

Statement of

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Chairman Smith, Ranking Member Johnson and Members of the Subcommittee:

Thank you for the opportunity to comment on the status and challenges of integrating Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS). I am a Professor of Aeronautics and Astronautics at the Massachusetts Institute of Technology and the Co-Chair of the FAA Research and Development Advisory Committee (REDAC). The REDAC is a Congressionally mandated committee which advises the FAA Administrator on research and development. I should note that while my testimony is informed by my participation on the REDAC, due to time constraints my comments have not been coordinated with my REDAC colleagues so I am speaking as an individual today.

The emergence of UAS technologies and potential operations are arguably the most exciting and innovative areas in aerospace today. The confluence high computational power and sensors in very small packages such as those in modern “smart phones” coupled with advanced flight control algorithms have opened the door to a broad spectrum of highly capable UAVs. From an aircraft design point of view entirely new performance regimes and configurations become possible when we don’t have to worry about the limitations of the human occupants and their life support systems.

The spectrum of emerging UAVs is quite vast. Ranging from very small and maneuverable UAVs weighing only a few grams to large scale military UAVs such as the Predator and Global Hawk. From a technical point of view even large scale transport category UAVs are feasible today.

When considering integration of UAS into the NAS it is important to consider the diversity of potential UAS vehicles and applications as it is clear that a “one size fits all” approach will not work due to broad range of vehicle size, capability and types of potential UAS in the NAS operations.

For the purposes of this discussion I will identify 4 different operating categories where distinct Concepts of Operation (Con-Ops) and standards are required. For each of these

operating categories it is necessary to develop a Con-Ops that allow safe UAS integration into the NAS. When considering UAS safety the traditional considerations of occupant safety which dominate requirements for manned aircraft do not apply. Instead the secondary considerations of avoiding injury or damage to property on the ground (“ground risk”) or risks from midair collisions (“midair collision risk”) drive the hazard analysis and system design.

Small UAS operating at low altitude in Line of Sight of the Operator (SUAS-LOS)

The easiest category to develop a Con-Ops for NAS integration is the Small UAS (SUAS) operating within Line of Sight (LOS) of the operator. Midair collision risk is minimized due to the low density of manned aircraft at low altitudes coupled with the UAS operators visual back up to land or avoid infrequent low altitude aircraft such as a Medevac helicopters. Ground risk is minimized by the small size of the vehicles and operator monitoring. New technologies such as “electronic bumpers” are being developed to improve the operators capability.

This category is the focus of the long anticipated and inexplicably delayed SUAS rule. We have a well established Con-Ops and years of experience based on radio controlled model aircraft which can, and should, provide the basis for this operating category. The delay in regulation has resulted in a somewhat perverse status where well informed, trained, responsible commercial and research operators are not allowed to fly while hobbyists with sometimes poor knowledge and limited experience are free to operate, often identical, SUAS.

Small UAS operating at low altitude Beyond Line of Sight of the Operator (SUAS-BLOS)

For the second category when SUAS are operated Beyond LOS of the operator the Con-Ops and standards development are much less mature. The ground collision risk remains relatively low, particularly for low mass vehicles. However, controlling the flight trajectory to avoid people or property will require some level of autonomy or a high quality communications system if the operator needs to be part of the control loop. In addition, although SUAS operations are below the majority of manned operations, some sort of surveillance or traffic management will be required to monitor for the possible presence of manned aircraft. There are currently many open research questions in this area. The appropriate Con-Ops will depend on the technical capabilities of the vehicles as well as standards and performance of the communication and surveillance systems employed. For example, can current cell phone communication networks be employed to give communication and surveillance beyond line of sight, what is the appropriate level of autonomy for SUAS-BLOS?

Until recently there has been very little research in this domain by either NASA or the FAA. The current NASA efforts in Unmanned Traffic Management are starting to address this issue but the efforts are in the embryonic stage. There has been some development by the DOD and the private sector but a well accepted Con-Ops has yet to emerge.

High Altitude UAS

The High Altitude UAS category has received significant attention due to the interest of the DOD and the Con-Ops are more mature here. These vehicles are large enough and of sufficient value to justify sophisticated, heavy, power hungry avionics and high bandwidth satellite communications. Such aircraft spend most of the time at altitudes or locations in which they can be segregated from manned aircraft and only need to have a method to transit to their operating altitudes or locations. They must be able to satisfy the “sense and avoid” requirement to replace the vision of the human pilot and this has been the focus of much research in UAS either through onboard systems or external surveillance. It is unclear if the approaches developed for these relatively large, expensive systems will be applicable to smaller UAS due to size, cost and power limitations.

UAS Integrated with Manned Aircraft

The most challenging category of UAS operations are those where the UAS must routinely operate in the same airspace as manned aircraft. Many of the most valuable UAS applications such as emergency and disaster response will require that the vehicles operate near airports or in locations and altitudes where manned aircraft also operate. Clearly in this category the risks associated with mid air collision are higher due to the close proximity of the manned and UAS aircraft. This risk must be mitigated by procedural and/or technical solutions. While this is the most difficult problem it is also the one that has received the least attention. To my knowledge there is no clear Con-Ops that has been defined for this category of operations. There are an enormous number of open questions on how these operations will occur.

As an example, for Instrument Flight Rule (IFR) operations it is possible to consider Con-Ops where the UAS operates just like a manned IFR aircraft with additional communication systems. Even in this domain, it is unclear how controllers and the pilots of the manned aircraft will interact with the UAS particularly in non-normal events such as when the communication link to the UAS fails.

While full integration of UAS operating in the same airspace as manned aircraft may be further away and thus may have received less attention, it is a much more challenging environment than the other categories I have discussed above. We should be conducting the research now that will support developing the Con-Ops and standards for the future.

I will comment briefly on the specific questions you have asked me to address.

- 1. What are the high priority and emerging issues associated with aviation safety resulting from the integration of Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS)?**

The fundamental issue which has emerged is the lack of clear Con-Ops for the various UAS operating categories to define the research requirements as well as the technical standards, procedures and regulations which would enable timely UAS integration in the

NAS. As I indicated above there must be multiple Con-Ops to account for the diversity of UAS vehicles and operating environments.

Many policy issues have also emerged. The integration of UAS into the NAS is very challenging for the FAA. The current system is exceptionally safe and the FAA is charged with maintaining and improving safety. Adding new types of vehicles and operations to the system adds new risk areas. There are legitimate policy questions on how to mitigate these risks and enable UAS access. Similarly there are policy issues about the relative importance of UAS vs. manned aircraft. Finally there are emerging concerns regarding the privacy implications of extensive UAS operations in the NAS.

From a research and technical perspective there are a number of generic issues which have emerged independent of the specific Con-Ops which are decided on. Some of these include:

- Communication architectures for low altitude UAS operations
- Development of autonomous systems for UAS operations
- Low cost, low power “detect and avoid” systems for aircraft and ground objects
- Applicability and limitations of ADS-B for UAS operations
- Interaction of ATC controllers with UAS systems and operators
- Loss of communication protocols
- Spectrum management
- UAS operator training requirements
- Emergency Procedures and non-normal operations
- Low altitude operations safety
- Certification of non-deterministic software
- Cyber security issues specific to UAS (e.g. Command uplink integrity)
- Alternatives to detect and avoid
- Ground risk based airworthiness standards for UAS

In considering the Con-Ops definition and technical issues it will be important to leverage the technical and operational capabilities of NextGen. For example, ADS-B should provide the basis for surveillance in UAS Con-Ops. In order to fully exploit ADS-B for SUAS, it will be necessary to develop standards for small, low power ADS-B systems and deal with potential issues of frequency congestion. System Wide Information Management (SWIM) will provide a mechanism for coordinating UAS and manned aircraft operations. Other areas such as Data Com may require UAS and SUAS specific solutions.

As a final issue, the delay in developing reasonable rules and inconsistencies in current guidance coupled with proliferation of low cost, highly capable vehicles has resulted in an effectively unregulated environment in the SUAS arena. In most cases the operations are responsible but there have been some cases of ill considered operations and some highly publicized interactions with manned aircraft or reported risks on the ground.

2. What does the FAA need to know before it can start initial UAS rulemaking and how does that knowledge relate to the high priority and emerging safety issues

you identified above? Are current plans and supporting projects for UAS research defined in such a way that they can provide FAA with the prioritized information conducive to making timely issuance of UAS rules? If not, what specific research needs to be done, how long will it take, and what is your estimate of the resources that are required?

The answer to this question varies by the category of UAS operations. For SUAS-LOS and probably for High Altitude UAS the FAA has what it needs to know to start initial UAS rulemaking. For the other categories of SUAS-BLOS and Integrated UAS there does not appear to even be an agreed upon baseline Con-Ops on which to base the research to support rulemaking.

From what I am aware of, the current plans and supporting projects for UAS research are not defined in such a way that they can provide the FAA with the prioritized information conducive to making timely issuance of UAS rules.

The FAA first needs to conduct research to inform decisions regarding Con-Ops and standards development. Once these Con-Ops and standards are defined this will provide the basis for prioritized research requirements to support the implementation of the Con-Ops.

I am not in a position to give a reliable estimate of the resources required but it is clear that the level of resources that the FAA has been able to devote to UAS integration in the NAS have not been sufficient to maintain the rate of progress that the Congress and the public have expected.

3. How could a collaborative research effort combining federal, academic, and private sectors be leveraged to help fill research gaps? What organizational models could Congress consider for such a collaborative effort?

I am encouraged by some recent activities by NASA and the FAA. The nascent NASA Unmanned Traffic System program has stimulated significant interest in industry and academia and is starting to work on key questions regarding SUAS-BLOS Con-Ops. The NASA effort should be encouraged and expanded to enable stronger participation by academia and industry and addressing a broader set of issues.

On the FAA side I am pleased that the FAA is in process to develop a Center of Excellence in UAS. The COE model is quite effective at developing collaboration between federal, academic and private sector researchers. It will be critical for the FAA to define research needs for the COE. This should include both research to support Con-Ops development and research to support implementation of those Con-Ops which have been defined.

I would note that is important to find ways to engage the DOD UAS research community in the FAA and NASA efforts. The DOD is one of the principal operators and has significant operational experience and research experience to bring to the table

I am less confident in the importance of the FAA test sites. There is a need for some experimental testing capability but the current 6 test sites appear to exceed the near term need. Selecting and managing the sites has been a drain on limited FAA UAS resources. It will be important to clearly define testing requirements to support Con-Ops development and implementation which should be the basis of a focused approach to the allocation of resources to test sites and the rapid approval of test plans.