Unmanned Aerial Systems Fleet Management Techniques

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Abstract — *Unmanned Aerial Systems show great economic potential and their use offer both opportunities and challenges that are unique to this type of aircraft. This study proposes that the challenges presented by their use can be managed using lean and normal management tools. Those tools will allow the Manager of an Unmanned Aerial System Fleet to operate a profitable business operation and predict problems before they happen. Therefore, the tools presented will help future Unmanned Aerial System Fleet Managers make the decisions and analysis needed to enter this exciting aerospace segment.*

Key Terms — *Drones, Federal Aviation Administration, Fleet Management, Unmanned Aerial Systems*

INTRODUCTION

Unmanned Aerial Systems (UAS) are a potential revolution in many fields and this is proven by the fact that the projected UAS impact on the United States economy is high. "The consulting firm Deloitte predicts that total revenue from nonmilitary drones in 2015 will be between $200 million and $400 million — equivalent to the price of a single midsize passenger jet. Longer-term forecasts are more optimistic, estimating commercial drones could become a billion-dollar industry by the 2020s" [1].

For this industry to grow in sales by 600 million dollars in only five years, there is a need to learn the possible uses of UAS and what regulations from the Federal Aviation Administration (FAA) affect them. The National Aeronautics and Space Administration (NASA) created a list of possible applications for UAS by categories [2] (see Figures 1 and 2 for reference UAS designs by NASA). For small-surveillance the following apply: Security of high-value, Surface-mine patrol, Oil-spill clean-up direction, Wildfire mapping, Ice-floe scouting, Spray block marking and tracking and Ground truth verification. For large-area surveillance these applications were found: Search and rescue, Wildfire detection, Fishing law enforcement, Oil-spill detection, Ice mapping, Fish spotting, Law enforcement and Surface resource survey. In linear patrol duties, these were identified: Pipeline, Highway, Border, Power line, Waterway and shoreline pollution detection. Aerial spraying is yet another application: Agriculture, and Wildfire fighting. For communications relay on Ad hoc and permanent applications. In Atmospheric Sampling, some of the applications include: Storm research, Meteorology and Mapping pollutants.

When monitoring ground sensors, UAS are helpful at detecting activities, monitoring cathodic protection of pipelines and looking for emergency rescue beacons. For aircraft research, UAS are used for aerodynamic testing and remote measurements. To round up the list of current UAS applications there is Air-to-Air surveillance, Security of nuclear materials in transit and the well-known recreational uses such as photography, video and UAS racing.

Also, a list of some future UAS applications has been developed [2]. On delivery Amazon Air, UPS and the United States Postal Service among others. Finally, Internet Providing by Facebook and Google.

With so many possible applications for UAS systems it is important to distinguish UAS types and operations by the segment they fall within the FAA regulations.

For this project, the suggestion is to rate UAS operations as small (UAS fleet of less than 10 vehicles), medium (UAS fleets smaller than 50 vehicles but larger than 10) and large (more than 50 vehicles). The focus will be on small UAS operations since those are the ones that can be found locally in Puerto Rico and can benefit from this research.

UAS operations are basically a new field since the FAA regulations that govern for profit operations went into effect in 2016 [3] and after an extensive Literature Review a lack of papers and references on the subject matter of UAS Fleet Management Techniques was found. After taking these factors into consideration it can be argued that: With the currently existing Management Tools (Quality and Lean) small UAS operations can be optimized and studied allowing future UAS Fleet Managers to foresee business and regulatory challenges and attack them allowing the growing UAS industry to mature faster than they would without the use of these tools.

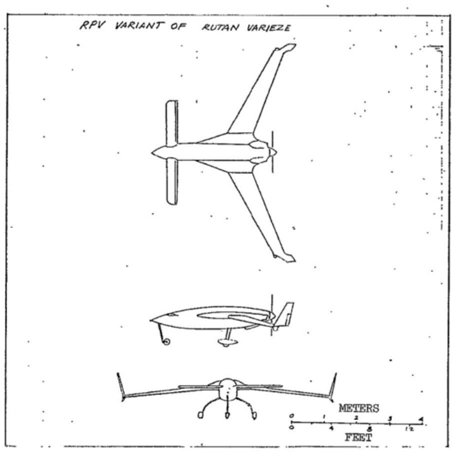

Figure 1
NASA concept for UAS that requires a runway

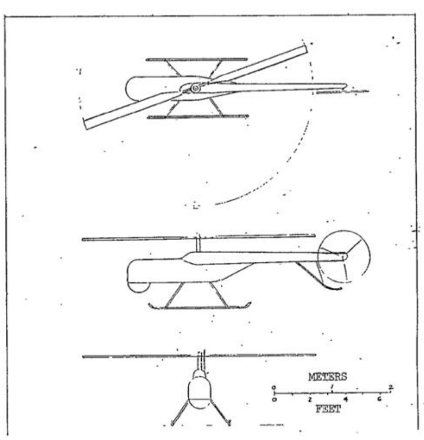

Figure 2
Another NASA concept for UAS that has Vertical Takeoff and Landing (VTOL) capability

LITERATURE REVIEW

UAS's have various definitions, but most deal with the fact that they are remotely operated (meaning the person in control of the aircraft and nobody for that matter is inside the vehicle) and that they are airborne (meaning they operate in the air). Various authors were consulted to get UAS properly defined, but for this project purposes, the Federal Aviation Administration (FAA) definition is the regulatory statement that will be followed for this project. Their definition reads as follows: "Unmanned aircraft means an aircraft operated without the possibility of direct human intervention from within or on the aircraft" [3]. A more detailed definition was found on the UAS Remote Pilot Test Prep and is presented below:

The small unmanned aircraft "Weight less than 55 pounds (25 kg), including everything that is onboard or otherwise attached to the aircraft" [3]. "Are operated without the possibility of direct human intervention from within or on the aircraft" [3].

It must be noted that not all aircraft that meet the UAS definition falls under the FAA Title 14 of the Code of Federal Regulations (CFR) which regulates the for profit use of UAS since amateur rockets, moored balloons or unmanned free balloons, kites and hobbyist use of UAS (among others) do not require the FAA pilot certification.

Also, according to the latest regulations of the FAA, the UAS that are currently regulated will meet the weight specifications (less than 55 pounds including the payload). The remaining UAS that do not fall under these categories are not directly regulated and therefore need special permits from the FAA to operate, like the Amazon delivery drones [4].

Additional regulations for UAS include the need to operate at heights no higher than 400ft and the prohibition to enter protected airspaces (like airports or military installations). Another restriction is to only do daylight operations and that a visual line of sight approach for the pilots is required (meaning the UAS must be visible for the pilot at all times). [3].

The United States Department of Defense (DoD) also categorizes UAS's and their five categories are based on performance parameters such as weight, maximum attainable altitude and airspeed. Those parameters are not used by the FAA when regulating UAS operations and, as such, they are included just for reference purposes on Table 1 below.

Table 1
List of UAS categories per the United States Department of Defense [5]

UAS Category	Max Gross Takeoff Weight	Normal Operating Altitude (ft)	Airspeed
Group 1	<20 pounds	<1200 above ground level (AGL)	<100 knots
Group 2	21–55 pounds	<3500 AGL	< 250 knots
Group 3	<1320 pounds	<18,000 mean sea level (MSL)	
Group 4	>1320 pounds		Any airspeed
Group 5		>18,000 MSL	

Note: If a UAS has even one characteristic of the next higher level, it is classified in that level.

The Federal Aviation Administration rolled out the UAS rules presented on this Literature Review on August 29 2016.

The local Government of Puerto Rico, by intervention of representative José Aponte, presented on January 26, 2015 the House Bill 2294 which seeks to create the "Law to limit the use of images taken by unmanned aerial systems" in order to prohibit the recording and photography using UAS on private property. The project stipulates that if privacy is breached, the complainant has the right to sue civilly against the UAS owner and demand the payment for damages, attorneys' fees and costs incurred during such civil action. Currently the project has not been approved into Law, which in turn makes the FAA rules the only rules that apply for UAS operation in Puerto Rico. Anyhow, UAS owners should be wary of any privacy violations during use of these systems to ensure ethical problems do to arise as part of their use.

A search performed on the Polytechnic University of Puerto Rico Library databases yielded no results to searches with the keywords UAS, UAS, Drone and Management tools that take in account the latest FAA regulations. The lack of official research found regarding the subject matter of management tools applied to UAS can be attributed to the fact that the FAA regulations were updated on August 29 of 2016.

The following list of Management (Quality/Lean related) tools was considered for this project as tools that can potentially help with the Management of a small scale UAS for profit operation. While the list intends to be representative of the tools available to Managers, it is not a complete list of all the tools that can be used, instead it aims to be a starting point for this research to aid in creating a foundation of a Quality/Lean culture in UAS for profit operations.

- Gemba Walk: A Gemba walk is a form of management in which leaders walk around the work area to gain firsthand insight into how processes are done [6]
- Kaizen Burst: used to highlight improvement needs and plan Kaizen workshops at specific processes that are critical to achieving the Future State Map of the value stream [7].
- Tack Time: is the maximum amount of time in which a product needs to be produced in order to satisfy customer demand. The term comes from the German word "takt," which means "pulse." Set by customer demand, takt creates the pulse or rhythm across all processes in a business to ensure continuous flow and utilization of capacities (e.g., man and machine) [8].
- Value Stream Mapping: Special type of flow chart that uses symbols known as "the language of Lean" to depict and improve the flow of inventory and information [7].
- Benchmark Study: Involves looking outward (outside a particular business, organization, industry, region or country) to examine how others achieve their performance levels, and to understand the processes they use [9].

ANALYSIS AND RESULTS

After applying some of the Quality/Lean tools to the for profit operations of small UAS fleets in Puerto Rico the following can be reported regarding the Gemba Walk. It was performed on the meeting of the Phantom Drone PR Club in Isabela (a locally operated UAS club) on Wednesday September 28 of 2016. The first step was to assess the spatial restrains for UAS operations (see Figure 3 to see some of the UAS owned by them). The area where takeoff and landing of the UAS occurs needs to be of at least 20 ft by 20 ft and be clear of aerial obstacles such as trees and electric lines. This also helps with the visual line of sight operations required by the FAA. The operational ceiling of 400 ft is enforced by the use of software within the UAS's used that automatically limit the height of operation. Also, the use of Global Positioning Systems (GPS) within the UAS serves to enforce the no-fly zones determined by the FAA such as airports. As explained by the Club members during the Gemba Walk, the UAS will basically drop its operational ceiling as it gets closer to no fly zones until reaching the ground when trying to enter a no fly zone.

One of the operational problems experienced was weather conditions. On windy days, only the more experienced pilots use their UAS's since it can be difficult to control them and, on rainy days, they prefer not to use them due to low visibility. The charging time could be a potential interference to their business or future business in general, since they can take up to 4 hours to charge and only be used for 15 to 30 minutes. A questionnaire was handed to the club members to answer questions related to UAS operations such as maintenance costs, maintenance intervals and the UAS pilot certificates.

The survey of the Phantom Drone PR Club was performed on 8 members that were present during the visit. The survey was divided on three sections. The first section was to identify the use of the UAS. The second was to know the maintenance information for their equipment based on their feedback. The last section was to establish how many of them have the FAA license.

The survey started with a question to know how many UAS's they have and, also, if they used them for recreation or business purposes. If they used them for business, they were asked to specify the kind of business between photography, agriculture, security or other. The survey showed that 50% of the members possess more than 3 UAS's and the other 50% only one. It also shows that 3 out of 8 use them for business purposes. They specified that they only use the Phantom UAS brand. The most common application was photography with a 62.5% and video recording (25%). These applications do not necessarily generate profit. Video recording was not an option provided on the survey, but they added on the other activity section. Since photography is the most common use on the group, it can be concluded that the market needs are higher for this kind of service.

Figure 3
Sample of UAS's owned by the Isabela Phantom Drone Club

The next section of the survey aims to establish if some parts fail with more frequency than others. Also, it aims to specify if replacement parts are available on Puerto Rico or they need to order them online. Maintenance needs for this equipment is very important to establish a UAS business. The flight time provided by the battery is 30 minutes or less, depending of the UAS. 62.5% of them give maintenance to their UAS every hour and 25% every 100 hours of flight. This depends on its use. Also, 75% report a maintenance cost lower than $50 and 25% admit to having paid more than $100 in repairs to their equipment. In this case the higher cost could be caused by the equipment the UAS have.

One of the most important things regarding a business using UAS is the access to the replacement parts. 100% of the members agree that there is no specific part that fail more than the others. 87.5% of them think that the replacement parts are easy to find online and that they arrive in a short amount of time. A member of the club has virtual reality glasses to see through the UAS camera which helps in meeting the FAA rules, but is an expensive addition to the UAS.

The last part of the survey was performed to gain insight of how many of the members have the UAS license required by FAA to operate an UAS for business purposes. The results show that 50% of the members are in the process to obtaining it and that the process for them takes less than 20 hours of preparation due to the knowledge that they already have of UAS systems and also because the FAA has already given orientations to the club regarding the latest UAS regulations. Only three out of eight members have the license. This could be caused by the fact that there is only one place in Puerto Rico that offers the test.

The commercial pilot certification process was mapped using Value Stream Mapping techniques to understand the challenges associated with obtaining the FAA UAS pilot license in Puerto Rico. The first Kaizen identified was that there is only one place in Puerto Rico where this test can be taken. The place in question is Isla Grande Flying School and they administer the test and they also sell a review book that serves as the test preparation guide. In Person UAS Ground School provide a review for the test since it includes the following topics; FAA Regulations, Airspace and requirements, Weather, Loading and Performance and Operations. The test contains 60 questions and it must be taken in 2 hours. Achieving a score of 70% or higher is required to be consider as satisfactory. After completion of the test, an Airman knowledge testing result (AKTR) will be given to the applicant documenting the score. The AKTR is valid for 24 months.

The second Kaizen found was the cost of the process since the test alone costs $150, the UAS Remote Pilot Test Prep Guide costs an additional $25.00. In addition, studying for exam approximately takes approximately 40 hours of study alone review or 8 hrs. with a UAS Ground School that costs $670.00 and has a duration of 1 day [10]. Basically, anyone would either need $175 and 40 hrs of study time or $820 and 10 hrs to pass the test. A more palatable Tack Time would be a 6 hr preparation review with a 2 hr test with a lower cost of $100 for both the review course and the test. The third Kaizen found on the Value Stream Mapping (VSM) is that the exam dates are Tuesdays and Thursdays, which means using a vacation day for people interested in the test and that work from Monday to Friday.

The benchmark tool used is implicit on the Gemba Walk, the survey, the literature review and the visit performed to Isla Grande Flying School. Basically, the information gathered on the Gemba and the VSM is analog to the output of a formal benchmark study. Also another finding form the Benchmark study is that the creation of a decision tree for managers will help make the decision if UAS's are the best option for a given task.

CONCLUSIONS

Like on all business operations, ethical concerns arise when companies are handling private information and, for UAS operations, there is a need to avoid additional regulations at Federal or Local level, therefore avoiding privacy issues or violations is very important for the fledging UAS industry and maybe self-regulation to avoid privacy concerns will help the public perception of the industry.

For the operation of small scale UAS Fleets (less than 10 UAS), the use of Gemba, VSM and Benchmarking can give insight into the planning of an UAS operation. For instance, the price point for the exam and two combinations of time/money were found that can allow a person to pass the UAS pilot certification test. The main problem is that the steep cost/time combination and the monopoly in Puerto Rico of Isla Grande Flying School as the only test center are barriers to get pilots certified for UAS operations.

As stated before, the FAA in conjunction with test providers should offer test-review packages that cover the test material and the test on the same day with an overall cost of about $100. Even though the test requires the pilots to be proficient in English during the Gemba walk none of the members of the Isabela Phantom Drone club mentioned that as a barrier. They mentioned that most of the technical terms they use are in English and that the operation manuals of their UAS are in English which gives them confidence on their use of English.

Additional barriers to the use of UAS on for profit operations are the weight limitation of 55 pounds, the operations ceiling of 400 ft, line of sight and daytime operations restrictions. While these restrictions were placed by the FAA to keep airspaces safe it should be noted that they restrict UAS operations to the point that companies like Amazon have suggested they hinder progress in the UAS field and even may affect the competitiveness of the United States in the UAS field [5}. This would be an example of barriers that affect the creation of medium and large scale UAS operations in United States airspace.

To overcome those challenges of medium and large UAS operations, it is necessary to reinvent the way airspace is managed so that safety is maintained while allowing possibly millions of UAS's to operate and share the airspace with the current aircraft using it [5].

The limitations to this research were mainly of time and therefore of scope, there are many Management tools that were not included in this article and that can and should be applied to small, medium and large scale UAS Fleet operations. Also, Military applications were not taken into account, wheere supply chain management would be even more critical while the regulatory aspects of those UAS are not as restrictive as on commercial operations.

With the use of simple Management tools challenges to operation of small UAS fleets were identified beforehand and Managers can take corrective actions to overcome them and be more competitive on the UAS market.

About the Author

Jimmy C. Pujols Cruz is a Mechanical Engineer that in 2007 completed his Bachelor's Degree from the University of Puerto Rico, Mayaguez Campus. During that year, he started his tenure as a Mechanical Designer and Structural Analyst of Aerospace Systems in Infotech Aerospace Services. Also, from 2008 to 2012 he sought and completed a Master's Degree in Mechanical Engineering from the University of Puerto Rico, Mayaguez Campus. Being the External's Design Quality Leader for more than four years helped shape his Lean/Quality approach to problems that in conjunction with the knowledge gained from his current pursuit of a Master in Engineering Management from the Polytechnic University of Puerto Rico showed him that Management tools can and should be applied on all fields with positive results, even emergent fields such as Unmanned Aerial Systems (UAS).

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