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This paper presents a model to address the increased workload for air traffic controllers (ATC) due to the integration of unmanned aircraft systems (UAS) into the airport ecosystem. The FAA established small UAS operational regulations in 2016. Already, UAS pilots comprise over 20% of the total pilot population, and UAS account for 89% of the total aircraft registrations. Given current FAA resource constraints and the forecast growth of air traffic, innovative safety management solutions are required to address the increase in controller workload and the associated safety risks. This research presents one perspective regarding the impact of UAS operations on air traffic controller workload and a conceptual model to address the increase in UAS operations at airports. The model proposes designating predetermined UAS safety zones, or routes, inside the airport. By limiting UAS operations to designated zones, controller resources may be more focused while maintaining an acceptable level of safety.

Air traffic controllers (ATC) are responsible for air traffic management in the national airspace system (NAS). ATC workload and ergonomics is a wide-ranging topic due to the multiple responsibilities that encompass equipment, operations, communications, and management (Loura, 2014). ATC workload is expected to increase due to projected increases in air traffic (after aviation recovers from the pandemic). The impact of this increase will be exacerbated when coupled with the number of UAS currently flying in the NAS and the continued growth of UAS activities

In 2012 the Federal Aviation Administration (FAA) introduced the Modernization and Reform Act that actively seeks to integrate civil UAS into the NAS (FAA, 2013). The FAA asserted that UAS standards shall mimic traditional "manned aircraft training standards to the maximum extent possible" (FAA, p. 28, 2013). This proliferation of UAS technologies requires ATC not only to undergo additional training but also maintain situational awareness across an increasingly complex airspace system, such as multiple aircraft types at different altitudes, emergency situations, and manned-unmanned interoperability. Ultimately, ATC will maintain overall responsibility for air traffic separation based on airspace class and the type of UAS without necessarily maintaining a direct link to the UAS. The FAA has also called for various entities in air traffic management to cluster and work towards air traffic interoperability, which in the current aviation scenario can create increased workload on existing ATC personnel. One example of this workload increase is the difference between UAS and manned aircraft flight plans (Semanek and Kamienski, 2015).

Integration of UAS in the NAS has certainly impacted the ATC system, which includes controller job tasks and responsibilities. For example, in 2017, the FAA launched the Low Altitude Authorization and Notification Capability (LAANC), which allows both civil and public UAS operators to expeditiously obtain FAA authorization to fly in controlled airspace near airports. LAANC automates the application and approval process for airspace authorizations through the use of internet-based technologies. LAANC allows pilots to receive their authorization in near-real time and is currently available at 538 air traffic facilities and 731 airports, and the FAA continues to add locations (FAA, 2020a). Another option is the FAA Drone Zone, which allows UAS operators to request airspace waivers; these waivers enable longer term access to controlled airspace and may allow for UAS operations on the airport property itself (FAA, 2020b). The maturation of these regulatory policies and processes have enabled more UAS operations near airports and at airports. These activities also require additional responsibility and/or tasks for ATC controllers.

According to Semanek and Kamienski (2015), the impact on ATC must be considered and the potential increase in ATC workload may be concerning. UAS issues include "UAS flight plan, UAS communication link, UAS types, and training for ATC regarding UAS" (p. 1049). UAS potentially increases ATC workload in terms of flight plan issues and control and communication (C2) link (Semanek and Kamienski, 2015). Traffic management of small UAS may be a strenuous task as the lack of UAS identification and tracking capabilities continue to persist. Vu et al. (2014) suggest UAS in the NAS negatively affects safety of the NAS, stating "[the] increasing number of UAS did negatively impact the ATC's performance to some degree" (Vu et al., p. 6, 2014). This increase in workload may adversely affect the performance of ATC controllers, such as increases in work-related stress and fatigue.

In response to these challenges, this research presents the use of UAS safety zones, which provide an operational area that has been predetermined to increase the safety of UAS operations within the airport area. These systems allow for ongoing hazard assessment through strategic use of technology that may only require monitoring by controllers, minimizing direct controller interdiction and communication with UAS operators. This model provides one way to simplify UAS operations at airports and help address the safety of the projected increase in UAS operations to support airport activities while minimizing the effect of this additional traffic on ATC workload. There is significant interest in UAS for airport operations due to its ease of use, mobility, and low cost. UAS can be used for scheduled maintenance of airport navigation aids such as the instrument landing system (ILS) and VHF omnidirectional radio range (VOR) system (Bredemeyer & Schrader, 2018). The mobility aspect of UAS allows "critical areas to be accessible only with a flying platform" (Bredemeyer & Schrader, p. 279, 2018). As the UAS is a relatively small machine, it is possible to record measurements in unsafe areas with more precision, cost-effectiveness, and optimal time (Bredemeyer & Schrader, 2018).

Lawrence and Mackie (2019) of Woolpert Inc. detailed the practical use of UAS at Savannah Airport. The team successfully integrated UAS into the airport ecosystem to support wildlife mitigation, first responder services, pavement inspections, and UAS based security services (Lawrence and Mackie 2019). Integrating UAS operations with traditional airport traffic may be achieved through ATC coordination, robust safety systems, coordinated flight systems, and compliance with all FAA guidance in Class C airspace (Lawrence and Mackie 2019).

Additional benefits of UAS were elucidated by Hubbard et al. (2017) regarding the applications of UAS at airports such as airport obstruction analysis, runway and taxiway pavement surveys, wildlife mitigation, emergence response services, airport construction aid, and post-snow runway inspections. Advances in UAS technology and the benefits it may provide to airport stakeholders has led to the exploration of UAS airport applications along with techniques to safely integrate UAS with manned aircraft operations.

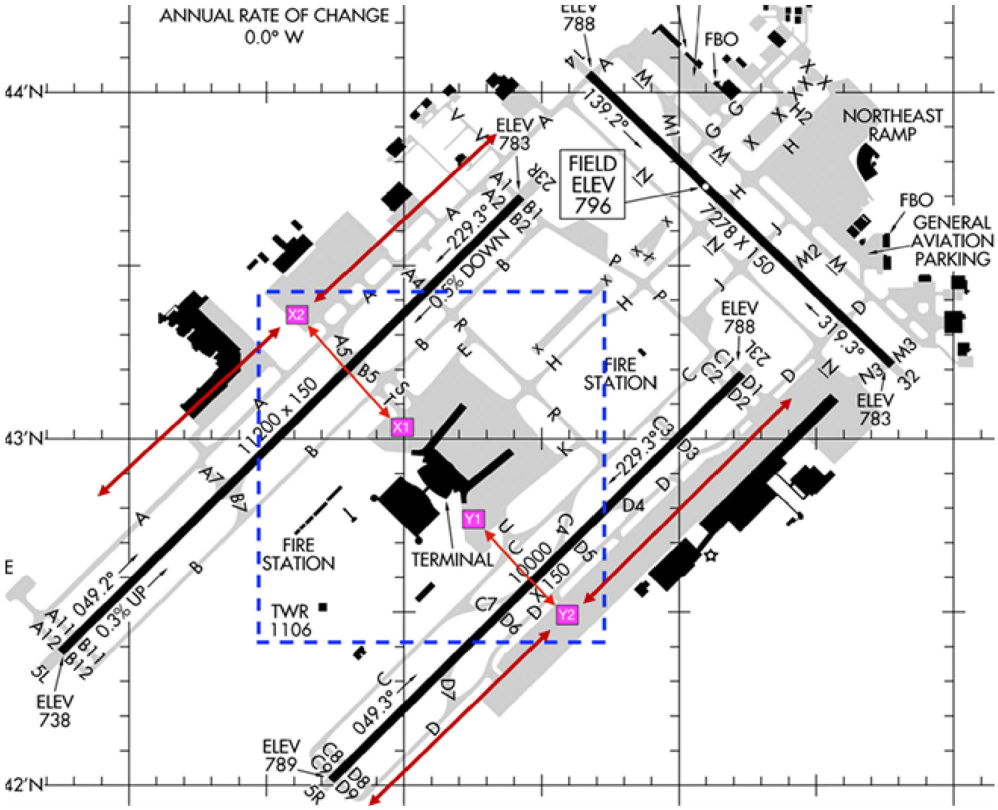
The initial review of literature found that ATC workload may be impacted with the integration of UAS in the NAS, whereas UAS operations on and near airports is expected to accelerate. Looking beyond the current use cases, the accelerated development of Urban Air Mobility has now moved well beyond the concept phase and presents further challenges to controlling air traffic in the NAS (FAA, 2020c). This paper explores the issue of ATC workload and attempts to provide a working concept of UAS at airports to aid day-to-day operations.

UAS Safety Zones – A Theoretical Model

The concept of designated operating areas for air traffic is not new. The FAA has designated air routes across the United States with one of the primary benefits being more efficient traffic management, increased safety, and reduced air traffic control workload. An intuitive way of facilitating the operation of UAS in the airport environment is by identifying dedicated corridors with appropriate safety zones for UAS. Zones that enable and restrict movement of UAS through certain waypoints in the airspace. This concept is similar to the FAA's military training routes (MTR), which are specific routes designated to separate military activities below 10,000 feet and speeds above 250 knots (FAA, 2016). In terms of flight corridors inside urban cities, utilization of a robust UAS traffic management (UTM) system, safety systems, and aligned interests between government bodies and UAS entities may promote the logistical use of UAS (Ronczka, 2018). The recent development of a 50-mile UAS corridor in the state of New York as a test site for UAS operations beyond visual line of sight (BVLOS) provides an example of the method to advance toward an ultimate goal of full interoperability between manned and unmanned aircraft.

Referring to Figure 1 below, UAS safety zones are identified on the airport map, which will facilitate UAS operations. Two safety zones: Zone X1 – X2 and Zone Y1 – Y2. UAS will be operated along a fixed designated route inside these zones. The UAS will be monitored by a ground controller to facilitate effortless movements. Points defined below, X1 and Y1 represent UAS-stations near the airport terminal whereas points X2 and Y2 are UAS-stations across the runways 05L and 05R respectively. Figure 1 also shows safety zones that run perpendicular to points X2 and Y2, illustrated by red arrows. Such zones support UAS transport inside the airport at some routes that may not overlap with a taxiway or runway and facilitate the formation of UAS safety zone linkages. These safety zones will extend across runways and taxiways to form a transportation route.

Figure 1. A theoretical example of UAS safety zones at Indianapolis International Airport.



Note. Airport diagram obtained from FAA website (for representation purpose only).

UAS flight paths through these safety zones will be defined based on fixed waypoints. Waypoints will be used by the UAS to fly specified paths across airport runways under a controller's supervision. These waypoints will also be developed with consideration for manned aircraft operations at airports. Designated flight times for UAS through these zones (especially zones that fly over runways) can be determined based on characteristics of manned aircraft activities. Due to its mobility feature, UAS may allow transport across runways in reduced times. Integration with the airport operations ecosystem will be the most essential feature of this model. UAS operations may be coordinated with manned aircraft operations to support simultaneous operations of manned-unmanned airport operations.

To provide clarity about the course of UAS, guidance paths can be setup on a virtual display that enables the controller to maintain a visual line of sight (VLOS) with the UAS. As seen in Figure 1, the location of the control tower (TWR 1106) is in line of sight of the proposed UAS safety zones, which are Zone X1 – X2 and Zone Y1 – Y2. These virtual paths will complement airport lights and taxiways to enhance UAS traffic management. A designated, identifiable UAS path on a virtual display will aid in better management of UAS operationally and visually.

Use of Technology

UAS integration may present a hazard during emergency situations at airports such as manned aircraft runway incursions and excursions, obstacle collisions, ground vehicle collisions, and wildlife strikes. To mitigate such hazards, geofence technology may be used. Geofence technology inside airport boundaries may prohibit the UAS from initiating launch. Ongoing emergency situations may require unobstructed airspace; therefore, restricting UAS flights. Inflight UAS will be forced to land at a designated location within these safety zones, such as those designated as X1, X2, Y1, and Y2 in Figure 1. Geofence activation may be easily initiated by controllers when responding to an emergency.

Safety is also enhanced by UAS sense and avoid technology. This technology uses onboard sensors to detect, sense, and avoid any obstructions in the UAS flight path. The use of sense and avoid technology may further increase airspace safety in terms of manned-unmanned interactions. The ability of an UAS to avoid dangers with the assistance of sensors may aid ground controllers when flying beyond visual line of sight.

Summary

Coupling UAS into daily airport operations presents some challenges but this paper presents one approach to support the safe integration of UAS at airports, manned-unmanned flight coordination, UAS strategic flight-path planning, and UAS safety zones. The proposed safety zones may also reduce ATC's UAS related workload. Initiation of UAS safety zones may support a decrease in the number of ground vehicle movements while reducing the time associated with such movements. Ultimately, the use of these UAS safety zones may promote efficient management of controller workload, while supporting safe UAS airport operations.

Future Research

Further research needs to be done to identify the technical aspects of integrating the UAS into the airport ecosystem using such proposed safety zones. This includes operational details, financial analysis, and regulatory issues. Financial analysis should be used to quantify the cost of using UAS and the benefits to the airport and airport tenants as well as benefits to ATC. Regulatory issues include compliance with FAA regulations for air traffic control as well as ground operations at the airport.

References

Bredemeyer, J., & Schrader, T. (2018, April). Employing UAS to perform low altitude navaids measurements. In *International Flight Inspection Symposium (IFIS), Monterey, California*. http://www.icasc.co/sites/faa/uploads/documents/20th_IFIS_Papers/Papers/IFIS18-0026.pdf

Federal Aviation Administration (FAA). (2013). *Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap.* Retrieved from https://www.faa.gov/about/plans_reports/modernization/media/Sec.332(a).pdf

Federal Aviation Administration (FAA). (2020a). *FAA UAS Data Exchange (LAANC)*. Retrieved from https://www.faa.gov/uas/programs_partnerships/data_exchange/

Federal Aviation Administration (FAA). (2020b). *FAA DroneZone*. Retrieved from https://faadronezone.faa.gov/#/

Federal Aviation Administration (FAA). (2020c). *FAA Urban Air Mobility and Advanced Air Mobility*. Retrieved from https://www.faa.gov/uas/advanced_operations/urban_air_mobility/

Federal Aviation Administration (FAA). (2016, August 24). *Pilot's Handbook of Aeronautical Knowledge,* Chapter 15. Retrieved from https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/17_phak_ch15.pdf

Federal Aviation Administration (FAA). (2016). The FAA's New Drone Rules are Effective Today [Press release]. Retrieved from https://www.faa.gov/news/updates/?newsId=86305

Hubbard, S., Pak, A., Gu, Y., & Jin, Y. (2017). UAS to support airport safety and operations: opportunities and challenges. *Journal of unmanned vehicle systems*, *6*(1), 1-17. https://doi.org/10.1139/juvs-2016-0020

Kamienski, J., & Semanek, J. (2015). ATC perspectives of UAS integration in controlled airspace. *Procedia Manufacturing*, *3*, 1046-1051. https://doi.org/10.1016/j.promfg.2015.07.169

Loura, J. (2014). Human factors and workload in air traffic control operations-a review of literature. *International Journal of Management and Social Sciences Research*, *3*(3), 1-5. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.428.6877&rep=rep1&type=pdf

Mackie, T., & Lawrence, A. (2019). Integrating unmanned aircraft systems into airport operations: from buy-in to public safety. *Journal of Airport Management*, *13*(4), 380-390. https://woolpert.com/resource/integrating-unmanned-aircraft-systems-into-airport-operations-from-buy-in-to-public-safety/

Ronczka, J. (2018, December). System engineering and logistical UAS corridors: Challenge the present to drive the future. In *2018 26th International Conference on Systems Engineering (ICSEng)* (pp. 1-8). IEEE. https://doi.org/10.1109/ICSENG.2018.8638249

Vu, K. P. L., Strybel, T., Chiappe, D., Morales, G., Battiste, V., & Shively, R. J. (2014, July). Air traffic controller performance and acceptability of multiple UAS in a simulated NAS environment. In *Proceedings of the International Conference on Human-Computer Interaction in Aerospace* (pp. 1-7). https://doi.org/10.1145/2669592.2669693