sUAS and UAS operators at some point in the future will have to prove to the FAA that they can operate a safe, airworthy vehicle using this new consensus-based safety approach to certification using performance-based requirements. Commercial operators previously had to demonstrate these requirements by obtaining a Section 333 exemption. The last 333 exemption was issued on September 28, 2016 and have since expired. 14 U.S.C Part 107 now regulates all commercial sUAS operations. Public safety agencies will continue to demonstrate these requirements by applying with the FAA for a Blanket or Jurisdictional Certificate of Waiver or Operation (COA). Also, 49 U.S.C. 44101 requires that, with a few exceptions (e.g. U.S. Armed Forces aircraft), an sUAS be registered. 14 CFR Part 48 provides for the registration of a sUAS through the FAA website. §48.15(b) provides an exception to the registration requirement if the the UA weighs .55 pounds or less. Registration was halted by a court action for several months until Congress reinstated sUAS registration on December 12, 2017 with P.L. 115-91 Section 1092(d).

P.L. 115-254 (2018) also mandated that all sUAS operations be regulated, even hobby flights. Model aircraft operators flying at local AMA clubs will be required to take an aeronautical knowledge and safety test. The FAA has 180-days from the enactment of P.L. 115-254 to develop this test. And eventually, anyone who flies anything in the NAS, including modelers, will be required to have Remote ID. This was the intent of Congress in P.L. 115-254 behind the repeal of Section 336 (the exemption in P.L. 112-95 that prevented the FAA from regulating model aircraft flyers). It is no secret that the model aircraft community is highly upset by this repeal, but they must be brought into the fold.

LAANC – The First Step toward UTM

A major portion of controlled airspace in the United States under 400’ AGL, as of this writing, is segmented into blocks with the LAANC system. This was the first step toward UTM. LAANC has processed more than 50,000 applications from drone operators for authorization to fly in controlled airspace since the program started in November 2017 (FAA News, 2018). Now that all aircraft operations (including kids flying big box store drones and hobby flyers flying model airplanes and helicopters) will be regulated, and LAANC has been fully implemented, operators in the next step will be required to demonstrate to the FAA that they know who else is flying in their area, and where. This will be accomplished through remote identification (estimated by an industry expert within one year).

Remote ID – The Next Step

In 2015, the FAA chartered the Unmanned Aircraft Systems Identification and Tracking Aviation Rulemaking Committee (ARC) to provide recommendations to the FAA regarding technologies available for remote identification and tracking of UAS. (ARC Recommendations. 2017). Although some decisions of the working groups were not unanimous, the ARC reached general agreement on many of their recommendations to the FAA. But the ARC did not reach consensus on an applicability threshold for ID and tracking requirements. The bottom line behind the difficulties the groups faced was due to competing interests, and who should be exempted from ID requirements. Modelers felt strongly that they should be exempt. Also, initially there was a push to exempt public safety from the requirements. FAA Administrator Daniel K. Elwell, during a speech at InterDrone Las Vegas on September 5, 2018 (before P.L. 115-254 became law), commented that the FAA must be able to identify everyone who is flying in the NAS, "But right now, the FAA's hands are tied by a law that says we cannot require remote identification on model aircraft," Administrator Elwell stated. He also pointed out that "until we can set remote ID requirements that will be universally applied to every drone…until we can make sure everyone is following the same rules inside the system…full integration just isn't possible." (Elwell, 2018).

Congress gave the Administrator what he wanted. But how long will it take to develop a Remote ID system or systems industry and government can agree upon? The DOD, the Department of Justice (DOJ), and the Department of Homeland Security (DHS) take national security seriously, and ID tracking is imperative to that mission. They must be able to identify anything flying near sensitive areas, especially considering Congress in P.L. 115-254 gave the DOJ and DHS permission to eventually down errant drones that are a threat to government and national security assets. They must coordinate with other agencies, conduct research, and conduct rulemaking first. The "Preventing Emerging Threats Act of 2018" (which was not included in the UAS section of P.L. 115-254, but later at page 337 in Division H) gives these agencies the authority to detect, identify, monitor and track UAS without prior consent if a UAS poses a threat to the safety or security of a covered facility or asset. Covered facilities or assets include a wide breath of protected government facilities like prisons, federal buildings and other federal assets. Protection missions undertaken by DHS (functions of the U.S. Coast Guard and U.S. Customs and Border Protection, including securing or protecting facilities, aircraft, and vessels); duties of the U.S. Secret Service (dignitary protection); DOJ assets and facilities under the protection of U.S. Marshalls and Federal Bureau of Prisons; and the protection of National Special Security Events, are all included. These agencies have the authority to identify and track errant UASs, attempt to warn the operator if possible, then disrupt, seize, or exercise control over the UAS. And if necessary, they can use reasonable force to disable, damage, or destroy the errant UAS. The Feds are serious about this issue and clearly want strict guidelines for an ID tracking system that will ensure security of high priority facilities and targets and address counter-UAS issues. Reaching a consensus with industry is difficult. And the plethora of developers and manufacturers of counter-UAS systems are not helping. These companies have a vested interest in exaggerating the fear of drones, and the perception of the threat they pose to the NAS and national security. According to a recent Wall Street Journal article, this issue is becoming a major impediment that will delay UAS rulemaking and integration (Pasztor, 2018).

Eventually, the path to full UTM will include redundant command and control paths to the vehicle (Command and Control or C2), and electronic identification that facilitates automated deconfliction, or Detect and Avoid (DAA).

UTM and Remote ID Funding – Who Will Pay?

The industry and legislators face a major challenge. Who will pay for these systems? The Drone Advisory Committee (DAC) – which until recently was under the auspices of the RTCA but is now commissioned directly by the FAA, is a broad-based, long-term federal advisory committee that provides the FAA with advice on key UAS integration issues. The committee is comprised of CEO/COO-level executives from a cross-section of stakeholders representing the wide variety of UAS interests, including industry, research and academia, retail, and technology (FAA. 2018). The DAC established Task Group 3 (TG-3) to research and recommend funding avenues to facilitate full UAS integration into the NAS. The sub-committee released their *Drone Integration Funding* final report in March 2018 (DAC, 2018). The group offered numerous suggestions for longer-term funding and potential funding mechanisms. The Airport and Airway Trust Fund should not fund UAS integration the group suggested. The group recommended, however, that drone industry-related activities should be funded by a comparable mechanism. TG-3 offers several options; user fees, point of sale tax, business use or transaction tax, public/private partnership, auction or lease of airspace, and/or airspace access charges.

The DAC TG-3 also summed up the issues facing UTM deployment in page eight of their report (DAC, 2018). They list eight impediments to rulemaking milestones. One of the more interesting includes President Trump's Executive Order 13771 (January 30, 2017) – which requires each agency to identify two regulations to repeal before initiating a new one. Could this delay FAA rulemaking? Also, on their list is the collaboration between FAA and the national security and law enforcement agencies on security and counter-UAS issues. Most importantly TG-3 stressed; resolution of the recommendations of the ARC on identification and tracking rulemaking is critical. UTM will only become a reality when the industry and government reach a consensus on some sort of Remote Identification, or Drone ID.

The Industry is Emerging Quickly

NASA's UTM national testing campaign consisting of four Technology Capability Levels (TCL) (started in 2016 with an anticipated completion date of 2020), is well into Level 3 tests according to documents on the NASA UTM website. (NASA-UTM). Level 2 testing focused on BVLOS in sparsely populated areas. Level 3 tests include cooperative and uncooperative UAS tracking capabilities to ensure collective safety of manned and unmanned operations over moderately populated areas. Level 4, with test dates to be determined, would involve UAS operations over high-density urban areas in anticipation of tasks for package delivery, news gathering, etc. The UAS Integration Pilot Program (FAA, 2017) was launched last year by President Trump as a means to further define and speed up this progress.

UAS Integration Pilot Program

The 2017-2018 work between industry and government under the UAS Integration Pilot Program (IPP) (FAA, 2017) is an effort to evaluate a host of operational concepts, including night operations, flights over people and BVLOS, package delivery, detect-and-avoid technologies and the reliability and security of data links between pilot and aircraft. These operational capabilities may allow supplementing more manned helicopter operations than previously thought. One such program emerging from this IPP is the Kansas Department of Transportation and IRIS Automation testing that began late October 2018, focusing on enabling new detect and avoid capabilities for UAS in BVLOS operations in rural communities (AUVSI News, 2018). The Lee County, Florida, Mosquito Control District, one of ten awardees of the program, proposes using a 1500-pound UAS for aerial applications to control and surveil mosquito populations. A majority of the awardees propose to research BVLOS, ADS-B and UTM and radar technologies that will give the FAA the data they need to implement programs and assist in rule-making.

Industry Standardization Efforts

Due to the lack of published UAS flight standards by the FAA, the industry has laid down a major effort to publish various standards that support elements such as manufacturing, flight training, flight operations, maintenance and specific segment (or functional area) uses. The information below comes directly from the relevant entities.

National Institute of Safety and Technology (NIST) Efforts. The National Institute of Standards and Technology (NIST) has developed a set of Standard Test Methods for Aerial Systems. These standards, which include flight testing methods, could eventually become the standard for credentialing local, state and federal government public service agencies, as well as hobbyists and commercial operators.

Association of Unmanned Vehicle Systems International (AUVSI) Efforts. The following is an excerpt from the AUVSI Top Operator Program website and literature:

> Becoming a commercial drone pilot and operating a UAS represents an exciting and rewarding career in a dynamic and emerging industry, but from a regulatory perspective, there is little required for the commercial drone operator to demonstrate competency or proficiency in his or her operations (AUVSI, 2018).

Excellent training courses are available to prospective UAS pilots, however to date, there is no industry unification with respect to Remote Pilot competency training or testing programs. This also effects the end users of UAS-enabled services, as there is no clear mechanism to ensure that the customer is going to receive what they believe they are paying for.

The product or service the customer receives is of critical importance. How UAS pilots conduct themselves and ultimately how their UAS-enabled services are perceived by customers and the public is also critical. Trust and reliability are direct positive outcomes of a professional, competent UAS pilot.

Research tells us that operating a UAS presents unique human performance and risk-producing factors that can manifest into mistakes, mishaps and accidents. Even simple mistakes can translate into both direct and indirect costs, ranging from small inconvenient losses to catastrophic expenses. If these risk factors are not perceived accurately and treated appropriately by the UAS pilot, they expose themselves and their clients to these potential losses. A professional UAS pilot's responsibility is above all else, safety, due diligence and duty of care, which covers many aspects of personal and professional responsibilities.

The Trusted Operator Program (TOP) and the TOP Protocol Certification Manual (PCM) is an international guide to closing the gaps between basic regulatory compliance and encompasses elements of:

- Safety culture
- Airmanship
- Codes of conduct
- Risk management
- Best practices
- Human performance in the system
- Automation awareness
- Non-technical skills

Mastering awareness and competency in these areas is paramount to ensure the safe and sustainable future of the commercial UAS industry.

American Society for Testing and Materials (ASTM) Efforts. The ASTM produced several standards for the UAS industry. One, is a guide to provide a standardized means of facilitating Remote Pilot training. The guide should be used by all individuals and agencies that train such persons and is intended for two distinct readers: educators who wish to develop curricula and training courses, and individual pilots wishing to raise their knowledge level for particular flight operations. The guide describes the knowledge, skills, and abilities required to safely operate unmanned aircraft for commercial purposes. A Civil Aviation Authority (CAA) may, at their discretion, use this guide to aid the development of existing or future regulations. The guide addresses powered fixed-wing, vertical-take-off and lift and rotorcraft UAS, but not other potential unmanned aircraft categories (for example, glider, lighter-than-air, etc.).

National Fire Protection Association (NFPA) Efforts. This organization has endeavored to publish standards for public safety operations. The *NFPA® 2400, Standard for Small Unmanned Aircraft Systems* (from their literature), is being developed by representatives from all types of public safety departments with UAS, including the fire service, law enforcement, and emergency medical services. The scope of NFPA 2400 covers the following; organization deployment and considerations for sUAS, professional qualifications for sUAS public safety personnel, and maintenance of sUAS.

Department of Interior (DOI). Published the *Interagency Fire Unmanned Aircraft Systems Operations Guide* (PMS 515) in July 2017. A publication of the National Wildfire Coordinating Group, the Guide types UASs, assigns operational characteristics and standardizes radio call signs, and lays out operational requirement and considerations for UAS in interagency wildland fire fighting roles. The Guide also defines airspace coordination, recommends elements for flight operation planning and procedures, considers safety and risk mitigation, and defines UAS incursion situations.

Public Safety UAS Best Practices – Regional UAS Standards. The North Central Texas Council of Governments (NCTCOG) and the Capitol Area Council of Governments (CAPCOG) collaborated on a project that created and published Standard Operating Guidelines to assist public safety jurisdictions regionally and statewide in developing UAS programs and response operations. The 45-page document of best practices is the collaboration of Coitt Kessler (Austin FD) and Greg Cutler (Mansfield OEM, and a member of the North Texas UAS Response Team) and members from the NCTCOG, CAPCOG, and their subcommittees. The intent is for jurisdictions to adopt and incorporate these best practices into their UAS programs. The document will assist in creating common program and response operation standards throughout the region and state. The Guidelines are meant to be a living/breathing document to be updated yearly and released by a joint committee of the two COGs or as needed.

Education Segment of Industry

One vital component of the future of the UAS industry is related to growing an intelligent, safety minded workforce who are capable of enhancing future industry accomplishments. Educating future pilots, engineers, operators, and related professionals has already begun. In the lower levels, we enjoy aggressive movement in the Science, Technology, Engineering and Math (STEM) programs from K-12 in public and private education offerings. UAS is fully integrated in this realm. States and organizations have been fully engaged. As an example, Embry-Riddle Aeronautical University supports the Gates Aerospace Institute in the state of Florida at over 85 high schools. Insitu INC supports an annual Roboflight Academy in Washington state which is a week-long sUAS STEM program of immersion into UAS engineering and flight. In Texas, Drone Innovations Inc. is an organization with a STEM outreach supporting a five-state area which brings drone kits to the K-12 levels focusing in robotics, engineering, and video production. In the collegiate environment, the FAA's Center of Excellence for UAS Research supports the Alliance for System Safety of UAS through Research Excellence (ASSURE). There are 23 institutions of higher learning who participate as members of affiliates.

Both STEM programs and collegiate education (degree seeking and professional programs) are on the rise and are feeding this industry with professionals who will provide continuous improvements and innovations. Exploration and discovery appears in K through Masters degree levels which mimics the levels of interest not seen since the Second World War. All of this work will continue to expand and develop a growing industry with future leaders.

Threats to the Integration of UAS into the NAS.

According to Brian Wynne, President of AUVSI and Gary Shapiro, CEO of the Consumer Technology Association (techcrunch.com, 2018), there is a group of lawyers (the Uniform Law Commission, or ULC) meeting soon in Detroit that are trying to limit UAS operations using the guise of "privacy concerns." According to Wynne and Shapiro, the group is planning to propose nationwide legislation that draws an inflexible, arbitrary line 200 feet in the sky and, if enacted by the states, would establish a new aerial trespass law. Essentially, it would prevent any overflight of UAS over private property below 200 feet above ground level. The ULC's proposal, according to Wynne and Shapiro, would create roadblocks to UAS use, stifle innovation, halt job creation and slow growth in a still-nascent industry. They also feel it could prevent businesses and public service organizations from using UAS and could limit, among other commercial operations, powerline and railroad inspections. And according to Wynne and Shapiro, the ULC proposal incorrectly states the DOT, FAA and others are supportive of their Act despite on-the-record letters opposing ULC efforts. But, the ULC plans to promote their Tort Law Relating to Drones Act (NCOCUSL, 2018) drafted in July 2018, anyway.

Similar legislation, the Drone Federalism Act of 2017, or S. 1272, was a bill introduced in the 115th Congress by U.S. Senators Tom Cotton (R-AR), Dianne Feinstein (D-CA), Mike Lee (R-UT), and Richard Blumenthal (D-CT) on May 25, 2017. The bill was read twice and referred to the Committee on Commerce, Science, and Transportation, but luckily never gained any traction and has since died.

Enforcing UAS Regulatory Compliance.

The U.S. Government Accountability Office (GAO) is currently conducting a study on how local law enforcement agencies are handling UAS compliance and enforcement issues. Among some of the questions asked include; to what extent are UAS operations a law enforcement issue or a risk to the public in a particular agency's jurisdiction; familiarity with FAA UAS regulations; the extent of contact with the FAA's Law Enforcement Assistance Program (LEAP), and/or communications with local Flight Standards District Offices. The study seeks to learn the amount of support local agencies give to the FAA during investigations of non-compliance with FAA rules. They also want to know if local agencies are pursuing separate criminal or misdemeanor UAS investigations and taking enforcement action separate from the FAA's compliance process. They want to know if the investigations local agencies undertake differ from those involving the FAA. The GAO also wants the respondents to rate the potential challenges their agencies undergo in completing a UAS compliance or enforcement investigation, for instance; lack of evidence, lack of Aircraft Safety Investigator (ASI) knowledge or training in handling UAS investigations, lack of FAA resources to devote to investigations, or other impediments. And lastly, the GAO wants to know what more the FAA could do, if anything, to further support the safety of all aircraft in the NAS.

State, county, and local police officers generally cannot enforce federal regulations. Also, state, county, and local police officers cannot make property seizures for violations of federal regulations. State, county, and local agencies can only take enforcement action, or seize property, when a local ordinance, county or state law is violated. Upon being alerted of an errant UAS operator, state, county, and local law enforcement officers can seek out the errant UAS operator, and if found conduct an interview. The errant UAS operator's information can then be passed to an FAA ASI. The extent of the interview is limited to whether there is a local ordinance, county, or state law violation. In the absence of both, if the person being contacted about the errant UAS operation refuses to cooperate, the state, county, or local law enforcement officer cannot detain that person and must let them go.

P.L. 115-254 (2018) (the 2018 FAA Reauthorization Bill), in its final stages through Congress, had a provision added by the Senate. Codified in the bill, it is now a federal crime to "knowingly" (acts consciously or with knowledge or complete understanding of the facts or circumstances) or "recklessly" (defined as the state of mind where a person deliberately and unjustifiably pursues a course of action while consciously disregarding any risks flowing from such an action) disrupt the operation of an aircraft carrying 1 or more occupants with a UAS in a manner that poses an imminent safety hazard to such occupant(s). Operating within a runway exclusion zone is included. An operator can be fined and imprisoned up to one year, or both. If serious bodily injury occurs out of such an act, the perpetrator can get a fine and imprisonment for up to 10 years, or both. Take out an airliner, and the UAS operator will get life. Each state now needs a law similar to 18 U.S.C. 39B, *Unsafe Operation of Unmanned Aircraft,* that gives law enforcement officers powers to make an arrest and seize a UAS when said UAS is operated in a reckless manner or posing a safety hazard to manned aircraft or people on the ground.

The development of laws prohibiting the shining of a laser light at an aircraft followed a similar path suggested above. In February 2012, it became a federal crime to aim a laser light at an aircraft (P.L. 112-95, 2012). Shortly thereafter, the Texas Legislature created Penal Code *42.14 Illumination of Aircraft by Intense Light*. Before this legislation was enacted, local, county and state law enforcement officers had few options to deal with individuals pointing laser lights at aircraft. This is the state of the law now in Texas, and many states, regarding errant UAS enforcement. If a law enforcement official caught a person aiming a laser light at an aircraft before the state law listed above was enacted, their only option was to charge the subject with the penal code violation of Assault if the intense light caused pain or damage to the eyes of the pilot(s). The perpetrator's information could then be turned over to the FAA for possible pursuit of civil fines. This ambiguity was removed from the law at both the state and federal level. A person pointing a laser at an aircraft can immediately be arrested by a local, county or state law enforcement officer, placed in jail, and the laser light seized as evidence. This gives the arresting agency time to contact the proper federal authorities, who can then decide if the case rises to the level needed for federal prosecution. The U.S. Attorney's Office can choose to take over prosecution of the case or allow the state court to handle the matter. Either way, the perpetrator is off the streets and no longer creating a danger to air commerce. Local, county and state law enforcement officers in every state need a respective state version of *18 U.S.C. 39B, Unsafe Operation of Unmanned Aircraft.* So far this year, only ONE state has proposed this kind of legislation; West Virginia.

Federal Preemption and State and Local Laws

As of July 2018, at least 30 states had attempted to pursue or were actively pursuing legislation to regulate the use of UAS. Eleven states (CA, DE, FL, IA, MI, MS, NM, SC, UT, VT and WA) were/are pursuing legislation to prohibit the operation of UAS over and into correctional institutions (Cauthen, 2018). Some municipalities have also done the same to limit drone flights over their city limits. The city of Newton, Massachusetts in December 2016, passed an ordinance requiring drone registration and banned flights below 400' AGL over city limits. The ordinance was later struck down by a U.S. District Court judge (Singer v. Newton, 2017). Many towns and states are more concerned about privacy rights and wording their legislation accordingly. Unfortunately, many of these proposals are redundant and attempt to create new voyeur or trespass laws for activity that is already illegal under existing statutes. One legislator in New Jersey introduced a bill that quote; "urges the FAA to expand restrictions on flights of unmanned aerial vehicles" (NJ Res. No. 103, 2018).

This SME Team is a huge proponent of FAA preemption, and at this time is not a fan of more state laws, or local ordinances hindering lawful, useful, and productive UAS operations. UAS are aircraft as defined by federal law, and thus should be regulated when they are being operated within the NAS, by federal regulations. Leave the regulating of UAS to the aviation experts. Unfortunately, politicians and legislators have a compulsive tendency to act purely on emotion or fear, creating bad law, or laws that have unintended consequences. An excellent case in point is the Texas Privacy Law added to the Texas Government Code in 2013. *Chapter 423: Use of Unmanned Aircraft*, which makes it a misdemeanor crime, with a drone; "to capture sound waves, thermal, infrared, ultraviolet, visible light, or other electronic waves, odor, or other conditions existing on or about real property in this [Texas] state or an individual located on that property." (Chapter 423, 2013). There are exemptions for law enforcement, utilities and ag inspections. But essentially, capturing images or video of private property with a drone – without immediately destroying them – is a crime in Texas. An owner or tenant of a privately-owned property can enjoin, in civil court, a penalty of $5000 for all images captured in a single episode. If those images are uploaded to the Internet or broadcast on television, the responsible person can be enjoined in civil court for a penalty of $10,000. Since most of the land in Texas is privately held, this law has essentially barred nearly all UAS use by journalists in the state. Yet a newsroom can send out a helicopter equipped with a high power gyrostabilized camera system to capture images of the same private property at any time. This is a shining example of bad and ill-conceived law. It is an unnecessary law that was created to prevent, ostensively in the future, what may or may not become an issue or problem and was already covered by existing laws.

Create Further Legislation: Only When the Timing is Right

In the future, however, once UTM is initiated and UAS are integrated into the NAS, it would not be considered unreasonable for local governments to impose some restrictions on UAS flights over their cities. This is especially true when delivery and passenger UASs take to the skies, as they certainly will. For instance, many cities have local rules that govern the weight of trucks that are allowed on certain streets or restrict truck traffic altogether. These are rules to ensure quality of life, by limiting excess noise and ensuring the safety of citizens and pedestrians. The same types of rules may be needed to limit the amount, type, or times (both day and night) of UAS traffic over certain areas. Citizens expect privacy, especially in their homes and immediate surrounds, or curtilage. Currently, UAS pilots must research or know the UAS laws in the areas where they are flying. An increasingly complicated patchwork of federal, state, and local UAS laws can and will be overwhelming for UAS pilots and discourage commerce. The FAA should take the bull by the horns and declare preemption. They should not be encouraging state and local legislative bodies to make new laws limiting UAS operations at this time. Once an autonomous UTM system, or systems, is developed, any new local rules for certain flight paths or altitude restrictions for instance that respect the concerns listed above, can be incorporated into those systems.

Summary

Change is coming fast to this industry. The USHST could have easily chosen to disregard this issue because UAS integration into the NAS is already in progress. Without the assistance or influence of this report, the marketplace may have self-resolved the challenges presented by the relevant incidents and accidents. This report does, however, provide validation of the need for all the UAS development projects that are now in progress or planned with respect to high risk, low-level operations.

UAS integration is happening because industries and consumers have captured the attention of Congress, and Congress is now ensuring it will happen. The technology advancements and speed to which they occur have become too important and beneficial to the masses. Therefore, Congress added Section 370 to P.L. 115-254, outlining the Sense of Congress on Additional Rulemaking Authority for the DOT and FAA. BVLOS, night time operations, and operations over people of UAS has tremendous potential, Congress stressed. It is believed this potential will enhance both commercial and academic use.

UAS will spur economic growth through innovative application of emerging technology, and most poignant to our discussion on reducing not only fatal accidents, but all accidents, Congress wrote; "…advancements in UAS technology will have the capacity to ultimately improve manned aircraft safety." All ongoing efforts listed in this document supports the USHST's fatal helicopter accident reduction goal of 20% by the year 2020.

Finally, as the integration of UAS into existing helicopter entities is conducted, there will likely be some resistance to this idea and issue and UAS integration recommendations of this effort. The business case should be debated and argued separately as the focus of HSE-90 is helicopter accident reduction in high-risk operations.

Recommendations

Optionally Piloted Vehicles. Aside from the documented safety benefits (in reducing lives lost) and reduced costs of operating sUAS in traditional low level, dirty, and potentially complacent flying jobs where fatigue and boredom can become significant risk factors; the technology can be integrated into existing helicopters to reduce pilot workload, increase accuracy of targeted tasks, and increase productivity. Technology is advancing rapidly, and the industry could benefit from enhanced safety should a successful completion of an Integrated Pilot Program be applied to OPA platforms as well.

Sense-and-Avoid Technology. The integration of sense-and-avoid technologies into new and existing helicopters is the next logical step in the evolution of helicopter flight. This technology could also have an immediate effect on reducing fatal accidents in manned operations.

Wire Strikes. UAS and OPA may also be able to save lives in the aerial application industry segment where too many fatal wire strike accidents occur. Sense and avoid technology is another capability that should be integrated with these platforms for these operations.

Preparing for the Future. Section 350 of P.L. 115-254 refers to the use of UAS at institutions of higher education. The FAA must also address the use of sUAS at K through 12 education levels, specifically STEM programs for school kids which get them interested in technology. The new regulations must address drone racing as well, an emerging sport that is growing in popularity and getting international attention. Knowledge, skills and abilities are continually built as a result of advancements. The workforce of tomorrow that will research, develop, manufacture and maintain these machines, however, must begin growing today.

UA Replacing Helicopters in Specific Operations. This analysis demonstrates that advancements and integrations can save lives with UAS in jobs that entail higher risk flight. Recommend operations for data collection in T&D and their supporting structures, conducting T&D surveys or patrol, pipeline patrol, and even wind turbine inspections be integrated first with UAS. As technology and regulatory environments allow, OPAs can help scale accordingly in these flight operations and most specifically to support frost protection in agriculture or similar jobs where risk to manned operations are susceptible to fatigue and boredom.

Skills Assessments Beyond the RPC. The current written test requirement for a Remote Pilot Certificate is acceptable with UAS under 55 pounds. However, UAS larger than 55 pounds are subjected to different rules at the moment. In the future, there will be a need to practically assess pilot flight skills due to complex operations with higher risk. Considering this, preparations have begun within the industry. The Trusted Operator Program from AUVSI extends the knowledge, skills and abilities beyond the limits of the RPC certification. The community based standards by these types of organizations can help reduce risk significantly.

Preemption. The FAA should declare Preemption. They should not be encouraging state and local legislative bodies to make new laws (except a state law similar to *18 U.S.C. 39B, Unsafe Operation of Unmanned Aircraft*) limiting UAS operations. Further state and local laws will only stifle the industry at this very important and delicate time.

A Consensus on Remote ID or ID Tracking Is Needed. There is confusion, disagreement, and divergent agendas separating industry and government (specifically federal law enforcement) on the resolution of recommendations for ID tracking. More research and development is imperative before rulemaking can begin. A consensus is critical and must be reached.

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Attachment 1

About the Authors

Mark Colborn, Senior Corporal/Instructor Pilot

Mark Colborn is a Senior Corporal and Instructor Pilot for the Dallas Police Department Helicopter Unit, which currently operates two Bell helicopters. Mark is also a retired Chief Warrant Officer Four (CW4) and former UH-60L Blackhawk Standardization Instructor Pilot and Safety Officer for the Texas Army National Guard. Mark started his law enforcement career in 1986 with Dallas, working as a patrol officer in the Southwest Patrol Division. Assigned to the Helicopter Unit in 1990, Mark has assisted in the apprehension of thousands of criminals and participated in hundreds of pursuits of violent offenders.

Mark is a certified FAA Remote Pilot and was one of the first Section 333 operators to receive a Part 107 daylight waiver from the FAA.

Mark joined the IHST in 2006 and has participated in the analysis of over 1000 U.S. commercial helicopter accidents. He is a correspondent for Rotor & Wing International magazine specializing in UAS, law enforcement, and helicopter safety issues. He has also written over 50 articles for other magazines since 1993, to include; AirBeat, Monitoring Times, Popular Communications, Scanning USA, HeliOps and HeliWeb.

Scott Burgess, Ph.D., RPI/CFI/IP, RPC

Dr. Scott Burgess' 34 years of aviation experience includes both military and civil aviation organizations. He is a qualified instructor pilot in seven military and civilian helicopters, with fighter jet experience, and numerous SUAS. Scott recently added an AUVSI Trusted Operator Program Remote Pilot Instructor certification.

With the Embry-Riddle Aeronautical University (ERAU), Dr. Burgess authored the helicopter academic and flight program at the Prescott Campus where he was from 1999-2007, then moved to the ERAU Worldwide Campus. Professor Burgess developed dozens of rotorcraft and UAS courses and several programs at both campuses.

He participated in numerous UAS and manned flight training concept developments and flight training for entities in the U.S., Asia and the Middle East. Dr. Burgess conducts accreditation visits with the Aviation Accreditation Board International, American Council on Education, and the Commission for Academic Accreditation (UAE). Burgess chaired Embry-Riddle’s largest degree program for four years before pursuit toward tenure and conducting aviation safety and UAS research.

Dr. Burgess works closely with the IHST and USHST, and Helicopter Association International, where he currently serves as Chairman for the UAS Committee.

Wayne M. Keeton, Owner/Manager, Helicopter Accident Consulting, LLC

Wayne Keeton served as a commissioned officer in Vietnam during a one-year combat tour and retired from the Texas Army National Guard as a Chief Warrant Officer Five (CW5). During a 40 year military career, Wayne served in various aviation pilot and leadership positions including Standardization Instructor Pilot, Electronic Warfare Officer, Tactical Operations Officer, and Joint Operations Officer and platoon leader. Wayne deployed to El Salvador for a humanitarian support mission in 1998, Bosnia for a NATO peacekeeping mission in 2003, and Operation Iraqi Freedom in 2007.

As owner of Helicopter Accident Consulting LLC, Wayne provides consulting services for aviation accidents and incidents to interested parties, including investigation, reconstruction, report writing and technical witness services. Wayne has broad-based experience in civil and military aircraft and aviation operations. This provides him with a solid foundation for producing well researched and accurate findings in accident investigations and reconstructions, leading to compelling reports and expert testimony. In 1982, Wayne founded a full-service marketing and communications firm (Keeton & Rich, Inc.) specializing in the aviation/aerospace industry.

Helicopter Safety Enhancement (HSE)-90 Use of UAS or OPA in High Risk Environments/Operations	
Safety Enhancement Action:	Technology/Equipment: FAA and industry to encourage the increased use of UAS (Unmanned Aircraft Systems), and continued development and integration of OPA (Optionally Piloted Aircraft) or autonomy-enabled helicopters, to supplement and support manned operations in high-risk operations or environments.
Expected Implementers:	• FAA – UAS Integration Office (AUS) • USHST Outreach Team • Helicopter Association International (HAI) UAS/OPA Committee • Association for Unmanned Vehicle Systems International (AUVSI)
Statement of Work:	In 10 of the 52 LOC-I, UIMC, and LALT fatal accidents from USHST's 2009-2013 dataset, the working group concluded that integrating either UAS or an OPA could have mitigated some of the risks during the operation. Applications that can be performed by UAS or an OPA continue to grow. Given the continued expansion of UAS and OPA (both in sensor and performance) capabilities, their use to supplement and support operations is logical when manned operations are particularly high risk, such as in low level situations, especially near wires. The intent of this H-SE is to mitigate risks in situations in which manned flight puts individuals at unnecessary risks of injury or death, and suitable unmanned or autonomously assisted options exist to support or supplement the operations. The following conditions should be met in order for UAS or OPAs to be a reasonable compliment to existing, conventional manned helicopter flight in higher-risk operations: 1) Easy to obtain. 2) Compliant with security requirements of various customer needs. 3) Cost-efficient for operators to utilize in performing a specific operation. 4) Does not result in any additional risk (to the safety pilot or remote pilot, support personnel, or bystanders) that would not have otherwise been present with the current manned operation. **Analysis:**

	Four (4) out of the ten (10) accident helicopters that spurred this H-SE struck a wire while engaging in low-level activities. This included: photo documentation of the condition of powerlines and their supporting structures, conducting power line surveys or patrol, or pipeline patrol. Small UASs (SUASs) feasibly could be used for these operations (within the limitations listed in *Potential Obstacles* section) instead of manned helicopters. Sense and avoid technologies are available and being enhanced and more widely implemented to prevent collision with obstacles. The team believes it could have an immediate effect on reducing fatal accidents in manned operations. The integration of autonomous systems and collision avoidance into new and existing helicopters is the next logical step in the evolution of helicopter flight. This technology should not be stressed as a replacement for a human pilot, but to assist and lighten the workload for the pilot during missions assessed in higher risk realms. Costs of implementation of these systems may be a challenge for many operators. One immediate benefit of installing a GPS flight logic controller system into an existing or optionally piloted helicopter is pilot workload is reduced. The machine can be put into hover mode so the pilot can concentrate on placing a payload depending on the mission profile. Perfect grid patterns can be flown on a search and rescue mission, and for topographic and magnetometer surveys. Sensors and systems enable target tracking. One example of how this technology would enhance existing operations is that it would allow a police helicopter to maintain observation while safely orbiting over a scene, thus reducing pilot workload and enhancing safety. In the other 6 cases, wire strikes occurred while engaging in aerial application (1), cattle mustering (1), frost protection (1), cherry orchard drying (2), and low altitude law enforcement search mission (1). Until UA develop to a size that can support mission requirements for frost protection and cherry orchard drying, most likely sUAS will not assume these missions, but they could be performed by optionally piloted helicopters currently capable of hovering around fields in most conditions with extremely low human factor threats. Currently available technologies in the UA marketplace are: 1. First person forward and multidirectional simultaneous view. 2. Automatic take-off and landing. 3. Self-level. 4. Altitude hold. 5. Hover/position hold.

	6. Autonomous and semi-autonomous flight with simultaneous data capture. 7. Headless mode: Pitch control relative to the position of the pilot rather than relative to the vehicle's axes. 8. Omni-directional collision avoidance: forward, rearward, sideward and downward. 9. Terrain following: maintaining constant AGL. 10. Automatic roll and yaw control. 11. GPS Waypoint navigation with mapping. 12. Geotagging of collected data 13. Georeferenced orthomosaics 14. 3-Dimensioonal point clouds 15. 3-Dimensioonal models 16. Digital Surface Modeling 17. Multi-spectral imagery 18. NDVI imagery 19. Automatic logging of all flight data parameters. 20. Failsafe: automatic landing or return-to-home. The 2017-2018 work between industry and government under the UAS Integration Pilot Program (IPP) is an effort to evaluate a host of operational concepts, including night operations, flights over people and beyond visual line of sight, package delivery, detect-and-avoid technologies and the reliability and security of data links between pilot and aircraft. These operational capabilities may allow supplementing more manned helicopter operations than previously thought. Action on this program starts in May 2018. This H-SE dovetails nicely with the following H-SEs already being implemented (especially HSE-70 and HSE-82): HSE-70: Stability Augmentation Systems (SAS) HSE-82: Helicopter Flight Data Monitoring HSE-91: Enhanced Helicopter Vision Systems HSE-100: Digital Cockpit **Project:** 1. Industry to identify operations and environments that are more susceptible to high-risk conditions for manned helicopter operations and for which use of a UAS or OPA could be viably integrated to mitigate risks. 2. Industry to consult with FAA regarding existing operating limitations for UAS and OPA and whether any policy/guidance change would be necessary for UAS or

	OPA to operate in the conditions or environments identified in Output 1. 3. USHST Outreach Team to promote increased integration of UAS for the high-risk conditions identified in Output 1 and deemed feasible based on the FAA's feedback provided in Output 2 (must meet both conditions). 4. Industry to work with the FAA to develop standards for integrating autonomous systems and collision avoidance into existing helicopters, and outlining requirements for future OPA still in development. The following 10 fatal accidents prompted this H-SE: WPR13FA343 ERA13GA046 WPR13FA080 ERA13LA057 CEN11FA053 ERA09LA139 WPR11FA350 WPR09FA284 WPR12LA259 ERA10LA348
Relation to Current Aviation Community Initiatives:	• 14 C.F.R. Part 107 allows for commercial UAS operations. • FAA Low Altitude Authorization and Notification Capability (LAANC) Prototype Evaluation (Fall 2017) • UAS Integration Pilot Program lead applicant MOA (May 7, 2018) • FAA UAS Data Exchange • Drone Advisory Committee • Focus Area Pathfinder Program • UAS Detection Initiative • UAS Operations in the Arctic Program
Performance Goal Indicators:	• Continuous technology advancements in the industry • Educational materials developed. • Educational materials distributed and promoted.

Key Milestones:	Total Months / Start Date / End Date Output 1: 12 / Jun. 1, 2018 / Jun. 1, 2019 Output 2: 12 / Jun. 1, 2019 / Jun. 1, 2020 Output 3: 6 / Jun. 1, 2020 / Dec. 1, 2020 Output 4: 6 / Dec. 1, 2020 / Jun. 1, 2021 **Completion: 36 months**
Potential Obstacles:	Currently, the major obstacle to UAS and OPA use for the missions referenced above is the FAA's restriction of flying Beyond Visual Line of Sight (BVLOS) and other operations, however, with the POTUS IPP initiative starting November 2017, this may resolve within the 36-month window. At present, approval of airspace waivers are slow because of backlogs, although with the planned implementation of LAANC in June 2018, airspace waivers will be somewhat instantaneous in many locations. Wide-scale use of UAS for power or rail line patrol will slowly become economically feasible as BVLOS flight is cleared, and sensor technology is improved. Most initiatives relate to UAS under 55 lbs. The integration of OPA is a potentially challenging but relevant issue. Technology is advancing rapidly and the industry could benefit from enhanced safety should a successful completion of the IPP be able to be applied to the OPA platforms.
Detailed Implementation Plan Notes:	Materials should include recommendations for training and mentoring crews to understand and implement the recommended (best) practices. Additional industry standards anticipated in 2018 that will be applicable to this H-SE are the AUVSI Trusted Operator Program and the UAS Pilots Code. Safety processes must also be integrated into the manned flight as an enhancement to existing safety protocols of implemented SMS.
CICTT Code:	LOC, UIMC and LALT
Output 1:	
Description:	Identify operations and environments that are more susceptible to high-risk conditions for manned helicopter operations and for which use of a UAS or OPA could be viably integrated to supplement or support operations to mitigate risks.

Lead Organization:	HAI – UAS/OPA Committee
Supporting Organizations:	• FAA (*e.g.*, AUS) • USHST • AUVSI
Actions:	1. HAI UAS/OPA Committee and USHST to establish a small team of UAS/OPA SMEs (H-SE 90 SME Team) to research operations and environments that are more susceptible to high-risk conditions for manned operations and for which a UAS or OPA could be a viable to support or supplement operations. 2. H-SE 90 SME Team to conduct a basic review or analysis of the fatal accidents where the working group recommended H-SE 90 as a solution is outlined above in the Statement of Work. The Team should use the USHST's working group data from these LOC-I, UIMC, and LALT fatal accidents as a starting point for further research. They should also consider any recent studies from academia on the subject. 3. H-SE 90 Team to organize the results of the analysis in Output 1 into a brief, formal report to submit to the USHST Outreach Team. The report should also have enough structure and formality to be submitted to the FAA such that any issues involving proposed new use of UASs or OPA can be clearly communicated, addressed, and resolved.
Output Notes:	A dedicated UAS/OPA subgroup/team within the USHST may be necessary in the future.
Time Line:	12 months
Target Completion Date:	Jun. 1, 2019
Output 2:	
Description:	USHST Outreach Team to consult with FAA regarding existing operating limitations for UAS and OPA and whether any policy/guidance change would be necessary for UAS and OPA to be integrated and operate in the conditions or environments identified in Output 1.
Lead Organization:	USHST Outreach Team
Supporting Organizations:	• FAA – AUS • HAI – UAS/OPA Committee • UAS SME Team (formed in Output 1) • AUVSI
Actions:	USHST Outreach Team will submit findings of the H-SE 90 Team to FAA – AUS. The purpose is for FAA – AUS to identify whether

	any of the conditions or operations identified in Output 1 would require any policy/guidance change(s) prior to implementation. The USHST Outreach Team will coordinate a meeting to receive feedback from the FAA after the FAA's review.
Output Notes:	It is possible that some of the conditions/environments identified by the H-SE 90 Team will be acceptable to the FAA under the current policy/guidance, while others will not. For those that are already acceptable without any policy/guidance change, the USHST Outreach Team should not delay in engaging industry.
Time Line:	12 months
Target Completion Date:	Jun. 1, 2020
Output 3	
Description:	USHST Outreach Team to promote increased integration of UAS for the high-risk conditions identified in Output 1 and deemed feasible based on the FAA's feedback provided in Output 2 (must meet both conditions).
Lead Organization:	USHST Outreach Team
Supporting Organizations:	HAI – UAS/OPA Committee
Actions:	USHST Outreach Team will use face-to-face opportunities, social media, website presence, and other forms of media to communicate the findings of the UAS/OPA SME Team and encourage operators to use UASs or OPAs in cases of the conditions or environments identified in Output 1 and acceptable under current FAA regulation, policy, and guidance.
Output Notes:	
Time Line:	6 months *(for initial outreach, ongoing after that time)*
Target Completion Date:	Dec. 1, 2020
Output 4	
Description:	Industry to work with the FAA to develop standards for integrating autonomous systems and collision avoidance into existing helicopters, and outlining requirements for future OPA still in development
Lead Organization:	H-SE 90 SME Team
Supporting Organizations:	HAI – UAS/OPA Committee
Actions:	The H-SE 90 Team shall explore mechanisms to encourage manufacturers and the FAA to invest in R&D and develop standards for integrating this technology into new and existing helicopter airframes, including drafting a white paper and or coordinating meetings to highlight the value and need.

Output Notes:	It is possible that some of the technologies identified by the UAS/OPA SME team will be acceptable to the FAA under the current policy/guidance, while others will not. For those that are already acceptable without any policy/guidance change, the USHST Outreach Team should not delay in engaging industry. The issues that do require policy/guidance revision would obviously need to wait for engagement with industry.
Time Line:	6 months
Target Completion Date:	Jun. 1, 2021