CHEMICAL ENGINEERING TRANSACTIONS
VOL. 53, 2016
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Valerio Cozzani, Eddy De Rademaeker, Davide Manca

ISBN 978-88-95608-44-0; **ISSN** 2283-9216
DOI: 10.3303/CET1653035

Remote Pilot Aircraft System (RPAS): just Culture, Human Factors and Learnt Lessons

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Significant efforts invested in unmanned air vehicle (UAV) technology lead to a wide variety of new applications such as aero-photography and surveillance (Kontogiannis et al., 2013) and the operation of remotely piloted aircraft system (RPAS) undoubtedly has a great impact on the aviation industry and on the industrial applications.
Experiments for measuring plume ash gas composition in the Stromboli Vulcan with a drone, inspections on wind turbine farms, high voltage lines and on antennae for the mobile connectivity, underline how the drones may be useful in case of disasters for analysis and for industrial applications.
Unfortunately, the still incomplete regulatory framework and the frequency with which RPAS operate in urban areas or in unsegregated airspace highlight the many risks and the potentially catastrophes in case of risk underestimation and human errors. The European Aeronautic Safety Agency (EASA) is working together with the Joint Authorities for Rulemaking on Unmanned System (JARUS) work group for Safety & Risk Management to analyse and review the different strategies for safety assessment and human factors. The "just culture" approach may not be sufficient to avoid responsibilities in case of an air or ground collision and dramatic accidents.
Exploring cases of near mid-air collisions between RPAS and commercial aircrafts, the paper firstly outlines and discusses the correlation between safety and knowledge through a survey conducted until the end of 2015 to assess the background of more than 1000 future RPAS pilots. Finally, examining the precarious situation when an incomplete preliminary risk assessment is conducted, the research work highlights how the human factor may affect the risks deriving from unsuitable selection of aircraft, airspace and weather conditions associated with the operator's lack of knowledge.

1. Introduction

The rapidly increasing use of a remotely piloted aircraft (RPAS), an unmanned aircraft vehicle (UAV) or a drone as it is often referred to, for civilian purposes or for recreational use by a growing number of avid aviation enthusiasts, is undoubtedly proving to be a very pioneering and lucrative technological expansion.
This innovative technological development that greatly impacts the aviation industry not only raises many important technical and operational problems but also brings forth many complex social, legal, environmental and safety issues which emanate from operating RPAS in non-segregated airspace for civilian or recreation use.There are mounting concerns in the aviation industry that use of RPAS poses safety threats when such devices are operated in an uncontrolled environment, thus increasing the risk of a collision between piloted aircraft and remotely piloted aircraft.

2. State of the art of the regulation for the Remotely Piloted Aircraft

Unmanned aircraft vehicles (UAVs) are a new component of the aviation system, one which the International Civil Aviation Organisation (ICAO), States and the aerospace industry are working to fully comprehend, define and ultimately integrate. The safe integration of UAVs into non-segregated airspace will be a complex, long-term activity requiring the expertise of many stakeholders

Please cite this article as: Fontaine O., Martinetti A., Michaelides Mateou S., 2016, Remote pilot aircraft system (rpas): just culture, human factors and learnt lessons, Chemical Engineering Transactions, 53, 205-210 DOI: 10.3303/CET1653035

At present, RPAS regulations, policies and laws are being created, amended, and implemented on different levels by several bodies. In Europe, the national Civil Aviation Authorities (CAA) are currently responsible for RPAS operations with a weight less than 150 kg, which leadings to divergent rules from state to state, thus, necessitating a response on a European level.
In March 2015, the first step towards EU-wide harmonisation has been undertaken by European Aviation Safety Agency (EASA) by presenting its anticipated regulatory approach and concept of operations for RPAS.
The way chapter titles and other headings are displayed in these instructions, are meant to be followed in your manuscript.

2.1 December 2015: the step forward

December 2015 might be remembered as the decisional month for RPAS rules. The European commission had publish a document entitled “An Aviation Strategy for Europe” in which drones are totally integrated in the aviation regulations. One week later, the EASA has published their 27 proposals for a European rules framework for drones built on clear concepts:

- Rules based on risk proportionality;
- Three UAV categories;
    - Open, light weight, inoffensive, regulated by police
    - Specific, operation based on risk assessment, regulated by National Aviation Authority (NAA);
    - Certified, considered as totally aeronautical and regulated by EASA;
- Operators centric.

We may add, performance based, progressive and smooth integration in pre-existing aeronautical field.
That clear statement forces Countries on the way of regulation to adapt the existing drafted rules. This new situation lets to suppose evident changes in the actual Italian rules but also in other countries.

3. A safety issue

Air Traffic management (ATM) systems are composed of many nested layers resulting in complex interactions (Rodrigues de Carvalho, 2011) between human operators, between human operators and procedures and between operators and hardware/software technical systems. Unfortunately, the systems involved do not take into account the interactions between aircraft and RPAS. For these reasons the prime safety goal of the ATM is to reduce the risk of mid-air collisions (Broeker, 2005) not only between piloted aircraft, but also between unmanned and manned aircraft. In particular, the safety of aircraft used for a variety of tasks, such as air rescue, general aviation activities, airport terminal operations, which fly at low-altitude, is vital (Juang et al., 2008); this is a particularly challenging issue due to various potentially hazardous objects such as free-flying wildlife, model aircrafts, lanterns, balloons, kites etc., which pose significant collision risks to low-flying aircrafts (Zhang et al., 2014).The following examples of near mid-air collisions involving recreational RPAS coming dangerously close to commercial passenger jets underline the many risks and potential catastrophic consequences which may result therefrom, which include, inter alia, loss of life and injury, as well as tremendous financial and environmental damage. Nevertheless it shows how the safety culture on the UAVs world has still a long way to go.

3.1 Near mid-air collision involving RPAS: a short case history list

On 4th March 2013, the pilot of an Alitalia Boeing 777 flight AZ608 flying from Rome to New York reported that he saw a small, unmanned aircraft while on approach to landing at JFK International Airport about 1 kilometre from the touchdown point of runway 31R at an altitude of approximately 400 metres. The small, unmanned aircraft which came within 50 metres of the aircraft was reported to be a four-propeller, black-coloured remotely controlled aircraft approximately 1 metre in diameter. The attempt by the investigating Federal Bureau of Investigation (FBI) to locate both the aircraft and its operator were unsuccessful (Kaminski-Morrow, 2013)
In May 2014 the co-pilot of an AT72 believed that he had seen a quadcopter close to his right wing-tip when the aircraft was on approach at Southend Airport, about 35 kilometres east of London (Assessment Summary Sheet for UKAB Meeting, 2014). He reported that the quadcopter had come as close as 100 metres to the commercial aircraft as it approached the aircraft from the right-hand side before making a turn and flying in the opposite direction around 25 metres away and at the same level. The remotely controlled device was so close to the aircraft that the co-pilot assessed the risk of collision as being high. The air traffic control then reported the sighting by the co-pilot to the police who contacted two model flying clubs which were operating in the area. Neither the RPAS nor the remote pilot was located.

Another near mid-air collision between a commercial airliner and a RPAS at London Heathrow airport occurred on 22nd July 2014 when the pilot of an Airbus A320 with 180 passengers on board reported that when the aircraft was on its approach at 175 metres, he sighted a RPAS which was described as a small model helicopter. The device did not appear on the air traffic control radar (Mailonline, 2014). The pilot landed the aircraft without any further occurrence but did indicate that seeing the device at that critical phase of the flight was a distraction to him. The UK accident investigation body stated 'That the dangers associated with flying such a model in close proximity to a commercial air transport aircraft in the final stages of landing were not self-evident, was a cause for considerable concern (The Guardian, 2014).

The following incident took place in Australia. A near collision occurred between an unknown flying object and an aircraft identified as De Havilland DHC-8 on 19th March 2014. The aircraft was approaching Perth Airport when the crew noted a bright light described as a grey, cylindrically shaped object flying directly towards the direction of the plane. The pilot immediately took evasive action and avoided a near collision. The unknown object then continued to pass at about 20 metres horizontally and 25 metres vertically from the aircraft. The Australian Transport Safety Bureau released a completed summary report on an unknown flying object in near collision with an aircraft. The Australian Transport Safety Board investigated two other incidents of RPAS operating near airports, one where a suspected RPAS almost collided with a helicopter and another where a RPAS was operating close to the aerodrome without making any radio calls (Yenko, 2014).

Recognising the inherent dangers of RPAS flying into controlled airspace and the risk of a mid-air collision, the British airline pilots' association, BALPA, reported that the rapid increase in the number of drones operated by amateur operators now presents a real risk to commercial aircraft.

BALPA has demanded that drones meet the same safety standards as that of piloted aircraft and that they are only flown by operators who have undergone specific training in order to better ensure the safety of the public and provide better protection for passengers, pilots and residents (The Guardian, 2014).

In the USA, there have been twenty-five reported incidents of near-collisions between commercial aircraft and RPAS between June and November 2014 (Whitlock, 2014).

3.2 Dislodging a wrong and dangerous myth

According to the near-mid collisions reported and despite the fact that in many of these incidents the RPAS were small devices, often only a 1 metre in diameter and weighing less than 5 kilograms, there is no doubt that they can cause tremendous harm ranging from damage or destruction of property, serious injury of persons and even death in the event of a serious incident or accident. Colliding with another aircraft may result in, inter alia, the following:

- the RPAS may be sucked into one of the engines of the aircraft which could possibly result in loss or reduction of thrust and even an engine fire;
- It may impact with the wing of an aircraft, which, depending on the extent of the damage, could result in part of the wing falling apart, or the debris damaging some of the control surfaces, causing instability or inability to move the ailerons, flaps, etc.;
- The device could even impact with the cockpit, possibly resulting in a damaged or destroyed windshield from the debris or impacting with another part of the airframe, damaging sensors, antennas and other essential equipment;
- The flying crew being distracted from having to be continuously on the look-out resulting in a decrease in the monitoring of the aircraft instruments.

4. Knowledge and safety: the results of the survey

To avoid possible collisions, near-mid collisions and other accidents between RPAS and aircraft, strict adherence to rules and regulations will not be sufficient. In addition, future RPAS pilots, operators and all stakeholders need to achieve an optimum level of knowledge regarding safety issues. To increase this level, an analysis of the average skills of future workers interested in RPAS is required in order to get an overview of the existing state of the art.

A survey to evaluate the background of future RPAS pilots was conducted at the beginning of 2014 and over 1000 responses were obtained. Despite a general belief that those interested in such activities would, at the very least, possess some basic aeronautic skills, it became evident that this was not always the case.

To investigate the existing level of knowledge regarding general aeronautical competences, the respondents were asked to provide some general information about their personal background: the total of 1043 participants were classified into 5 categories (Figure 1).

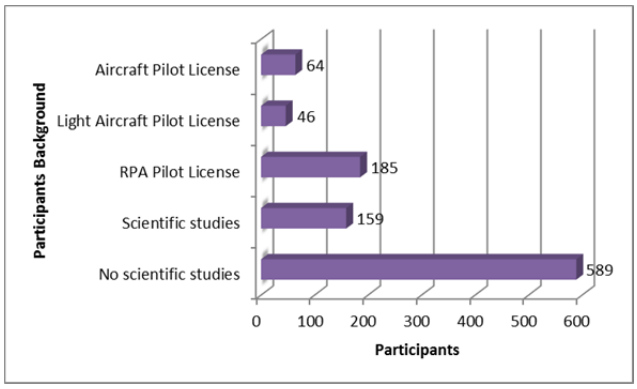
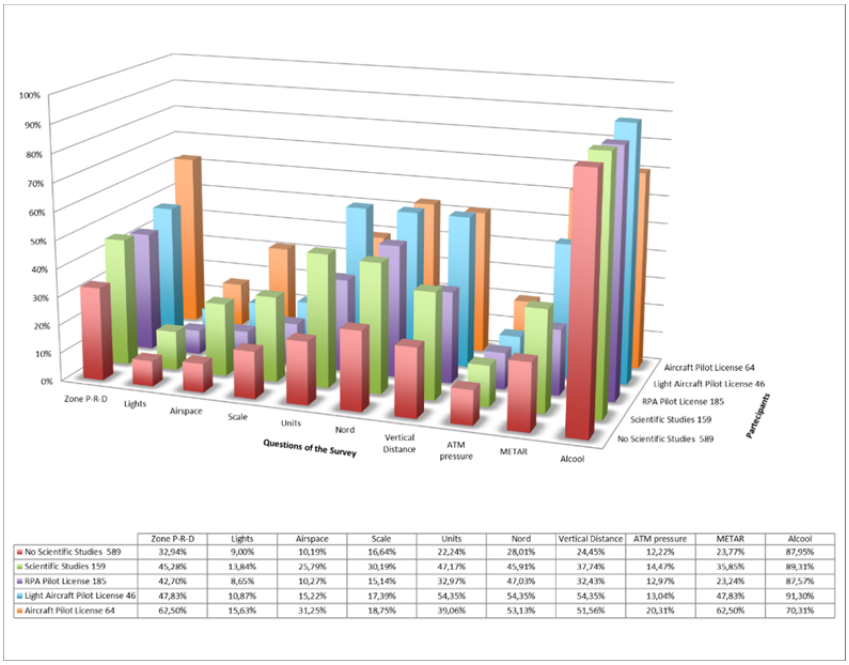


Figure 1: Participants identified categories

It is interesting to underline that the 30% of the participants stated that they have a pilot license.
The survey was comprised of 10 questions regarding aeronautical general knowledge (pressure, measure units, temperature, airspace, light, vertical distance etc..), aimed at establishing the level of knowledge / competency of each respondent. The results (Figure 2) indicate that the aircraft pilots achieved the highest scores.



	Zone P-R-D	Lights	Airspace	Scale	Units	Nord	Vertical Distance	ATM pressure	METAR	Alcool
No Scientific Studies 589	32,94%	9,00%	10,19%	16,64%	22,24%	28,01%	24,45%	12,22%	23,77%	87,95%
Scientific Studies 159	45,28%	13,84%	25,79%	30,19%	47,17%	45,91%	37,74%	14,47%	35,85%	89,31%
RPA Pilot License 185	42,70%	8,65%	10,27%	15,14%	32,97%	47,03%	32,43%	12,97%	23,24%	87,57%
Light Aircraft Pilot License 46	47,83%	10,87%	15,22%	17,39%	54,35%	54,35%	54,35%	13,04%	47,83%	91,30%
Aircraft Pilot License 64	62,50%	15,63%	31,25%	18,75%	39,06%	53,13%	51,56%	20,31%	62,50%	70,31%

Figure 2: Results of the survey

It is also important to highlight that 40% of the participants did not achieve an acceptable level of competence, which is fixed at a higher value of 75% for all the aeronautics exams in general.
This might be as a result of the fact that the aim of the survey was to verify whether knowledge obtained in the past, by, for example, an ex-pilot, was still evident in order to perhaps determine if operating a RPAS could possibly offer alternative employment. The results of Light Aircraft pilots only reflected a 33,3% of correct answers. This is considered to be an inadequate result and that might be due to the fact that the Italian National Safety Flight Agency (ANSV) is underscoring into the 2013 safety statute report (Italian National Safety Flight Agency, 2013).
During the survey, the respondents were allowed to use a calculator or other computing device in order to solve the problem of the chart scale. The results highlighted the point that they were unable to estimate a horizontal distance from an airport or to communicate a correct vertical distance to the ATM, underlining important lacks in terms of basic mathematical knowledge.

There was a very low score of 6,3% of correct answers regarding the question on the airspace, the METAR or the atmospheric pressure and whilst it may be understandable that untrained aviation enthusiasts do not know the classification of the airspace, it is however, unacceptable that several declared pilots had a score lower than 30% of correct answers for this question.
Taking the results of the survey into account, it is suggested that a considerable improvement is required for the RPAS community to be able to reach a reasonable level of safety and aeronautical general knowledge and for the pilot community to refresh the skills acquired during their pilot flight class.

5. Human factor and just culture approach

Almost all countries are concerned with the increasing of RPAS operations in its National Airspace System (NAS). This situation requires an integration of the current regulations in order to achieve, at a minimum, an equivalent level of safety to that of manned aviation. Safety is defined in terms of the risk to human life, although potential collateral damages to property can also be taken into account.
The critical rates of occupational injuries and fatalities, typical of some industry sectors, need to be faced with suitable Risk Analysis techniques (Patrucco et al., 2010) and obviously, the availability of reliable input data drawn from accidents is essential for the development of an exhaustive Risk Analysis and Management in the Prevention pro-active approach in order to include the human factor in the equation.
As described (Reasons et al., 2003) human error, in general, is defined as the failure to perform a specific task that could lead to disruption of scheduled operation or result in damage to property and equipment. Nowadays (IATA, 2003), humans constitute the largest cause of accidents in transportation sector and although it is nearly impossible to completely eliminate human error (Figure 3 shows a general classification of the human failures), the first goal should be to minimize human error, preventing failure and restoring failed systems effectively with minimum risk of accident.
In this context, the just culture approach signifies the growing recognition of the need to establish communication and training initiatives and advance arrangements amongst those in the aviation safety sector, regulators, law enforcement and the judiciary in order to avoid unnecessary interference and to engender mutual trust in and an understanding of the relevance of their respective activities and responsibilities.

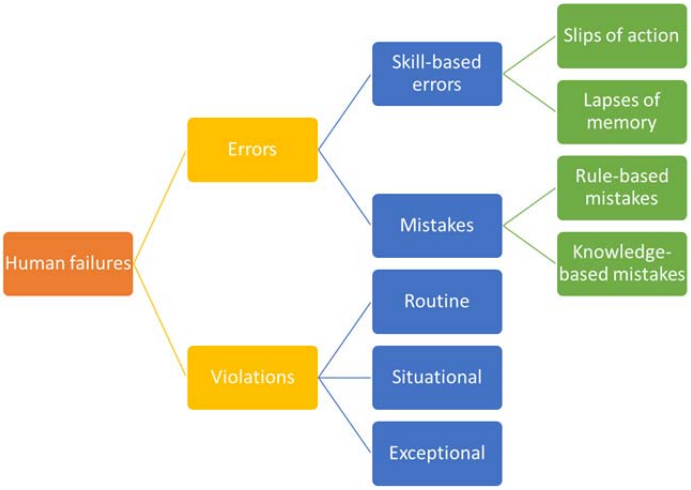


Figure 3: Classification of human failures (HSE, 1999)

The concept of a just culture represents the fundamental recognition that both aviation safety and the administration of justice would benefit from a carefully established equilibrium, moving away from fears of criminalisation. That is easier said than done, of course, but the time has come to seriously question the added value of endless and generally unsuccessful efforts at international level to “protect” controllers and pilots against legal action by creating standards, regulations and laws which are supposed to shield them from intervention by the justice system.
As suggested by the results of the survey is becoming a mandatory to provide to the future RPAS pilots the right knowledge and training in order both to guarantee a deep understanding and perception of the possible dangerous situations related to the air space sharing between aircrafts and unmanned vehicles and both to minimize the likelihood of human errors.

Conclusions and further research

As shown by the numerous reports of near-miss mid-air collisions it seems evident that for many operators a perception of risk is notably missing. As highlighted by the survey, the evident lack of aeronautical training underscores the relationship between knowledge and safety. Moreover, a correct risk analysis to reduce the human factor is of paramount importance for the safety in the surrounding RPAS area, for both manned aircraft and urban possible targets.

In the authors' opinion, the only way to prevent accidents having dramatic consequences is to:

- Make the public aware of the real risks of a collision. It is vital that the RPAS community be safety conscious;
- Reach a minimum acceptable level of safety. In addition, those that have older PPL licenses need to undergo refresher course(s) to increase their knowledge and obtain a high level of current and up-to date knowledge;
- Conduct a careful Risk Assessment in order to ensure the safe running of RPAS and possibly identifying a new methodology to assist in the evaluation of the risks related to the critical operation of RPAS;
- Ensure a constant and well-structured training to the future RPAS pilots and operators.

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