Shining the Light on Public Attitudes Toward Laser Attacks on Aircraft

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With increasing incidents being reported, laser attacks present a significant threat to aircraft safety. Although no aircraft accidents have yet been directly attributed to laser attacks to date, experts agree that it is a legitimate threat to safety. To better understand this phenomenon, and ways in which it can be addressed, an important area to understand is the public perception of the severity of such incidents. This would include examining the attitudes the general public hold toward laser attacks, and what views they may hold towards regulation and punishment for these offences. Members of the general public (N=208) completed an online survey that examined their views towards the perceived occurrences and severity of laser attacks, whilst also examining their expectation of criminality and punishment of using a laser against an aircraft. Responses were analysed and presented, with discussion around the nature of public perception and expectation to laser attacks. Mitigations and interventions are explored, focussing on targeted educational/awareness programs that can be used to increase the awareness amongst the general public on the consequences of laser attacks on aircraft.

I. Introduction

On the 14th of February 2016, a Virgin Atlantic aircraft bound for New York contacted Irish Air Traffic Control and advised them the first officer on board was suffering from a 'medical issue'. This event was triggered by a laser that originated from the ground being directed into the Airbus A340 cockpit shortly after take-off from London Heathrow. This example is typical of a reported instance of a laser attack. In the context of aviation, a laser attack may be considered the act of illuminating the cockpit of an aircraft using a laser pointer, with or without intent. The aviation industry prides itself on facing many challenges over the years, and yet it has successfully become one of the safest methods of transportation (Savage, 2013). This new and potentially lethal threat has become prevalent in little more than a decade, and the aviation industry is struggling to mitigate it.

Laser attacks on aircraft have been on record since the mid 1990's (Nakagawara & Montgomery, 2001), although official reporting of laser incidents really only began in the mid 2000's. Reported incidents since then have increased worldwide; in the United States alone the number of recorded incidents has risen from 311 in 2005 to 7,442 in 2016 (Murphy, 2017b), representing an astounding 2293% increase. Worse yet, the United Kingdom has witnessed an increase in laser attacks by 4093% since 2007. According to Eurocontrol (2011), 30 instances occurred in 2007, while 1,258 laser attacks were reported in 2016 (Landells in The Guardian, 2017). The British Airline Pilots Association claims that 55% of member pilots experienced a laser attack in 2015, while 4% suffered 6 or more attacks (BALPA, 2017). While many governments and aviation authorities have implemented some form of strategy in an attempt to reduce the number of laser attacks on aircraft, the industry has thus far been unable to effectively counteract the increasing number of laser attacks we are witnessing.

There is little research discussing laser attacks on aircraft, and as such the available literature directly addressing this area is limited. In most cases, it focuses on the physiological effects on pilots subjected to laser attacks, and the potential consequences on safety (Houston, 2011; Nakagawara & Montgomery, 2001; Nakagawara et al., 2004; Nakagawara, Wood, & Montgomery, 2008). It is important that the public's attitudes and perceptions of lasers and laser attacks is documented and understood if campaigns and strategies to create awareness are to have any chance of success. We have seen this approach in other areas of societal importance such as recycling; with active educational and public engagement strategies have been used to create awareness in order to adapt public attitude and behavior. Thus any first step to addressing laser attacks in aviation is to establish the nature of public attitude in

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the first instance. This would also involve understanding the regulatory environment in relation to laser devices, and the punishment of offenders. Addressing these issues will assist in better planning for mitigation strategies in the future that can have a real impact on behaviour.

II. Laser attacks

When a laser beam 'hits' the cockpit glass, the special coatings used in the production of the glass, combined with imperfections and pitting in the glass, may cause the beam to scatter and generate secondary and tertiary beams to the extent that it will invariably affect the flight deck crew (D'Andrea & Knepton, 1989; Marshall, O'Hagan, & Tyrer, 2016; Murphy, 2017a). Although laser attacks have not yet been cited as a contributing factor in an aircraft accident (Nakagawara et al., 2004; Nakagawara, Wood, & Montgomery, 2008), 'the potential for an aviation accident definitely exists' (Nakagawara et al., 2004: 2). Laser attacks are predominantly reported when the aircraft is operating near the ground; during critical phases of flight such as take-off, taxi, and landing, where aircrews do not have the luxury of time to recover from such distractions. The effect of a laser being shone into the cockpit has significant physiological and psychological impact on the flight crew, both of which are widely recognised as having the potential to result in an accident. This is thought to introduce a confounding factor to safety during the critical take-off and landing phases of flight (Nakagawara, Montgomery, & Wood, 2007).

A. Hazards

The physiological implications of laser attacks on aircrews have been the focus of most existing research in this area. Support appears strongest for the argument that handheld laser devices have the potential to immediately disrupt the vision of pilots (Palakkamanil & Fielden, 2015). Green lasers are responsible for the majority of reported laser attacks and are more widely available (Palakkamanil & Fielden, 2015; Weekes, 2016). They are also the most likely to affect a pilot's vision. Disruptions are also most likely to occur at night, when a pilots eyes are somewhat dark adapted and at their most sensitive to the bright light emitted by lasers. Following exposure to bright light, it can take up to 30 minutes for dark adaption to be fully restored after a brief illumination (Nakagawara et al., 2004). When we consider the possible affect to exposure to a laser, the visual disturbances most frequently reported are:

1) **Glare** - obscuration of an object due to a bright light;
2) **Flash blindness** - a visual interference that persists after the light source has been removed;
3) **Afterimages** - transient images left in the visual field after an exposure to bright light.

Although the primary threat to aircrews is the aforementioned visual disturbances, laser pointers of more than 5mW may cause permanent physiological impairment (American National Standards Institute, 2007). Most cases of permanent damage are non-aviation linked, and are as a result of deliberate misuse. A number of authors argue that the distances and low power of devices generally involved in laser attacks on aircraft reduces the irradiance to levels incapable of producing irreversible retinal damage. However, most agree that accidents may occur as a result of distraction (DeMik et al., 2013; Elias, 2005; Marshall, O'Hagan, & Tyrer, 2016). Elias (2005) states that such distractions can also induce spatial disorientation and compromise situational awareness, which are well documented as being causal factors in many aviation accident reports. Laser attacks have also been documented as having a detrimental effect on crew coordination (Air Accident Investigation Unit Ireland, 2015). Considering approximately 90% of information required by a pilot to fly an aircraft is visual, any interference is unacceptable (Nakagawara et al., 2003).

B. Countermeasures

To date a number of methods have been proposed to reduce the occurrence of laser attacks on aircraft. The most prominent method adopted tends to be the use of harsh penalties defined within the justice system. Many countries, such as the United States, United Kingdom and Canada, have implemented strict laws regarding the malicious illumination of aircraft. In Australia, the state of New South Wales considers laser pointers to be dangerous weapons and outlawed the sale and possession of such items (Esler, 2016). Penalties often include hefty fines and increasingly seek the imprisonment of offenders. Many people have successfully been prosecuted and received custodial sentences under such laws. For example, in 2014 an individual was jailed for 14 years in the US (Jansen, 2014; The Guardian, 2017), while the next year two separate incidents were recorded in the UK and Northern Ireland which resulted in sentences of 6 months each (PSNI, 2016; The Guardian, 2017). In an attempt to increase the prosecution success of such individuals the FBI (2014b) recently ran a campaign offering $10,000 for information leading to the arrest of those suspected to be involved in a laser attack.

Airline pilots associations worldwide have called for even stiffer penalties; in the UK BALPA have criticised the government for dropping proposed amendments to the law to make it easier to convict those found guilty, and imposing increased sentencing for individuals who commit laser attacks (The Guardian, 2017). The Air Canada Pilots Association also want offences to attract stricter penalties (Palakkamanil & Fielden, 2015). Fundamentally, airline associations seek stricter control and regulation pertaining to the sale of laser pointers. This is a strategy that has been suggested previously by researchers in this area (Elias, 2005; Nakagawara, Wood, & Montgomery, 2008; Palakkamanil & Fielden, 2015).

Of course one of the main challenges in prosecuting these offenders lies in locating the perpetrators after the occurrence of a laser strike (Palakkamanil & Fielden, 2015). Occasionally, police helicopters have been used as bait in order to attract laser attacks, locate the suspect and coordinate ground response teams in the apprehension of the suspect. This concept of operation may be of particular use in areas that are known to be hotspots for such activity. Indeed, such areas do exist, such as 'laser block', a high rise building in Glasgow known to both pilots and police (The Guardian, 2017). However, even targeting know hot spots only addresses the apprehension element of this issue and not the wider problem. In many instances, perpetrators claim to have no knowledge of the illegality, nor the impact, of laser attacks. This brings us to the need for better education in this area in order to raise awareness of the severity of the effect and consequence of laser attacks.

BALPA (2017), in conjunction with their call to increase penalties for offenders, also note that education is key in facilitating the public appreciation of the dangers associated with lasers. To date, there have been several noteworthy public engagement initiatives to increase awareness of the seriousness of the issue. For example, authorities in Northern Ireland recently teamed up with a local drama group to create a production to educate more than 2,000 students (Doyle, 2016). Another example is the 2012 U.S Federal Bureau of Investigation production of a public service announcement (FBI, 2014a). Despite such campaigns, numerous arrests and convictions have occurred worldwide including the U.S, U.K and Northern Ireland (BBC, 2012; Futty, 2013; Jansen, 2014; McMahon, 2014; PSNI, 2016; The Guardian, 2017).

Rockwell Jr, Ertle, and Moss (1998) summarised it well when they commented that the hazards of laser pointers are simply 'not well understood by the general public'.

III. Attitudes of the general public

Research into attitude is complex and multi-factorial, drawing primary upon the disciplines of Psychology and Sociology. There are many different theories of how attitudes are formed, retained and changed; but this paper will focus on the attitude composition model, commonly referred to as the ABC model (Breckler, 1984). This proposes three distinguishable components that make up an individual's attitude, which are:

1) **Affective** component - this consists of emotions/feelings related to an attitude object,
2) **Behavior** component - this is the way in which the individual is likely to behave to the attitude object,
3) **Cognition** component - the knowledge and belief values that are associated with the attitude object.

All three components should be considered when measuring and attempting to alter attitudes, as the relationship between the components may vary and may be inter-related. Indeed, both affective and cognitive attitude components have been found to be factors in influencing behavior (Kahle & Berman, 1979). The strength and confidence with which an attitude is held is also considered to be a good predictor of future behavior (Glasman & Albarracín, 2006).

Many researchers (eg. Elias, 2005; Nakagawara, Wood, & Montgomery, 2008; Palakkamanil & Fielden, 2015) suggest that educating the public on the risks of laser attacks is a 'promising' strategy that may be able to mitigate the frequency of laser attacks. However, evidence exists to suggest that when education is used to change public attitudes the impact may only be realised in the short term (Maruna & King, 2004). It has been suggested that most strategies to alter public attitudes merely address the knowledge function of attitude, whilst failing to appreciate that attitudes may exist due to other reasons (Maruna & King, 2004). They go on to state that that attitudes 'are not easily altered' if based on non-informational aspects (p102).

Further complicating the issue is that safety related topics such as laser attacks typically involve detailed information, and as such require a high degree of information regarding the topic. An individual's ability to process this information into something meaningful and useful is likely to be reduced (Australian Transport Safety Bureau, 2006). Despite these challenges, ascertaining the current attitudes held by the general public in conjunction with how much they know of laser attacks is a fundamental aspect to any potential strategy moving forward.

IV. General public survey: Results and Discussion

In order to ascertain a number of relevant questions to be incorporated into an online survey a small number of participants who were subject matter experts in this area were interviewed. This lead to a number of attitude statements that required Likert-scale responses, and in some instances allowing participants to expand on their answers. Before the survey was launched a small pilot study was held in order to assess the reliability of the survey items and to gather feedback before distributing the survey wider.

The survey was open to the general public, but it was important that demographic information was requested at the beginning of the survey, followed by a number of open questions to gather participant knowledge of laser attacks. This allowed us to ascertain the background influence on the nature of the attitude being expressed. Following small amendments of the pilot survey, the final survey was distributed electronically via social media channels. Participation was restricted to those aged 16 or older. In total 208 responses were took forward to be analyzed. The data used in the analysis was gathered between May 16th and June 15th 2017.

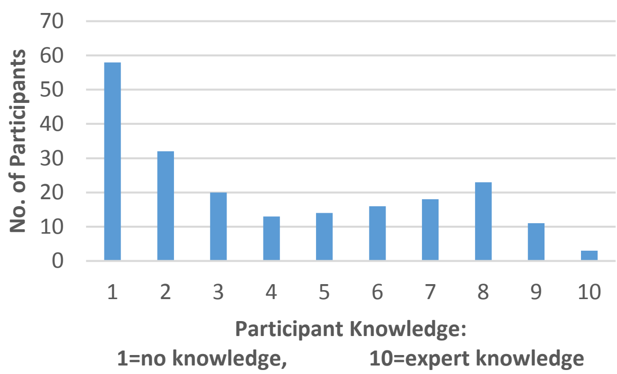

Figure 1 Participant level of knowledge of laser attacks

A variety of parametric analysis techniques, such as ANOVA and regression, were used to explore and describe the data gathered regarding attitudes to laser attacks, regulation of laser devices and punishment of offenders. Knowledge levels of laser attacks was also analyzed. There is substantial debate over the appropriateness of parametric techniques for ordinal data such as Likert type scales used during the survey data collection. However, Norman (2010) contends that parametric tests can be more robust than nonparametric tests, even when statistical assumptions are violated to an extreme degree and may be used 'without concern for getting the wrong answer'.

Knowledge of laser pointers and laser attacks among respondents was quite high at 88% and 76% respectively. Figure 1 shows the self-reported level of knowledge held varied. Knowledge levels were reported to be significantly higher for males (*M*=5.66, SD=2.61) than that of females (*M*=2.20, SD=1.76). The results also suggested that people aged 21-40yrs knew less about laser attacks than those aged 41-60yrs. A number of comments collected during the survey indicated a perception that the group 21-30yrs (and younger) were responsible for many of the laser attacks. Judging by media reports, this age group does appear to constitute a large proportion of those caught and punished for such activity.

People who travel often (10+ trips per annum) reported to know significantly more than those who took 1-4 trips per annum than those who typically never travel by air; (*M*=5.97, SD=2.99), (*M*=3.43, SD=2.52) and (*M*=2.4, SD=1.67) respectively. Unsurprisingly, respondents who worked in the aviation industry (*M*=6.04, SD=2.65) also reported to know more than those who did not (*M*=2.81, SD=2.17). This may be due to professional training and general interest in the aviation industry.

Participants were asked if they knew how many laser attacks occurred in the United Kingdom in 2016. The mean response was 243.73, (SD = 364.19, n = 195). This was substantially lower than the 1,258 reported. Although not all respondents were from the UK, it demonstrates a large gap between the perceived and actual prevalence of laser attacks.

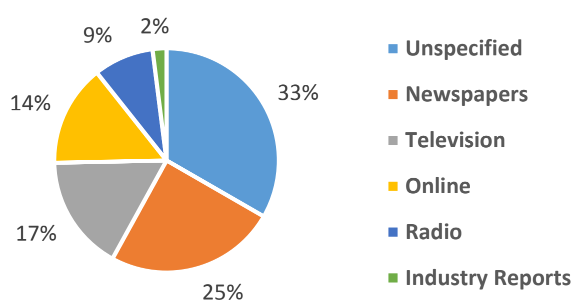

Fig. 2 Media channels from which people gained knowledge of laser attacks

Many researchers and industry experts suggest education is a viable option in the ongoing struggle to reduce/eliminate the threat of laser attacks on aircraft. As the results show, there are several factors which may influence the level of knowledge an individual may hold. The training which aviation professionals receive, has almost certainly increased awareness and knowledge of laser attacks within this group when compared to non-aviation related respondents. One could argue that this supports the case for increasing public knowledge and awareness in this area. Almost 71% of respondents heard of laser attacks through the media, as shown in Fig. 2. It is worth considering utilizing these channels as an effective means by which to reach a large proportion of the target audience.

The attitudes of participants was measured by rating their overall level of agreement or disagreement with 15 attitude statements. The responses of the 15-item 5-point scale were summed to give the mean score (*M*=67.34, SD=6.92). This demonstrates that in general, strongly negative attitudes are held towards laser attacks on aircraft.

In one section of the survey, participants were asked to state their opinions on the acceptable use of lasers (Fig. 3). Many (23%) agreed that it was ok to point a laser at a building however only 0.5% of respondents felt it was acceptable to shine a laser at a person, a car or an aircraft. This difference may imply that respondents considered the building to be unoccupied, or that the risk of danger to occupants to be acceptably low.

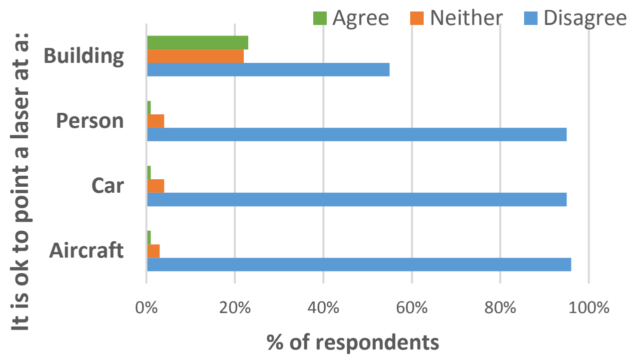

Fig. 3 Participant attitude towards acceptable use of lasers

Participants were subsequently asked how they would feel if a person pointed a laser pointer directly at them; 87% responded that they would be annoyed, while 53% said they would have health concerns as a result. Only 6.5% of respondents said they would not care (Fig. 4).

Next, they were asked how they would feel if they were a passenger on board an aircraft and they became aware that a laser was being pointed at the aircraft they were travelling in. Very few responded that they would not care (3%), while 79% would be very concerned (Fig. 5).

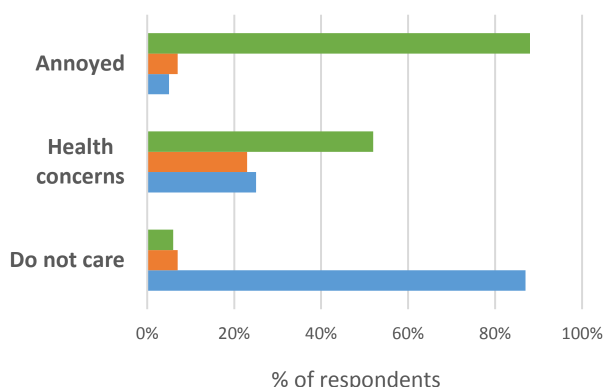

Fig. 5 Respondents feelings if a laser was pointed directly at them

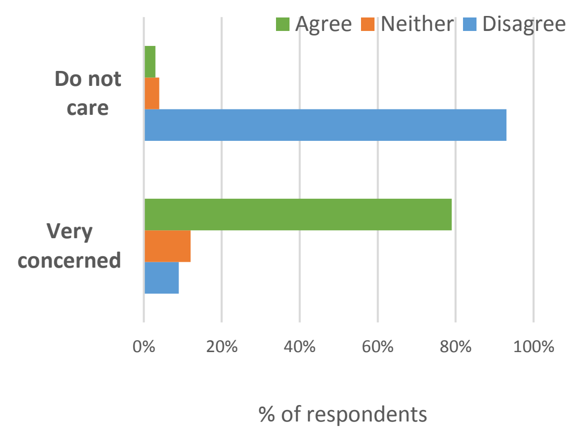

Fig. 4 Respondents feelings if a laser was directed at the aircraft they were travelling in

In order to determine what participants believed could be potential outcomes of laser attacks they were asked another short series of questions. As seen in Fig. 6, most agreed that pilot distraction was a possible outcome. Likewise, the vast majority (correctly) believed that temporary blindness could occur. This majority quickly dissipated when asked if permanent blindness could occur. Almost 31% neither agreed nor disagreed, while 27% disagreed that this could occur. This result is unsurprising considering it is a disputed element even amongst experts and researchers. Further to this 64% of respondents thought that a laser attack may result in an aircraft crash. As noted earlier, no crash has been attributed to laser attacks, however researchers and experts alike agree the likelihood certainly exists.

In assessing an attitude, it would be remiss not to measure the strength of attitudes presented by participants given its influence on behavior. A series of one-way ANOVA's was used to compare the effect different cross sections of the public would have on attitude strength. Consistent with the study's hypotheses, participants who worked in the aviation industry had stronger attitudes toward laser attacks on aircraft than those who did not work in the aviation industry, $F(1,206) = 11.384$, $p<.05$. However, attitude strength did not significantly differ between frequent and infrequent flyers, despite frequent flyers claiming to have more knowledge regarding laser attacks.

The vast majority of people (90%) indicated they would inform a member of the cabin crew if they became aware of a laser attack on their aircraft. A linear regression indicated attitude strength is a significant predictor of behavior. The regression equation was: behavior = -0.21 + 0.07* attitude strength, $R^2 = .298$, $F(1, 206) = 87.53$, $p < .01$.

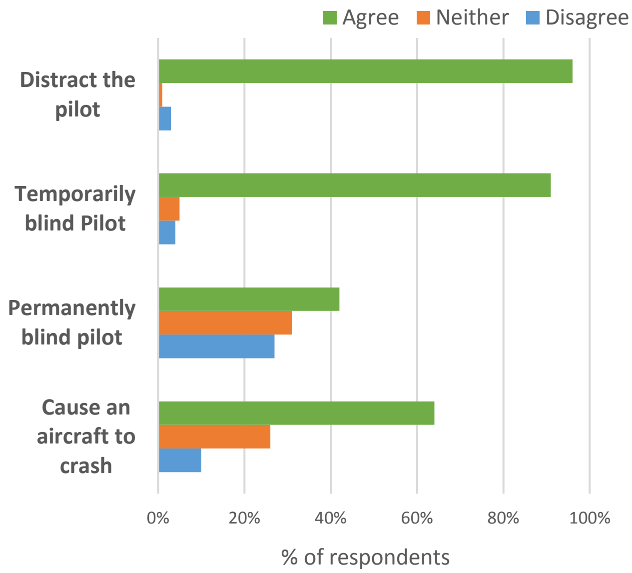

Fig. 6 Respondents feelings toward potential outcomes of a laser attack

Public perception toward punishment is a key consideration within the national justice system, therefore it was important to capture the attitudes of respondents in relation to laser attacks on aircraft. The final section of the survey asked five closed questions; two relating to the regulation of laser devices and three questions regarding the punishment of offenders.

As shown in Fig. 7 the attitudes of participants quickly becomes obvious, mostly in support of regulation and punishment for offences. Restrictions on the import and sale of laser pointers found substantial support from respondents (64%), as did making it illegal to carry a laser without good reason (61%). In fact, many of the comments from respondents called for an outright ban on the sale of laser pointers. It should be noted that in many countries laser pointers are already strictly regulated and often prohibited, albeit enforcement of such legislation is difficult. Online retailers operating outside certain jurisdictions are under no obligation to comply with these laws. Given the incredibly low cost of laser pointers from such sellers, offenders seem to be quite happy and willing to take the risk of having their purchase confiscated by customs agencies.

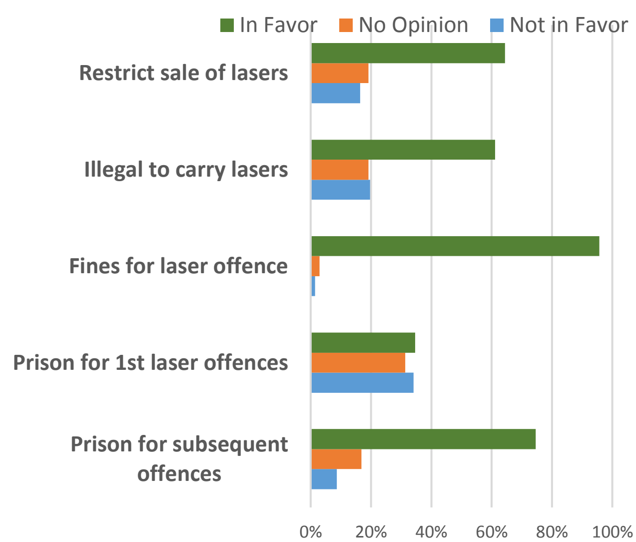

Fig. 7 Participants attitudes towards regulation and punishment of offenders

There was an overwhelming majority (96%) in favor of issuing fines to those caught for lasing aircraft. The respondents were next asked if offenders should be imprisoned for a first offence. This topic quickly divided opinion, with 35% of respondents in favor and 34% opposing. It is likely that respondents view fines as a slap on the wrist, while not having the negative impact on an offender's personal life the way prison would. Although respondents perceived laser attacks to be a concern, they apparently do not feel it warrants such a 'hard' response. Looking a little deeper into the socio-demographic aspect of this, those over 61yrs old were most likely to favor a prison sentence for first offenders, while those aged 31-40yrs were least likely. Interestingly, those respondents who worked in the aviation took a relatively neutral stance on the matter. Prison sentences for offenders who had previously been apprehended garnered quite a bit more support; 75% were in favor while 9% opposed. This may imply that participants feel offenders should have learned from their previous offence and modified their behavior accordingly.

Fines and imprisonment of offenders are legal avenues often utilized in some countries, with sentences ranging from weeks to decades being imposed. Unfortunately, these methods do not seem to have deterred offenders, who may view their chances of being caught and punished as acceptably low. Roberts and Hough (2002: 201) muse that the problem with opinion on punishment is 'over-estimating the utility of punishment and, in particular, the value of imprisonment; and under-estimating the value of alternative responses to crime'. Prison sentences appear not to be the deterrent some aviation stakeholders think it to be.

V. Conclusion

There were three aspects of laser attacks which the study aimed to investigate; first was to ascertain how much knowledge the general public possessed regarding laser attacks. Second to this was the assessment of the attitudes held by the general public toward laser attacks, and finally to investigate attitudes towards regulation and punishment for laser offences. The results indicated that generally speaking, the public hold low to moderate levels of knowledge and strong negative attitudes toward laser attacks against aircraft.

Laser attacks are a problem, and it is not going away. Not by itself at least, and if left unchecked the incidence of laser attacks will likely continue to increase. Mitigating strategies presently in place do not appear to be having the desired effect, and if a discernible reduction of reported incidents is to ever be realized then alternative ways and means to address the issue of laser attacks on aircraft are essential. These can and should include as a minimum; education and awareness strategies, increased regulation, restriction and screening of imported laser devices. This should be in parallel to activities towards more effective enforcement of laws currently in place. Education plays a key part in any mitigation strategy in this area, and as indicated in the survey in terms of perceived offenders, should begin at an early age. Therefore any educational campaigns should be carefully designed and targeted; a wide spectrum advertising campaign is unlikely to achieve the desired result. Simply telling the public that something is illegal is unlikely to change the attitude nor the behavior of offenders. The good news is that there are a number of avenues yet to be tested in the effort to reduce laser attacks on aircraft.

VI. Acknowledgments

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