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UAS WITH INFLATABLE WINGS-HOW IMPORTANT A CERTIFICATION IS: JOURNEY TOWARDS THE FIRST STEP

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A B S T R A C T

UAS with inflatable wings (UASWIW) is relatively a novel and complex arena and more to that is its certification process, which is more complex as well as challenging. This paper broadly presents a three-tier architecture to identify the potential hazards associated with UASWIW and proposes the necessary certifications required according to 14CFR. For the sake of simplicity, only a few aerodynamic potential hazards are taken into account and evaluated accordingly. The proposed analytic approach completely satisfies the rules and guidelines controlled by the Federal Aviation Administration (FAA) and would prove a milestone for future researchers who wish to pursue in the same arena.

1. INTRODUCTION

Unmanned aircraft system (UAS) is a fast-developing technology with tremendous potential. This has been a term which has been used by the International Civil Aviation Organization (ICAO) even though there are called with lots of other commercial names like unmanned aerial vehicle (UAV), remote powered aircraft system (RPAS) and drones. For an aircraft or UAS certification process is equally important as manufacturing and operation. At the time when the Wright Brothers took the first flight which was powerless and very short. It was mainly controlled with mechanical links. Manufacturing of the aircraft took a leap during the World War I and World War II until that time there was no such concept of having certification of aircraft and its components. As technology has developed over the years so has the certification for a manned aircraft but not for UAS which seems like a generational gap between the two.

2. UAS TYPES USESAND ITS HISTORY

A UAS is a type of aircraft which does not have the presence of a human pilot on the aircraft but has the capability to fly under guidance from a remote station using a radio link or fly itself autonomously. The first use of UAS was in the early 1900s where balloons were being utilized with explosives to attack its enemy. The development picked up somewhat 20 years ago and showed promising results with lots of advantages of operating in all weather conditions with great economics which could be seen in the various wars over the years. Mainly they are being used for intelligence, surveillance and reconnaissance (ISR) (Pham et al., 2008), aerial photography, public safety, agriculture spraying, logistics support, defence and wildlife surveying with the possibility of providing Wi-Fi hotspots in very remote places. With the number of UAS increasing in the sky a way of regulating is needed so that their controlled and certified for their intended

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purpose and airspace. It is an obligation of the user to have airworthy aircraft under an airworthiness system to provide safety to not just the UAS itself but its surroundings like people and property which could be destroyed if the UAS is not airworthy. To achieve this National Aviation Authorities (NAA) like Civil Aviation Safety Authority Australia (CASA) have the certification standards for different categories of UAS under the CASA part 101 rules which were published initially in the year 2001 as CASA's primary aim is to develop, implement rules and regulations so that they align with International Civil Aviation Organization (ICAO)

The UAS also has very unique and unmatched capabilities due to which they are being used in the civilian and defense environments in order to carry out various types of missions as they are capable of carrying out destruction using various kinds of lethal weapons at very reduced risk in jobs which is considered dull, dirty or dangerous (Takayama et al., 2008) in order to save valuable lives of soldiers on a mission alongside providing critical information to the ground station which could be needed to change the mission tactics. Even with all the exceptional and unparalleled abilities, the UAS also have limitations like their launch and recovery so they cannot be utilized in high turbulence and heavy crosswind areas, at this point of time they are also not designed for operating in the icing conditions due to the fact that they don't have anti-icing systems like manned aircraft other limitations include limited battery/fuel capability, excessive heat or corrosion depending on the type of environment they are being operated and with the biggest limitation of them all is losing contact with the ground station.(JAPCC,2020)

According to the inventor, an Inflatable wings is a "bladderless inflatable kite used to propel humans" (Legaignoux et al., 2006) It could also be said that it is a deployable structure which can be deployed before or during the flight and can be used as a primary structure to support the flight dynamics. This type of wing came into existence in the 1930s with improved version around 1950s. The inflatable wings provided an edge over the conventional UAS as they could save space which was around one-tenth its size. It could also provide higher serviceability rate as the wing will incur less damage if was needed to land on a hard surface. It also needed lesser maintenance cost which could add to the profitability and would provide higher dispatch reliability to the operator. Because of all the advantages over conventional wings, inflatable wings have its utilization in various places and industries like transportation, automotive, aeronautical and missile stabilization surfaces. With the recent development in search of newer materials and manufacturing process, wings have also been developed by composite materials which get their aerofoil shape once they are exposed to ultraviolet (UV) radiations. (Wang et al., 2012)

Inflatable wings which fall under a structural group called tensile structure which has a membrane-like structure that requires pre-stress so that they bear externally applied loads (Black, 2006). They also have been used for generating lift in aircraft which were heavier than air and lighter than air (LTA) UAS at the same time again proving its worth that they could save ample space and can be stored away when not use. (Simpson, 2008).With the development going back to 1930s a certification for this type of wing is not been in place which could give certifications to a UAS fitted with the inflatable wings. Various tests which were conducted during the development of the inflatable wings have shown that if a UAS is fitted with the inflatable wings the changes that the UAS can survive with slightest of damages to other components. If at all the wing gets punctured it can be restored back to its original shape by putting adhesive or by stitching it which can be heaps cheaper if repairs have to be connected onto a metal or composite (Catogan et al., 2008).

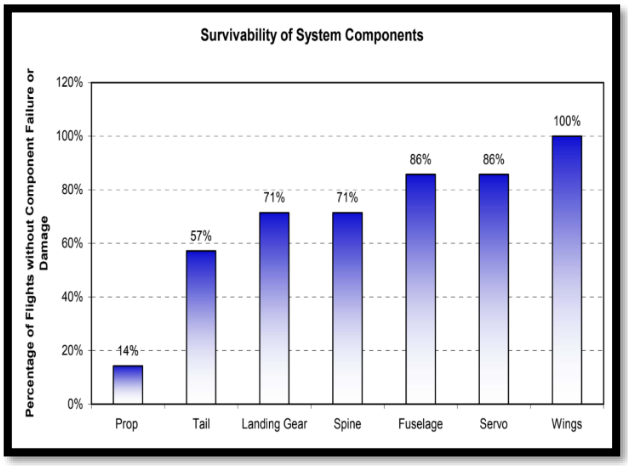

Figure 1. Survivability of various components of a UAS (Cadogan et al., 2008)

Apart from the UAS itself, other factors which need to be considered for certification are the various ground facilities like the ground control station, radio link, various flight control systems and software which are needed to keep the UAS operational. Majority of the certification standards can be utilized in the same format as they are being used for the manned aircraft but some of them are needed to be modified to suit the needs of UAS operations. According to Degarmo the certification process of UAS can be divided into 4 major parts namely Design and Production certification, Autonomous system and Software Certification, ground control system (GCS) system certification and finally command and control data link certification to give a total system certification of the UAS (Degarmo, 2004)

In the development of a UAS, the certification although small plays a vital role as the production could start only start once only if the design and other parameters pertaining to it are certified and approved. The figure 1 shows the various phases of a UAS development from carrying out the research to its production and support phase. A draft of the certification and compliance program is usually prepared and submitted for any recommended changes early in the development stages. (Austin, 2010)

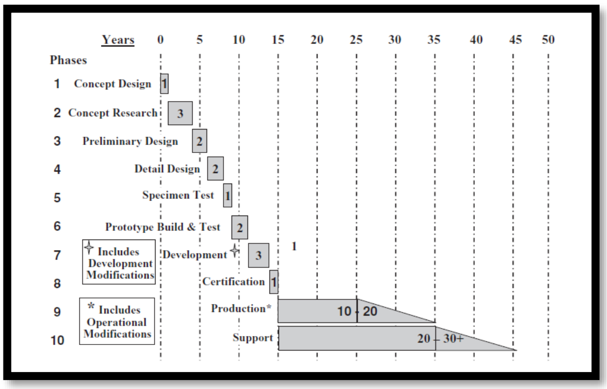

Figure 2. Phases of UAS Development (Austin, 2010)

The support phase is usually the biggest due to the fact that initial and recurrent training of the manpower with the relevant systems is needed to comply with various regulations laid down by various national aviation authorities. (Austin, 2010)

2.1 Identification of Various Gaps

Based on gaps identified after rigorous literature survey, this paper would highlight the following objectives. The objectives of the research project are summarized under the following research questions and our proposed methodology has been designed accordingly:

1. Identification of critical aerodynamics hazards of UASWIW and addressing the serviceability issues associated with it.
2. Evaluation and analysis of the suitability of current rules by NAA.
3. To propose the certification requirements according to current regulations given under 14CFR

2.2 Comparison of current UAS classification under FAA and CAA regulations

The word "airworthy" has been described in the Federal Aviation Administration (FAA) rules for manned and unmanned vehicles under 14CFR3.5 states that an aircraft can only be considered airworthy if it conforms to the type design and is in a safe condition to operate whereas it is done under the AC21-13 for CASA. The FAA and CASA evaluate, amends, publishes and supervises all the rules mentioned for both manned and unmanned aircraft in order to get the certification needed for them to operate. Generally, there is no classification by which the UAS is classified but it is commonly accepted due to the fact that it has different abilitiesand uses so they have been classified on the total gross weight that they can carry by CASA and for its operating range and its endurance by FAA. The current categorization done by CASA according to the mass is shown in table 1, where the first category has mass lesser than 100 gms and can be operated for recreational purposes.

Table 1. Classification of UAS (CASA, 2020)

Category	Operating Limits (Kgs)	Application
Micro	Less than 100gms	Recreational
Very Small	Greater than 100gms and less than 2Kgs	Sport, Recreational
Small	Greater than 2.01Kgs and less than 25 Kgs	Sport, Recreational
Medium	Greater than 25.01Kgs and less than 150Kgs	Recreational, Reconnaissance
Large	Greater than 150 Kgs	Recreational, Reconnaissance

Most of the fatal accidents occur due to their loss of control conditions (Grigoriou K et al., 2013)

Table 2. Classification of UAS (FAA, 2020)

Category	Operating Limits (lbs)	Application
Small	0-20	Recreational
Medium	21-55	Sport, Recreational
Large	Less than 1320	Sport, Recreational
Larger	Greater than 1320 and operating altitude less than 18,000 ft	Recreational, Reconnaissance
Largest	Greater than 1320 and operating altitude more than 18,000 ft	Recreational, Reconnaissance

The UAS in the FAA system is classified with weight and their operating altitude range.

3. METHODOLOGY

Majority of the certification requirements currently in use for a manned aircraft and civilian airspace are well defined and can be used for UAS as mentioned in the various subparts of the 14CFR with a dedicated subpart 107 for unmanned aircraft systems with other parts like. Although the UAS is currently being utilised for various applications its boundaries in regards to the safety cannot be overlooked. Majority of the regulations are laid under chapters 1, 2 and 3 addressing the majority of the aspects of aviation for manned and unmanned aircraft.

As we are discussing the issues relating to the safety of the UAS the biggest task is to study the need for airworthiness certification for the type of UAS we have selected. In this paper, the proposed methodology would highlight the following key parameters of UAS with Inflatable wings. Figure 3 highlights the broad overview of the projected methodology and aims to answer the proposed research questions.

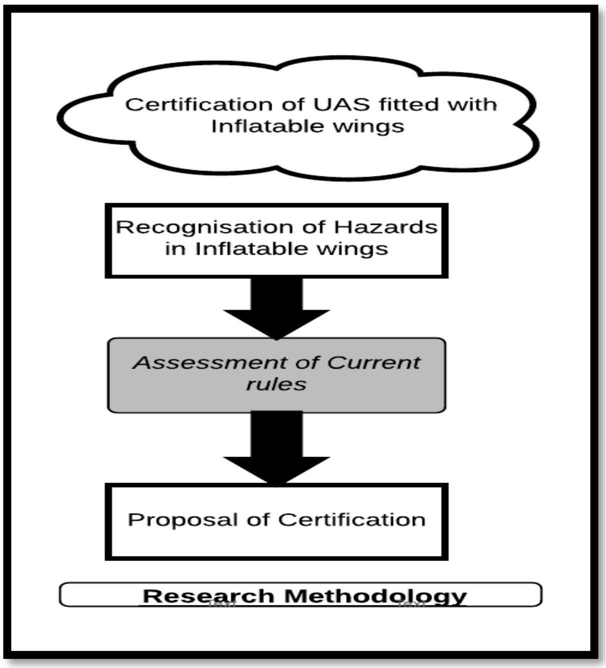

Figure 3. Methodology Overview

- Recognizing the potential hazards in Inflatable wings

The need for the proposed certifications is based on recognizing the potential risks which were classified on various factors as in this case. Firstly it is needed to recognize the potential risks which inflatable wings pose which could harm people or their assets in a complete catastrophic failure of its operation taking into consideration the overall functionality for what the UAS was made for. Risks are usually mapped out by looking at how severe it can be and the outcomes relating to it and the FAA has defined all the potential risks in its safety and risk manuals. The primary objective has been to identify the potential risks and try to mitigate them according to the current rule and propose new ones if needed so to improve the performance and safety of the UAS.

- Assessing the current rules mentioned in 14CFR

Based on the above mentioned potential risk. The secondary task after recognizing the risks is to stipulate the FAA rules provided under chapter 1, volume 1 thru 4.The FAA also provides the guidelines to operate for all the UAS for government and public use. Majority of the rules relating to UAS are laid under 14CFR part 107. I have tried to utilize and access the rules stipulated under chapter 1 subpart C and G for its relevance in the UAS nature which are meant to be used for normal category aircraft. As mentioned earlier that some of the rules can be utilized in the same way as they are written for a normal transport category aircrafts to alleviate the risks posed and propose some new revisions to current regulations to make them suitable for use in the UAS programs. Due to the fact that the majority of the UAS utilizes a rotary engine because of their efficiency so many of the regulations for 14CFR part 27 have been comprehensively utilized at the same time focusing on other factors.

- Proposing the certification standards as per the proposed UAS

Finally, the risks posed by the inflatable wings which have been ascertained rules mentioned under 14CFR parts 23,25,27 and 107 can be utilized but there are few factors which have not been addressed in respect to the certification are like damage tolerance limits which would increase the survivability rate of the inflatable wings, higher aspect ratio and wing morphing for aerodynamic controls (Cadogan et al., 2006), UAS with the inflatable wings in uncontrolled airspace (Christine et al,2017) and environmental factors (Lawrence et al,2017). The proposed certifications have been described in the following section. Existing regulations written under 14CFR parts 23,25 and 27 are for a standard type aircraft but have not been assessed for UAS fitted with the inflatable wings. Numerous regulations mentioned in 14CFR are inflexible in lots of situations so many simulated certification conditions have been build-up for the UASWIW to mitigate the hazards posed by them.

3.1 Discussion and Method

- The potential risk associated in a UAS with Inflatable wings and addressing the issue.

To propose the right certifications, we need to consider the autonomous behavior of a UAS which is one of the biggest difference between a manned and unmanned aircraft. For this, several regulations from the 14CFR were taken into account to consider the hazards like auto-deployment of inflatable wings, wing morphing, an engine failure out of two engines if fitted, power source failure which in many cases is a battery, losing its ability of sensing and avoiding various obstacles and finally destruction of the UAS itself in a severe case which can produce catastrophic results to the people, property around them. All the hazards mentioned In this case, I am considering the following three scenarios

- The structural integrity of the inflatable wings hasfailed
- Onboard engine failure
- Failure of the power source while flying over water

All the above-mentioned conditions can be catastrophic for humans including the operating crew and other UAS or manned aircraft flying in its vicinity. Theoretically, the inflatable wings can have infinite length and for doing so the manufacturer would need numerous ways of actuating it. The loss of a primary structure like the inflatable wings which provides the dynamics of flight when it comes in contact with the air could have further consequences linked to it like losing overall control of UAS which need to be alleviated and avoided. This can happen due to the impact of environmental factors like hailstorms, bird strike and damage due to any other form of foreign object debris and erosion of the inflatable wings material due to corrosive rainfall. These sorts of factors would cause a turbulent aerofoil and lose a stable flight. Losing the structural integrity of the wing would need other systems fitted alongside to alert the operator regarding the failure.

Engines are the main source of power and the same power is used to propel the aircraft forward or upward. The engine used in the UAS is mainly fitted with rotor blades which produces shaft horsepower as thrust while changing the angle of the blades at the same time for different phases of flights. In the event of a failure, the rotor can strike the ground which would, in turn, reduce its thrust capability, can hit a hurdle or can hit other parts of the UAS causing further damage. In a case when there is a one engine inoperative (OEI) while the UASWIW is carrying out its mission it will affect its capability of gliding.

These days UAS and other modern aircraft manufacturers are in a great rush to move away from traditional fuels towards cleaner fuels, some of them use a combination of both fuel and electric power and are called hybrid-electric aircraft. The benefits of moving from the traditional way of flying onto something greener are quite compelling like the reduction of noise and overall greenhouse emissions, improvement in efficiency by saving fuel. The inflatable wings were also thought of being used onto the space exploration projects some of the projects have not been fulfilled because the battery technology has not developed enough till that time the issues like failure of the UAS battery need to be addressed which could happen over a populated, non-populated area or it can even occur over water. It would be great if the UAS has the capabilities like locator beacons or the emergency locator beacons (ELT) which can start transmitting the location of the UAS if it has drowned due to power failure.ELT is a device currently in use with commercial aviation which can transmit a very low-frequency signal after coming in contact with water which can be picked up by the receiver to get the location of the UAS underwater.

The following section discusses the current rules laid under 14CFR and talks about its practicability in the situations discussed above.

- Assessing the current rules laid under 14CFR

All the rules mentioned under 14CFR do not focus on all the issues but they are there so that they can reduce the hazards posed by one UAS to other UAS operating in the same region alongside people and their property. Majority of the regulations laid under 14CFR are meant for voluntary reporting and compliance. Rules mentioned under 14CFR 107 which meant for unmanned aircraft systems do not address the issue which has been identified. They only address the issues in a generalized manner for eg. 14CFR 107.41,14CFR107.43 and 14CFR 107.45 states *the operator should not operate a UAS in any of the controlled airspaces manner that might interfere with the operation of an aircraft or airport.* This is a generalized statement which can be solved if something like traffic collision avoidance system is installed in a UAS. There are techniques and way which would tell all the vital parameter like height, speed etc while flying. The following rules from the 14CFR part 27 which can partially address all the three-issues as the majority of the UAS are rotor driven have been identified are discussed as follows.

14CFR 27.25 Weight Limits

The operator must be aware of operating weight limits which include empty weight and maximum weight which includes payload weight and have a corresponding effect on the centre of gravity (CG) mentioned in 14CFR 27.27. The classification of the UAS by FAA discussed earlier in the paper only talks about the maximum operating limits in regards to its height. The operating weight is also very important alongside the operating height. The UASWIW has the capability to fly at great heights but the issue of the operating weight need to be addressed.

14CFR 27.67 One Engine Inoperative

This regulation corresponds to the situation which could arise when there is an engine failure, it is most likely that the majority of the UAS would have more than one engine. This certification only addresses the issue of an engine being inoperative in climb phase only. Certification needs to address the other phases of flight as well where the engine could go inoperative. UASWIW can be flown with one or more than one engine which is not being addressed by this certification.

14CFR 27.143 Controllability and Maneuverability

The operator of the UASWIW must be able to safely control and maneuver in all the phases of flight to avoid *the unintentional deployment of inflatable wings and in case it happens the UAS must be controllable over a range of speeds and altitudes. In a condition, if at all there is unintentional deployment it is going to disturb the flight dynamics which is also not addressed with this certification.*

14CFR 27.605 Fabrication Methods

Every new UASWIW fabrication method by sustained by test program and it should go through various fabrication procedures like gluing, heat treatment according to the process specification to improve the serviceability.

14CFR 27.611 Inspection Provisions

UASWIW need to have recurring inspection provisions to carry out any functional checks, adjustment, alignment and lubrication of various parts which in this case would let the operator inspect its actuators and inspect any damage to the inflatable wings

14CFR107.37 Operating near aircraft; right of way rules

The operator of the UASWIW and must not operate any UAS very close to the vicinity of the manned aircraft and it needs to yield its right of way from other UAS or manned aircrafts

- Proposing the certification standards as per the proposed UAS

The operating crew or the pilot should not be accountable for all the various risks which have been discussed above as well as things like the unintentional opening of the inflatable wings, the engine being inoperative in other phases of flight, UAS getting drowned in the sea where it is not traceable. There should be enough safety nets by which should address all the possible risks are addressed and mitigated. The various parts of 14CFR like parts 23, 25, 27 and 107 have no airworthiness conditions which could address the issues raised.

A UASWIW must have the capability of sensing an obstacle and avoiding it from other UAS, manned aircraft's alongside obstacles on the ground whenever there is a failure related to the structural integrity of the wing happens and operation is being carried out on a very low altitude. On a manned aircraft, this function is carried out by traffic collision and avoidance system which senses and gives the opposites command to the pilots coming for an impact to move the aircraft up or down to avoid a collision. The subject UAS must be able to have a system in place to avoid collisions and for doing so there is a need of standardization of the certification process under the 14CFR107 rules and by doing so the integration of manned aircraft to the UAS which would put an end to all the expectations to the pilot of manned aircraft and increasing the safety of the airspace at the same time. The technology needs to bring in change and utilize all the newer materials which can improve the factors like damage tolerance, survivability rates of something like inflatable wings. Some changes have been made to the manufacturing process of the inflatable wings lately which have made them almost damage-resistant for performing landing on very hard surfaces. 14CFR107 does not have any section which would address that issue whereas 14CFR 27.605 does talk about the fabrication methods of structures of a rotorcraft.

Failure of a UAS or an aircraft engine during any phase of flight can be catastrophic. It could happen due to lots of various reasons which might include damages caused by foreign object damage, bird strike, debris coming from another UAS or aircraft or another engine if installed. The 14CFR 107 meant for UAS does not provide any guidelines pertaining to the issues of an engine onboard, whereas the other parts of the 14CFR like part 25 and 14CFR 27 do have a certification for one engine inoperative that too only in climb phase. The Engines are most likely to fail in the climb phase the most but they can fail in other phases of the flight too like cruise phase, hover mode, failure in decent mode or failure of an engine after landing which would have a minimal effect. The UASWIW must have an onboard reporting mechanism like UAS health monitoring which can tell the health of the UAS and its systems to the operating crew and the ground station. My proposal, in this case, will be to have all the phases of flight and have a dedicated certification made for the proposed UAS under the 14CFR 107.67.

UASWIW or any UAS for that matter has the capability to fly over land or water to carry out the intended work. UAS has been a great alternative where the human reach is difficult or unreachable which are otherwise called as dull and dirty jobs. While the majority of UAS use battery as a power source for carrying out their work, they do have limitations. In a situation when the battery dies when UAS is flying over water it needs to have a capability that it can tell the health of the battery to its operator and can radiate a low beam frequency as it is radiated by an emergency locator transmitter (ELT). Looking at the rules laid under 14CFR 27.562 *Emergency landing dynamic conditions*,14CFR 29.801 *Ditching*,14CFR 107.21 *In-flight emergency* do not address this sort of issue. My recommendation for this case will be to have a new set of certifications set under 14CFR 107 and have an ELT made mandatory.

4. CONCLUSION AND FUTURE SCOPE

With the process where the UAS has been simulated to develop a certification when it is fitted with inflatable wings has brought equal perceptions for UAS and the role which is it intended for. The narrative of functioning for this type of UAS is very important to understand all the risks posed and propose the certification which can mitigate such identified risks. All the identified risks for the UAS like the failure of wing integrity, engine failure and drowning of the UAS in water will not have a similar outcome as for a manned aircraft and need preparation of new or amended regulations for addressing all the safety concerns and not changing its intended operation. It's very hard to predict that one regulation mentioned under 14CFR would be able to address all the issues. Failure of one hazard which could have a snowball effect on other systems, processes and the overall operational processing of a UAS would need the comprehensive insight of all the risks involved and their mitigation processes.Proposing certifications for a UASWIW has been very difficult and tricky at the same time and it has given me great insight and has been a massive learning curve for as far as certification is concerned

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References:

Administrator, N. C. (2015, August 21). Inflatable Wing Aircraft. Retrieved February 28, 2021, from NASA website: https://www.nasa.gov/centers/dryden/multimedia/imagegallery/InflatableWing/InflatableWing_proj_desc.html

Austin, R. (2010). Unmanned aircraft systems. Retrieved from https://doi.org/10.1002/9780470664797

Bat Unmanned Aircraft System (UAS). (n.d.). Retrieved from: https://www.northropgrumman.com/what-we-do/air/bat-uas/BAT UNMANNED AIRCRAFT SYSTEM (UAS).

Black, J. T. (2006). New Ultra-Lightweight Stiff Panels for Space Apertures.

Cadogan, D., Scarborough, S., Gleeson, D., Dixit, A., Jacob, J., & Simpson, A (2006). Recent Development and Test of Inflatable wings. Structures, Structural Dynamics, and Materials and Co-located Conference. doi: 10.2514/6.2006-2139.

CASA AUS AC101, Retrieved from: https://www.casa.gov.au/sites/default/files/101c01.pdf

Civil Aviation Safety Authority. 2020. Types of drone | Civil Aviation Safety Authority. [ONLINE] Available at: https://www.casa.gov.au/drones/rules/drone-types.

Classification of the Unmanned Aerial Systems, GEOG 892. Retrieved from: https://www.e-education.psu.edu/geog892/node/5

DeGarmo, M. T. (2004). Issues concerning integration of unmanned aerial vehicles in civil airspace. *Center for Advanced Aviation System Development*, *4*.

DeGarmo, M. T. (2013). Issues Concerning Integration of Unmanned Aerial Vehicles in Civil Airspace. Retrieved from https://www.mitre.org/publications/technical-papers/issues-concerning-integration-of-unmanned-aerial-vehicles-in-civil-airspace

Electronic Code of Federal Regulations (eCFR). (n.d.). Retrieved February 27, 2021, from: https://www.ecfr.gov/cgi-bin/text-idx?SID=64520b2986ce31e7e6bc4b4199698297&mc=true&tpl=/ecfrbrowse/Title14/14tab_02.tpl

Evans, A., & Nicholson, M. (2007). Safety Assessment & Certification for UAS. In *22nd International UAV Systems Conference*.

Grigoriou, K., Clothier, R., & Sabatini, R. (2013). Assessing the Lethality of UAS.

Legaignoux, D. and Legaignoux, B., Diamond White Servicos de CondultoriaLtda, 2009. *Wing having a negative dihedron for towing a load*. U.S. Patent 7,494,093.

Maddalon, J., Morris, A. T., Hayhurst, K., & Verstynen, H. (2013, August 10). Considerations of Unmanned Aircraft Classification for Civil Airworthiness Standards. Retrieved from: https://www.researchgate.net/publication/268469140_Considerations_of_Unmanned_Aircraft_Classification_for_Civil_Airworthiness_Standards

Pham, T., Cirincione, G.H., Verma, D. and Pearson, G., 2008, June. Intelligence, surveillance, and reconnaissance fusion for coalition operations. In *2008 11th International Conference on Information Fusion* (pp. 1-8). IEEE.

Simpson, A. D. (2008). Design and evaluation of inflatable wings for UAVs.

Takayama, L., Ju, W. and Nass, C., 2008, March. Beyond dirty, dangerous and dull: what everyday people think robots should do. In *2008 3rd ACM/IEEE International Conference on Human-Robot Interaction (HRI)* (pp. 25-32). IEEE.

Uas army. (2010). Retrieved from https://fas.org/irp/program/collect/uas-army.pdf

Wang, Z., & Wang, H. (2012). Inflatable wings Design Parameter Optimization Using Orthogonal Testing and Support Vector Machines. *Chinese Journal of Aeronautics*, *25*, 887-95.

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