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Review Article

Public Perception of Drones... or Should that be Remotely Piloted Aircraft Systems?

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Abstract

The media coverage of remotely piloted aircraft systems (RPAS) has highlighted some issues, particularly in terms of security and privacy concerns. As such, it is essential to understand the public's perception towards these systems. The purpose of this study was to assess the public's perception towards 1) The terminology used to define RPAS, which varies across the industry; 2) The applications, current and future, of RPAS; 3) The future of passenger transport involving RPAS, and 4) RPAS in general. It was found that there was little difference between the "terms" used to describe RPAS; however, there was a significant difference at the 90% confidence level for "remotely piloted aircraft systems" over "drones". In terms of RPAS applications, community based applications had a positive perception, while personal applications were neutral. The implementation of RPAS into passenger transport aircraft was strongly negative. Finally, there was an overall positive perception towards RPAS.

Keyword

Autonomous vehicles, Computers and society, Privacy, Social issues

Introduction

Drones are commonly thought of as military assets which brings to mind the launching of Hellfire missiles from Predator UAVs [1]. In fact, this premise has recently been popularized in feature films such as *Good Kill* [2] and *Eye in the Sky* [3]. But the term drone, intimately associated with military applications, has not been adopted by the International Civil Aviation Organisation (ICAO). The official term utilized by ICAO is Remotely Piloted Aircraft System (RPAS) [4]. Other initialisms are also used to describe these aircraft, including unmanned aerial vehicles (UAVs) and unmanned aerial systems (UASs).

In terms of civil RPAS, there is an expected growth from approximately \$1.41 billion (USD) in 2017 to almost \$180 billion (USD) by the end of 2025 [5]. Since RPAS are therefore an emerging pervasive technology, the impact they have on society and individuals needs to be assessed. To that end, a preliminary pilot study has been undertaken to investigate the public's perception of RPAS. Further work will expand on the public's perception in a second stage, refined by the outcomes of this first stage. This will then be followed by a study of "regular" pilot's perceptions towards RPAS, investigating aspects such as shared airspace etc. An extensive body of literature already exists on the perspective of regulators, across multiple countries [6] which effectively assesses the perception of regulators.

As previously mentioned, there are a number of "terms" used when discussing RPAS. Therefore, one of the goals of this public survey was to assess the reaction to the various "terms", as alluded to in the title of the paper. In addition to this, the public's perception to various RPAS applications was also assessed; that is, to determine how positively the public feels about the application of RPAS to firefighting etc. The public's perception of future single-pilot and pilotless passenger aircraft was also investigated. Finally, the overall perception of RPAS was assessed in terms of the different demographic groups identified.

Background

"Drones" recently celebrated their 100th birthday, based on the radio controlled heavier-than-air aerial torpedo from 1917 [7]. In fact, it could be argued that the history of unmanned aviation is the history of "drones", including rockets, balloons, and kites from hundreds/thousands of years ago [8]. When these other prospects are included, the

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first radio controlled aircraft were in fact balloons in the late 1800's [9].

Military RPAS have been identified to fill a variety of roles. These have previously been defined as [10]:

- Tactical UAVs: divisional level - reconnaissance, surveillance, target acquisition,
- MALE and HALE strategic UAVs,
- Tactical UAVs: regimental/brigade level - (additional roles) threat detection, communications,
- Vertical take-off and landing UAVs - naval applications, electronic warfare, psy-ops against civilians,
- Offensive UAVs - such as cruise missiles,
- Armed UAVs,
- Lighter-than-air UAVs,
- Micro Air Vehicles MAVs,
- LALE,
- Optionally piloted aircraft, and
- UCAVs.

The first armed UAV which actively killed a target was a Predator equipped with Hellfire missile in 2001 [11]. Due to the unit cost, the current military market for RPAS is greater than the civil market, worth approximately \$9.6 billion (USD) in 2018 [12]. The military market was estimated to grow such that by 2027 there is a projected total market value at that time of over US\$80 billion [12]. So the non-military market of RPAS will eventually outpace the military market.

Today, the applications of RPAS in non-military settings are diverse. These include [13]: traffic monitoring, volcanography, firefighting, maritime observation, and wildlife monitoring. In addition to this, RPAS are used in precision agriculture [14], mapping [15], civil engineering [16], and law enforcement [17], as well as search and rescue, filmmaking, demining, and scientific research [18]. One of the most anticipated applications (discussed extensively in the news media, trade publications, and academic journals) is the advent of package delivery by RPAS, such as Amazon Prime Air [19], and even for general mail delivery [20].

Approach

Survey

The survey was conducted at RMIT University Open Day, on a Sunday when the campus was open to the public. It should be noted that the survey was conducted on the street, and the campus is in fact 6% of the Melbourne central business district. As such, participation was open to the general public, with diverse demographics collected. One hundred paper surveys were distributed and collected, of which 83 were completed correctly. Mistakes were made, some with multiple options selected etc; these responses were omitted.

The questionnaire for the survey consisted of two parts. The first part was four demographic questions (age, gender,

education level, and occupation). The second part was four multipoint questions. The first of these was the question regarding perception towards the various "terms":

- UAS,
- RPAS,
- UAV,
- Unmanned Aerial Systems,
- Remotely Piloted Aircraft Systems,
- Unmanned Aerial Vehicles, and
- Drones.

Note that the "terms" were presented in the exact order listed, noting that the participant information and consent information clearly identified the survey was about remotely piloted aircraft and the public's perception towards them. Following this was a question regarding perception towards the application of RPAS, including:

- Firefighting,
- Policing,
- Filmmaking,
- Real estate,
- Pizza delivery, and
- Parcel delivery.

Once again, the applications were listed in this order, and the first four were presented as current applications, and the final two were presented as future applications. The next question asked about the respondent's perception towards being a passenger onboard a commercial airline flight with a) A single pilot onboard and a remote pilot external to the aircraft, and b) No pilot onboard the aircraft with the entire flight crew located remotely. The final question asked about the respondent's overall perception towards remotely piloted aircraft.

The survey instrument, or questionnaire, was constructed using a five point Likert scale for each question. The five point scale was very negative, negative, neutral, positive, and very positive. The questions were phrased as statements about the respondent's perceived feelings towards the construct being assessed.

Analysis

The first step in the analysis was to test if the responses received were normal or not. That is, to assess if the perception measured by the survey was average, below average, or above average. To test for normality a z-test was utilized. The z-score for the z-test is given by,

$$z = \frac{\bar{x} - \mu}{\sigma / \sqrt{n}} \quad (1)$$

Here, \bar{x} is the measured average, μ is the expected average (3 for a 5 point Likert scale from 1 to 5), σ is the

measured standard deviation, and n is the number of samples. The corresponding statistical hypotheses that are associated with the z-test are,

- $H_0: \bar{x} = \mu$
- $H_A: \bar{x} \neq \mu$

That is, the null hypothesis (H_0) states that the sample mean is not different to the expected mean, and the alternative hypothesis (H_A) states that the sample mean is different to the expected mean.

In addition to the z-test, which compares the measured mean to the expected mean, a comparison between means was also necessary. This required a t-test, and based on the fact that responses were tested across questions, with the same respondents, for various demographics, a paired t-test was used. The t-statistic for the t-test is given by,

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \quad (2)$$

The corresponding statistical hypotheses that are associated with the t-test are,

- $H_0: \bar{x}_1 = \bar{x}_2$
- $H_A: \bar{x}_1 < \bar{x}_2$

That is, the null hypothesis (H_0) states that the sample means are not different, and the alternative hypothesis (H_A) states that the sample mean 1 is less than sample mean 2. The t-test is therefore one tailed.

Findings

Terminology

The results showing the public’s perception of the differ-

ent “terms” which can be used to describe RPAS are summarized in Figure 1. This shows a box and whisker plot highlighting the mean for each “term”, with the box showing one standard deviation, and the whiskers showing the range. The expected mean is also shown in Figure 1, as a dashed line at the value of 3. All of the means can be clearly seen as greater than the expected average. The maximum mean corresponded to “remotely piloted aircraft systems”. The minimum mean corresponded to “drones”. All of these “terms” were tested to see if the difference to the mean was statistically significant, using the z-test. These results are shown in Table 1. It is clear that the only result which is not significant is for the term “drone”, all of the others show a statistical significant difference, being greater than the expected average of 3 (although RPAS is 94% significant, while all of the others are more than 95% significant). Next the most positive and least positive “terms”, “remotely piloted aircraft system” and “drones”, respectively, were compared using a paired t-test. The corresponding p-value was 0.08. That is, there is a moderate claim to state that the “term” “remotely piloted aircraft system” is perceived better than the term “drone”, at the 90% significance level (92% to two significant figures).

Table 1: Test for RPAS terminology.

	z-Score	p-value
UAS	2.96	0
RPAS	1.53	0.06
UAV	3.21	0
Unmanned Aerial System	2.45	0.01
Remotely Piloted Aircraft System	2.57	0.01
Unmanned Aerial Vehicle	1.67	0.05
Drone	0.47	0.32

All values rounded to 2 decimal places.

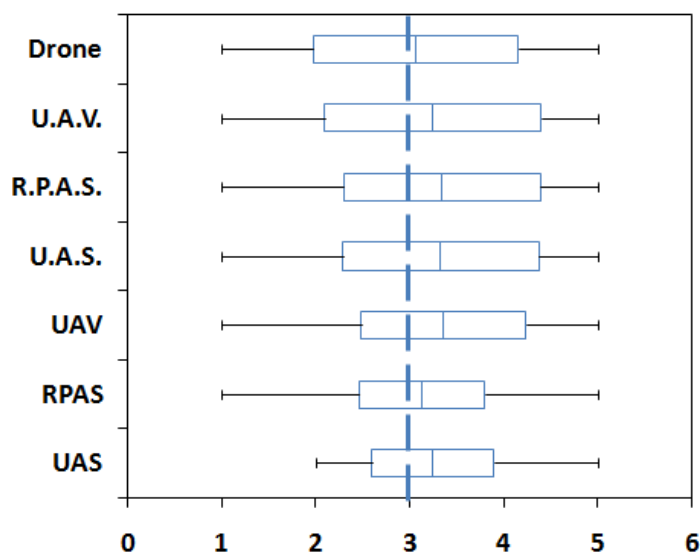


Figure 1: Public perception of different terms used to describe RPAS. The expected population average is highlighted as the dashed line at 3. The box and whisker plots shows the mean, then the box is 1 standard deviation, and the whiskers are the range. The categories with the baseline dots are the full length terms, contracted here for the scale of the plot.

It should be noted that as part of the survey, no follow-up open-ended questions were asked to enable an understanding of "why". There are two possible reasons why "drone" would be the least favorable term, which are the two ways the term is most commonly used; the first is the association of the term with military systems, and the second is the association with toys. The fact that the full term "remotely piloted aircraft system" is preferred is likely due to the reason ICAO selected the term, it indicates a pilot is controlling an aircraft, albeit remotely.

Application

The public's perception towards the applications of RPAS, current and future, are shown in Figure 2. Note that for the first application, firefighting, none of the responses are negative, as illustrated by the fact the entire box and whisker plot is above the expected mean line drawn at the value 3. The second application, policing, is also significant with the box being above the expected mean value line. The use of RPAS in filmmaking is positive, while the last current application, real estate, is neutral. We also note that both of the two popular proposed future applications, parcel and pizza delivery, are also both neutral. These observations are supported by the z-tests as seen in Table 2. The p-values for the first three are significantly greater than 99%. That

is, there is an overwhelmingly positive view towards these applications. The second group of three (real estate, pizza delivery, and parcel delivery) are clearly neutral.

Airline RPAS

Figure 3 shows the comparative perception of the public towards reduced flight crew in airline travel. The question was explicitly framed around the respondent as a passenger on an aircraft with a pilot onboard and a co-pilot on the ground, and then in the second part, both flight crew members located on the ground. As is clearly indicated in the plot, both questions elicited a negative response, where the "no pilot" case resulted in a significantly negative response with the entire box located below the expected mean value of 3. Although not asked (an acknowledged flaw with this pilot study), it would be fair to assume that the comparative value for a two-crew onboard question would in fact be higher than neutral. The z-test results highlight the strength of the negative sentiment, with both values far more than 99% significant. A paired t-test was also used to compare these two questions. The result was a p-value much less than 0.01, and hence it can be concluded that the public's perception towards a pilotless passenger aircraft is significantly more negative than their perception towards a single pilot passenger aircraft.

Overall feelings

Finally the overall perception of the public towards RPAS in general was assessed. This single question was broken down into pairs based on three of the four demographics collected. It should be noted that the array of occupations was extremely diverse with no trend or significant clustering, and hence no statistical inference could be drawn utilizing this demographic. The three demographics utilized were, gender (shown in Figure 4), age (shown in Figure 5), and education level. Age was split into "young" and "old", or more correctly, respondents 34 and under, and respondents 35 and over. Education level was split into those with a degree or higher, and

Table 2: Test for RPAS applications.

	z-Score	p-value
Fire	18.38	0.00
Police	8.20	0.00
Film	3.08	0.00
Real Estate	-0.12	0.55
Pizza	-0.29	0.62
Parcel	0.10	0.46

All values rounded to 2 decimal places.

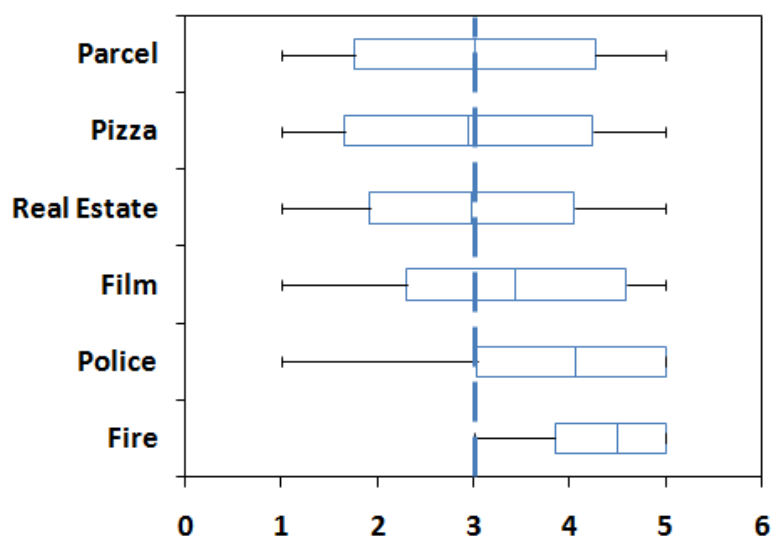


Figure 2: Public perception of RPAS applications. The expected population average is highlighted as the dashed line at 3. The box and whisker plots shows the mean, then the box is 1 standard deviation, and the whiskers are the range.

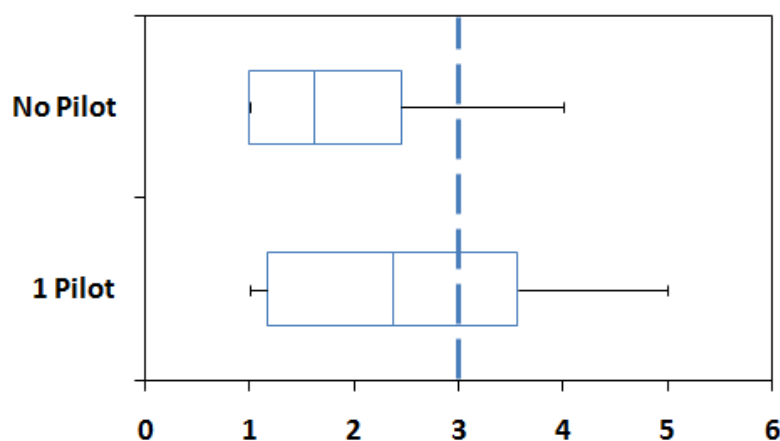


Figure 3: Public perception of RPAS in regular passenger transport. The expected population average is highlighted as the dashed line at 3. The box and whisker plots shows the mean, then the box is 1 standard deviation, and the whiskers are the range.

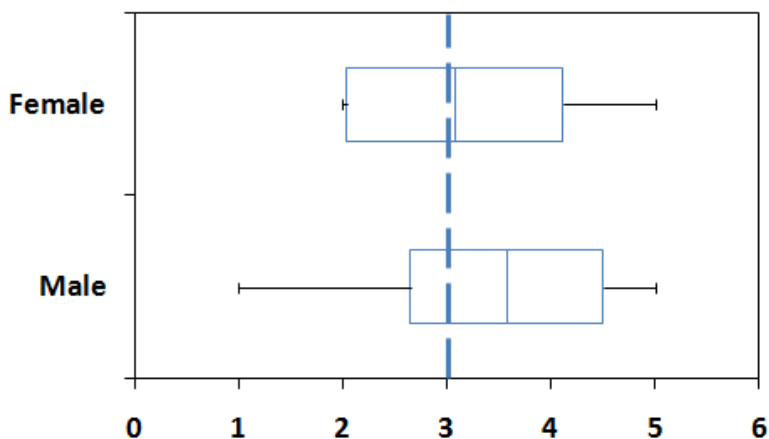


Figure 4: Public perception of RPAS in general for males and females. The expected population average is highlighted as the dashed line at 3. The box and whisker plots shows the mean, then the box is 1 standard deviation, and the whiskers are the range.

those without. These divisions closely split the sample in half with a logical justification. The results for the education level were statistically insignificant, and the box and whisker plots were almost identical. The associated unpaired t-test to compare respondents with a degree to those without a degree gave a p-value of 0.8. As such, it can be concluded that education level does not influence a person’s perception towards RPAS, nor would it be expected to (Table 3).

From Figure 4 we can clearly see that males have a more positive perception towards RPAS than females, while neither of the two means is negative. A t-test was then used to determine if the observation was statistically significant. The corresponding p-value was 0.0471. As such, we can reject the null hypothesis and state that males have a more positive perception towards RPAS compared to females, at the 95% confidence level.

A similar trend for age is also shown when looking at Figure 5. It can be seen that “younger” respondents have a more positive perception of RPAS relative to “older” respondents. Both of the means are still above average. To determine if this observation is statistically significant an unpaired t-test was

Table 3: Test for RPAS based commercial passenger transport.

	z-Score	p-value
1 Pilot	-4.22	0.00
No Pilot	-13.18	0.00

All values rounded to 2 decimal places.

utilized. The corresponding p-value was 0.035. Therefore, at the 95% confidence level, “younger” people have a more positive perception towards RPAS compared to “older” people.

Contextualisation

The results of this study are comparable to other related studies. Previous work asking the public's perception about risks associated with RPAS gave mixed results [21]. Some results showed the risks associated with RPAS were more acceptable than those associated with drones, while in general the risks were comparable, with unmanned perceived as less risky than both, but then the acceptability of the risks associated with unmanned aircraft were the lowest. The main issue in comparing this study with that work,

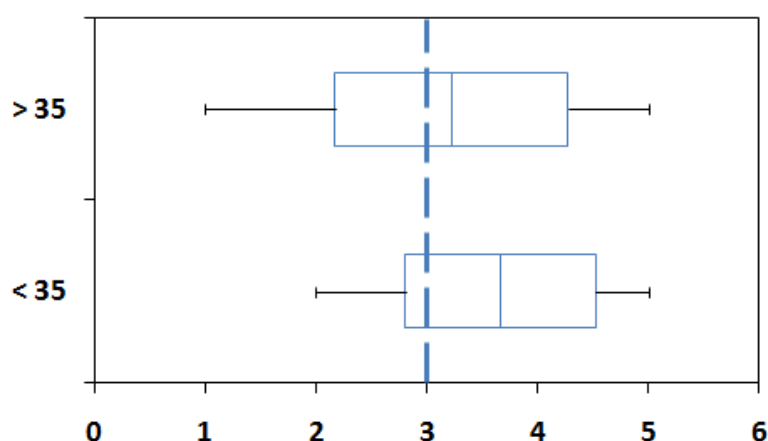


Figure 5: Public perception of RPAS in general for “old” and “young” people. The expected population average is highlighted as the dashed line at 3. The box and whisker plots shows the mean, then the box is 1 standard deviation, and the whiskers are the range.

is that the samples of 100 respondents were independent. While here, we use dependent samples, so we are more confident of the rankings given that all the respondents assessed all labels.

It should be noted that the term RPAS is not commonly used in the US, and surveys conducted there have omitted this term completely [22]. Other work [23], has surveyed the general public about “drones”, and their acceptability. However, the confounding influence the use of this term has on the survey responses needs to be assessed. That is, would the respondents have found remotely piloted aircraft technology more useful than drone technology?

Conclusion

The public’s perception of the “terms” used to describe RPAS shows no great difference. There is a slight improvement in perception when the full “term” is used in place of an initialism, and although “drone” had the worst perception, this was not negative. Also, “remotely piloted aircraft system” had the best perception, and there was a statistical difference between the two at the 90% confidence level, but not at the 95% confidence level. Interestingly when comparing “RPAS” with “remotely piloted aircraft system”, there was also a statistical significance between the two at the 90% confidence level, but not the 95% confidence level. As ICAO has officially adopted the “term” “RPAS”, the slightly less positive perception of this “term” (while still above the expected average), suggests that public awareness of “RPAS” should be improved. Another interesting conclusion to draw is that using initialisms or acronyms should be avoided. So if a business were to market RPAS, either in terms of a product or application, clear terminology should be utilized.

When used for helpful and noninvasive applications, the public’s perception of RPAS is overly positive. This was especially significant for the use of RPAS in firefighting situations, where all responses were non-negative. There is a wider spread of data for policing applications; from very negative to very positive, which is understandable in terms of people’s diverse perception of civil liberties. Also of interest is the fact

that the perception of implementing RPAS into everyday situations is neutral. This is interesting for two reasons, a great deal of effort is being invested into services such as pizza delivery [24], and there have been some notable negative situations involving the use of RPAS in real estate [25].

The public’s perception of the future implementations in airline based passenger transport was also assessed. There is, arguably, a future possibility for the use of RPAS in the aviation industry, where crew costs are on average 22% of an airlines total direct operating budget [26]. As such, the fleet-wide migration to single pilot operations with a remotely located co-pilot [27], and then potentially all remote flight crews [28] will offer attractive reductions in the aforementioned direct operating costs. As one may expect, the public’s perception, as currently measured, of RPAS in passenger transport is negative, and for fully remote flight crew passenger aircraft it is severely negative. A future goal of this ongoing research will be to regularly reassess the perception of RPAS passenger transport, especially as familiarity with RPAS technologies and operations increases over time, but so too will the number and potentially severity of incidents and accidents involving RPAS.

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