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Unmanned vs manned Aircraft Systems accidents investigation: post-accident analysis, benchmarking and improvements

Susana Monje Sánchez, Rosa Mª Arnaldo Valdés**, Fernando Gómez Comendador*** and Cristina Cuerno-Rejado*****

E.T.S.I. Aeronáutica y del Espacio (Universidad Politécnica de Madrid)

Plaza del Cardenal Cisneros 3, 28040 Madrid, Spain

susana.monje.sanchez@alumnos.upm.es;rosamaría.arnaldo@upm.es**; fernando.gcomendador@upm.es***; cristina.cuerno@upm.es*****

Abstract

The growth in operation of Unmanned Aircraft Systems (UAS), and the concerns about possible accidents, has lead safety authorities to extend accident investigation processes from manned to unmanned aviation. In this study, the authors analyse the causes of a large list of UAS accidents, study manned aircraft accidental rate in their first growth phases, and derive a chronological similarity between manned and unmanned systems regarding maturity and accidental rate. Authors also identify which aspects of the accident investigation process must be improved or completely developed to transform RPAS accident investigation into such refined process as it is in manned aviation.

1. Introduction

The growth in the number of Unmanned Aircraft Systems (UAS) Operations, otherwise known as drones and Remotely Piloted Aviation Systems (RPAS), and the number of related safety events, including both accidents and incidents, is increasing rapidly [1]. This presents an emerging and insufficiently understood transport safety risk [2] .

UAS operations have multiplied in the last two years within the EU and so did the number of reported occurrences, most of which were related to the control of the flight path of the RPAS or to airspace infringements that occasionally caused a near collision with an aircraft. According to 2017 EASA Annual Safety Review [3], the European Central Repository (ECR) includes 606 occurrences, 37 of them accidents that fortunately did not involve fatalities. The rising number of UAS non-fatal accidents and serious incidents proves the speedy advance of drone operations. Based on these data EASA had recently identified three priority key risk areas for UAS operations: i) Aircraft Upset; ii) Airborne Collision, and iii) Obstacle Collision in Flight. However, since EASA report relays on incipient UAS occurrence reporting and inexistent UAS accident investigation, it does not provide any hindsight into the causes of those incidents and accidents, neither provide safety improvement recommendations.

Nowadays, UAS safe operation is a priority of all aviation safety agencies and governments. However, its production, certification and operation is still in a very emerging stage, as it was manned aviation´s in its earlier steps of development. At this point, accident investigation becomes one of the aviation safety processes key to understand different risks and improve operational safety. The investigation and root cause analysis of UAS accidents are vital to confirm the efficacy of the safety approach in this emergent sector. UAS accidents investigation and root cause analysis are also essential to define future safety controls and mitigations to the operation and design of UAS. However, although the accident investigation process is extremely mature in manned aviation, it is in a very preliminary phases when unmanned aviation is considered. While various programs have been established to collect UAS encounters and possible accident information, the sharing of data and standardization of accident reporting and investigation are still in primary steps of maturity [4] [5, 6].

The accident investigation of manned civil aviation is contemporary of the first aircraft appearance. The first organization responsible of accident investigation date back to 1915 in EEUU, when The President Woodrow Wilson founded The National Advisory Committee for Aeronautics (NACA) [7]. The NACA put into practice analysis methods for accident investigation and defined the technical terms used to assign causes and identify contributing factors. After the ICAO creation in 1945 and the Annex 13 publication, this process was regularized internationally and became a responsibility of the States. Analysis methods and procedures for accident investigation were created to guarantee a homogenous investigation, and to contribute to the improvement of the aviation safety via causes identification and issuance of recommendations. [8]

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The UAS growth and the fear about increased accident rate took the authorities to spread out the accident investigation process from manned to unmanned aviation. This initiative has led to modify the accident definition in Annex 13 in 2010 [9] with the purpose of enlarge the states responsibility in UAS accidents and serious incidents. The new Annex 13 accident definition selectively refers to unmanned aircraft as follows: "*...Accident. An occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down, in which…*" [9] .

This definition is also included in the Regulation (EC) 996/2010 on the investigation and prevention of accidents and incidents in civil aviation [10]. Nevertheless, the adaptation of the accident investigation process has been limited so far. ISASI, the International Society of Air Safety Investigators, highlighted in 2015 the need to identify what additional investigative capabilities should be developed or improved to support the investigation of UAS-involved accidents. ISASI also pointed out the need to develop some UAS Investigation Guidelines [11]. Very recently, the FAA (Federal Aviation Administration) has opened some debates regarding UAS accident investigation [12]: Up to what extent is it appropriate or useful to investigate accidents of UAS of different sizes? What types of UAS accidents warrant in-depth investigation? It is worthy to expend investigative resources on small UAS accidents?

Additionally, the nature of UAS accidents and their main causes and contributing factors are not known essentially due to the lack of available information. Some authors have centered their study area in identifying main factors in UAS accidents in order to examine their consequences, causes and lessons learned. At [13] the authors considered 9 investigations of UAS mishaps to examine their consequences, causes and lessons learned. The book focused mostly on experimental UAS. At [14] the authors extracted, from the U.S. Army's Flightfax and Knowledge magazines, a set of approximately 400 reported incidents and cluster them into five categories according to take-off weight, operating speed, and impact energy. Although very few information was available about the failed components, some conclusions were raise for particular UAS models. For example, engine, generator, and ignition were among the main failing components for RQ-7 UASs, whereas lost link and lost control often caused problems in RQ-11. In [15] and [16] a sample of 152 UAS accidents and incidents, collected from 2006 to 2015, have been studied to analyse the distribution of contributing factors. However, do to the scarcity of information in the reports, the analysis of causes remains at high level distinguishing only between "human factors, equipment failures, organisational issues, environmental issues and unknown". The analysis of unmanned aircraft (UA) accident (collected from the U.S. Army, Navy, and Air Force) [18] pointed out that human error (which varied across aircraft from 21% to 68%) was less of a causal factor than electromechanical failure.

In this paper, the authors complement and extent previous work in the literature by tackling the challenge of UAS accident investigation from two different angles: the nature of UAS accidents and the particular characteristics of UAS operation, which conditions the investigation process. The first point of view deals with unmanned aircraft accidentally nature, and to deal with it a statistical analysis of investigated UAS accidents is done. This analysis allows us stablish a chronological reciprocity between different eras of manned and unmanned aircraft accidentally. This analysis also allows us to identify those accident investigation facets that must be prioritized. The second point of view emphasizes the accident investigation process, the differences between manned and unmanned aircraft investigation, and how the current investigation process can be renewed and improved for dealing with the challenges in UAS accidents. This perspective brings to light key aspects in accident investigation that are applicable to both manned and unmanned aircraft.

In this study, authors analyse the causes of a large list of accidents to perform a comparative study of manned and unmanned aircraft accident rate in their respective initial phases. This analysis allows us to stablish a chronological similarity between manned and unmanned systems regarding systems maturity and accident rate. The analysis also allows identifying which accident investigation aspects must be improved or completely developed to turn RPAS accident investigation into such a refined and productive process as it is in manned aviation. In addition, authors make a critical analysis comparing the process of accident investigation in both manned and unmanned aircraft, and suggest some improvements based on the UAS operation and accident characteristics.

In section 2 the methodology followed in the study is summarized. In section 3, the UAS accident are compiled and their main causes are detailed and analysed. In section 4 the accidental rate in first phases in manned aviation is analysed and parallelisms with unmanned aviation are also pointed out in section 5. The section 6 identifies the necessary improvements in the unmanned accident investigation process. Finally, section 7 summarizes the main conclusions and recommendations of this work.

2. Methodology

Methodology used in this study is graphically represented in Figure 1. As it can be seen the methodology pursue and exploit the fact that unmanned aircraft accident investigation resembles manned field, whose procedures can be taken and conformed to particular unmanned aviation characteristics. After the identification of sources of accident

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investigation reports of unmanned aviation (step 1), it was possible to assess causes and contributing factors of UAS accidents (step 2). At the same time and additionally, the identification of accident investigation in early stages of manned aviation (step 3) and the analysis of their causes (step 4), allowed a comparative study of manned and unmanned aircraft accidental rate and causation in their first growth phases (step 5). From this analysis, a chronological similarity between accidentally in both types of aviation is derived (step 6).

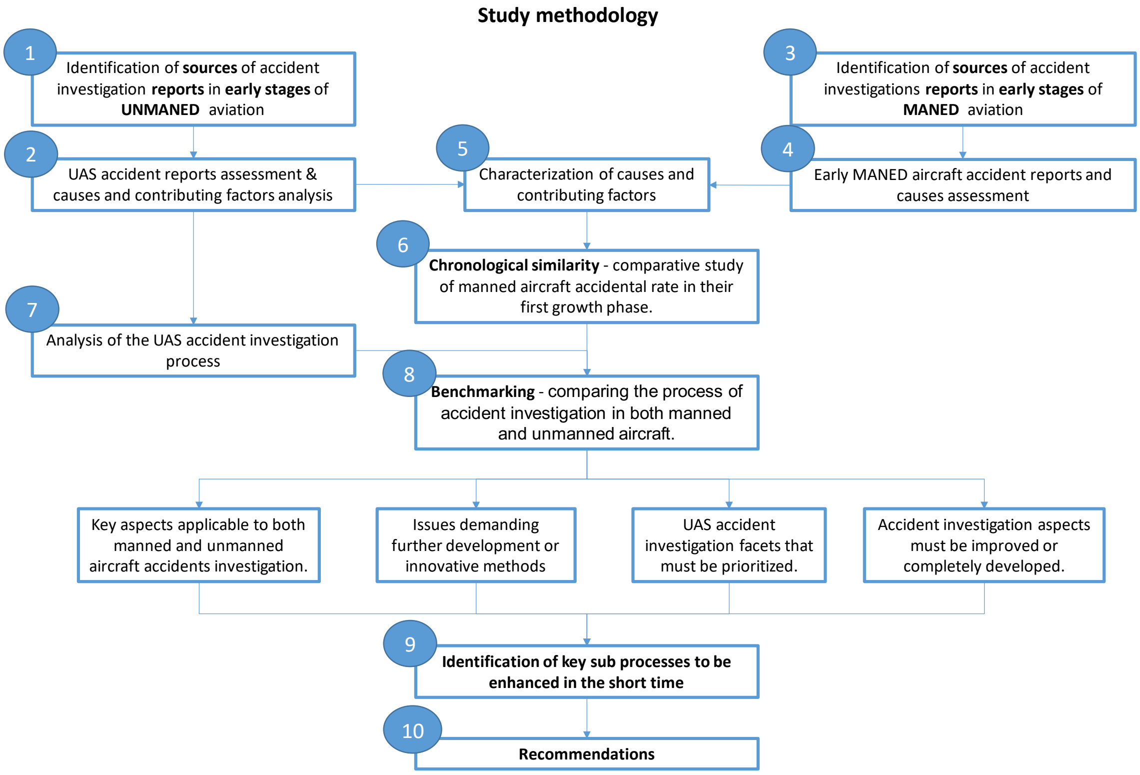

Figure 1: Study methodology

A second phase of the study is devoted to the analysis of the accident investigation process itself. This process is well developed and standardised for managed aviation, and it does not required an in depth research, as ICAO has developed procedures and are publicly available. However, this is not the case for unmanned aviation. In step 7, we have look into the details of:

- how UAS accidents and incidents are reported in different countries and under different regulations;
- how each safety investigation authority digs into the facts and causes of each accident, which methods and techniques are employed and to which depth the investigation is performed; and
- how the outcomes of the investigation are stated and communicated into a final report.

All of these allow determining several recommendations such as keys aspects applicable to both manned and unmanned investigation, facets of UAS accident investigation that must be prioritized, aspects that are demanding innovative methods or must be improved, or completely developed. Outputs of this analysis are used to perform a benchmarking comparing the process of accident investigation in both manned and unmanned aviation in step 8. Benchmark criteria include:

- Key aspects applicable to both manned and unmanned aircraft accidents investigation.
- Issues demanding further development or innovative methods.
- UAS accident investigation facets that must be prioritized.
- Accident investigation aspects that must be improved or completely developed.

In step 9, we balance the effort required to improve each UAS investigation sub-process to standards equivalent to those of maned aviation, with the possible gains in the short time, that allow identifying the key sub-processes to be further enhanced and standardise in the short time. Finally, recommendations to for this upgrade are issued in step 10.

3. Accident characterization during early stages of unmanned aviation

As stated in the introduction, one of the mayor difficulties to understand the nature of UAS accidents is the current lack of uniformity, and sometimes the inexistence, of formal occurrences notification process, since different agencies publish different UAS accident reporting requirements, what can breed confusion and duplication [18]. The lack of

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sound sources of information about the causes and factors present on those accidents is also a big difficulty. Compiling a relevant and exploitable set of UAS accidents investigations is a challenging task that includes consulting a wide variety of sources, filtering incomplete accident records and "false positives", clarifying disparate reporting requirements and unequal investigation procedures, and integrating non-homogenous taxonomies for contributing factors and causes.

Due to the scarcity of resources, the authorities are still considering what types of UAS accidents warrant in-depth investigation, or if it makes sense to expend the limited resources of the accident investigations authorities on small UAS accidents. For example, the National Transportation Safety Board (NTSB), under the premise that "investigators should concentrate on accidents/incidents involving see-and-avoid breakdowns" [19] has considered the 5 UAS accidents notified since 2010 as lower-level cases which did not warrant the launching of an NTSB investigation. This is because those accidents did not involve a potential for a mid-air collision and the result were only UAS damage during a test flight or remote operation. As a matter of fact, after analysing more than 20.000 accident reports published by the NTSB (related to both manned and unmanned aircraft) since the Predator accident (April 2006) to date, only 12 of them were related to unmanned aircraft.

In this work, the authors have conducted a semi-systematic survey of additional accident databases such as the Incident Reporting Information System (IRIS), the Federal Aviation Interactive Reporting System (FAIRS), the FAA's Accident and Incident Data System (AIDS). The three main NASA supported database have been also surveyed: Aviation Safety Reporting System (ASRS), NASA Aircraft Management Information System (NAMIS), and NASA Incident Reporting Information System (IRIS). It is worth to mention that NASA operates a variety of UAS platforms, such as SIERRA, Ikhana, Global Hawk, DROID, Dragon Eye, BAT-IV, Swift UAS [13] . Other relevant accident investigation authorities consulted include the Australian Transport Safety Board - ATSB, the Transport Safety Board of Canada - TSB, the UK Air Accident Investigation Branch – AAIB, and the Bureau d'Enquêtes et d'Analyses (BEA) pour la Sécurité de l'Aviation Civile, although unfortunately very few complete UAS accident investigation reports have been produced by these organizations up to now.

For example, although between January 2012 and December 2016, 180 RPAS-related occurrences (47 accidents, 15 serious incidents or near accidents, and 118 incidents) were reported to the ATSB in Australia [2], only two investigation reports have been published by this organization, corresponding to two collisions with terrain involving a Lockheed Martin Stalker XE VTOL UAS in October 2016. UK safety board has already published 6 UAS accidents investigation reports, while Canada Safety Board and BEA have not published any.

Given that RPAs are part of the military inventory from a long time ago (basically as watching platforms operating from military airfields located very often in conflict areas), the search for unmanned aircraft accidents reports was successfully broaden to the military field, including the information published by different Armed Forces (mainly US Army, Marine Corps, Navy and Air Force). Finally, by collecting information from the various sources mentioned, 288 UAS accidents investigations have been analysed over a period of 10 years, drawing to the conclusions shown hereafter.

First, Table 1 shows the main different reasons that caused the accidents, compiling some of the previously mentioned aircraft types and emphasizing the most common causes of the accidents of each one of them. Predator is the UAS with the highest number of incidents and accidents reported. Most of them are due to communications system failures because, normally, the operating missions assigned to this aircraft have place in conflict areas where radio interference countermeasures are active. Some of these units have been shot down. The majority of the reported mechanical failures took place during the early stages of operation and occurred due to inadequate maintenance tasks.

Widely used by the US Navy, the Shadow is one of the main platforms used for border surveillance and damages evaluation after attacks in conflict areas. This UAS is launched by mean of a pneumatic catapult and sends real time images to the ground station. It is possible to see that, as mentioned before, the main causes for Shadow accidents are communications failures. This type of aircraft is replacing the ScanEagle, whose accidents are caused by similar reasons, as it is depicted in Table 1. In the case of the Skylark type, communications failures are also the main cause of accidents. Only one of the 15 published reports shows that the aircraft was shot down. This could lead us to conclude that navigation or communication systems failures are the only cause of Skylark accidents and it is necessary a redesign of these systems. Moreover we have to take into account that in conflict areas the communications interference are widely used. Table 1 includes, also, the failures that have affected other types of aircraft, being the communication failures the common element to all of them.

Next, despite the fact that communications failure is the most common accident cause for all the platforms, second and third causes in the ranking are not the same for all the aircraft. The main reasons causing the accidents are shown in Figure 2. Standing out communication failures, enemy firing is other main cause of military unmanned aircraft accidents.

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Table 1: Main accident causes in selected UAS from de database.

	Communications failure	**Enemy fire**	**Loss of control**	**Engine failure**	**Mechanical failure**	**Others**	**Unknown**
Predator	31%	6%	12%	7%	8%	5%	31%
Shadow	28%	-	5%	19%	5%	5%	38%
Raven	63%	-	7%	1%	1%	8%	20%
Scan Eagle	28%	7%	29%		-	-	36%
Skylark	93%	7%	-	-	-	-	-
Heron	67%-	17%	-	-	-	-	16%
Global-Hawk	50%	-	-	-	-	-	50%
Dragon-eye	67%	-	-	-	-	-	33%
DJI Phantom	-	-	-	-	-	67%	33%

Putting aside the accident causes, Figure 3 show schematically the yearly recurrence of them for the period from 2004 to 2017. The percentages are calculated over the overall number of UAS accidents accounted in those thirteen years. On one hand, it is possible to deduce that in 2006 the reporting of unmanned aircraft accidents were first documented, more precisely after the Predator accident during a border surveillance operation in Arizona. On the other hand, we can see that the higher number of accidents coincide with war periods. Having in mind the geographical distribution, we can see that the majority of military RPAs accidents included in the database took place in conflict areas such as Afghanistan, Lebanon, Syria or Israel from 2014.

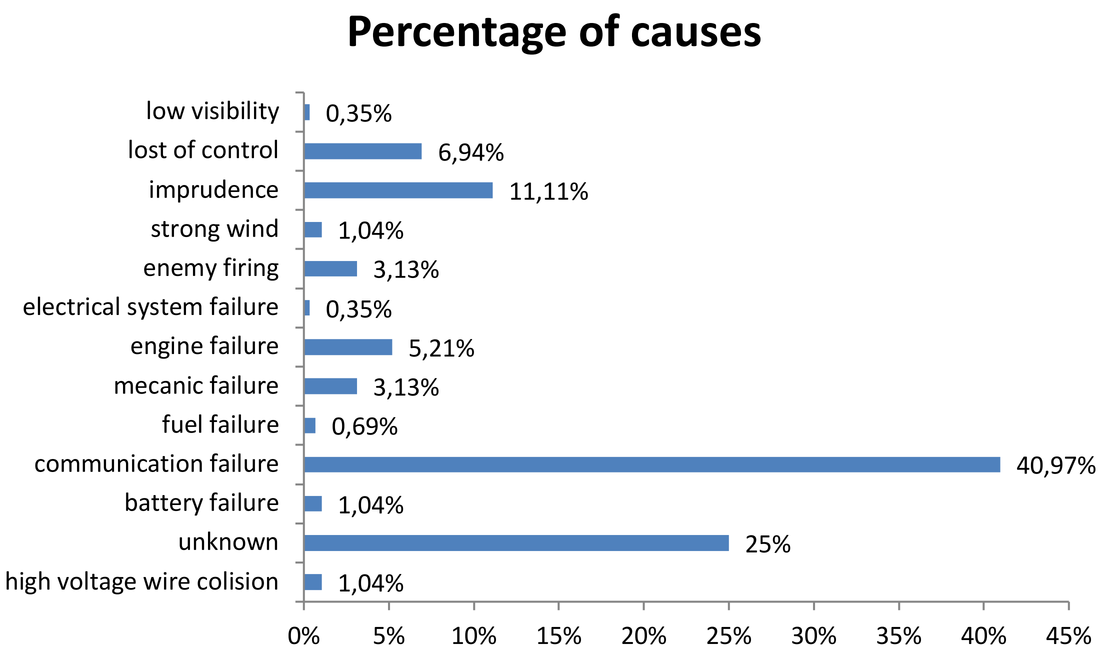

Figure 2: More repeated causes

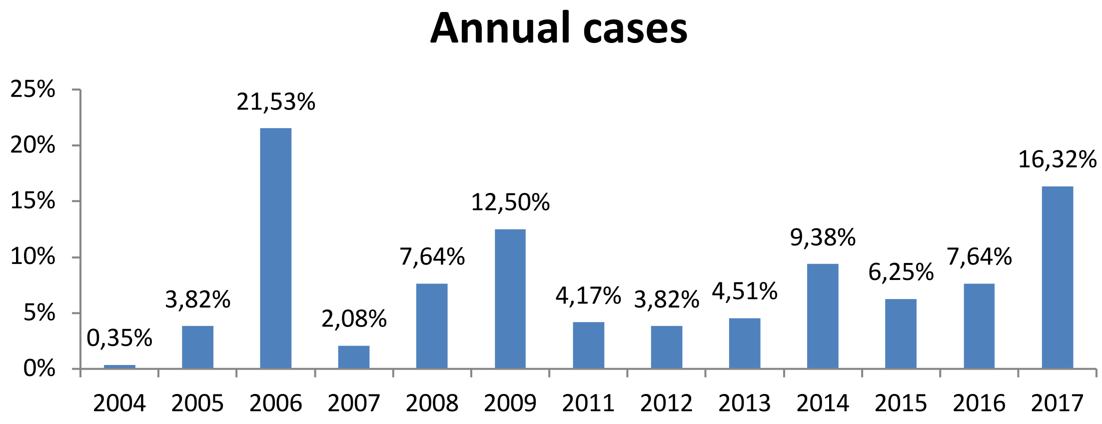

Figure 3: Annual cases

4. Accident characterization during early stages of manned aviation

The following graphics show the evolution of the manned aviation accidents during its early stages, and reasons that caused them. This analysis is based on NACA's database of accidents, which includes commercial flights accidents with some casualties; and cargo, ferry and test flights, as well as accidents of military airplanes with at least 10 casualties. In terms of accident rate, the early stages of the unmanned aviation can resemble to manned aviation before the 1960s. This analysis covers the period from the beginning of the aviation until the 1960s, to make manned and unmanned technology and maturity comparable. Figures 4, 5 and 6 show the detailed analysis of the reasons that caused the accidents in three different phases: from the beginning to 1920, up to 1940 and up to 1960.

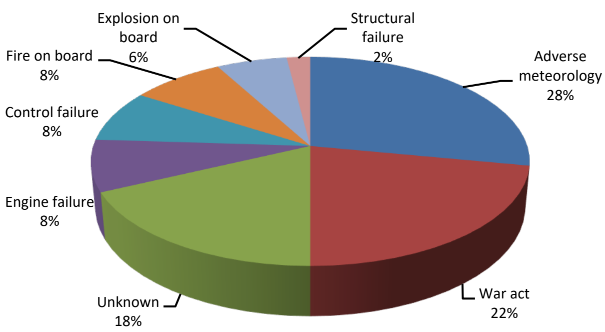

Figure 4: Accidents causes up to 1920

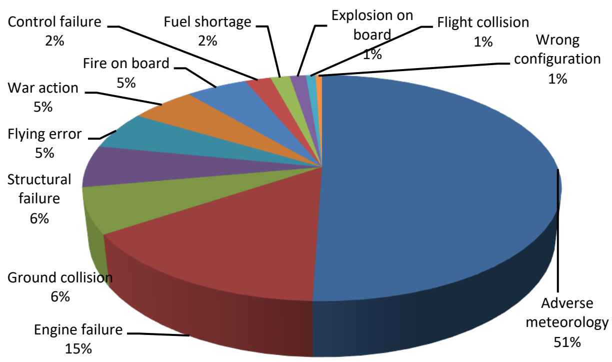

Figure 5: Accidents causes up to 1940

Figure 4 shows that adverse meteorological conditions was the main cause of accidents during the early stages of maned aviation. At that time the navigation aids were insufficient, and the information that the pilot had available were, in many occasions. The graphic also shows the influence of I World War in the development of the aviation, because since its beginning all the airplanes were placed at the service of the Army. The high percentage of accidents with unknown cause, provides an idea of the lack of information and immaturity that characterized the investigation procedures during this period. Figure 5 shows that adverse meteorological conditions is also the main cause of the accidents that took place up to 1940, with engine failure as the second one. Figure 6 shows a tendency change of the accidents reasons up to 1960, because the accidents that took place during them II World War are included. The analysis also shows that piloting errors were a relevant amount, because the pilot training were inadequate and many times their inexperience caused the fatal ending. Engine and structural failures were also of great importance, because the performance of the engines and the response of the materials to the flight conditions were not thoroughly known.

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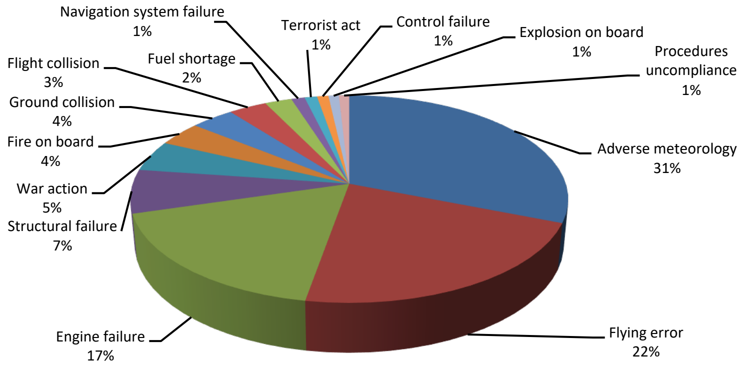

Figure 6: Accidents causes up to 1960

5. Comparative analysis of manned and unmanned aviation accident causes

In order to better conclude, the analysis of accident causes to civil RPAS has to be included. So, in addition to the analysis carried out in section 3, the conclusions can be extended also taking the results of the study carried out with a database of 152 accidents and incidents of civil RPAS occurred between 2006 and 2015 [21]. Most of the events in this database have occurred due to failures in various on-board systems due to problems in some equipment. Therefore, the problems related to the airworthiness of these aircraft must be taken into account in a preferred place. Both failures due to human factors and loss of control in-flight have turned out to be the second contributing factor and the second type of event, respectively. This allows influencing, in addition to airworthiness, aspects related to crews, which on the other hand, is a relevant common cause of aircraft accidents, as demonstrated by [22].

Even though the cause of a large part of UAS accident is unknown, the parallelism with the causes of the manned aviation accidents in the 40´s is clear; accidents due to unfavourable meteorology have been prevented, although failure in communication systems is still one of the principal problems.

It is noticed that principal causes of unmanned aircraft systems accidents are very different from first ones in manned aviation. That is because the first one takes into account with a previous century of experience, whose failures have allowed extracting some lessons, which have been applied to avoid repeating the same failures, being that the main goal of accident investigation.

However, what it is interesting to note is the great parallelism between the causes of accidents and incidents of civilian and military RPAS, which is a big difference with what happens in manned aviation that should move us to reflection in order to be able to extract the correct lessons learned from all these new events [23].

6. Augmentation and supplementation of existing investigative capabilities for UAS investigations

There is rising mindfulness in both the UAS and Safety communities, about the fundamental differences between manned and unmanned aircraft, and how those differences need to be fully understood and addressed in accident investigations. As results of the benchmark performed during this study, we have identified a series of differences that need to be addressed with certain urgency. To be proactive it is necessary to apply lessons learned from manned aircraft accidents to the emerging issues associated with unmanned aircraft operations, instead of emulating the safety evolution of the present-day aviation environment with a new generation of UAS accidents. Our main findings regarding how existing investigative capabilities need to be augmented and supplemented for better UAS investigation are summarised hereafter:

1. **Standardise the notification** report and the criteria to perform a formal investigation. This is necessary to assure a homogenous attention to UAS accident worldwide, with an effective use of the available resources. It its necessary also to increase awareness of the real risk and to dimension the real magnitude of the problem. [24]
2. Making sure safety lessons written in blood from previous accident investigations stay learned. This imply to **standardise the outcomes** of the accident investigation so as everybody can benefit from the learnings in each case.

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3. **Improve investigative skills and knowledge**. There are certain domains that will require further study and a better understanding to improve the quality of the investigation and the recommendations, including:
    - **Human factors**: Aviation authorities should further study and regulate unmanned aircraft system pilot training and certification, and should perform specific human factors studies on pilot conditions and fitness to fly. There is insufficient objective research available to allow air safety investigators to make any independent judgments regarding these issues. Safety investigation requires a better understanding of how UAS pilots obtain and maintain situational awareness regarding the conduct of their operations and the kinds of automation needed to support certain types of flight activity.
    - **Telecommunications**: Safety investigation will require understanding of radio waves properties at different frequencies, available spectrum and its management, effects of degraded modes and interference, potential of control link failure or disruption, impacts of latency impacts (built-in lag in the communications between pilot and controller and pilot and aircraft), security and cyber security hazards and risks, etc,…
    - **Aircraft structures**: Safety investigation will require understand how unmanned aircraft designers elected to solve certain challenges absent both formal certification standards and the need to protect human occupants.
    - **Emerging propulsion systems**: Instruction in new types of propulsion systems used by many cutting-edge unmanned aircraft such as battery power, solar power or fuel cells.
4. **Pre accidents hazard analysis.** Identification of scenarios most likely to be encountered based on the certificated systems.
5. **Investigations involving Beyond Line of Sight UAS operations.** Securing evidence and gathering testimony in scenarios involving separate ground control stations in different parts of the world, the crash site and a satellite or network operations center.
6. **Investigation of accidents involving model aircraft.** The main challenges imply 1) confirming the exact type of model aircraft used; 2) determining the exact trajectories of both aircraft in the case of mid-air collisions; 3) reconciling the observed impact damage with the physical properties of the model aircraft.
7. **Special circumstances where additional accredited representatives may be warranted.** Provisions for additional accredited representatives need to be considered, such as: State of Design for the ground control station; State of Manufacture for the ground control station; Aircraft and Ground Control Station Registered in different States, Location of Pilot/Operator different from State of Occurrence, etc…
8. **Data fields associated with UAS operations requiring capture.** Taxonomies need to better ensure that occurrence categories broad enough to allow the inclusion of UAS-involved events with the same or equivalent outcomes. Taxonomies should add primary and secondary occurrence types to accommodate UAS-related events. It will also be necessary to expand the human factors taxonomy as needed to ensure pilot-to-aircraft interface, perception and awareness issues.
9. **UAS-specific air safety investigator skills.** Investigator-in-charge of an UAS accident investigation should be provided familiarization training regarding unmanned aircraft system characteristics and operations as conducted within their area of responsibility.
10. **Evidence preservation following unmanned aircraft system accidents.** Procedures should be stablished for gathering On-Scene and Ground Control Station investigations, and for gathering testimony from the Pilot-in-Command and other crew members.
11. **Investigation procedural and functional considerations.** Current procedure checklists need to be adapted and local guidance on the following items needs to be created: wreckage (on-scene) investigation; organizational investigation; operations investigation; aircraft operational environment; aircraft performance investigation; flight recorders; reconstruction of wreckage; sstructures investigation; Mid-air collision investigation; fire pattern investigation; powerplant Investigation; systems investigation; maintenance investigation; helicopter investigation; investigating human factors; survival, evacuation, search, rescue and fire-fighting; pathology investigation, investigation of [explosives] sabotage.
12. **Investigation outcomes reporting and communication.** Ensuring current criteria for the development of accident final reports incorporate relevant UAS-unique content into both the factual and analytical portions of such reports.

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7. Conclusions

The operation of remotely piloted aircraft is considered today an emerging risk to transport safety that requires close monitoring of the accidents and incidents since the popularity of these aircraft continues to rapidly grow and so does the number of safety occurrences which are reported. Currently aviation is in the path towards higher levels of automation. The incorporation of more automatic systems has been continuous last years. Technological advances in robotics, artificial intelligence and telecommunications has contributed to this progress. This transformation to more automatic systems drive the development and growth of unmanned vehicles. Due to their constantly increasing utilization and their better market position, the safety investigation of unmanned aerial vehicles could avoid many future problems.

Authorities must develop a normative that allows the sector displaying all its strength. Nowadays, UAS safe operation is a priority of all aviation safety agencies and governments. The phenomenal growth in the operation of Unmanned Aircraft Systems (UAS), and the concerns about the possible accidents, has lead the safety authorities to extend accident investigation processes from manned to unmanned aviation. However, the reporting and collection of data on UAS occurrences and the investigation of UAS accidents is still in its infancy and there is still a lot of work to be done to ensure the correct lessons and recommendations can be derived from them.

In this study we have consider the conclusions of the investigation of more than 280 military UAS accidents investigations and 152 accidents and incidents of civil RPAS occurred between 2006 and 2015. Analysing the causes of a large list of UAS accidents has allowed making a comparative study of manned aircraft accidental rate in their first growth phases, and to stablishing a chronological similarity.

Finally, the paper summarises our findings regarding how existing investigative capabilities need to be augmented and supplemented for better UAS investigation. Based on this analysis, it appears there are two key challenges that can be and need to be tackled in the short time:

- Standardise the notification report and the criteria to perform a formal investigation. This is necessary to assure a homogenous attention to UAS accident worldwide, with an effective use of the available resources. It its necessary also to increase awareness of the real risk and to dimension the real magnitude of the problem.
- Making sure safety lessons written in blood from previous accident investigations stay learned. This imply to standardise the outcomes of the accident investigation so as everybody can benefit from the learnings in each case.

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