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Looming Pilot Supply, Shortage and Proposed Solutions

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Abstract: A pilot shortage issue has been raised several times over the past few decades, although several things have continued to change, such as the growing demand for air travel, fewer pilots in training, and the increased time required to become eligible to fly for airlines. Recent research and industry reports have identified a larger gap in the expected shortage of pilots. This finding is verified through the United States Federal Aviation Administration's Civil Airmen data. The key finding is that the gap between available pilots and airline needs continues to widen. Regional airlines have considered pay to be an issue and have made adjustments, however, this is likely to be only a short-term solution. The COVID-19 pandemic may have delayed some of the issues, however. This paper details the historic and current challenges the industry faces with pilot availability, provides future projections, and outlines potential solutions that may help address the shortage.

Keywords: pilot shortage, airline shortage, airline pilot shortage, airline pilot supply

Introduction

The general growth in air travel and demand has prompted the continuous need for new pilots. However, the growth may be resulting in a continued and increasing concern for a pilot shortage (Caraway, 2020; Higgins et al., 2013; Klapper et al., 2019; Lutte, 2018; Lutte & Lovelace, 2016; Moehle & Clauss, 2015). The projections of new and additional aircraft, along with expanding airline route networks demonstrates the ongoing and future needs the airlines face (Boeing, 2016, 2017, 2025; Caraway, 2020; Gorowsky, 2019; Higgins et al., 2013; Klapper et al., 2019; Lutte, 2018; Lutte & Lovelace, 2016; Moehle, & Clauss, 2015; Pettitt & Dunlap, 1994; Smith et al., 2016; Thompson, 2018).

This has become a point of disagreement among industry groups, with some stating that the shortage is merely a matter of compensation (Higgins et al., 2013; Lutte, 2018; Lutte & Lovelace, 2016). Pay may result in decreased interest in jobs and the field itself, though the industry should consider that even a 'pay shortage' means that even if there is an adequate number of qualified individuals presently, it is likely to result in decreased numbers of available pilots in the future. However, the number of certificated pilots, coupled with the increase in planes and flights, means that the gap continues to increase between who is available and what the needs are and will be (Boeing, 2016, 2017; Gorowsky, 2019; Higgins et al., 2013; Lutte, 2018; Pik, 2022). Further understanding of the historical changes in certificated pilot numbers, along with possible solutions, is necessary for both industry and researchers to explore.

This challenge will continue for airlines trying to fill pilot roles unless alternative measures are considered and implemented. As occurred during the 2008 and 2013 periods, regional airlines will again be the first to feel the effects (Higgins et al., 2013; Klapper et al., 2019; Lutte, 2018; Lutte & Lovelace, 2016). Given the pathway from regional to major airlines, it will take the major airlines approximately five to seven years to encounter any direct impacts from changes in pilot availability (Higgins et al., 2013; Klapper et al., 2019; Smith et al., 2013). Any negative impacts that were to be seen in the early 2020's, however, were pushed aside due to the COVID-19 pandemic.

Most of the information presented comes from the pre-COVID timeframe. While the industry suffered a short-term financial crisis, it also experienced accelerated losses of pilots through normal retirements, early retirements, and layoffs without return. Although the

industry has returned to a relatively normal volume of flights and passengers, the duration of the lower volume allowed the risk of pilot availability to be largely be ignored.

The purpose of this research is to expand on previous literature by exploring the factors leading up to the pre-COVID and current pilot shortage, as well as providing updated estimates of pilot demand and expected shortage. Solutions to address the shortage will also be explored.

Statement of the Problem

Previous literature exists on both pilot shortage and solutions, however, they are separate and limited in depth. The pilot shortage has received limited data analysis, with the most recent detailed studies being conducted by Higgins et al. (2013) and Crouch (2020), both of which were conducted prior to the COVID-19 pandemic. Two problems need to be explored through research: the declining pattern of available pilots and the potential solutions along with their outcomes.

Research Questions

RQ1: What changes have been seen in the United States regarding the demand for pilots over time (for example, an increase in flights)?
RQ2: What changes have been seen in the United States in the number of certificated pilots who are eligible for employment within the airline, or Part 121, environment, or will be within the coming years?
RQ3: What other predictive measures exist, such as the number of current student pilots compared to earlier times?
RQ4: What solutions could help directly or indirectly increase the pool of potential pilots, and/or decrease the overall need for more pilots?

Literature Review

A looming pilot shortage has been noted in research on multiple occasions, most notably in the 1960s, 1990s, and the present day, if not more frequently (Higgins et al., 2013). Previously, airline pilots came from the military or as flight instructors (CFIs). However, the number of pilots from the military has been on a constant decline, and is presently the lowest portion ever (GAO, 2014; Lutte & Lovelace, 2016; Pettitt & Dunlap, 1994). Another major change in the industry due to regulatory adjustment has only recently began showing its effect. Prior to 2013, anyone with a commercial or CFI rating was eligible to fly as a First Officer, until Public Law 111-216, and later FAR 121.436 went into effect (Bjerke et al., 2016; Caraway, 2020; Higgins et al., 2013; Lutte & Lovelace, 2016; Smith et al., 2013; Smith et al., 2016; Smith et al., 2017). This regulation requires all pilots in Part 121 operations, airlines, to have the Airline Transport Pilot (ATP) certificate, which requires 1500 hours, or a Restricted version (R-ATP) that can be granted at a lower time if training is conducted at approved training centers, such as universities (Bjerke et al., 2016; Caraway, 2020; Higgins et al., 2013; Lutte, 2018; Lutte & Lovelace, 2016; Smith et al., 2016; Smith et al., 2013; Smith et al., 2017). According to a survey conducted by Lutte and Lovelace (2016), this change has had at least a small effect on the number of pilots in training who were previously interested in an airline career. Additionally, some studies have been showing that the quality has not increased with the change in flight training, and in some regards, has had a significant drop based on factors such as repeated training or other markers airlines use to track pilot quality internally (Bjerke et al., 2016; Smith et al., 2016; Smith et al., 2017). Overall, the best pilots seem to come from university-based training programs, regardless of total flight time (Pettitt & Dunlap, 1994; Smith et al., 2013; Smith et al., 2016; Smith et al., 2017). Other research has also supported ab initio programs over the traditional training pathway, though these studies have focused on a university structure rather than airline-driven (Pettitt & Dunlap, 1994).

Higgins et al. (2013) state that between 2013 and 2033, 95,000 pilots will be needed. This follows the then-current Boeing Pilot Outlook, as it was used in their data analysis, and also follows the updated 2016 and 2017 projections similarly (Boeing, 2016, 2017). However, the industry is also facing a challenge, as both those training numbers have dropped, and there is an increasingly higher percentage of pilots in the US who are foreign, leaving the US after training to fly for other airlines (Higgins et al., 2013). Even the desire to fly for airlines has dropped (Higgins et al., 2013; Lutte & Lovelace, 2016). As pointed out in the Higgins et al. (2013) study, one useful tool for analysis is looking at current hiring trends, as they can predict the number of Certified Flight Instructors (CFIs) that will occur in the following four years. This is also impacted by flight training costs, and for pilot availability and shortage predictions, approximately 54 percent of CFIs are interested in airline careers (Higgins et al, 2013). Coupled with their estimate of 45,000 pilots retiring over the same aforementioned time period, and an estimated 19,000 regional airline pilots, the expectation is a shortage of 35,000 (Higgins et al., 2013). This again is reemphasized in other research and the Boeing Pilot Outlook (2017) (Lutte, 2018; Lutte & Lovelace, 2016; Smith et al., 2013; Thompson, 2018). Notable as well is the overall continued reduction in military pilots, which previously provided a large supply to the airlines, though as been on an overall decline for several decades, even if short time periods have seen an increase (Higgins et al., 2013; Lutte, 2018; Lutte & Lovelace, 2016; Pettitt & Dunlap, 1994; Thompson, 2018).

With Boeing estimating at least 39,000 new planes over the next twenty years, and then a large range of pilot needs per year, from 1,900 to 5,200, it appears just in the North American market alone, over 100,000 pilots will be needed in the twenty year span (Boeing, 2016; Lim et al., 2017; Lutte, 2018; Lutte & Lovelace, 2016; Smith et al., 2017). Based on FAA airmen data, the number of pilots in training has decreased over the past several decades, and the number of pilots sitting for a commercial rating exam has shifted upwards for foreign pilots (AOPA, 2011; FAA, n.d.; GAO, 2014; Higgins et al., 2013). Coupled with the actual decline, this means that the number of eligible pilots is markedly lower, as the ones from the foreign group are not likely to wish to fly for a US airline.

The Airline Pilots Association (ALPA) has consistently said that there is no actual pilot shortage, only a pay shortage for pilots entering the workforce (Bjerke et al., 2016; Lutte & Lovelace, 2016; Smith et al., 2013; Smith et al., 2017). The Regional Airlines Association, however, has noted an actual shortage, and some statements have come after pay raises were implemented (Lutte & Lovelace, 2016). Whether or not pay is a factor becomes irrelevant when the number of those in training has been on the decline, and even without that, issues resulting in an inability to hire negatively impact the industry both in the short and long term. Beyond the shrinking number of eligible pilots, two other themes have emerged that refute the argument that the pilot shortage is merely a problem of low pay. Outlook on the industry as a viable career option has shifted downward, which may be due to pay, lifestyle or other factors such as training time and cost, or a combination of those (Lutte & Lovelace, 2016). Second, the demand for air travel continues to grow and airlines continue to add more flights and aircraft, resulting in an increasing demand for pilots (Boeing, 2016, 2017; Caraway, 2020; Gorowsky, 2019; Higgins et al., 2013; Lutte, 2018). For the industry, this growth is a positive sign, however, it means that the gap will continue to widen between what is needed and the number of pilots eligible and available. Additionally, another compounding factor seems to be the growing number of mandatory retirements that are coming up between now and 2028 (Lutte & Lovelace, 2016; Thompson, 2018). Since the pathway to flying starts with regional airlines, the issue with any shortage will first be experienced there. Around 2014, due to an increase in pay and bonuses, the shortage issue was able to be remedied quickly (Lutte, 2018; Lutte & Lovelace, 2016). However, this is unlikely to solve the problem permanently (Lutte & Lovelace, 2016). If the trend continues as is, it appears the major airlines will see effects within less than a decade.

The literature is consistent that while the actual cause of the decrease in pilots may be due to a variety of reasons, there is indeed a decline, and it is something that the airlines, especially regionals, will have to face. While the major airlines have been protected from these negatives for several years, it may become less likely for them to delay noticing as the retirements start to pick up even more. Therefore, it is important for the industry to understand the actual numbers and trends, rather than simple conjecture in the media and at conferences. Relying on available data may help develop new strategies or refocus on older strategies to help increase the pilot availability. No one solution, however, is likely to solve the entire problem.

Data Sources

Utilizing data from the FAA US Civil Airmen Statistics (2012–2024) provides the most accurate whole numbers of certificated pilots in the US (FAA, n.d.). While the FAA does not include earlier reports, the Airplane Owners and Pilots Association (AOPA) provides the same data set for the 1929-2009 period, with predictions for 2010 and 2011 at the time of publication (AOPA, 2011). Additionally, the FAA does provide details down to region, which is based on the pilot's address. While that was not utilized for the purpose of this analysis, other researchers may find it beneficial for other research or further verification.

By combining these datasets with the Boeing Pilot Outlook (2017; 2025) and other research that includes estimates on retirements (Higgins et al., 2013), a general trend is shown in the next section, along with calculations predicting the shortage.

Calculation of Shortage

According to the Boeing Pilot Outlook (2017), North America will need about 127,000 pilots. This has been reduced slightly to 119,000 in the Boeing Pilot & Technician Outlook (2025). The predictions are based on a 20-year forecast (Boeing, 2025). These predictions are close to the Higgins et al. (2013) estimate of 95,000 in the United States. Utilizing the data from the FAA (n.d.), AOPA (2011), and Higgins et al. (2013), it appears that between 1988 and 2017, the number of pilots of any type were 694,016 and 609,306, respectively. For the same time, student pilots also were 136,913 and 149,121, while commercial rated pilots were 299,786 and 162,455. Table 1 below shows a more detailed picture of changes between the years provided.

For 2024 numbers, the total pilots went up to 848,770, over 200,000 more compared to 2017. The number of student pilots also more than doubled, to 345,495. However, the commercial rated pilots, and more importantly, the ATP rated pilot numbers have shifted in a much smaller proportion, even if still upwards.

Table 1. Pilot Population Trends (1988–2024)

Year	Total Pilots	Student	Private	Commercial	ATP	CFI
2024	848,770	345,495	172,012	109.727	179,194	138,127
2017	609,306	149,121	162,455	98,161	159,825	106,692
2012	610,576	119,946	188,001	116,400	145,590	98,328
2008	613,746	80,989	222,596	124,746	146,838	93,202
1998	618,298	97,736	247,226	122,056	134,612	79,171
1988	694,016	136,913	299,786	143,030	96,968	61,798

Source: FAA (n.d.) and AOPA (2011)

In addition to the table above, 1978 showed a student pilot population of 203,510 and a private pilot population of 337,644. For 1968, it was 209,406 for students and 281,728 for private. Looking from 1988 to 2017, there has been a slow decline in the total number of pilots certificated in the United States, about 85,000. That has since recovered and grown for 2024

numbers. While student pilots increased from 2008 to 2012, it is important to note that the FAA increased the length of certification in 2009 based on medical requirements for those under the age of 40 (FAA, n.d.). However, the total numbers have still shrunk, especially when looking at the 1968 to 1988 timeframe. Again, this has also increased in 2024. Next, private pilots have had a large decline every decade since 1978, except in the 2020s. This may mean that even with a small increase in the student pilot base, pilots may not be completing training. Moreover, while the large increase over the past 7 years is encouraging, it alone should not be relied on as a sign of recovery. This alone eliminates some of the potential pool of aspiring airline pilots. There has also been a small decline in commercial rated pilots up to 2017, which also meant less potential for CFI and ATP candidates. While the ATP holding pilots have mostly held steady or had a notable increase recently, given the changes to the requirement for all airline pilots to hold an ATP, this number should have risen significantly given that need. While some first officers may have had an ATP at any point prior to the law change, the airlines essentially doubled their need, not to mention any increases with aircraft and routes, as Boeing and others have pointed out (Boeing, 2016, 2017; GAO, 2014; Higgins et al., 2013). Finally, CFIs have slightly risen over the time period shown. This is good for the aviation industry, as it means there are more potential candidates, although it meant more competition for instructors with a similar or smaller student pilot pool, and with no substantial increase in ATP, it may also mean that less are choosing to go the airlines, which has been previously mentioned in other research (Higgins et al., 2013; Lutte & Lovelace, 2016). The opposite is true as well, with the substantial increase in student pilots, while it can make a positive opportunity for CFIs, two results can occur. Instructors could continue to instruct, resulting in those individuals not going into airlines. On the other hand, if instructors are spread too thin with too many student pilots, it can shift the demands, affecting pricing for training, pay demands, stress levels, and so on. Admittedly, this perspective may seem alarmist. It is a net positive for the industry, though as the numbers have shown, one increase does not necessarily correspond evenly to the others.

When combining the above data on pilot availability, the expected growth needs mentioned above from Higgins et al. (2013) and Boeing Pilot Outlook (2017), it is important to reiterate the expected retirement numbers from Higgins et al. (2013), 45,000 by the early 2030s, and the approximate 19,000 pool of regional pilots that would be where mainline carriers would hire from. With a need of 95,000 pilots, and essentially no significant change since 2013 in pilot numbers according to the FAA, a shortage of about 35,000 is possible. The Boeing Pilot Outlook (2016) estimated 39,000 new aircraft within a 20-year period, and Higgins et al. (2013) provided a weighted staffing of 14.44 pilots per plane in their research. Without any significant change in the pilot population upward, or downward projections in aircraft and pilot needs, this gap will continue to widen. Boeing's Commercial Market Outlook (2025) predicts continued traffic growth, 2.8% for North America over 20 years. This outlook also predicts a delivery of 8,680, resulting in a net 1.3% increase in aircraft for the North American market (Boeing, 2025). Most of the aircraft growth is expected in single-aisle aircraft, with a drop in regional jets (Boeing, 2025). This offset will indeed require more pilots, and more experienced pilots, with a potential large reduction in the regional to mainline carrier pipeline.

Finally, while some numbers have improved based on the 2024 data, arguably in substantially more positive ways than at any prior point in recent history, there is some subset of data that suggests it is indeed worse than the numbers make it seem (Pik, 2022). Notably, the number of graduating pilots from training in 2021 was about 4,300 (Pik, 2022).

Proposed Solutions

Several prior discussions on pilot shortage have offered a few solutions to help alleviate the demand, from regulatory to business operation changes (Higgins et al., 2013; Lim et al., 2017; Liu et al., 2016; Lutte, 2018; Lutte & Lovelace, 2016; Pik, 2022; Smith et al., 2016; Smith et al.,

2013; Vu, Lachter, Battiste, & Strybel, 2018). The proposed solutions at this point are likely to work better when combined, given the challenges with any implementation, likely inconsistency between airlines or other operations, regulatory hurdles and unknowns. The proposed solutions contain changes to training to help reduce costs, changes to flight hour requirements, and single pilot operations.

Training

In order to help address the pilot shortage in regard to training, two main options exist: reduce time and reduce cost. Since the time requirement is regulatory, this is likely to be difficult, even if everything were to show it does not improve safety. To reduce cost, one option is the method of training, such as using alternatives to instructors and airplanes. Eliminating the instructor component is not advisable, given the training and experience a CFI is required to have. Therefore, the recommendation here is to utilize flight training devices (FTDs) or simulators. These offer a transferrable skill at roughly half or third of the cost, sometimes more (de Winter, Joost, Dodou, & Mulder, 2012). Several studies have shown the success of training with FTDs and simulators, even without motion (de Winter et al., 2012).

Simulators and FTDs have also been shown to produce similar mental workload when testing physical parameters such as heart rate (Dahlstrom & Nahlinder, 2009). This means that the psychophysiological response in a simulator and an aircraft is the same, which helps support the notion that simulators are a quality training device as a replacement for aircraft (Dahlstrom & Nahlinder, 2009). Similarly, maintenance can also be successfully simulated, as shown through F-16 engines in a study by Pinheiro et al. (2014). There are several studies of varying types relating to simulators and FTDs and their successful transfer of training, which is advisable for industry and researchers to continuously review as the replacement for aircraft may certainly help flight training costs, as well as provide an increase in safety and reduction in missed training sessions due to unavoidable events such as weather and maintenance of training aircraft.

Additionally, flight training could be sponsored by airlines that select candidates early in their training and cover the costs, similar to what JetBlue and Mesa, among others, have recently started (Pik, 2022; Smith et al., 2017). The idea here is to offer a position prior to eligibility and either help fund training, reduce training costs or offer reimbursement under particular circumstances. Alternatively, overall sponsorship by groups, whether airline or airplane manufacturers, may also help alleviate some cost, although the implementation may be difficult. A high number of hours will mean a high cost; therefore, the airlines especially need to find a way to be involved in flight training as it may help reduce cost for potential pilots, likely attracting more qualified candidates to the field, and to their particular operation early on. While this does carry some risk, the overall effect should be positive for every airline in operation.

Flight Hours

Pilots are required to undergo extensive flight training, with the current requirement for airline pilots being at least 1500 hours to achieve the Airline Transport Pilot, or ATP, certificate (Bjerke et al., 2016; Caraway, 2020; Higgins et al., 2013; Lutte, 2018; Lutte & Lovelace, 2016; Smith et al., 2013; Smith et al., 2016; Smith et al., 2017). Given that achieving these hours can be expensive for many, and the amount of time has increased from a much lower requirement in 2013, many students have considered not pursuing airline piloting as a career due to costs (Higgins et al., 2013; Lutte, 2018; Lutte & Lovelace, 2016; Smith et al., 2013). This increase in flight training was believed to increase safety given prior accidents, most notably the Colgan Air crash in 2009 (Bjerke et al., 2016; Higgins et al., 2013; Lutte, 2018; Lutte & Lovelace, 2016; Smith et al., 2013; Smith et al., 2016; Smith et al., 2017). However, some individuals and groups believe that the increase does not indeed produce a safer pilot and has been shown to result in

lower time in multi-engine and potentially lower quality training given (Caraway, 2020; Lutte, 2018; Smith et al., 2013; Smith et al., 2016).

One alternative that the FAA implemented early in the ATP requirement of 1500 hours was to have a Reduced ATP certificate, or R-ATP. This would allow for somewhere between 750-1250 hours, depending on training, such as military or an approved university flight training program that included other coursework (Higgins et al., 2013; Lutte, 2018; Lutte & Lovelace, 2016; Smith et al., 2013; Smith et al., 2016). This inherently admits that flight training time is not the primary concern, if the type of training is otherwise viewed, at least by the FAA, as superior in some way. With this in mind, the industry needs to look at ways of either requiring flight training to be completed through military or college training, at least for the airline level, or find ways to match the training quality and goals these programs have, and get the approval for R-ATP. Around 1994, 95% of pilots held a Bachelor's degree, which means that both airlines and pilots see this as a means of training, even if indirectly (Lutte, 2018; Pettitt & Dunlap, 1994; Smith et al., 2013; Smith et al., 2016).

The overall idea here is to either reduce training time or cost, while also providing more efficient pathways to complete the necessary training. Competency based training can offer the skills in a fraction of the time, while still ensuring quality training and skill development (Pettitt & Dunlap, 1994; Smith et al., 2013). Ensuring quality in flight training is likely to fare better than merely requiring time alone, as that may not result in anything more than just additional hours in the traffic pattern for CFIs trying to complete their hours. While unrealistic, changing the flight hour requirement option would also be a quicker and less expensive way to enter the field. The ultimate goal needs to be quality of training, not the amount of training.

Single Pilot Operations

Single pilot operations (SPO) have been discussed previously, although the reality of it has many challenges (Moehle & Clauss, 2015). However, by eliminating one of two flight crews, it could nearly double the available pilot population. The challenge though is regulatory and technological, although both have points supporting them, as well as public perception and acceptability. First, prior to the 1980s, airlines were required to have three pilots on the flight deck (Lim et al., 2017; Moehle & Clauss, 2015; Vu et al., 2018). Given the technology change, the navigator was no longer needed at that time (Moehle & Clauss, 2015). Even earlier, four pilots were required, the fourth being a radio operator (Lim et al., 2017; Moehle & Clauss, 2015; Vu et al., 2018). This occurred due to technology and a regulatory system that realized the need was no longer there for safe operations.

In the SPO environment, the technology would need to allow for one pilot to operate all controls, including during an emergency, as well as allow for linking with ground-based pilots to assist during challenges or in case the pilot became incapacitated. As it stands, the FAA requires that aircraft used for Part 121 operations must be operable with only one pilot as a backup safety measure (Moehle & Clauss, 2015). While more changes would likely be helpful to make this easier, the basis for it exists. The challenge then is linking aircraft systems with an operator, and ensuring those systems remain secure and safe. While traffic is already viewed both by pilots and those on the ground, expanding the technology may look like camera access to flight deck and any view the pilot may need. Electronic control would require systems upgrades, as well as a stable link, likely by satellite, although those have challenges too. However, given the use of auto-pilot and auto-land systems in existence, those could be programmed for backups if a link dropped off and a pilot was unresponsive. That leaves the final challenge to be regulatory approval and acceptance by the general public. Again, all of this has occurred before in a similar way, and with enough testing and time, it is likely the next major step in the aviation market.

Summary

The pilot shortage has been a constant concern in the industry, although it has only recently become a larger conversation. The numbers continue to change in retirements, hiring, and pilots available in training, which provides evidence to the industry that indeed, something has changed (AOPA, 2011; FAA, n.d.; Higgins et al., 2013). While pay may indeed be a concern, it is unlikely to be the only one, and steps need to be taken to bring people both into flight training, keep them through private training and get them into the CFI stage, as well as moving towards ATP (Higgins et al., 2013; Lutte & Lovelace, 2016).

Based on the original analysis by Higgins et al. (2013), Boeing Pilot Outlook (2016, 2017), FAA (n.d.) and AOPA (2011) data, the current projection shows an overall decline in several key pilot categories, such as student, private, commercial and ATP ratings, as well as no overall increase in the pilot population, while a simultaneous increase in aircraft growth and pilot needs has occurred. In line with the original projection of a 35,000 shortage of pilots by Higgins et al. (2013), their projection of 95,000 additional need of pilots by the 2030s and the Boeing Pilot Outlook (2016) projection of over 100,000 pilots needed, the shortage is already increasing and will continue to do so. The gap between available pilots and the need continues to widen.

The industry will need to act quickly and encourage quality university programs to take the lead. While a reduction in flight training time requirements may help in both time to qualification and lowering cost, it is unlikely. University programs remain expensive, although they also produce a quality pilot, and should be the focus of recruiters and airlines to help grow. The most critical step the industry should take is to continue to both attract pilots and keep them moving through training. Future researchers are encouraged to continue to analyze the data and update calculations, as well as research specific techniques, such as JetBlue's pathway program, to see what effects may work.

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