UAS in the NAS: Survey Responses by ATC, Manned Aircraft Pilots, and UAS Pilots

James R. Comstock Jr.

Raymon McAdaragh

Rania W. Ghatas

Daniel W. Burdette

Anna C. Trujillo

UAS in the NAS: Survey Responses by ATC, Manned Aircraft Pilots, and UAS Pilots

James R. Comstock, Jr.
NASA Langley Research Center

Raymon McAdaragh
SGT, Inc., Hampton, VA

Rania W. Ghatas
NASA Langley Research Center

Daniel W. Burdette
Northrop Grumman Technical Services

Anna C. Trujillo
NASA Langley Research Center
Hampton, VA

NASA currently is working with industry and the Federal Aviation Administration (FAA) to establish future requirements for Unmanned Aircraft Systems (UAS) flying in the National Airspace System (NAS). To work these issues NASA has established a multi-center "UAS Integration in the NAS" project. In order to establish Ground Control Station requirements for UAS, the perspective of each of the major players in NAS operations was desired. Three on-line surveys were administered that focused on Air Traffic Controllers (ATC), pilots of manned aircraft, and pilots of UAS. Follow-up telephone interviews were conducted with some survey respondents. The survey questions addressed UAS control, navigation, and communications from the perspective of small and large unmanned aircraft. Questions also addressed issues of UAS equipage, especially with regard to sense and avoid capabilities. From the ATC and military ATC perspective, of particular interest is how mixed-operations (manned / UAS) have worked in the past and the role of aircraft equipage. Knowledge gained from this information is expected to assist the NASA UAS in the NAS project in directing research foci thus assisting the FAA in the development of rules, regulations, and policies related to UAS in the NAS.

The NASA "UAS Integration in the NAS" project is tasked with facilitating the process of developing the rules, regulations, and requirements needed to safely fly UAS of a variety of sizes and capabilities in the NAS. The U.S. General Accountability Office (2012) recently published a status report of progress towards integration efforts led by the FAA towards UAS Integration. A UAS Access Research and Development roadmap has also been developed by the NASA Langley Research Center (Verstynen, Foggia, & Hoffler, 2010). Key to the success of having UAS fly in the NAS, regardless of their size, is attention to the human factors issues of the Ground Control Station (GCS). The U. S. Department of Defense (2012) has published a GCS Human-Machine Interface Development and Standardization Guide, and other publications (e.g., McCarley & Wickens, 2005) have focused on the human factors issues of UAS in the NAS.

The purpose of the present paper is to present preliminary findings from on-line surveys that were conducted sampling the three major players involved when UAS are flying in the NAS. The surveys were targeted at ATC, including military ATC, pilots of manned aircraft, and UAS pilots. The surveys assessed the participant's background and experience in their particular area, followed by questions asked of all three groups as well as questions unique to the ATC, manned aircraft pilot, and UAS pilot operational domains.

Methodology

Separate on-line surveys were created and administered to Air Traffic Controllers (ATC), pilots of manned aircraft, and pilots of UAS. These on-line surveys were hosted on web-based SurveyMonkey. Survey content was reviewed by the NASA Langley Research Center Institutional Review Board and a "*Human Subject Research Volunteer Informed Consent Statement*" was presented at the beginning of the survey, with the survey respondent having to select "I Agree" in order to continue on to the survey questions.

For respondents there was a two step process, first signing on to the NASA Langley Human Subjects Recruitment website, and registering with contact information. Second, they would then receive an Access Code which would need to be entered on the survey website. This Access Code permitted a NASA Langley human subjects recruiter to pay subjects who were eligible to be paid (non-government, non-military), and to provide contact information for follow-up interviews, while keeping all other identifying information out of the response data files. To recruit survey respondents, the human subjects recruiter sent targeted emails to organizations identified by the research team (e.g., FAA, selected military bases, general aviation and commercial pilots, and selected manufacturers). There was a set of questions that were asked of all three groups as well as questions unique to each of the groups. The survey for ATC had 48 questions, the survey for pilots of manned aircraft had 46 questions, and the survey for UAS pilots had 72 questions. There were text box comment fields for most questions. Most respondents (90.5%) indicated that they would be willing to participate in a follow-up telephone interview.

For the ATC group, usable responses were obtained from 8 persons (5 male, 3 female), with a range of years as a Certified Professional Controller from 0 – 36, with a median of 7 years. For the manned aircraft pilot group usable responses were obtained from 27 persons (26 male, 1 female). The UAS pilots group was comprised of 9 persons (8 male, 1 female). Because of the limited space available for this paper, only selected results will be presented here.

Questions asked of all groups

Figure 1 shows the responses from each of the three groups to the question "Should the rules and requirements for the various classes of controlled airspace (Classes A, B, C, D, E, & G) be the same for UAS operations as they are for manned aircraft?" An interesting finding here is the dropping in "yes" responses from both Manned Aircraft Pilots and ATC towards the Class E and G Airspace, while the UAS Pilots did not show this change. This is also interesting in that many of the UAS pilots who responded have also been Manned Aircraft pilots. This may reflect that UAS pilot group expects to meet whatever rules and requirements there are for a given Airspace.

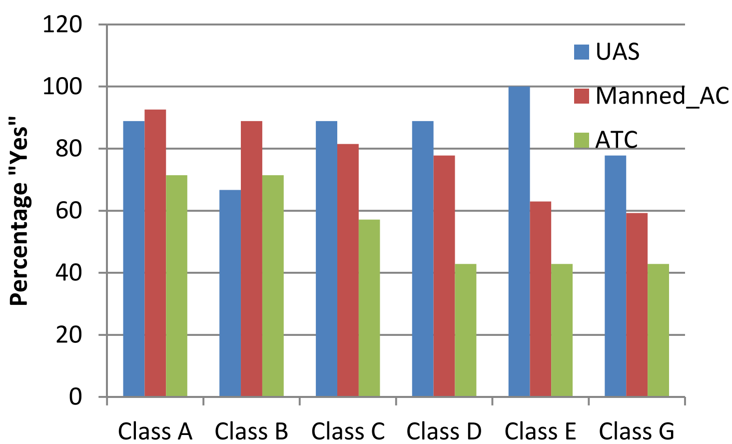

Figure 1. "Should the rules and requirements for the various classes of controlled airspace (A, B, C, D, E, & G) be the same for UAS operations as they are for manned aircraft?"

Figures 2, 3, and 4, show responses to related questions concerning the need for separate or special airspace, depending on the size and equipage of the aircraft. In Figure 2, the aircraft description is a small UAS without ATC communications and not transmitting position information. In this case the figure shows that some 58% of ATC respondents, about 80% of manned aircraft respondents, and about 50% of UAS pilots indicated "agree" or "strongly agree" to this statement. However, there were some UAS pilots who "strongly disagree."

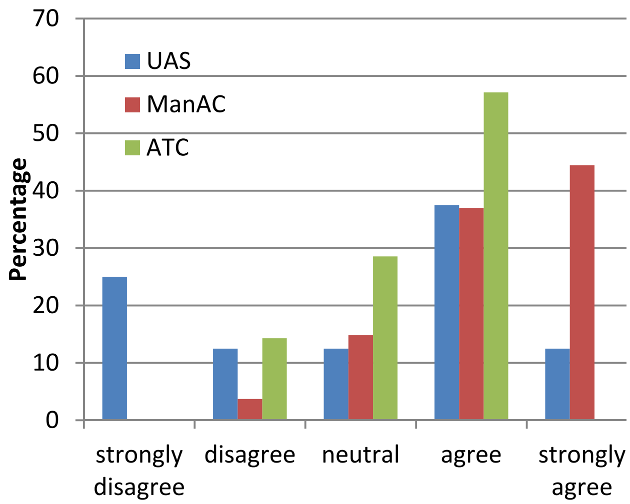

Figure 2. “I believe that small UAS (under 55 lbs) without ATC communications and without transmitting position (ADS-B) information will need separate or special airspace for their operations.”

Figure 3 asks the same question but for small UAS “with ATC and transmitting position information,” and the responses shift dramatically towards “disagree” or “strongly disagree” with regard to needing separate or special airspace. This result shows the importance of equipment that provides information that will allow the UAS to be “seen” and “communicated with” on perceptions of whether separate or special airspace will be needed.

Figure 4 shows the responses for medium and large UAS (> 55 lbs) with communications and transmitting position information. While there was 100% “disagree” or “strongly disagree” for the UAS pilots, and just over 50% disagreement for manned aircraft pilots, the ATC respondents were nearly evenly divided on the agree / disagree continuum. It is interesting that for the ATC group, the “agree” category was much higher for the medium and large UAS than for the similarly equipped small UAS shown in Figure 3. This may reflect a weighting of operational differences (e.g., Airspace Classes, airports needed) between the small and larger UAS in the response to this question for the ATC group.

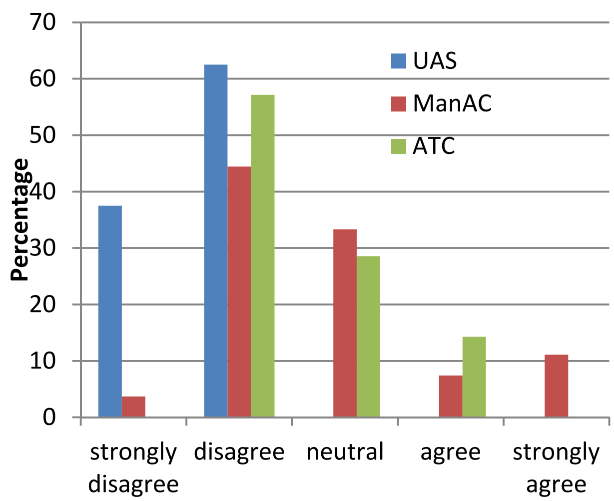

Figure 3. “I believe that small UAS (under 55 lbs) with ATC communications and transmitting position (ADS-B) information will need separate or special airspace for their operations.”

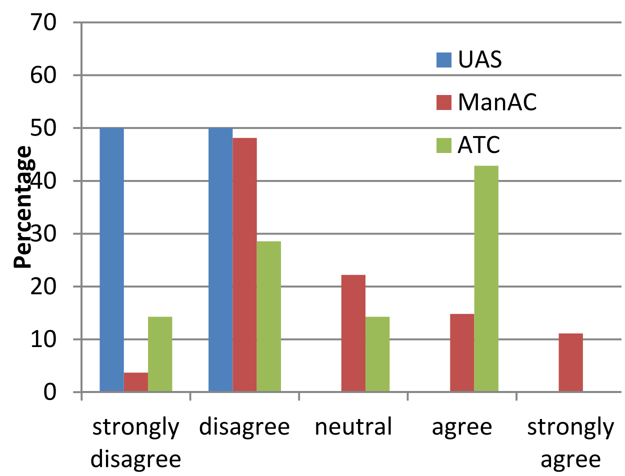

Figure 4. “I believe that Medium and Large UAS operating in the NAS with ATC communications and transmitting position (ADS-B) information will need separate or special airspace for their operations.”

Manned Aircraft Pilots Questions

Several questions on the survey for pilots of manned aircraft addressed display of these aircraft on traffic displays and overhearing communications between ATC and these aircraft, also known as “party-line” information. Figure 5 shows the results for the question “When flying in an area in which UAS Operations are being conducted, how important is it to know that an aircraft shown on a Cockpit Display of Traffic Information (CDTI) is unmanned? (e.g., through symbology or data-tag information)." As shown in Figure 5, 20 of the 27 respondents (74%) rated this information as either "desirable" or "essential." Two pilots, commenting on this question, said they needed to know if the UAS has TCAS (Traffic alert and Collision Avoidance System) and will automatically respond to an RA (Resolution Advisory). Another comment said that knowing the traffic aircraft was unmanned was more important if it was not able to respond to TCAS.

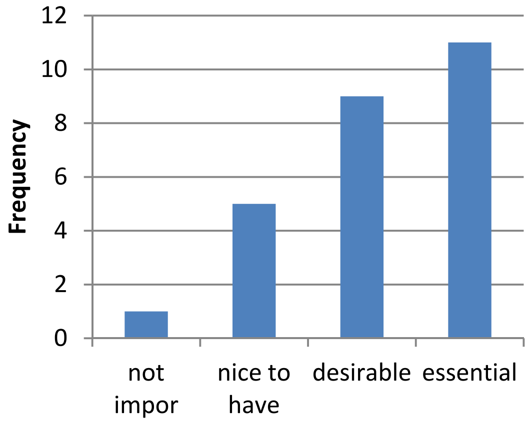

Figure 5. "When flying in an area in which UAS Operations are being conducted, how important is it to know that an aircraft shown on a Cockpit Display of Traffic Information (CDTI) is unmanned? (e.g., through symbology or data-tag information)" – manned aircraft question

In Figure 6 the results are shown for the question "When flying in an area in which UAS Operations are being conducted, how important is it that you hear ATC communications with the unmanned aircraft pilot? (sometimes referred to as the "party line")" The responses here show 23 of 27 respondents (85%) indicated having "party line" information was "desirable" or "essential" and no one indicated that it was "not important." Comments to this question said having this information: (1) was part of total situation awareness; (2) is a way to know if the UAS is responding appropriately to ATC and operator input; and, (3) is another trap for errors such as a clearance given in error or misunderstood that another set of ears might act as a barrier against.

Figure 7 presents the results for the question "If you are flying 1000-3000 ft Above Ground Level (AGL) in an area in which small UAS (under 55 lbs) are operating below 400 ft AGL, how important is the display of that aircraft on a Cockpit Display of Traffic Information (CDTI) display?" The responses here show 18 of 27 (66%) indicating that this information would be "desirable" or "essential", while 4 of 27 (14.8%) indicating that this information was "not important." Comments to this question noted that: (1) this information would be vital for altitude separations less than 1000 ft; (2) small UAS (under 55 lbs) would be nearly impossible to see air-to-air; and, (3) this

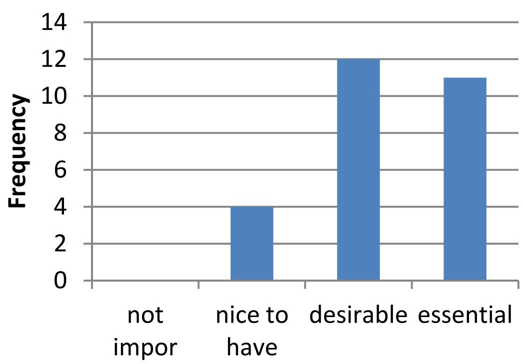

Figure 6. "When flying in an area in which UAS Operations are being conducted, how important is it that you hear ATC communications with the unmanned aircraft pilot? (sometimes referred to as the "party line")" – manned aircraft question

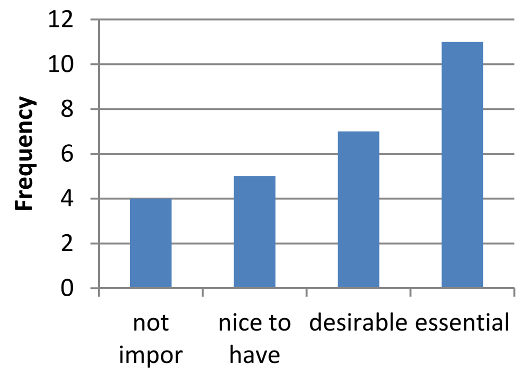

Figure 7. "If you are flying 1000-3000 ft Above Ground Level (AGL) in an area in which small UAS (under 55 lbs) are operating below 400 ft AGL, how important is the display of that aircraft on a Cockpit Display of Traffic Information (CDTI) display?" – manned aircraft question

information, while valuable, may not be available on many older generation General Aviation aircraft.

Selected ATC Questions

The following question was asked on the ATC survey: "When working manned aircraft and UAS in your airspace of responsibility, how important would it be to know that an aircraft shown on your radar display is unmanned? (e.g., through symbology or data-tag information)." ATC respondents were evenly divided between "desirable" and "essential," with no responses of "not important" or "nice to have." Comments said this information would be "essential" for many reasons, including the lack of maneuverability and climb rate of UAS aircraft, as well as their inability to see and avoid, thus making this information a controller will need to make decisions regarding traffic calls, separation, and sequencing.

A related question concerning display of small UAS was "When you are working aircraft in your airspace of responsibility, in which small UAS (under 55 lbs) are operating below 400 ft AGL and more than 3 miles from an airfield, how important is the display of that aircraft (data tag information) on your radar display?" No ATC respondents indicated that this was "essential" information. The response of highest frequency was "desirable" (57%), followed by "not important" (28%) and "nice to have" (14%). Comments included: (1) Aircraft in Class D airspace can have arrival/departure route/pattern altitudes as low as 500 ft AGL; (2) in general, not important unless those operations are conducted within Class D airspace or in close proximity to the traffic pattern of any airports; and, (3) below 400 ft makes it generally safe, but would still want to know they were there to give traffic to low-operating aircraft/helicopters.

Selected UAS Pilot Questions

When viewing these results, keep in mind that the respondents indicated that they have experience with UAS of differing sizes and equipages. There were a number of open-ended questions addressing the GCS and related issues. One of these was "What sensory cue information, not provided currently, would help improve your situation awareness of the environment of the aircraft, the integrity of the aircraft's flight and its mission?" Comments included: (1) "integrated displays for traffic (from ATC), TCAS, GCAS (ground collision avoidance system), weather;" (2) "Pilot's view camera;" (3) "weather radar;" (4) "Being able to see other traffic and weather surrounding UAS;" (5) "Audible cues would be helpful if the UA is not instrumented adequately;" and, (6) "Spoken messages."

The next question was "How often is the UAS camera system used for navigation purposes?" Responses included (1) never (most frequent response), (2) "almost never, it can be useful in the terminal area," (3) "For emergencies only," (4) "Often, especially to avoid weather," and (5) "Whenever any clouds or precipitation is proximate" A related question was "How often is the UAS camera system used for "see and avoid" purposes?" The responses here included (1) Never or rarely, (2) "Never, the field of view is too wide," (3) "Taxi only, and it only views forward," (4) "Weather avoidance primarily, not traffic," and, (5) "almost always during takeoff, departure and then during approach and landing."

In answer to the question "Can a single UAS pilot perform all the tasks necessary to fly safely in the NAS?" the responses were 7 "yes" to 1 "no." Responses to the question "How frequently during a typical mission are you in contact with ATC or other aircraft?" yielded 8 of 9 respondents indicating either "occasionally" or "routinely." In response to the question "How frequently does the UAS automation do something unexpected?" answers were evenly distributed across "never," "rarely," and "occasionally," but no one indicated "routinely."

The following question addressed voice communications and communications latency: "If there is voice communications in the GCS, what could be improved to enable better voice communications, and has latency or delay in voice communications been a problem?" Responses included: (1) better radio equipment, (2) a second or third radio instead of just one, (3) second radio and radio selector, (4) no problems with latency or delay, (5) a faster link with a higher bandwidth; latency and delays are always a problem; faster link decreases the amount of processing the aircraft does with the voice signal, (6) latency is not normally a problem, however sometimes signal quality can be poor, and (7) latency is only a problem when the radios are busy and operations are by satellites; it can be hard to break in to make a call.

Implications for UAS design

Based on the survey responses and information from the follow-up interviews, there are two areas that will be briefly covered here, these are see-and-avoid/ sense-and-avoid and workload. In the area of see-and-avoid, it was noted that most UAS aircraft have not been designed for visual conspicuity. Improvements in this area can be made through high visibility colors and through the use of strobe and/or anti-collision lights. It was noted that the Light Emitting Diode (LED) strobes can even be used on small UAS. With regard to sense-and-avoid, answers to many of the questions indicate the desire of both ATC and manned aircraft pilots to know the presence of the UAS (such as through ADS-B), so advisories can be issued if needed by ATC, or for pilots, whether the UAS will respond to a TCAS RA. The UAS pilots also noted that the mission for UAS is typically quite different from that of manned aircraft in that it is typically not a Point A to Point B operation, and may involve sustained operations in a certain area with transits in and out to return to base.

UAS in the NAS have workload implications for all three groups, ATC, manned aircraft pilots and pilots of the unmanned aircraft. For the UAS pilot, there can be less workload than for a manned aircraft pilot if inner loop control is done by the aircraft (e.g., airspeed and altitude hold and fly heading). However, if failures occur, such as a global positioning system failure, high workload can occur as there may be no backup for the primary system. As noted in the survey responses, UAS camera imagery, as it exists at present, may not be of a resolution or field-of-view to assist in the piloting task. This seems an area ripe for research and development, especially in light of small low cost video sensors and on-board video processing to reduce downlink bandwidth. It has also been noted that GCS are typically not limited in terms of display area, so that has led to separate displays for different functions instead of intelligent integration of information which can reduce workload.

From the ATC perspective, it was noted that for military mixed operations of UAS and manned aircraft, an increased buffer is often needed around the UAS due to factors such as longer runway occupancy times or wake considerations following larger manned aircraft. For a controller used to the pacing of manned aircraft only operations, higher workload can result as additional traffic maneuvering may be required to establish and maintain the larger buffers. This higher workload may be evident especially for controllers new to this environment. It was reported that having a manned aircraft in the mix with UAS can actually result in lower ATC workload than a stream of UAS only, as the manned aircraft can respond and maneuver more quickly as well as self-separate from other traffic.

References

McCarley, J. S., and Wickens, C. D., (2005). Human Factors Implications of UAVs in the National Airspace. Technical Report AHFD-05-05/FAA-05-01, Federal Aviation Administration, Atlantic City, NJ.

U. S. Department of Defense, (2012). Unmanned Aircraft Systems (UAS) Ground Control Station Human-Machine Interface (HMI) Development & Standardization Guide. DoD Unmanned Aircraft Systems Task Force, Public Release 12-S-2388, V. 1, July 2012.

U. S. Government Accountability Office (2012). Unmanned Aircraft Systems: Measuring Progress and Addressing Potential Privacy Concerns Would Facilitate Integration into the National Airspace System. GAO-12-981, September 2012.

Verstynen, H. A., Foggia, J. R., Hoffler, K. D., (2010). An R&D Roadmap of UAS Access to the Next Generation Air Transportation System, Vol 1 (NASA ARD). NASA Langley TEAMS Contract NNL07AA00B, Task Order NNL10AM00T, December 17, 2010.