

# Flight School Perceptions of Electric Planes for Training

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**Abstract**—Flight school members are facing a major disruption in the technologies available for them to fly as electric planes enter the aviation industry. The year 2020 marked a new era in aviation with the first type certification of an electric plane. The Pipistrel Velis Electro is a two-seat electric aircraft (e-plane) designed for flight training. Electric flight training has the potential to deeply reduce emissions, noise, and cost of pilot training. Though these are all attractive features, understanding must be developed on the perceptions of the essential actor of the technology, the pilot. This study asks student pilots, flight instructors, flight center managers, and other members of flight schools about their perceptions of e-planes. The questions were divided into three categories: safety and trust of the technology, expected costs in comparison to conventional planes, and interest in the technology, including their desire to fly electric planes. Participants were recruited from flight schools using a protocol approved by the Office of Research Ethics. None of these flight schools have an e-plane in their fleet so these views are based on perceptions rather than direct experience. The results revealed perceptions that were strongly positive with many qualitative comments indicating great excitement about the potential of the new electric aviation technology. Some concerns were raised regarding battery endurance limits. Overall, the flight school community is clearly in favor of introducing electric propulsion technology and reducing the environmental impacts of their industry.

**Keywords**—Electric planes, flight training, green aircraft, student pilots, sustainable aviation.

## I. INTRODUCTION

ANTHROPOGENIC climate change has been altering the world we live in and share with billions of species for decades. The emissions released from industrial processes, energy production, and transportation linger in the atmosphere and warm the planet. Fortunately, there has been an increase in accountability for these emissions as well as technological and behavioral changes to mitigate global effects and reduce emissions. The transportation sector is responsible for 16.2% of global greenhouse gas emissions, 1.9% of which are attributed to aviation [1], [2]. At a slightly higher percentage, aviation is responsible for 2.5% of global CO<sub>2</sub> emissions [2]. Although aviation represents a small portion of global anthropogenic emissions, it is important to introduce more sustainable technologies as global air travel demand is expected to grow by 4.3% per year [3]. The use of electric aircraft (e-planes) in place of conventional fossil-fuel powered aircraft allows for the complete elimination of in-flight emissions, providing deep reductions in greenhouse gases from aviation [4]-[8]. Although this technology has not yet advanced to the commercial aviation

level, integrating electric aircraft into small scale flight operations provides an opportunity for the technology to be explored and optimized for integration into future airline applications [5]-[8]. As current electric aircraft have short ranges and small aircraft sizes, they can be easily integrated into flight training [4], [5], [7].

An example of such an aircraft is the Pipistrel Velis Electro [9]. In 2020, the Pipistrel Velis Electro (a two-seater electric aircraft manufactured in Slovenia) was officially certified by the European Aviation Safety Agency [9]. This certification made the Velis Electro the first fully electric aircraft in the world to be type certified [10]. In addition to the deep emissions savings from using electric aircraft such as the Velis Electro for flight training, costs to student pilots can also be dramatically cut due to the elimination of cost from fossil fuel [5]. If an e-plane such as the Pipistrel Velis Electro is used in place of a conventional aircraft such as a Cessna 152 for a student's Private Pilot's License (PPL), the cost savings can be over \$1800 (CAD) and the carbon emissions savings more than 2.3 tonnes [11], [12]. However, before assuming the success of electric aircraft in flight training, understanding must be achieved regarding the perceptions of key stakeholders on e-planes. In Canada and worldwide, studies have been completed on public views on electric vehicles, revealing overall positive opinions about the technology [13]-[15]. As electric vehicle technology has huge potential for emissions reductions in the transportation sector, studies on perceptions in potential markets have become increasingly important. However, perceptions on e-planes for flight training have not yet been thoroughly studied.

This study analyzes survey responses from the flight school community on their perceptions of e-planes for flight training. The survey asks participants questions involving their perception on the safety of the technology, how much they trust the technology, their perceptions on cost differences between training on conventional or electric planes, and what reasons are important for them to want to fly e-planes.

In Section II the data and methods of the study are discussed, followed by study results in Section III, and a discussion and conclusion in Section IV.

## II. DATA AND METHODS

### A. Data Collection

To gather information on perceptions regarding e-planes, a survey was sent out to flight schools and student pilots in

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Canada and India. The survey was created using Qualtrics and was approved by the Office of Research Ethics at the University of Waterloo (ORE# 43089). The survey consisted of 34 questions regarding individual perceptions on different aspects of the use of e-planes for flight training, including personal knowledge on the subject and personal opinions on safety, cost, and emissions. Questions were used to identify the level of knowledge that the participant had on electric aircraft. Analysis then tested whether the level of knowledge influenced later answers regarding perceived safety and trust of the technology. These questions were answered on a 0-10 graphic scale. At the end of the survey, demographic questions identified what decade they were born in, where they were from, and their gender. These data were collected to identify any demographic patterns in the perceptions of e-planes.

The survey was distributed through contact with flight school managers and through online distribution to student pilot groups.

### B. Sample Characteristics

In total 186 responses were collected. Of these, 117 were Student Pilots, 35 were Flight Instructors, 15 were Managers/Owners, and 19 selected were Others. There was a total of 28 females, 155 males, and 3 who preferred to not indicate gender. 158 respondents were from Canada, 24 were from India, and 4 were from other countries.

### C. Data Analysis

Data analysis of the responses was completed using Qualtrics.

### D. Limitations

As the 0-10 graphic scale was automatically set to 0, we found some questions where a 0 was likely (high number of participants choosing values such as 1 or 2) there was a significantly lower number of respondents. If the number of respondents was lower than 150, and there were clear trends on the low side of the scale (high numbers for 1 and 2) the values were adjusted based on the last question that had more than 150 respondents. For example, if a question only had 130 respondents and had high numbers of responses for levels 1 and 2, the number of respondents on the last question (with over 150 respondents) was added to the 0 column.

Questions with adjusted values include: "I do not trust the electric motor/controller technology", "I expect an increased accident risk with e-planes" and "Willingness to pay for electric training if cost is 50% more".

Adjustments were not made for the values in Tables I and II, therefore an asterisk was added next to questions where the mean is likely lower and a change in standard deviation is a possibility based on the criteria discussed above.

## III. RESULTS

### A. Knowledge and Trust

The first section asked participants about their knowledge on electric planes, their trust on electric planes, and how interested they are to fly an electric plane. On a scale of 0-10, with 0

representing "none at all", and 10 representing "complete knowledge", the average rating of the question "How much do you know about e-planes?" was a 3.73, with a standard deviation of 2.78. 41% of participants chose a knowledge level from 0-2, and 64% chose between 0-4. In comparison, when asked the question "How much do you know about e-planes for flight training?" the average rating was a 3.14, with 70% of participants choosing a knowledge level between 0-2, and 81% choosing between 0-4, representing less knowledge of e-planes for flight training than in general. Despite having little knowledge of e-planes, when asked how much they trust the technology, from 0 representing "not at all", and 10 representing "completely", there was an average level of trust selected, with a mean of 5.99 and a standard deviation of 2.39. 77% of participants claimed to have a moderate to complete level of trust in the technology of e-planes. In addition, there was an overwhelmingly positive response when the participants were asked whether they would like to learn to fly a type certified e-plane, with 84% of participants choosing an 8-10 on the 0-10 scale of whether or not they would like to learn to fly a type certified e-plane, and 67% choosing 10 (Fig. 1).

### B. Reasons for Wanting to Fly E-Planes

In the next section of the survey, participants were asked how important different reasons are to them for wanting to fly e-planes on a scale of 0-10, with 0 representing "not an important reason", and 10 representing an "extremely important reason". A strong positive response was received for whether emissions reductions was an important reason for the participants to want to fly e-planes, with a mean of 7.86 and a standard deviation of 2.87 (Fig. 2). 74% of respondents rated the importance from 7-10, and 51% rated the importance a 10 (Fig. 2).

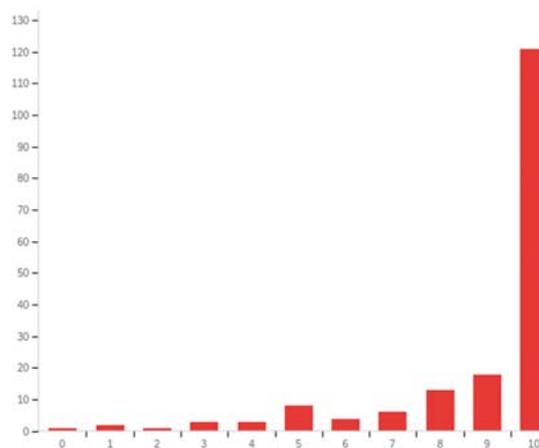


Fig. 1 Number of responses (y axis) to the question "Would you like to learn to fly a type certified e-plane"; Note: 0 represents "not at all", and 10 represents "definitely"

Other strong reasons for the participants wanting to fly e-planes was to learn to fly the "technology of the future", with 67% of respondents choosing an importance level of 7-10 (36% chose 10), and that reduced cost of training was expected, with 69% choosing between 7-10 (44% chose 10). Participants found that the expected growing share of e-planes in aviation was not

a strong reason to want to fly e-planes. Participants had varied opinions on how important the possibility of reduced risk from simpler engines are for wanting to fly e-planes, with a mean of 6.00 and a standard deviation of 3.03 (Fig. 3). 17% of respondents chose an importance level of 5, and 21% chose a level of 10 (Fig. 3).

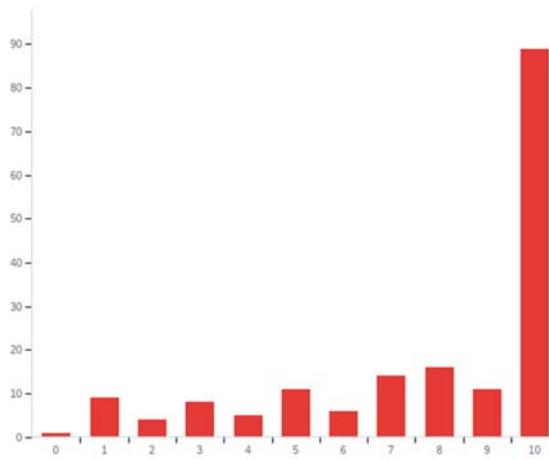


Fig. 2 Number of responses (y axis) to the statement “I expect reduced emissions from using e-planes”; Note: 0 represents “not an important reason to me” (to want to fly e-planes), and 10 represents an “extremely important reason to me”

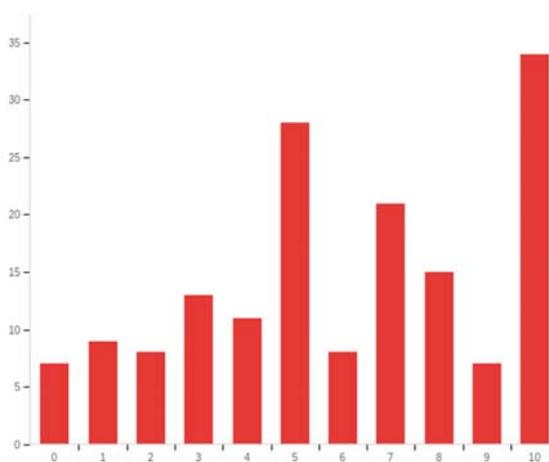


Fig. 3 Number of responses (y axis) to the statement “I expect reduced accident risk from simpler electric motors”; Note: 0 represents “not an important reason to me” (to want to fly e-planes), and 10 represents an “extremely important reason to me”

In a qualitative response, participants were asked if they had any other reasons for wanting to fly e-planes. Responses included: “I want to be part of a growing industry with highly developed technology”, “I feel that learning to fly electric planes would be a very interesting and worth while experience”, “They’re new and exciting”, “Advertising and marketing”, “Reduced fuel/maintenance costs”, “Simpler aircraft systems”, “Lower cost of operation/ownership”, “I believe electric operated vehicles are the way of the future and the more we as individuals show interest in the technology the more cost efficient, powerful, and environmentally friendly electric

powered vehicles and machines become”, “I think it would be cool to fly”, “I want to fly as many types of aircraft as I can”, and “I think e-planes and the idea of them is super cool, and I’d love to fly, and one day maybe own one”.

### C. Reasons for Not Wanting to Fly E-Planes

Following reasons for wanting to fly e-planes, participants were asked how important different reason are to them for *not* wanting to fly e-planes. Overall, the trends were not as strong as the reasons the respondents had for wanting to fly e-planes. One question which received a somewhat trend for being an important reason to not want to fly e-planes was that the battery endurance is not trusted, with 21% of respondents choosing an importance level of 10, and 44% choosing 7-10 (Fig. 4). However, many respondents found that this reason was not very important (Fig. 4). Respondents also agreed on some reasons which are not important, such as distrust in the electric motor technology (Fig. 5) and an increase in accident risk (Fig. 6). In terms of distrust in the electric motor technology, 65% of respondents rated this as not important at all to somewhat important by choosing 0-3 on the scale (Fig. 5). 77% of respondents chose an importance level of 0-5 for expecting an increased accident risk, with 53% choosing levels between 0-3 (Fig. 6).

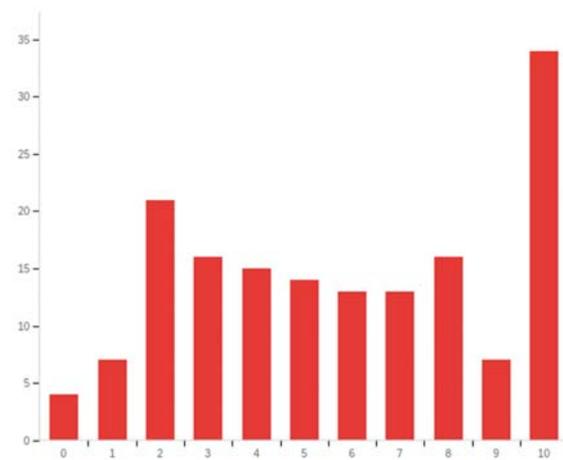


Fig. 4 Number of responses (y axis) to the statement “I do not trust the battery endurance technology”; Note: 0 represents “not an important reason to me” (to not want to fly e-planes), and 10 represents an “extremely important reason to me”

The responses shown in Figs. 5 and 6 show that the participants *do* trust the electric motor technology, and that they *don't* expect an increase in accident risk from use of e-planes. Respondents considered the concern that oil-based technology may dominate their career a moderately to very important reason to not want to fly e-planes, with 24% of respondents choosing an importance level of 5, and 70% of respondents choosing 5-10.

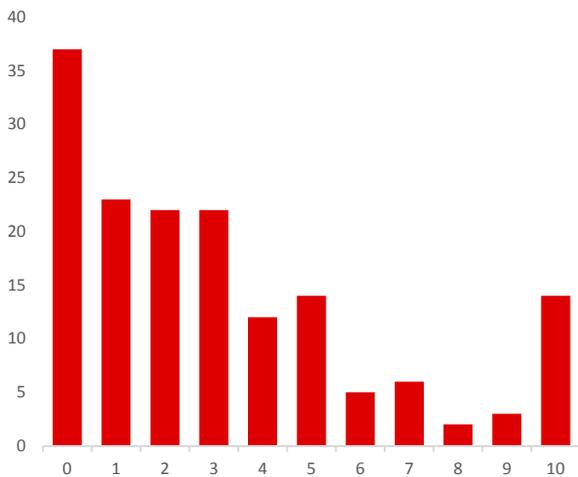


Fig. 5 Number of responses (y axis) to the statement “I do not trust the electric motor/controller technology”; Note: 0 represents “not an important reason to me” (to not want to fly e-planes), and 10 represents an “extremely important reason to me”

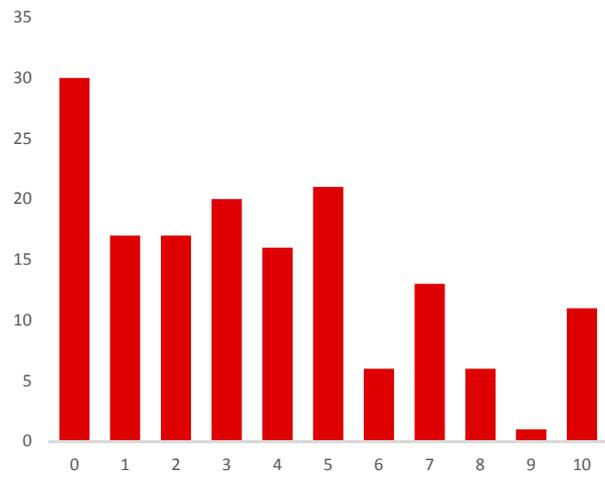


Fig. 6 Number of responses (y axis) to the statement “I expect an increased accident risk with e-planes”; Note: 0 represents “not an important reason to me” (to not want to fly e-planes), and 10 represents an “extremely important reason to me”

In a qualitative response, participants were asked if they had any other reasons for not wanting to fly e-planes. Responses included: “New technology is bound to have defects”, “If the engine is silent then it becomes difficult to judge certain issues while flying”, “I don’t know how they will hold up in cold weather. If it’s cold my car might not start so how will e-planes handle?”, “Unsure about potential range issues, however if only used for local training flights or such this could not be an issue. I think more awareness and knowledge of this fact would improve its acceptance”, “Turnover time between flights for recharge”, “Too much down time for charging the aircraft”, “Battery life and added weight from heavy batteries”, “Battery endurance”, “Recharge time”, “Battery life”, “Batteries don’t do well in the cold and take too long to charge for a flight college to benefit from with back to back flights with such short battery run times”, and “New planes are very expensive so to buy a new plane total tuition cost would likely go up”. These comments focus mainly on concerns of battery endurance and charging times for the aircraft, matching results in Fig. 4.

Some comments such as “They will not fly the same as piston powered aircraft”, “I feel that the battery life and the amount of power needed to be produced by these electric motors might burn the battery or motor out”, and “If there is an electrical problem and resultant engine failure, what is the backup?” show that increasing education on e-planes is necessary.

#### D. Cost Changes

Participants were then asked several questions regarding how willing they were to pay for e-plane flight training with different costs relative to the cost of current flight training. Not surprisingly, as the savings were increased, the willingness to pay increased, and as the savings decreased, the willingness to pay decreased. Fig. 7 shows that with a 50% cost decrease in comparison with conventional flight training, there is an overwhelming willingness to pay, and a corresponding lack of willingness to pay when the cost is 50% more (Fig. 8).

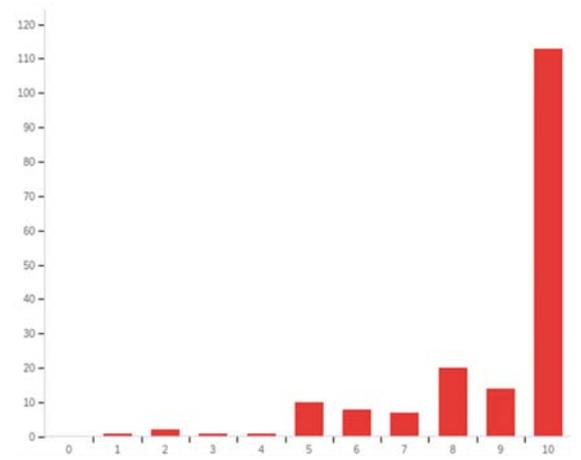


Fig. 7 Willingness of the participants to pay for e-plane flight training if the cost is 50% less than conventional flight training; Note: 0 represents “not at all willing” and 10 represents “very willing”. Y axis represents number of participants who chose each value

The pattern between Figs. 7 and 8 shows that cost is a strong driver for participants’ willingness to pay for flight training. Fig. 9 shows the willingness to pay if the cost is the same, which displays two strong peaks at moderately willing and extremely willing.

#### E. Emissions Guilt

Participants were then asked a series of questions regarding any guilt they feel about carbon emissions in general, from aviation, and from flight training. Responses were widely varied and there were no significant trends found.

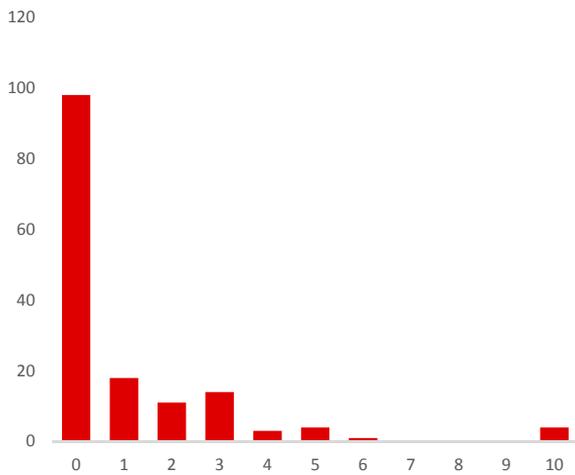


Fig. 8 Willingness of the participants to pay for e-plane flight training if the cost is 50% more than conventional flight training; Note: 0 represents “not at all willing” and 10 represents “very willing”. Y axis represents number of participants who chose each value

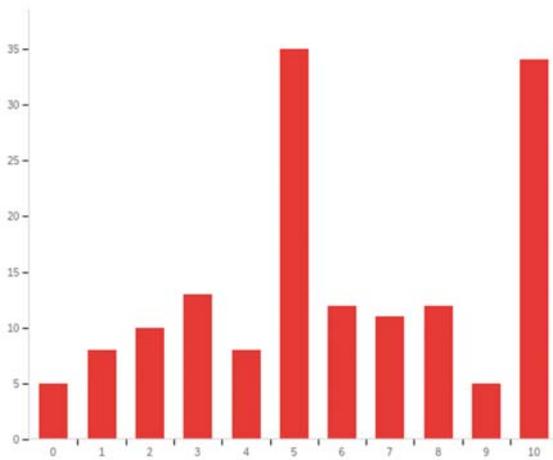


Fig. 9 Willingness of the participants to pay for e-plane flight training if the cost is the same as conventional flight training; Note: 0 represents “not at all willing” and 10 represents “very willing”. Y axis represents number of participants who chose each value

#### F. Group Analysis

To analyze any trends in the flight center groups, Student Pilots, Flight Instructors, flight center Managers/Owners, and Others were analyzed separately (Table I). When asked the question “How much do you know about e-planes”, the Managers/Owners and Others indicated a higher level of knowledge than the Student Pilots and Flight Instructors (Table I). The Student Pilots had a mean of 3.30 and the Flight Instructors had a mean of 4.00, compared to the mean of 4.71 for Managers/Owners, and 5.00 for Others. All groups showed moderate levels of trust in the technology, and strong eagerness to fly a type-certified e-plane (Table I).

In terms of reasons for wanting to fly e-planes, all groups found high importance in reasons including wanting to fly the technology of the future, that reduced emissions were expected, and that reduced cost of training was expected (Table I).

“Reduced emissions expected” was the strongest reason for the Student Pilot group to want to fly e-planes, with a mean of 8.21, and 56% of the Student Pilots choosing an importance level of 10 (Flight Instructors had 42% at 10, Managers/Owners 47%, and Other 39%) (Table I). The Managers/Owners strongest reason was that reduced cost of training is expected, with a mean of 8.53 (Table I). Reduced training cost means more students able to attend flight school, therefore higher revenue for the flight center. Managers/Owners also chose a higher level in comparison to the other groups for the importance of reduced accident risk from simpler motors (Table I). Safety of students is a top concern for flight center managers/owners and continued safety helps maintain reputation and increase clients at the flight center. Surprisingly, Student Pilots chose the lowest importance level of the groups for expecting reduced accident risk from simpler electric motors (Table I).

In terms of reasons the groups had for not wanting to fly e-planes, the groups had similar levels of importance for the reason “I do not trust the battery safety technology”, with importance levels ranging from 4.48-5.56, representing a moderate level of importance (Table I). Flight Instructors had the highest concern of battery endurance technology, with a mean importance level of 6.70 (Table I). The Managers/Owners had the greatest concern that oil-based technology would dominate the aviation industry for their career.

In terms of cost, all groups were very similar and matched the general results. In terms of willingness to pay for e-plane flight training when the cost is 50% less than conventional flight training, the difference between the groups was only 0.54, with each group being very willing to pay (Table I). When the cost is the same as conventional flight training, the groups all agreed within a similar margin of only 0.57 (Table I). The largest difference occurred when the cost was 50% higher, with a range of mean of 1.62 (Table I). The higher values here result from some members of the Student Pilots, Flight Instructors, and Other choosing a willingness level of 10, indicating extremely willing (Student Pilots had 2% respondents choose 10, Flight Instructors 14% and Other 16%).

The groups had similar guilt from their carbon emissions, and all groups indicated less guilt about their emissions from flight training than their emissions in general (Table I). Student Pilots and Flight Instructors had a higher level of guilt from their flight training emissions than Managers/Owners and Others (Table I). The group with the lowest concern for emissions in both categories was the Managers/Owners (Table I).

Overall, Student Pilots had the greatest concern for the reduced emissions from e-planes and the greatest guilt for their carbon emissions from flight training (Table I). This could be due to the stronger base knowledge on climate change and emissions in the younger generations. In addition, despite indicating the lowest level of knowledge on e-planes, the Student Pilots also indicated the highest level of trust, in the electric motor technology, and in the battery safety technology, and were the least concerned about change of accident risk (Table I).

TABLE I  
DIFFERENCES IN GROUP MEAN AND STANDARD DEVIATION

| Question  | Student Pilots | Flight Instructors | Managers/Owners | Other      |
|---|----------------|--------------------|-----------------|------------|
| How much do you know about e-planes?                                      | 3.30, 2.61     | 4.00, 2.57         | 4.71, 3.53      | 5.00, 2.83 |
| Do you trust the technology of e-planes?                                  | 6.07, 2.35     | 6.15, 2.65         | 5.27, 2.26      | 5.82, 2.12 |
| Would you like to learn to fly a type certified e-plane?                  | 8.96, 2.15     | 8.71, 2.22         | 9.47, 0.96      | 8.72, 1.69 |
| I want to fly e-planes because they are the technology of the future      | 7.27, 2.85     | 7.68, 2.75         | 7.00, 2.42      | 6.94, 3.12 |
| I expect reduced emissions from using e-planes                            | 8.21, 2.67     | 7.23, 3.04         | 7.53, 3.12      | 7.06, 3.12 |
| I expected reduced cost of training from using e-planes                   | 7.30, 3.14     | 7.97, 2.26         | 8.53, 2.31      | 6.93, 3.23 |
| I expect reduced accident risk from simpler electric motors               | 5.80, 3.00     | 6.03, 3.17         | 7.38, 2.56      | 6.13, 3.03 |
| I do not trust the battery endurance                                      | 5.57, 3.03     | 6.70, 3.10         | 6.31, 3.22      | 5.12, 3.12 |
| I do not trust the electric motor/controller technology*                  | 3.36, 2.81     | 4.12, 3.20         | 4.31, 3.07      | 4.53, 3.14 |
| I do not trust the battery safety technology*                             | 4.48, 3.13     | 5.35, 3.11         | 4.80, 2.36      | 5.56, 2.61 |
| I expect that oil-based technology will dominate aviation for my career   | 5.63, 3.02     | 4.92, 3.00         | 6.23, 2.49      | 5.12, 3.08 |
| I expect an increasing in training time with e-planes*                    | 3.44, 2.66     | 3.19, 2.52         | 4.00, 2.97      | 4.92, 2.96 |
| Willingness to pay for electric training if cost is 50% less              | 9.04, 1.81     | 8.53, 2.29         | 9.07, 1.34      | 8.53, 1.54 |
| Willingness to pay for electric training if cost is the same              | 5.90, 2.82     | 6.19, 3.33         | 5.62, 3.25      | 5.73, 3.15 |
| Willingness to pay for electric training if cost is 50% more*             | 1.98, 1.88     | 3.00, 3.36         | 1.38, 0.99      | 3.00, 3.56 |
| Do you feel guilty about your carbon emissions in general?                | 5.31, 2.91     | 5.22, 2.83         | 4.17, 3.16      | 5.67, 2.89 |
| Do you feel guilty about your carbon emissions from your flight training? | 4.69, 2.98     | 4.26, 2.61         | 3.25, 2.38      | 3.93, 3.02 |

The Flight Instructors also claimed a low level of knowledge and a high level of trust, however had the highest concern for battery endurance (Table I). The strongest reason the Flight Instructors had for wanting to fly e-planes was that reduced cost of training was expected (Table I). Reduced cost of training means more students for instructors, and more working hours. The Flight Instructors had the lowest level of concern that oil-based technology would dominate aviation for their career, and that using e-planes would increase the training time (Table I). In addition, the Flight Instructors had the highest number of members choose “extremely willing” for willingness to pay for electric training if the cost was 50% more.

The strongest reason the Managers/Owners had for wanting to fly e-planes was that reduced cost of training was expected (Table I). This group also indicated the highest level of importance of all groups when responding to the statement: “I expect reduced accident risk from simpler electric motors” (Table I). As discussed earlier, both these factors can influence the number of clients at the flight centers. The Managers/Owners also indicated the highest level of importance for not wanting to fly e-planes because oil-based technology was expected to dominate aviation for their career (Table I). The Managers/Owners indicated the lowest overall trust in the technology, and a low level of trust for the battery endurance, however a higher level of trust in the electric motor technology and the battery safety technology (Table I). Of all the groups, the Managers/Owners indicated the lowest level of guilt for their emissions (Table I).

The Others indicated the highest level of knowledge of e-planes, the most trust in battery endurance, and the lowest trust in battery safety technology (Table I). The strongest reason the Others had for wanting to fly e-planes was that reduced emissions were expected, however this group also had the lowest mean in this category (Table I). In addition, the Others indicated the highest level of guilt from their emissions in general (Table I).

### G. Gender Analysis

A gender analysis was completed to assess whether there are differing views between genders. Females claimed to have a much lower level of knowledge of e-planes than the males, with 41% of females choosing a 0, representing no knowledge at all (males only had 10% select 0) (Table II). Despite having different levels of knowledge, both groups claimed to have very similar levels of trust in the technology in general, in the battery endurance, battery safety technology, and electric motor technology (Table II). The strongest reason for both groups to want to fly e-planes was that reduced emissions are expected, however the response from the females indicated higher importance (Table II). The males considered “flying the technology of the future” a stronger reason to want to fly e-planes than the females, and the females found that the possibility of increased training time was a more important reason to not want to fly e-planes than the males (Table II). In addition, females were significantly more concerned with their emissions both in general, and from their flight training than the males (Table II). However, as with the group analysis above, both females and males indicated a lower level of guilt from their emissions from flight training than their emissions in general (Table II).

## IV. DISCUSSION AND CONCLUSION

### A. Past Research

Past studies on electric ground vehicles have shown that the public perception of the sustainable technology is widely positive and has great potential to lower transportation emissions [13]-[15]. Less research has been performed regarding perceptions on electric aircraft of the aviation public or student pilots. Therefore, this study fills a significant knowledge gap regarding the perceptions of one of the primary stakeholders of this upcoming technology. Regarding views of future air passengers on electric aircraft, it has been found that reducing customers perceived risk as well as increasing product

knowledge is critical to boost trust and create positive attitudes [16]. Reference [16] found that the largest concern found from future electric aircraft passengers was regarding possible

physical threats to their safety, including possibility of battery explosion, and the battery running out during flight.

TABLE II  
 DIFFERENCES IN FEMALE AND MALE MEAN AND STANDARD DEVIATION

| Question   | Females    | Males      |
|--|------------|------------|
| How much do you know about e-planes?                                       | 2.30, 2.69 | 3.95, 2.73 |
| Do you trust the technology of e-planes?                                   | 5.52, 2.25 | 6.06, 2.41 |
| Would you like to learn to fly a type certified e-plane?                   | 8.38, 2.25 | 9.11, 1.91 |
| I want to fly e-planes because they are the technology of the future       | 6.08, 2.81 | 7.48, 2.80 |
| I expect reduced emissions from using e-planes                             | 8.77, 1.58 | 7.68, 3.01 |
| I expected reduced cost of training from using e-planes                    | 7.59, 2.50 | 7.50, 3.06 |
| I expect reduced accident risk from simpler electric motors                | 5.76, 3.10 | 6.01, 3.03 |
| I do not trust the battery endurance                                       | 5.44, 3.11 | 5.85, 3.11 |
| I do not trust the electric motor/controller technology*                   | 3.68, 2.75 | 3.74, 3.05 |
| I do not trust the battery safety technology*                              | 4.83, 3.06 | 4.77, 3.07 |
| I expect that oil-based technology will dominate aviation for my career    | 5.50, 2.57 | 5.54, 3.07 |
| I expect an increasing in training time with e-planes*                     | 4.76, 2.82 | 3.35, 2.68 |
| Willingness to pay for electric training if cost is 50% less               | 8.56, 2.08 | 8.95, 1.82 |
| Willingness to pay for electric training if cost is the same               | 6.04, 3.31 | 5.87, 2.95 |
| Willingness to pay for electric training if cost is 50% more*              | 3.27, 2.49 | 2.15, 2.40 |
| Do you feel guilty about your carbon emissions in general?                 | 6.60, 2.68 | 4.88, 2.84 |
| Do you feel guilty about your carbon emissions from your flight training?* | 5.87, 2.40 | 4.17, 3.01 |

A global study completed by Ansys of 16,037 participants from 10 different countries (U.K, U.S, Austria, Germany, Switzerland, France, Sweden, Japan, Chile, India) found that 63% of those surveyed think about the emissions they create from personal or work air travel [17]. Of the 10 countries surveyed, the U.S was the only country where the majority of participants (61%) recorded that they do not think about their emissions [17]. In comparison, India, which represents the 3<sup>rd</sup> most polluted country in the world [18], had 89% of participants respond that they do think about their emissions [17]. The findings from the Ansys global study also showed that 89% of participants would pay for greener air travel, with 60% of participants considering electric aircraft because of the benefits to the environment [17]. In terms of what would prevent the participants from wanting to travel on an electric aircraft, the most popular reason, at 49% of respondents, was that the technology is not yet proven [17]. The other top reasons included the plane running out of battery, the battery technology failing or exploding, and expensive ticket prices [17]. Pilot training was also addressed, with 17% concerned about additional pilot training needed on the technology [17]. Only 14% of participants chose that they have no concerns [17]. The findings by these studies are similar to those in this study, that identify that main “reasons for not wanting to fly e-planes” include concerns for battery endurance (Fig. 4) and that the benefit to the environment in the form of emissions reductions is a large driver of the technology (Fig. 2).

#### B. On the National Scale

In Canada, half of the population agrees that now is the best time for the nation to be ambitious in addressing climate change, with an increasing number of citizens claiming that climate change cannot wait [19]. Aligning with these views, the

majority of Canadians would choose to buy an electric car over gas, and also want the majority of vehicles sold to be electric [15], [20]. A national study by Klynveld Peat Marwick Goerdeler (KPMG) also found that the primary reason Canadians desire to buy an electric vehicle was because of the benefits to the environment, including eliminating sources of greenhouse gas emissions and reducing air pollution [20]. As of late 2020, the total number of registered electric vehicles in Canada totaled 168,000, with over 6,000 charging stations across the country to support these vehicles [21], [22]. In terms of aviation, Canada currently has 19 airports that are in recognized stages of addressing and reducing their carbon emissions [23]. These include six airports which have proven they have reduced their CO<sub>2</sub> emissions, and encouraged related entities (airlines, air traffic controllers etc.) to reduce their emissions as well [23]. In addition, Canada successfully set a world record in 2019 by operating the world’s first fully electric commercial flight [24]. Harbour Air, a seaplane charter airline based in Richmond, British Columbia, completed this flight in a 1950’s DHC de Havilland Beaver seaplane retrofitted with a fully electric engine [24]. Harbour Air has ambitions to retrofit all of their aircraft to become fully electric and free of in-flight emissions [24]. Canadian flight schools have an increasingly aging fleet [25]. As of 2021, over 60% of Canada’s single engine flight training fleet was over 42 years old [25]. If these aircraft were replaced by electrically powered e-planes, Canada would see emissions savings of 25.7 Kt of CO<sub>2</sub> each year, drastically reducing the carbon emissions from flight training [12].

#### C. Study Conclusions

Strong positive results revealed that members of flight schools including Student Pilots, Flight Instructors, Managers/

Owners and Others are very eager to learn to fly a type certified e-plane such as the Pipistrel Velis Electro (Fig. 1). Though the overall knowledge of electric aircraft technology is low, there was significant trust in the technology, with 77% of participants claiming moderate to complete trust in the technology. The most important reason found for wanting to fly e-planes was that reduced emissions are expected (Fig. 2), with other important reasons including flying the technology of the future and expecting a reduced cost of training. Participants had varied opinions on how important of a reason reduced accident risk from simpler electric motors had on them wanting to fly e-planes. This can be explained by the lack of knowledge of e-planes, as identified in the knowledge and trust questions. The most consistent reason for not wanting to fly e-planes was because of lack of trust of the battery endurance, however, the participants responded that lack of trust in the electric motor technology was *not* an important reason for not wanting to fly e-planes. Cost was found to be a large driver in how willing the participants were to pay for flight training on an e-plane. With costs savings of 50% less in comparison to conventional aircraft flight training, participants were overwhelmingly willing to pay for electric aircraft flight training. As expected, when costs were 50% more, there was a strong lack in willingness to pay. These results are intuitive as flight training already represents a significant source of financial stress for student pilots.

The main findings from the group analysis showed that though Student Pilots claimed to have the lowest knowledge of e-plane technology they also indicated the highest level of trust in the electric motor technology and battery safety technology. In addition, the Student Pilots represented the group with the highest level of importance for expecting reduced emissions from e-planes and had the highest overall level of guilt for their carbon emissions. These results coincide with the likelihood that this group of younger participants have more knowledge on climate change and emissions impacts, therefore a higher level of concern. Flight Instructors also had low levels of knowledge and high levels of trust, but were found to be more concerned with the reduced cost of training from using e-planes, and also had the highest level of concern for battery endurance. Managers/Owners had the lowest overall concern for emissions guilt, and the highest level of importance for both expected reduced cost of training and expected reduced accident risk from using e-planes. The latter two are important aspects for maintaining and increasing clients at the flight center. However, this group also indicated the lowest trust in the technology in general. The Others claimed to have the highest level of knowledge of all the groups, and also the highest level of trust in the battery endurance. The strongest reason the Others had for wanting to fly e-planes was that reduced emissions were expected, and they also indicated the highest level of guilt from their carbon emissions in general. The two strongest reasons for wanting to fly e-planes were that reduced emissions were expected (most important reason for Student Pilots and Others, second most important reason for Managers/Owners) and that reduced cost of training was expected (most important reason for Flight Instructors and Managers/Owners, second most important reason for Student Pilots). In addition, each group

was less guilty about their emissions from flight training than in general.

In terms of female and male differences, it was found that females claimed a lower level of knowledge on e-plane technology than males, and females were more interested in the emission reduction possibilities of e-planes. Females also had higher levels of guilt from their emissions than males. This mirrors findings in past research that suggests a slight gender gap in terms of female and male levels of concern for the environment [26]-[29]. Females were also more concerned about an increase in training time from using e-planes than males. Males had a higher importance level for “flying the technology of the future” for a reason to want to fly e-planes. Both groups had very similar responses for the majority of the reasons why not to fly e-planes.

This work has outlined that the flight school community, including Student Pilots, Flight Instructors, Managers/Owners, and Others have strong positive feelings towards use of e-planes for flight training, with some concerns raised regarding the battery endurance, charging time, and winter operations. Increasing knowledge and understanding of electric aircraft remains extremely important to ensure stakeholders are thoroughly informed on the benefits and research on the technology. Continued communication and education on e-planes will allow the aviation public to have a stronger understanding of the capabilities of the aircraft and its electric engine. With a strong majority of the flight school community eager to train on this new technology, demand for e-planes in the flight training space is high. As a second step to this research, flight training units should use this demand to invest in the technology and test e-planes under local environmental conditions. Electrification of flight training has the potential to act as a catalyst for the significant steps needed for electrification of aviation, and towards incredible emissions reductions both in Canada, and across the world.

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