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USABILITY TEST OF A PROTOTYPE UAS AWARENESS INTERFACE FOR PUBLIC USERS

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A tool to give the public a window into Unmanned Aerial Systems (UAS) Traffic Management (UTM) operations was created from an existing data collection tool. The interface included a map and a table showing details about UAS operations that could be queried in a number of ways. Eleven participants attended the study, successfully completing a 19-item task set in about 30 minutes. They correctly found information for 87% of the non-subjective tasks at a rate of around a minute per task and rated the usability of the tool at the end of the session above the industry benchmark. Participants gave favorable reviews of the "public portal tool", even reporting that they would be satisfied with less information than it presented. There were one or two elements of the display that users found distracting and some navigation functions that need improvement but, on balance, the public representatives liked the features they saw in, and had few criticisms of, the public portal tool. One important issue for the small Unmanned Aerial System community to resolve will be how much or how little information should be available about UTM operations to members of the public.

The use of sUAS (small Unmanned Aerial Systems) for deliveries, mapping activities and a host of other applications is rapidly becoming a reality. The FAA predicts that there will be over nine million sUAS operations during 2021 (FAA, 2018). Work at many organizations, including NASA (see, for example, Aweiss, et al., 2018), is ongoing to investigate and propose the automation and procedures to achieve sUAS operations. However, one segment of the population, the general public, has been less involved in these activities. Clothier, Greer, Greer & Mehta (2015) found the Australian public hold relatively neutral attitudes towards sUAS but argue the public has a low level of knowledge of the technology. For the project discussed below, our primary objective was to explore what information the US public wants to obtain about sUAS operations, and how this information might be best presented.

Five different test sites across the USA were funded to explore a public interface. One of these was the NASA Airspace Operations Laboratory (AOL) in Mountain View, CA, and only this study is discussed below. The AOL functionality study took place during September 2018 and was preceded by a series of focus group meetings in May of 2018 where ideas and themes for the functionality study were collected. The aim was to use what had been learned during the focus groups to design an easily usable interface, creating a prototype public portal tool. A requirement was to draw real-time data from the Unmanned Aerial Systems Traffic Management (UTM) system, and that it be demonstrated to people who were not familiar with UTM (e.g., the general public) but who were likely to want to know about UAS flights operating near them (see Homola 2017 for more details). The study focused on the ease where a set of tasks were completed by participants unfamiliar with UTM, and to collect feedback on participants' perceived usefulness of a public portal tool representing sUAS operations.

DEPICTIONS OF sUAS ACTIVITY

The AOL already had a number of purpose-built, in-house tools that were constructed to assist with laboratory situation awareness, test support, UTM data collection and data management. One of these, the Situation Display (SD), already contained much of the information that focus group participants listed as desirable.

The Situation Display

The Situation Display tool has a web interface that links to a data collection repository and streaming service. The tool draws data from the UTM system, in particular the UDC (USS (UAS Service Supplier) Data Collector), and creates a visualization of those data which the user can then filter and sort in real time, and edit if necessary, to support data collection. The SD is written in Javascript (ES6+) and will run on any browser, although Chrome has been most often used.

The Situation Display represents data in two ways: on a map display (Figure 1) and in tabular format (Figure 2). These can be opened side by side and viewed simultaneously. The map display, supplied by Google Earth (Perez, 2016), shows a satellite or road layout view on which operations and aircraft telemetry that are known to the UTM system are represented. The color of the operations indicate the state of that operation. Aircraft shown on the map have data blocks that are optional and contain limited flight information, mainly about flight parameters (e.g., call-sign, speed, altitude, heading).

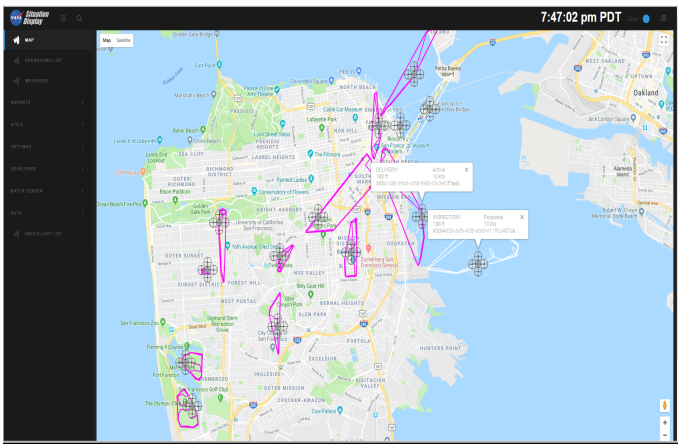

Figure 1: Situation Display map with operation volumes and vehicle positions with San Francisco as the location

There are a number of tables to complement this map view, each of which focuses on a different set of information that can be accessed from a menu in a left bar. The most commonly used types of information in the AOL were the registration, operations, and messages tables. Registration tables showed the certification details for the currently active and proposed flights, and message tables showed the UTM messages that were flowing through the UTM system at a rate of one Hertz. The operations tables include details about the nature of the flight, its status, and the USS employed, while a drop-down panel lists the operators, flight parameters and vehicle details. Each table is equipped with a scrollbar and can be filtered and sorted on any column to facilitate data management. Each page displays approximately 40 flights when presented on a–26-inch monitor.

Public Portal Overview

Using the feedback collected from the above-mentioned focus groups (Martin, et al., 2018) as a guide, the Situation Display tool was modified to create a prototype of a NASA Public Information Portal (PIP). The previous design of a dual presentation format was retained from the SD. The first step for building the PIP was to reduce the tabular information available in the operations table (e.g., Figure 2), deleting the messages table and the UAS certifications tables. The PIP operations table still houses similar information to the SD: the nature of a flight, its status and the USS providing the information. Operations information about the operator and certifications, that operators would be unwilling to share with the public, were reduced or removed and replaced with more information about flight location and vehicle mission. The scrollbar feature and filter/ sort functions were retained, and a filter feature that filters vehicles on the map from actions via the table was added. Each table page shows approximately 40 flights when displayed on a 26-inch monitor with a map view also open.

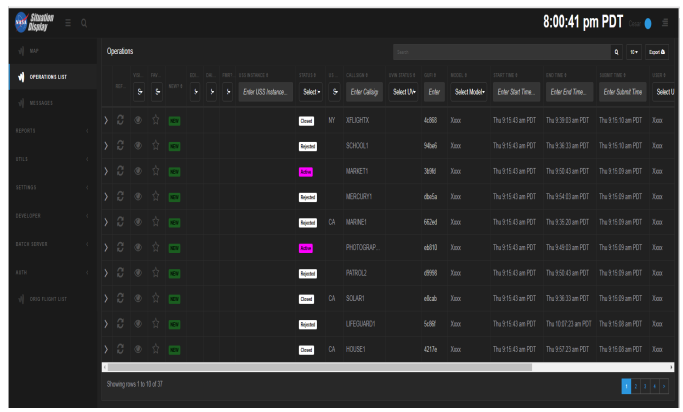

Figure 2: Public Portal Tool tabular display example, showing the operations list with status and operations' times

FUNCTION STUDY

The function study was intended to test the features and interface of the PIP and to gain feedback from typical users.

Method

Participants. Eleven people took part in the function study, with ages ranging from 21 to 70. Six were male and five were female. Three of the participants had attended one of the earlier focus group discussions and five others had some knowledge of UAS operations and/ or automated systems, but on average the group reported they were only "a little" familiar with UAS operations.

Apparatus. Participants viewed the newly-designed public portal tool at a workstation that included a 26-inch monitor with a browser window showing the PIP map display on the upper half of the screen and a second browser window showing the PIP table on the lower half

of the screen. A mouse for scrolling and keyboard for entering search terms were provided. The traffic was run from a second neighboring workstation, and Camtasia screen and audio recording software was used to record the session.

Approach. Participants completed the function task individually. After a short explanation of the purpose of the study, participants completed a consent form (HRIRB form ARC475). Traffic was started and one of the research team demonstrated the features and functions of the public portal tool. Intentionally, participants were not given time to practice but did have an opportunity to ask questions. The traffic was restarted while participants were given a few minutes to read a list of 19 tasks they were going to work through on the public portal. They were then asked to work through the tasks and think aloud as they did so, if able. After the interaction tasks, participants completed an online survey with 15 questions asking about their experience of using the public portal tool and how much they anticipated using a similar tool. One of the questions was the System Usability Scale (SUS; Brooke, 2013). The entire session took approximately an hour to complete.

Usability assessment. Participants provided a usability rating by completing the SUS (Brooke, 2013), a ten item, five-point scale participants used to rate PIP properties from "strongly agree" to "strongly disagree". The generic wording (of "website") from the SUS was replaced to read "public portal." Ratings were converted into a SUS score of between 0 and 100 points.

Tasks. The scenario involved 83 sUAS flights across four locations in the Bay Area, CA (San Francisco (SFO), Oakland (OAK), Fremont (FRE) and San Jose (SJC)) that were simulated using the MACS system (Prevot, 2016) and displayed on the PIP. Operations were a mix of commercial, recreational and public safety flights, with an additional two priority safety flights between local hospitals. Traffic was set to be active for about 40 minutes. Participants were asked to complete 19 tasks, which required them to find various items of information about specific flights, or to identify flights based on certain characteristics. Fifteen of these tasks had definable answers and four were subjective. The first five tasks with definable answers were focused on the San Francisco area, the second five on the Fremont area and the last five tasks were split between queries about the Oakland and the San Jose areas, The tasks required participants to make 12 different kinds of actions (e.g., zoom in and out, filter the table by one field in a specific column, use the search window), which guided them to look at as much of the available information fields and use as many of the tool's features as possible.

Data collection. As noted, participant interaction with the public portal tool was recorded. From these recordings, the time to complete each task was assessed and the 15 tasks that had definable answers were evaluated for completion. The online survey responses were recorded and analyzed, and participant comments were listed and compared.

RESULTS

Task completion

As the tasks were intended to be straightforward queries—the kind a general user might ask—it was expected that most participants would find all the information requested. This was the case, with participants completing 13.2 of the 15 non-subjective tasks on average (range 12-15) (Figure 3) and, in all but one case, all four of the subjective tasks. On average, participants took 23 minutes and 13 seconds to complete all 19 tasks, with the participant who finished most quickly taking under 14 minutes and the slowest person taking nearly 40 minutes.

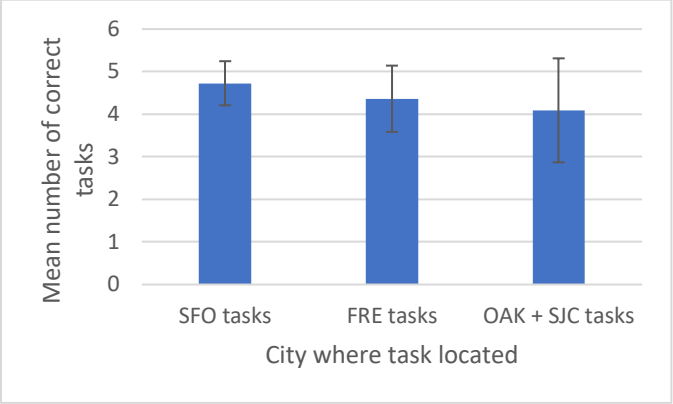

Figure 3: Mean number of tasks correct by location (city) – five tasks for each location

On average, each of the 19 tasks took just over a minute ($\bar{x}$ = 73.1 seconds) to complete, with task #6 (callsign of Fremont package) taking most participants the longest time to complete (average 194 seconds) and task #13 (altitude of a specific vehicle) taking most participants the shortest time (average 24 seconds) to complete. It was observed that one of the reasons the #6 task took the longest was because a number of people could not find the location. This is unlikely to be a real-world issue, as most people reported they would want access to sUAS

information where they lived or worked, or where relatives lived or worked, and would therefore know where these locations are. Also, many of the subtasks or second tasks on the same operation were completed more quickly because the participant had already found the flight and only needed to look up additional information.

The five tasks located in Fremont took longer ($\bar{x}$ =100.3 seconds) to complete than the other two sets of five tasks (San Francisco $\bar{x}$ = 59.2 sec and Oakland/San Jose $\bar{x}$ = 54.3 sec). One reason for the faster task completion for the SFO area is that these tasks required fewer steps to complete – on average 1.9 steps to access the information – whereas those in San Jose and Oakland required 2.6 steps on average. Also, the SJC tasks had to be completed using different windows and features of the tool. Taking the map, table, data block and dropdown as four distinct display areas, the San Jose tasks required users to look at 1.8 of these areas on average, while the tasks in San Francisco only required users to look at 1.4 of these areas on average.

Participant Opinions

Participant opinions were collected through the online survey and the transcripts of the information finding task. Of interest was the perceived usability of the PIP, which was requested through the SUS. Figure 4 shows the mean agreement ratings for the ten items of the SUS. When converted, the SUS score for the public portal tool was 76.1, above the industry benchmark where a tool with acceptable usability scores at least 68. Only one person, who stated that he thought the tool had poor usability, gave the PIP ratings that resulted in a score below 50 points, and only 27% of the participants rated the SUS to give a score below the 68-point benchmark. While participants disagreed most strongly with the statement "there was too much inconsistency in this tool" (see bar on furthest right in Fig. 4), they agreed least often with the statement "I would like to use this public portal tool frequently" (see left-most bar in Fig. 4). This latter item is the only one of the ten that did not receive a rating that would put it notionally above the industry benchmark (orange line). In general, participants disagreed more with the negatively worded items than they agreed with the positively worded ones, i.e., there are more positively worded items to the left of Figure 4, and more negatively worded items to the right.

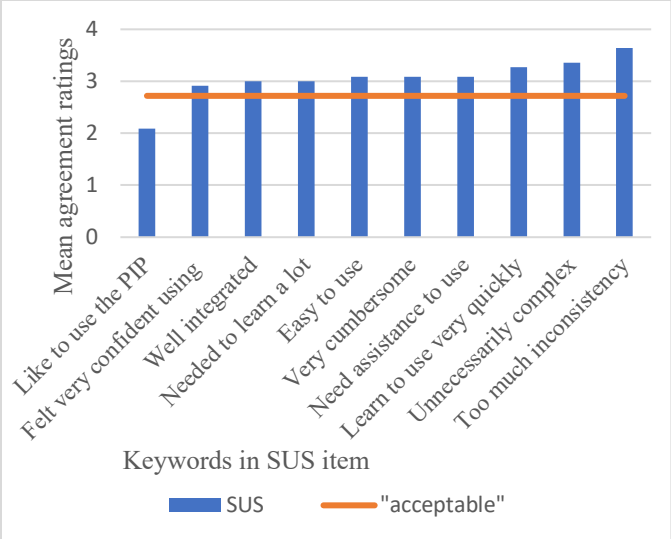

Figure 4: Mean 5-point ratings for the 10-item SUS
Note: Ratings on negative items are converted differently into a positive score, giving partial scores out of 10 for all 10 items, where a higher score is more positive.

Participants were generally positive in their reports about using the public portal tool, listing the map and the ability to search as two of the features/functions they liked. Most participants (8 out of 11) reported that the ability to identify UAS operations was "moderately" to "very" important to them ($\bar{x}$= 4.7 on a 7-point scale), while only one person felt that it was "not important" to them to be able to look up UAS activity. In general, participants thought they would want to know the same information about operations close to their place of work as they would want to know about operations close to their home. All participants listed the priority of the UAS mission and UAV (Unmanned Aerial Vehicle) owner as desired information, with type of data being collected by the UAV also ranking very high on the list.

When using the public portal tool, participants reported "occasionally" ($\bar{x}$= 2.6) having any difficulty finding an operation, and thought they found the information they wanted in a "reasonable" amount of time ($\bar{x}$= 3.36). Although one person described their experience as frustrating, the other participants, while acknowledging there were improvements to be made, especially with navigation functions, did not say their experience was frustrating. Overall, participants reported being "satisfied" ($\bar{x}$= 5.7) with the public portal tool.

DISCUSSION

Although the PIP was very well received, the study tasks were not difficult, and the criticisms raised were rectifiable, it should be remembered that participants were asked to project their opinions into the future, and imagine how they would respond to something they have not experienced – heavy UAS activity over cities where they live and work. It is probable that general public opinions, and the sUAS information they would like to have access to, will evolve as they gain more experience with sarus operations.

Despite participants' opinions of the PIP being positive on the whole, there were one or two features that distracted users by interrupting the flow of their information searches. One of these was that there was no "clear-all" feature, forcing participants to back out of their searches before they could begin another. A second issue was a bug in the snap-to feature of the map that re-centered the map on a previously viewed location. Depending on how a user navigated the map this occurred to varying degrees.

Comparing study participants' comments with the opinions collected from the focus group members shows a disconnect between the two that highlight an issue which is at the crux of giving the public a window into UAS operations – specifically, the desire for privacy versus transparency. The participants using the PIP remarked they wanted to know information that would identify many aspects of UAS operations, while participants in the earlier focus groups (and in other debriefings) that included sUAS operators and first responders (as well as the general public), argued that some of this information should remain private to protect both business and operator interests. The focus group participants agreed that they would not want their own information exposed (e.g., no destination address shown on UAS deliveries), and so it would not seem fair for an operator to have to provide such information. Additionally, it might be a safety risk for pilots to give out a contact number as they could potentially get many calls while operating. It was suggested that contacting sUAS teams during operations should be reserved for emergencies only and go through a dispatch service.

SUMMARY AND CONCLUSIONS

A tool to give the public a window into UTM operations was created from an existing data collection tool. The interface included a map and a table showing details about sUAS operations that could be queried in a number of ways. A functional usability study was designed to gather feedback on the usefulness of the tool. Eleven participants attended the study in the AOL, correctly finding the information to complete 19 tasks, with an 87% success rate (for the non-subjective tasks), in around 30 minutes, by using the prototype public portal tool. Participants gave favorable reviews of the tool, including SUS ratings that indicated they found the tool "acceptable" to use, even reporting that they would be satisfied with less information than it presented. There were one or two elements of the display that users found distracting but, on balance, they liked the features they saw and used, and had few criticisms of the AOL public portal tool.

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