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Needs Based Assessment of Agricultural Pilots in the Upper Midwest

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One of the major issues currently facing the aviation industry is a forecasted shortage of pilots to fill the seats of commercial airliners (Bjerke et al., 2016). This shortage has caught the attention of both government and industry leaders who recognize the need for a solution to help mitigate this future dilemma (United States Government Accountability Office, 2014). However, the concern of a pilot shortage appears to reach beyond the cockpit of commercial airliners, and into all segments of the industry (National Agricultural Aviation Association [NAAA], 2018a).

The agricultural aviation industry is also facing a shortage of pilots to fill the seats of agricultural aircraft nationwide. As current pilots reach retirement age, many agricultural operates claim they are struggling to find qualified pilots to take over the controls. One of the main qualifications that operators look for in a new hire is experience, something that pilots say they can only obtain by having an opportunity to sit at the controls of these single seat aircraft. With that in mind, it is important for future pilots to know what other skills or qualifications operators use to determine if they will give an aspiring pilot a chance to gain that experience (NAAA, 2018a).

This paper will discuss a pilot study that was conducted of aerial agricultural pilots in the tristate region (Minnesota, North Dakota, and South Dakota) in 2015. The study was developed to answer what skills and training agricultural aerial operators believe are most important for future agricultural pilots to have. This will allow individuals who are interested in entering the field to develop these desirable skill-sets and prepare themselves to be successful aerial agricultural pilots.

Future Dilemma of Agricultural Aviation Industry

Pilots that work in the agricultural aviation industry face challenges unlike most. Flying at extremely low altitudes carrying heavy loads of precisely mixed chemicals while trying to avoid unpredictable weather is no easy task (Thurman, 2014). They say it is a lifestyle that allows for hands on work that provides a feeling of accomplishment unlike anything else (Byrne, 2012).

With such a passion for their careers, it is hard to believe "the biggest dilemma facing the small, aging agricultural aviation industry is retirement" (Wheeler, 2012, p. 28). In a survey conducted by the National Agricultural Aviation Association (NAAA) about 20% of the nation's 1,600 hired agricultural pilots listed their average age as 50 and almost a third of the nation's 1,625 aerial application business owners listed their average age as 54 (2012). Additionally, the NAAA (2018a) average aerial applicator pilot has 21.3 years of experience.

Another issue that adds to this dilemma of aging aerial agricultural applicators is the increasingly important role that aerial application plays in meeting the world demands of food, fiber, and bio-fuel (Byrne, 2008). It is estimated that by 2050 there will be just over nine billion people populating the earth. This

increase in population will require a substantial increase in world food needs without the equivalent land necessary to meet those needs (Byrne, 2008). According to Byrne (2008), aerial applicators will be a necessary component to be able to meet the growing demands through higher yield agriculture.

With the forecasted demand of aerial application needed to help with higher crop yields, and the obvious love of the carrier described by current aerial agricultural pilots, the question remains as to why there is not a steady flow of new pilots ready to take controls. One might think there must be a lack of interest and people in the field of aviation would prefer to pursue other aviation related fields. The reality, according to Calleja (2010), is that aspiring aerial agricultural pilots are having a hard time finding operators who are able to mentor them into the field. To help combat the lack of mentorship in 1996 the National Agricultural Aviation Association developed the Professional Aerial Applicators' Support System (PAASS) whose primary purpose is to "educate pilots on key safety and drift minimization issues important to flying, modern agriculture and crop protection" (NAAA, 2018b, p. 1).

Many articles suggest that aerial application is a career that can only truly be learned through participation, and in order to participate a pilot needs to convince an operator that he or she has what it takes to be successful. According to Calleja (2010), aerial operators are risking a lot when they take on a new pilot. With the cost of equipment and insurance, as well as the time commitment required for training, operators tend to be extremely selective when choosing to take on new pilots into their operations. They want to ensure that the individuals they chose to hire will become successful aerial agricultural pilots who can help further the success of their operation.

The Growing Importance of Soft Skills

Pilots working in industry today typically need have two specific skill-sets in order to maintain a successful career. According to the International Federation of Airline Pilots Associations (IFALPA; 2012), these skill-sets include a technical side which includes manipulating the aircraft controls and understanding procedures, and a non-technical side which focuses on pilot soft skills. Soft skills consist of a number of different qualities including communication skills, networking abilities, leadership potential, and decision making to name a few.

Historically, medical qualifications as well as evidence of strong stick and rudder skills have been the leading factors in the selection process of hiring pilots (IFALPA, 2012). While these skills are still extremely important, soft skills have quickly moved up in level of importance (Wheeler, 2012). The best practices guides created by the IFALPA in 2012 suggest three specific soft skill areas that should be reviewed in the hiring process of all pilots: academics, social skills, and

psychomotor skills (IFALPA, 2012). The discussion that follows looks at each of these areas.

The first area suggested is a pilot's academic characteristics. Pilots need to be able to successfully learn and retain knowledge. They need to be able to grasp complex subjects such as physics, aircraft systems, and human factors. Pilots also must have the ability to cognitively understand and incorporate new learning while working in a three-dimensional platform. Strong academic qualities are often seen through evidence of previous formal training or education, and are a key component to ensuring successful completion of initial pilot training.

The second recommendation by the IFALPA is looking at social skills. Every day, pilots work with people from different backgrounds, cultures, educations, and environments. It is crucial that pilots be able to work with others in the role of both a leader and a follower. Communication skills and the ability to relay messages between operators, pilots, loaders, clients, and regulators is vital to the success of an aerial applicator. This requires a well-rounded individual with a motivated, dedicated, socially adapt, balanced personality (IFALPA, 2012).

The final soft skill described as highly important by the IFALPA is strong psychomotor skills. "To safely operate a modern aircraft in today's complex and technologically advanced cockpit, a pilot needs to have highly developed hand-eye coordination and mental capacity to maintain spatial orientation under normal situations as well as in stressful emergency environments" (IFALPA, 2012, p. 10). Pilots must be well adapted to flying with one hand, controlling the load application with the other, coordinating the aircraft with their feet as well as constantly scanning for towers, fences, wires, obstacles, and GPS light bars (NAAA, 2018).

Soft Skills in Agricultural Aviation

While agricultural aviation pilots are unique in their skill-sets and responsibilities, soft skills are as important for determining a successful pilot as they are in other areas of aviation. According to Wheeler (2012), the agricultural industry needs pilots who have strong stick and rudder skills, can show loyalty to employers, have the knowledge to understand what fields to spray, and what crop-protection or growth-aid products to use. They also need to demonstrate integrity by admitting to, and learning from mistakes. All of these attributes listed fall directly in line with the suggested soft skills previously discussed.

One of the major barriers to becoming an agricultural pilot is the inability for pilots to gain experience in agriculture aircraft with an experienced pilot or instructor. Most of these aircraft are designed to be flown with just a single pilot. (NAAA, 2012). This means agricultural operators are extremely limited in their ability to judge a pilot's technical skills during the hiring process. According to Calleja (2010), because of this, operators are heavily reliant on the evaluation of soft skills to help mitigate some of this risk.

While future aerial applicators will certainly need strong technical skills, literature shows that operators currently have limited avenues in which these skills can be tested or verified. Because of this, and the high risk for both pilots and operators, soft skills appear to be an extremely important part of selecting future aerial applicators. As the agricultural aviation industry faces a future shortage of pilots, it is more important than ever that agricultural operators determine a successful hiring process.

Methodology

This pilot study was designed to describe the current state of agricultural pilots in the upper Midwest (Minnesota, North Dakota, and South Dakota) and to examine and support further research on desirable skill-sets for future agricultural aviation pilots. A mixed methodology, cross-sectional study method was used to guide the following research questions:

1. What is the current state of agricultural aviation pilots in the tristate region (MN, ND, SD)?
2. What levels of formal education do current agricultural aviation pilots perceive as important for future agricultural aviation pilots?
3. What other training or education do current agricultural aviation pilots perceive as most beneficial for future agricultural aviation pilots?
4. Which soft skills do current agricultural aviation pilots perceive as most beneficial for future agricultural aviation pilots?

Participants completed a 21-item survey that was developed by the researchers following the work of previous studies by the NAAA (NAAA Aerial Application Industry Survey: Pilots, 2012). Following the data collection, the results were downloaded from QuestionPro© into a Microsoft Excel 2010 file where the data were cleaned and coded to ensure that all data were accurate. As suggested by Pedhazur and Schmelkin (1991) and Creswell (2008), any responses that included missing data or appeared to be inaccurately recorded were deemed unusable and were removed from the data set.

The coded Microsoft Excel file was then uploaded into the PASW (version 18.0) statistical package using the method described by Cronk (2010). Participants' training and backgrounds were analyzed using descriptive statistics to answer the first research question. To determine which education and training requirements would be most beneficial to future aerial applicators for the second and third research questions, relative frequencies, means, and standard deviations were calculated. The fourth research question was studied in a similar manner.

A composite score was defined by averaging the Likert-scale questions presented in tables 3, 4, and 5 for each individual. Composite scores for individuals with any missing responses were calculated as the mean of the remaining non-missing responses. A two-way ANOVA was conducted in R version 3.6.1 to

compare the composite score for survey participants between years of experience (less than 10 years, 10 or more years), and highest levels of education (high school / GED / some college, associate / technical degree, bachelor's degree or higher). Years of experience and highest level of education were grouped in this manner due to the small sample size. The level of significance was set at $\alpha=0.05$ prior to all tests.

Population

The targeted population for this pilot study included all aerial applicators in Minnesota, North Dakota, and South Dakota. A convenience sampling method was used to obtain a sample of current aerial applicators in participation at the Tri-State Ag conference in Grand Forks, North Dakota in February of 2015. This conference is the largest annual gathering of aerial applicators in the area. Surveys were completed on a volunteer basis, resulting in a total sample size of forty-one. Of the 41 surveys, all were determined valid and included in the results. However, some participants skipped one or multiple survey questions during completion of the survey. These questions were excluded from analysis.

Results

Demographic Data

The respondents in this study consisted of 41 aerial applicators that participated in the 2015 Tri-State Ag Applicators Conference. To address the first research question, the aerial applicators answered questions about their state of operation and flight background. These questions are summarized in Table 1. The majority of the participants were from Minnesota (43.9%) followed by South Dakota (34.1%), with North Dakota, Nebraska and Wisconsin having participants as well. Most applicators indicated they flew between 30,001 to 50,000 (44.1%) acres per year, followed by nine applicators (26.5%) flying less than 30,000 acres, five applicators (14.7%) flew between 50,001 to 70,000 acres and five more that flew more than 70,000 acres per year. The mean age of the participants was 41 years old ($m = 41.2$, $sd = 14.0$) and almost half of the participants have been flying as aerial applicators for less than 10 years, as indicated in Table 1.

Table 1
Demographic Characteristics of Participants (n = 41)
State of Primary Operation, Acres Flown, and Years as an Aerial Applicator

Characteristics	Frequency	Valid Percent
State of primary operation (n = 41)		
Minnesota	**18**	**43.9**
North Dakota	7	17.1
South Dakota	14	34.1
Other (Nebraska and Wisconsin)	2	4.9
Number of acres flown (n = 34)		
<30,000 acres	9	26.5
30,001 – 50,000	**15**	**44.1**
50,001 – 70,000	5	14.7
>70,000	5	14.7
Number of years working as an aerial applicator (n = 41)		
< 10 years	**20**	**48.8**
10-20 years	8	19.5
21-30 years	5	12.2
> 30 years	8	19.5

Note. Largest groups are bolded.

The aerial applicators also answered questions about their educational backgrounds. These questions served to expand the scope of the survey, as compared to previous studies by the NAAA. The majority of respondents (67.5%) completed some type of post-secondary education: 16 (40.0%) indicated they received an associate or technical degree, nine participants (22.5%) received a bachelor's degree, and two (5.0%) indicated a master's degree or higher as their highest attained degree. These results are presented in Table 2. Most aerial applicators responding to this survey did not have additional FAA ratings and certificates beyond the Airplane Single Engine Land Commercial Pilot Certificate, which is required by the Federal Aviation Administration to fly aircraft for hire (Federal Aviation Administration, 2018). See Table 2 for additional ratings and certificates held by respondents.

Table 2
Demographic Characteristics of Participants
Federal Aviation Administration Certificates/ Ratings and Education

Characteristics	Frequency	Valid Percent
Highest level of education (n=40)		
Did not complete high school	0	0.0
High school / GED	6	15.0
Some college	7	17.5
Associate / Technical degree	**16**	**40.0**
Bachelor's degree	9	22.5
Master's degree or higher	2	5.0
FAA Certificates and Ratings (beyond ASEL Commercial)		
Commercial (Multi-engine)	**26**	**63.4**
Instrument rating	24	58.6
Flight Instructor (CFI)	10	24.4
Flight Instructor Instrument (CFII)	7	17
Multi-engine instructor (MEI)	6	14.6
Airframe and Powerplant (A&P)	12	29.3
Inspection Authorization (IA)	4	9.8

Note. Largest groups are bolded. Percentages of FAA certificates and ratings sum to more than 100% since participants could select multiple responses.

Importance of Education for Future Aerial Applicators

The second research question aimed to discover what level of formal education current aerial agricultural pilots perceive as important for future agricultural aviation pilots. The majority of respondents on all three education questions indicated that formal schooling, both in a traditional classroom and specialized agricultural operation, is not perceived as an important factor when considering a career in aerial application. However, it is interesting to note that completion of a specialized ag applicators school was more evenly split across the levels of perceived importance, with 22.0% of respondents indicating that it is very important. Full results are in Table 3.

Table 3
Frequencies of perceived importance of education level for future aerial applicators

Likert-Scale Statement	Not important (1)	Slightly important (2)	Moderately important (3)	Important (4)	Very important (5)	Mean (SD)
Associate degree (Community or Technical school) (n=40)	14 (35.0%)	8 (20.0%)	11 (27.5%)	4 (10.0%)	3 (7.5%)	2.4 (1.3)
Bachelor's degree (College or University) (n=40)	22 (55.0%)	5 (12.5%)	7 (17.5%)	5 (12.5%)	1 (2.5%)	2.0 (1.2)
Completion of a specialized ag applicators school (n=41)	11 (26.8%)	5 (12.2%)	8 (19.5%)	8 (19.5%)	9 (22.0%)	3.0 (1.5)

Benefit of Training for Future Aerial Applicators

The goal of the third research question was to determine what training or education current agricultural aviation pilots perceive as most beneficial for future agricultural aviation pilots. The Merriam-Webster dictionary defines *beneficial* as "producing good results or helpful effects: conferring benefits" (Merriam-Webster, 2019, p. 1). The term "beneficial" was not defined for the participants and could therefore be considered a limitation of the study since participants may have interpreted the term in different ways. Examining the pilot training aspect of this portion of the survey, 41.5% of the participants indicated that education or training in aviation was very beneficial to future aerial applicators. Having experience in a tailwheel aircraft was the single highest factor with 31 (77.5%) of respondents indicating that it would be very beneficial to future operators.

The position of aerial applicator is multifaceted. This agrees with observed results that in addition to flying the aircraft, specialized training in crops, chemicals, and technology were seen as beneficial to future applicators. Over a third of the respondents (39.0%) indicated that it would be very beneficial to have training in chemistry or pesticides and (30.0%) saw validity in training in crop and plant management. When addressing the need for technology in the aircraft, 15 (36.6%) responded that training in agricultural technology such as GPS and spray

technology would be very beneficial. Flight instruction experience was not seen as very beneficial, but an apprenticeship or internship with an operator was seen as at least moderately beneficial by all (100%) of the applicators, as indicated in Table 4.

Table 4
Frequencies of perceived benefit of other training or education for future aerial applicators

Likert-Scale Statement	**Not beneficial (1)**	**Slightly beneficial (2)**	**Moderately beneficial (3)**	**Beneficial (4)**	**Very beneficial (5)**	**Mean (SD)**
Education or training in aviation (other than aerial application) (n = 41)	2 (4.9%)	3 (7.3%)	11 (26.8%)	8 (19.5%)	17 (41.5%)	3.9 (1.2)
Education or training in chemistry/ pesticides (n = 41)	1 (2.4%)	5 (12.2%)	9 (22.0%)	10 (24.4%)	16 (39.0%)	3.9 (1.2)
Education or training in crop/ plant management (n = 40)	1 (2.5%)	3 (7.5%)	9 (22.5%)	15 (37.5%)	12 (30.0%)	3.9 (1.0)
Education or training in agricultural technology (GPS, Spray Equipment, etc.) (n = 41)	1 (2.4%)	4 (9.8%)	10 (24.4%)	11 (26.8%)	15 (36.6%)	3.9 (1.1)
Tail wheel rating (n = 40)	3 (7.5%)	0 (0.0%)	2 (5.0%)	4 (10.0%)	31 (77.5%)	4.5 (1.1)
Flight instruction experience (n = 41)	12 (29.3%)	9 (22.0%)	9 (22.0%)	10 (24.4%)	1 (2.4%)	2.5 (1.2)
Apprenticeship or internship (On-the-job training with an ag operator) (n = 41)	0 (0.0%)	0 (0.0%)	4 (9.8%)	8 (19.5%)	29 70.7(%)	4.6 (0.7)

Importance of Soft Skills for Future Aerial Applicators

Results followed trends discussed in previous literature. Over half of the respondents (58.5%) stated that communication was very important. Problem solving and critical thinking, as well as professionalism were also indicated as very important by more than half of respondents. Furthermore, all of the soft skills - communication, enthusiasm and attitude, teamwork, networking, problem solving and critical thinking, as well as professionalism - were viewed on average as at least moderately important by the participants.

Table 5
Frequencies of perceived importance of soft skills for future aerial applicators

Likert-Scale Statement	Not important (1)	Slightly important (2)	Moderately important (3)	Important (4)	Very important (5)	Mean (SD)
Communication (n = 41)	0 (0.0%)	0 (0.0%)	4 (9.8%)	13 (31.7%)	24 (58.5%)	4.5 (0.7)
Enthusiasm and attitude (n = 41)	0 (0.0%)	0 (0.0%)	2 (4.9%)	9 (22.0%)	30 (73.2%)	4.7 (0.6)
Teamwork (n = 41)	1 (2.4%)	1 (2.4%)	5 (12.2%)	17 (41.5%)	17 (41.5%)	4.2 (0.9)
Networking (n = 41)	2 (4.9%)	8 (19.5%)	9 (22.0%)	9 (22.0%)	13 (31.7%)	3.6 (1.3)
Problem solving and critical thinking (n = 41)	1 (7.5%)	0 (0.0%)	2 (5.0%)	5 (10.0%)	33 (77.5%)	4.7 (0.8)
Professionalism (n = 40)	1 (2.5%)	1 (2.5%)	3 (7.5%)	8 (20.0%)	27 (67.5%)	4.5 (0.9)

Effect of Education and Experience

The final phase of the analysis aimed to determine whether the level of experience or highest level of education of the operator were significant factors in their responses to the survey questions on the importance and benefit of education, training, and soft skills for future aerial applicators. To study this, a ‘composite score’ was calculated for each individual by taking mean of their responses to the Likert-scale questions (all questions in Tables 3, 4, and 5). The mean of the composite score across the 41 observations in the data set is 3.8. The standard deviation is 0.5.

Results of the two-way ANOVA showed that main effects for years of experience ($F(1,36)=1.7$, p-value=0.2) were not statistically significant at the 0.05 level. However, the main effect for highest level of education yielded $F(2,36)=4.8$ and p-value < 0.001, indicating a statistically significant difference in composite scores between agricultural pilots whose highest level of education was high school / GED / some college (M=3.4, SD=0.3), associate or technical degree (M=3.9, SD=0.6), bachelor's degree or higher (M=4.0, SD=0.3). Means and standard deviations of the composite score across level of experience and highest level of education are presented in Table 6.

Table 6
Composite scores by levels of education and experience

Characteristics	n	Mean (SD)
Years of Experience (n=40)		
Less than 10 years	20	3.6 (0.6)
10 or more years	20	3.9 (0.4)
Highest Level of Education (n=40)		
High school / GED / some college	13	3.4 (0.3)
Associate / Technical degree	16	3.9 (0.6)
Bachelor's degree or higher	11	4.0 (0.3)

Discussion

This study was designed as a pilot study to examine and support further research on desirable skill-sets for future agricultural aviation pilots and, therefore, to assess the educational needs for aerial applicators in the Midwest. This study only took into account limited factors within the study, and is limited by the design and scope of the questions.

The first research question in this study was to identify the current state of agricultural pilots in the tristate region, which consists of Minnesota, South Dakota, and North Dakota. The results showed that the majority of pilots represented in this study identified themselves as being from Minnesota, followed by South Dakota, and then North Dakota. There was also a small population who identified as operating outside of these three specific states. In addition, the majority fly between 30,000 and 50,000 acres each year and have been working as aerial applicators for less than 10 years. The study also showed that the most common certificate and rating held by participating applicators in this region was a commercial certificate with a multi-engine rating, and that an overwhelming majority have some kind of education beyond a high school degree - even though a multi-engine rating and formal education are not required as part of the position.

While many of these results simply attempt to describe the typical agricultural pilot participating in this study of tristate area agricultural applicators, some allude to interesting findings. Current research indicates that across the nation, the aerial agriculture industry is facing a shortage due to the upcoming retirement of many of its pilots, indicating that the average age of an agriculture pilot is 54 years old (Wheeler, 2012). However, our study shows that the average age of responding pilots in the tristate region is 41 years old. It also shows that half of the pilots have only been working as applicators for less than 10 years. These two findings would appear to indicate that the aerial applicator industry in the tristate region may not be experiencing the same type of operator retirements/ pilot shortage as other regions across the country. Additional research and analysis is needed to determine if, in fact, the average age of applicators in the tristate area is below the US mean age.

This study also examined the highest levels of education attained by agricultural pilots, as well as the perceived importance of education in the agricultural aviation industry. Results showed that the majority of pilots surveyed in the tristate region held an associate or technical degree, followed by a bachelor's degree. The study also showed that a small number of the sample also held a master's degree or higher. These findings were higher than anticipated, primarily because there is currently no educational degree requirement to become and agricultural applicator. Interestingly, most of the respondents to this survey indicated that formal education beyond high school was not important for the next generation of aerial applicators, however, this aligns with the fact that currently there are no educational requirements for agricultural pilots. The respondents of this survey also did not see flight instruction experience as very beneficial, however, flight instruction accounts for a majority of experience for other sectors of aviation such as airlines, which should be of interest to the profession (Bjerke et al., 2016).

As discussed earlier, soft skills are those such as communication and teamwork. These skills are often learned through the process of acquiring higher education. Pilots in other areas of the aviation industry have recognized these skills as important for some time, and it would appear from this study that agricultural applicators are recognizing the importance as well. While many survey respondents did not indicate that education was important, the skills they would acquire while in higher education would be those that applicators are most looking for: good communication skills, critical thinking skills, problem solving skills, crop and pesticide management practices, and agricultural systems technology (Wheeler, 2012). All of which would fit well into a bachelor's degree program. The skills acquired through such education seem to play a role in the viability of the pilot and the trainability of the applicator. Future research is needed to determine if a specific curriculum would benefit the profession.

This study also addressed the idea of perceived importance of education and training. As noted, it appears that aerial applicator pilots in the sample recognize the benefit of higher education, albeit they do not want to call it higher education. The overwhelming majority of pilots in this study indicated they had received education beyond high school.

Finally, the findings within this study show a difference in the level of education obtained by agricultural pilots in the tristate region compared to what they perceive as important. This pilot study is limited by the design and scope of the questions. The convenience sampling approach is also a limitation of the study, as it may have resulted in a biased sample that is not representative of the targeted population of all aerial applicators in Minnesota, North Dakota, and South Dakota. Further research is warranted.

The overall role of this survey was to gauge perceived level of importance and status of training, education and needs for aerial applicators, and to motivate and justify future research on a more robust, valid instrument to measure this construct. This survey was limited to the respondents that participated in the study and is not transferable outside of the sample. Additional research is needed to address the state of agricultural aviation and what education is most beneficial within the industry, which ultimately will lead to additional agricultural pilots and an ample supply of pilots pursing aerial application as a career.

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