The supply and demand for commercial airline pilots: Impact of changing requirements

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ABSTRACT

This study evaluates the impact of changes in the laws and FAA regulations pertaining to the training, scheduling and experience of certified Airline Transport Pilots on the future supply of commercial airline pilots. It examines the methodology and conclusions reached in supply and demand studies conducted by government agencies and researchers from universities. Using both FAA data and methodology from previous studies, it estimates the supply and demand for certified Airline Transport Pilots for the period 2016-2035. The study specifically examines the supply issues relating to the cost of pilot training, expected retirements, attrition, the number of military pilots, international demand, and the hiring practices of airlines. It also examines the demand for pilots in terms of manning requirements for the FAA estimated fleet of commercial aircraft, turbine general aviation, and air taxi aircraft. The expected shortage will require airlines to raise entrance level salaries and help address training costs and financing to assure an adequate future supply of qualified pilots.

Keywords: Pilot supply, pilot training, pilot demand, pilot rest requirements

INTRODUCTION

There has been substantial turmoil in the demand for Airline Transport Pilots (ATP) over the past 15 years primarily due to the sharp drop in demand by the flying public for airline seats following the 9/11 attack on the United States; the increase in ticket prices due to higher fuel costs; and the decline in demand, again, in 2008-09 due to the economic recession. Each of these events occurred when the demand for pilots was on the verge of exceeding the available supply, and the events pushed the shortage into the future.

Now as the U.S. economy is recovering and the demand for airline seats is rising, the airlines have recalled furloughed pilots, and they are hiring pilots again. The question becomes, what is the pipeline of available, qualified pilots, and what will the demand for pilots be over the next ten to twenty years?

There are a number of factors that impact the domestic supply of available and qualified pilots. These factors include:

- Changes in Legislation and Rules

  -Enactment of the "Fair Treatment for Experienced Pilots Act" in 2007
  -Enactment of the "Airline Safety and Pilot Training Improvement Act of 2009" and the "Airline Safety and Federal Aviation Administration Extension Act of 2010"
  -New ATP Certified Training Program Standards
  -New Rest Requirement Rules
- The impact of the above changes on mandatory retirement age
- The impact of the above changes on the cost and length of time needed to become a ATP certificate holder
- The increased need and availability of financial assistance for students to meet the new requirements
- The continuing decline in the number of military pilots
- The low entry level wages and perceived working conditions at the regional airlines, and
- The predatory hiring practices of the major and regional airlines
- The rapidly expanding foreign airline carriers and their demand for pilots
- The impact of the above changes on pilots' work schedules

In this analysis, the impact of the above factors on the supply of ATP certified pilots is examined along with the derived demand for ATP certified pilots. The demand for ATPs is evaluated using forecasts prepared by both the FAA and industry sources. The changing supply and demand conditions indicate a potentially large deficit in the pipeline of qualified pilots over the next 10 to 20 years unless training costs, entry level salaries, and work conditions are immediately addressed.

BACKGROUND

Fair Treatment for Experienced Pilots Act of 2007.

In December 2007, the House and Senate pulled the retirement "age provision" out of the FAA reauthorization legislation, and quickly passed it as the "Fair Treatment for Experienced

Pilots Act" (H.R.4343). It was signed into law by President Bush. The bill increased the mandatory retirement age for U.S. airline pilots (Part 121 operations) from 60 to age 65. The FAA Retirement Age-60 Rule had been in effect since 1959. Previously, in November 2006, the International Civil Aviation Organization (ICAO) raised the retirement age to 65 for two-pilot crews, as long as one of the pilots was less than 60 years of age.
The new U.S. law brought the mandatory retirement age in line with the international standard. More importantly, it permitted airlines to keep highly experienced pilots in the cockpit for up to five additional years. At that time, an Atlanta-based consultant specializing in pilot hiring estimated that about half of those turning 60 each year would continue in the workforce (Johnsson).

Air Safety and Pilot Training Act of 2009 and the Airline Safety and Federal Aviation Administration Extension Act of 2010.

Air safety concerns resulting from several aircraft accidents involving regional airlines led Congress to enact H.R. 3371/S.B. 1451 (2009), the "Airline Safety and Pilot Training Improvement Act of 2009" and H.R.5900 (2010) "Airline Safety and Federal Aviation Administration Extension Act of 2010." These laws requires airlines to more thoroughly screen pilot applicants, enhance existing pilot related training programs, codifies professional standards, and clearly defines acceptable levels of pilot performance both in training and during the conduct of line operations. It provides rulemaking specific to all sources of ground and flight training in the areas of:

- Stall avoidance
- Recognition and recovery from a stalled condition
- Avoidance and recognition of aircraft upset and the initiation of proper recovery techniques
- Specialized training for aircraft that utilize "stick pusher systems," and
- Conduct of operations during icing conditions, microburst and wind-shear weather events

The law contains recommendations on training methods and the number of flight hours needed to master aircraft systems, maneuvers, procedures, takeoffs and landings, and crew coordination. In terms of impacting existing revenue operations, the bill requires more restrictive pilot work rules relating to fatigue, commuting, and maximum time on duty.

Perhaps two of the most significant changes in the law are: 1) Increasing the minimum flight time requirement, up from the current minimum of 250-hours, to 1,500 hours to serve as a second-in-command (SIC) at a FAR Part 121 airlines (as well as Part 135 and Part 91K as PIC), and 2) the new educational and training standards to receive the ATC Certificate.

The change in minimum flight time standards went into effect in January 1, 2014. It has adversely affected Part 121 regional airlines as they no longer are able to hire new low-time pilots to fill positions left open by pilots leaving to work for major carriers. The impact of the law is believed to significantly curtail the number of new pilots and siphon off experienced pilots from other segments of the aviation industry to the major airlines (Collogan, 2010).

The final rules permitting pilots with less than 1,500 hours of flight time, or who are less than age 23, to obtain a "restricted" R-ATP certificate to serve as a co-pilot until the 1,500 hours have been obtained, have been adopted by the FAA. The restricted options are as follows:

- Military pilots with no less than 750 hours of flight time as a pilot,
- College graduates holding a Bachelor's degree with an aviation major with 1,000 hours of flight time as a pilot,
- Graduates holding an Associate's degree with an aviation major with 1,250 hours of flight time as a pilot, and
- Pilots that are at least 21 years of age with 1,500 hours of flight time as a pilot.

Although many pilot training experts testified that this "quantity of hours - rather than quality of hours" solution will do little to increase safety in the airline industry, Congress imposed the restriction anyway. The Regional Airline Association indicted that building hours can be done "in ways that do not meaningfully prepare students for airline operations" (Collogan, 2010).

The final rules, required by the Acts of 2009 and 2010, also made major changes in the ATP Certificate requirements that became effective on August 1, 2014. Under these rules a pilot must be 23 years age, have the required hours of flight time, hold a commercial pilot certificate with an instrument rating, have at least 50 hours in a multi-engine aircraft, 500 hours of cross-country flight time, hold a second class medical certificate, have completed an aircraft type rating, and successfully complete the new ATP Certification Training Program CTP) prior to taking the ATP knowledge test. To serve as a pilot in command, the pilot must meet the above requirements plus hold a First Class medical certificate and have at least 1,000 flight hours in air carrier operations (FAA, 2013).

The new ATP Certification requirements, along with the increase in required hours of flight time, increased the pilot training costs substantially. With the new ATP Certification requirements the number of certificate holders authorized to conduct the ATP Certification Training Programs are limited. The pre-approved Certified Training Program (CTP) must include at least 30 hours of classroom instruction covering specified aviation and airline topics and 10 hours of simulated flight time. Six hours of the simulated flight time must be conducted in a costly Level C, full motion, simulator that replicates a multi-engine turbine aircraft with a minimum take-off weight of 40,000 pounds (Pieringer/Wikimedia, 2014).

Concerns about pilot qualifications and availability are not unique to the United States. The International Civil Aviation Organization (ICAO, 2010) has been actively seeking new global standards for pilot training and licensing to proactively address safety concerns as well as meet the growing global demand for highly trained and qualified aviators.

The new U.S. law on minimum hours far exceeds the ICAO standards and may violate the spirit of the "Chicago Convention" that provides for worldwide recognition of flight crew licenses issued by member states.

Additionally, this new law does not address the issue of how to deal with pilots who have repetitive failures during the multiple training and checking iterations required to become an airline pilot. Unlike the military that eliminates student pilots from training after consecutive failures (varies by military branch), the FAA only requires that pilots receive documented training to correct deficient performance and be rechecked to ensure they now meet standards. The only limit on a pilot's career progress is how much money they can spend on additional

training and checking. Many training experts believe that if the FAA had a restriction limiting a pilot's further progression to higher licenses/ratings based on their accumulative number of failed checking/qualification events, several of the airline mishaps that generated recent legislation could have been prevented.

New Rest Requirement Rules under CFR 14 Part 121.

The FAA changed and increased the rest requirements for flight crew members effective January 2014. The changes included:

- Maximum flight time, i.e., when the plane is moving, is limited to 8 or 9 hours depending on the start time.
- Maximum length of flight duty time (when required to report for duty) limited to 9-14 hours depending on beginning times, number of flight segments, and number of time zone changes.
- Requires a minimum of a 10-hour rest period prior to reporting for flight duty with an opportunity for 8 hours of uninterrupted sleep.
- Limits weekly flight duty time and requires 30 consecutive hours free from duty on a weekly basis. It limits the flight time in any four week period and any 365 day period.
- Requires pilots to sign-off that they are "fit" to take the flight, and, if the pilot reports fatigue, the airline must remove that pilot from duty.
- Requires annual fatigue education and awareness training for all individuals involved in flight operations and flight operations control and scheduling. The fatigue education and awareness program must be up-dated every two years. (FAA 2011)

The changes in the rest requirements grew out of the investigation into the Colgan Air crash in 2009, where investigators believed that pilot fatigue could have contributed to the accident. The increased rest hours and changes in scheduling should reduce pilot fatigue. The changes were welcomed by the pilots and the airline unions. The Airline Pilots Association stated, "The new…rules are a significant victory for safety and…long-overdue…"(Trejos 2014).

The airlines were given a two-year lead time to implement the revised rules. The airlines have responded by adjusting scheduling and hiring additional pilots. The Regional Airline Association indicated that regional carriers increased staffing by approximately 5 percent in order to accommodate the scheduling changes (Trejos 2014).

The greatest concern for the revised rest rules appears to be their impact on flights that have been disrupted or diverted because of weather, scheduling, or mechanical delays. In some of these cases, the flights will not be able to continue without a crew change. This will increase the cost to the airlines and increase the wait-time for passengers (Sumers, 2014).

The revised rest requirements do not apply to flight crews assigned to cargo planes.

Skills and Automation. The Transportation Department's Office of Inspector General, in January 2016, criticized the FAA for falling short in ensuring that pilots keep up their manual flying skills and ability to monitor sophisticated automated control systems (Fox News 2016). The FAA 2013 rules require airlines to periodically update their training programs to ensure that pilots maintain proficiency in manual flight skills and monitoring systems; however, the FAA

rules do not take effect until 2019. Studies and accident investigations indicate that there are few opportunities for pilots to use their manual flying skills, and these skills may become "rusty" over time. The studies also show that pilots have a hard time staying focused on monitoring the flight path and automated systems (Yahoo 2016). When flight deck automation was introduced in large scale during the early 1980's, it was designed to be used by pilots to reduce their workload thus enhancing overall safety.

Unfortunately, many training experts believe that ever-increasing levels of flight deck automation combined with inadequately structured training/qualification programs and myopic company automation usage policies have contributed to an overall reduction in both manual flying skills and the fostering of an "automation-born complacency" adversely impacting the monitoring skills necessary to maintain situational awareness (SA).
The FAA rules and Office of Inspector General's criticism will lead to additional periodic training requirements and coverage at the airlines.

PREVIOUS STUDIES

There have been several attempts to reach a consensus on whether the U.S. is facing a pilot shortage both in the short-run and over a longer time horizon. All of these studies use data sets that predate the most recent changes in education, training, minimum flight time, ATP Certification Standards, and rest rules. This previous data generally does not reflect the impact of the new rules on the costs of education and training, nor the additional staffing needs of airlines. And to date, an accurate number reflecting how many ATP pilots are actually available based on their possession of an ATP certificate with appropriate ratings AND a current Class 1 FAA medical certificate who are not currently employed or over 65 has never been established. In 2012, an industry group formed to study the supply and demand conditions for ATP's. A subgroup, collegiate aviation researchers, analyzed the supply and demand conditions and estimated that the industry faced a substantial shortage (35,000) of ATP's over the next 20 years (Higgins, 2013). The study used a percentage of the number of new Certified Flight Instructors (CFI) as a proxy for the supply of new ATPs. The regression model used both the cost of training and number of new hires by major airlines to estimate the number of new CFIs. The number of CFI's was found to be positively related to the number of new hires at the major airlines and negatively related to the cost of training.

The study has been criticized by the GAO and McGee studies primarily around the assumption that training cost would continue to increase year after year at a rate well above the inflation rate. If this assumption were relaxed, the estimated ATP shortage would be much less than forecasted.
The Higgins, et. al. study provides several survey results that have been important and used in later studies. The study indicated that in recent years about 45% of commercial pilot licenses have been issued to foreign students not planning to work in the U.S. while most of the individuals receiving the CFI designation planned to work in the U.S. It also found that of the CFI's only 53.67% were planning to seek employment careers with major airlines. The study also indicated that over half of the students would likely consider working outside of the U.S. due to the lower flight time requirements for SIC pilots (Higgins, 2013).

An interesting point is that a U.S. pilot employed by a foreign carrier operating under 14 CFR Part 129 can fly as a First Officer on the largest aircraft operated in commercial aviation, in and out of the most challenging international airports in the United States even though they

couldn't be a First Officer on a regional jet for an American Part 135/121 operating in the same airspace by U.S. law.

At the request of Congress, a comprehensive study of supply and demand for airline pilots was completed by the U.S. Government Accountability Office (GAO) in February 2014. The study concluded that there was "mixed evidence" on the extent of a pilot shortage (GAO). The GAO study indicated there was, at that time, contradictory evidence. The information available indicated a low rate of unemployment of pilots (an unemployment rate of 2.7% for pilots vs. 6.3% for other occupations, 2000-2012), a direct measure of a shortage, while at the same time reflecting a decrease in jobs and wages since 2000.

The GAO study further noted that the Bureau of Labor Statistics (BLS) was projecting a need for 1,900 to 4,500 pilots per year, on average, over the next ten years.

The McGee dissertation is an even more recent study, and it develops a Pilot Flow Model that considers the training of pilots, pilot attrition, pilot retirements, career progression – moving from the regional to major airlines, airline manning requirements, and fleet growth. This study provides an in depth analysis of a number of assumptions regarding the supply and demand for commercial, military, and airline pilots developed in other studies. It provides the most extensive analysis of the flow of military pilots into the major airlines (McGee 2015). McGee's findings recognizes the pressures on the regional airlines (the need to raise salaries, improve work conditions, fly larger aircraft); however, he does not see a shortage developing for the major airlines.

Several other studies suggest that there is an adequate supply of trained pilots to meet current needs (FAA) while other studies suggest that the increased cost of training, low starting salaries, and high numbers of pilots retiring (Barton and Akins, 2013) will lead to a near-term shortage and a long-term shortage (Higgins 2013) unless major changes are made in training costs, starting salaries, and work conditions.

There are several areas of analysis where there is some level of consensus:

- The number of individuals seeking pilot training and licensing has declined substantially in recent years.
- Under the new rules, there is a substantial increase in costs, both in terms of flight time and financial expenditures, for training new pilots.
- The recent pay practices, scheduling, and quality of employment for new pilots has had a negative impact on career paths.
- The very recent changes in FAA Certification practices has limited the availability of certified training facilities and further raised the costs.
- The regional airlines will be more immediately impacted then mainline airlines by a decrease in qualified pilots.
- The service contracts between the mainline carriers and the regional carriers, as well as union labor contracts, may limit the ability of regional airline to change wages and work conditions, in a timely manner. Currently, under many service contracts, major airlines control the entire seat inventory of their regional carriers. This allows the major airline to set ticket prices; lacking any inventory, the regional carrier has no ability to adjust ticket prices. With little control of fuel costs, regionals are left to control labor costs as their best way to seek profitability.
- The military has its own issues in terms of a shortage of pilots, and the military is not seen as a major source of new pilots. With active duty service commitments for training often exceeding 12 to 14 years and the advent of significant bonuses for

continued service, many military pilots elect to complete a 20 year career which guarantees them a retirement.

- There appears to be a sizeable increase in the number of pilots reaching mandatory retirement age between 2016 and 2025.
- There is a major divergence in minimum flight hours between the FAA and the ICAO, which may channel more new pilots into employment with foreign carriers as SIC.

RESEARCH METHODS

Much of the debate over the adequacy of the future supply of ATP pilots stems from the fact that there are and have been for the past 15 years a large number of ATP certificate holders that are not employed by the mainline and regional airlines. The FAA and the GAO studies both considered these pilots "available" to meet any projected shortfalls in the future (FAA, GAO).

The methodology used in this study is organized into two parts:

Part I uses the FAA forecasted number and size aircraft fleet needed to meet the future demand for passenger travel and cargo shipments to derive the demand for ATP certified pilots. Included in the demand analysis is the rapidly growing fleet of General Aviation and Air Taxi turbine aircraft. Using the projected number and type of aircraft and current reported manning requirements, the number of ATP pilots needed over the next 20 years is estimated. This estimate is compared with the FAA forecast of ATP certified pilots over the next 20 years.

Part II examines the future supply of ATP pilots based on a pilot flow model that considers the cost of training, anticipated retirements, attrition, the supply of military pilots, and the international demand for U.S. commercial and ATP certificate holders.

Part I: Commercial Aircraft and Pilot Demand

The demand for ATP certified pilots is a derived demand that is a function of the size and utilization of the commercial airline and general aviation fleet of aircraft.
Aircraft manufactures base their forecasts for new and converted aircraft on a complex set of factors that include projected passenger miles, load factors, freight tonnage, economic growth, the regulatory environment, fuel costs, and fleet replacement needs. Forecasts of the demand for aircraft are provided annually by a number of sources including Boeing (2015), Airbus (2015), Bombardier (2015), and the Federal Aviation Administration (2015).

Table 1 shows the world-wide estimates of what the commercial aircraft passenger and freighter fleets were in 2014 and what they are expected to be in 2034-35. The FAA forecasts show the U.S. passenger and cargo aircraft increasing 21.2 percent from 5,987 in 2014 to 7,253 by 2035, and the number of cargo jets increasing 59.7 percent from 740 to 1,182 over the next 20 years. The FAA forecast of U.S. passenger aircraft have been revised downward slightly and cargo aircraft been revised upward from just three years ago because of the recent economic recovery and the project change in size of regional aircraft in service.

Table 1 - World-Wide Aircraft Demand 2015-2035

Year	Size of Aircraft Geographic Area	FAA United States Number of Planes	Boeing World-Wide Number of Planes, 2014
2014	Mainline Jets	3,774	17,350
	Regional Jet & Piston	2,213	2,530
	Mainline Cargo	740	1,720
	General Aviation & Air Taxi Turbine Aircraft	28,085	
	Africa		690
	Asia-Pacific		5,850
	Russia & Central Asia		1,180
	Europe		4,450
	Latin America		1,470
	Middle East		1,260
	North America Passenger and Cargo	6,727	6,700
	Total World-Wide		21,600
2035	**Size of Aircraft Geographic Area**	**FAA U.S. Only**	**Boeing World-Wide, 2034**
	Mainline Jets	5,112	37,990
	Regional Jet & Piston	2,141	2,640
	Mainline Cargo	1,182	2,930
	General Aviation & Air Taxi Turbine Aircraft	45,905	
	Africa		1,650
	Asia-Pacific		16,180
	Russia & Central Asia		1,720
	Europe		7,560
	Latin America		3,620
	Middle East		3,480
	North America Passenger and Cargo	8,435	9,350
	Total World-Wide		43,560

Source: FAA (Forecast, 2015), pp. 118-119, 124-125; and Boeing (2015), p.53.

Boeing (2015) has estimated that the world-wide fleets of passenger aircraft will more than double in the next 20 years, increasing from 21,600 in 2014 to 43,560 by 2034. The Airbus (2015) forecast is slightly lower than the Boeing Company's forecast with the exception of the size of the passenger fleet estimates for Africa and the Russia and Central Asia regions.

The U.S. share of the worldwide fleet of passenger aircraft is expected to decline from 31 percent in 2014 to 19.4 percent by 2034. The U.S. share of the cargo jets/freighters is only expected to decrease slightly from 43 percent in 2014 to 40 percent by 2034 (Boeing 2015, FAA 2015).

The industry worldwide estimates for the next 20 years indicate a slight decrease in the number of large wide-body aircraft in service; almost no change in the number of regional jets in service; substantial growth in the fleet of small and medium wide-body aircraft; and a 116

percent increase in the number of single-aisle jets in service. The single aisle passenger jets include aircraft similar to the Boeing 737, Airbus A320, and Bombardier CS100.

Worldwide, Boeing is estimating 533,000 new pilots will be needed over the next 20 years to man the expanding worldwide fleet of aircraft. Over half of the new pilots alone will be needed to meet the passenger travel demand in the Asia-Pacific Region. The estimated number of pilots needed by region is given in Table 2.

Table 2 - Pilot Outlook: New Pilots by Region 2014-2033

Region	**Pilot**
Africa	17,000
Asia-Pacific	216,000
Russia and Central Asia	18,000
Europe	94,000
Latin America	45,000
Middle East	55,000
North America	88,000
Total	533,000

Source: Boeing (2013), p. 33**.**

Table 3 reports the FAA forecast of U.S. ATP certified pilots (Column 1). The estimated demand for ATP certified pilots (Column 2) is based on of the FAA aircraft forecasts using current manning estimates. The manning estimates assume that 14.74 ATP pilots are needed for each mainline passenger aircraft, 12.06 ATP pilots for each major cargo aircraft, and 18.93 ATP pilots for each regional passenger aircraft. These figures were calculated from the active pilots and aircraft fleet by carrier as reported by Airline Pilot Central (2016). The scheduled airlines, alone, account for the employment of 90,917 ATP certified pilots. The use of one ATP certified Pilot for each General Aviation and Air Taxi turbine aircraft is estimate based on partial data. (The FAA forecasted number of aircraft by classification is reported in the Appendix, Table A-1 and the calculated manning averages are reported in Table A-4).

The assumption by the FAA and GAO that there is a large reserve of qualified ATP certified pilots that can fill the short-fall is open to question on the following grounds:

1. The expected shortfall will occur in the regional airlines as Captains move up to the mainline carriers; for other ATP pilots to move from current positions to the regional airlines, they would have to start at the bottom of the seniority list which may not be attractive to these pilots.
2. The airlines advertising for ATP certified pilots, often set standards that cannot be met by pilots that have been away from flying for an extended period of time, i.e., age of less than 45 years old, recent flight time of less than six months, current type rating, minimum flight hours in type, etc.(Pilot Career Center, 2016).
3. Historically, there is no period of time in the past 20 years when there has been an extended trend of change in the percentage of total ATP certified pilots working for the airlines.
4. There may be more ATP certified pilots flying business turbine and air taxi aircraft and helicopters than previously estimated.

The differences between the two estimates are shown in Column 3. Column 4 shows the difference between Column 1 and 2 assuming that the total number of ATP pilots in excess of

the manning estimates remains at the same percentage level as it is today. Column 5 reports the shortfall in U.S. ATP certified pilots.
This process for estimating the U. S. ATP pilot demand indicates that unless there is a major change in training, manning, and salaries, the industry will be facing increasing shortfalls in trained ATP pilots. The annual shortfall will exceed 5,000 per year within six years and over 20,000 per year within 17 years.

Table 3 -- Estimated Supply and Demand for U.S. ATP Pilots by U.S. Carriers, 2015-2035

Year	FAA ATP Certified Pilots Forecast (1)	Manning Estimates U.S. ATP Pilots (2)	Difference Between Manning Estimates and FAA Forecast (1-2) (3)	Demand for U.S. ATP Pilots Using Constant Percentage (4)	Annual Shortfall of U.S. ATP Certifi ed Pilots (4-3) (5)
2014	152,933				
2015E	153,000	135065	17935	17932	-3
2016	153,200	135986	17214	17955	741
2017	153,400	137233	16167	17978	1811
2018	153,600	138496	15104	18002	2898
2019	153,800	139439	14361	18025	3665
2020	154,300	140477	13823	18084	4261
2021	155,100	142064	13036	18178	5142
2022	156,000	144068	11932	18283	6352
2023	156,800	146172	10629	18377	7748
2024	157,400	147848	9552	18447	8895
2025	158,100	149609	8491	18529	10038
2026	158,900	151698	7202	18623	11422
2027	159,900	153869	6031	18740	12710
2028	160,800	155796	5004	18846	13842
2029	161,800	158056	3744	18963	15219
2030	162,900	160782	2118	19092	16974
2031	164,000	136812	188	19221	19033
2032	165,100	166637	-1537	19350	20887
2033	166,300	169728	-3428	19490	22919
2034	167,400	172740	-5340	19619	24959
2035	168,600	176040	-7440	19760	27200

Source: FAA (Forecast 2015), Airline Transport Pilots, Table 30, p. 127; the manning estimates use the FAA forecast for mainline passenger aircraft, mainline cargo aircraft, regional aircraft, and general aviation and Air Taxi aircraft forecasts, 2015-2035.

The estimates in Table 3 are based on FAA data and forecasts. These estimates in terms of the number of U.S. carrier aircraft are somewhat lower than those of Boeing, and may understate the pilot shortage.

Part II: Supply of ATPs

The previous studies have attempted to find a "proxy" for the estimated supply of airline pilots. The most commonly used research methodology has been to use the number of pilots that achieve Certified Flight Instructor status, instrument rated, (CFII) as the proxy. The number of new CFII has been forecasted using a linear regression model, where the independent variables are the number of pilots hired by the major airlines and the cost of pilot training annually; while the dependent variable is the number of new CFII's by year.

Once the number of CFII's is determined, survey (n=1600 collegiate aviators) results are used to approximate the number that will become airline pilots (53.67 % or 87%). This estimated number of new pilots is added to the total and then adjusted for retirement, attrition, and entry of military pilots to complete the pilot flow model. The forecasted number of total airline pilots is then compared with the manning requirements for the projected number and type of airline aircraft in service.

The previous studies have had very little to say about the rapidly increasing demand for ATP certified pilots in the general aviation turbine and air taxi sector as well as the foreign demand for U.S. pilots.

The Cost of Pilot Training.

The path to becoming a pilot for a major commercial air carrier has historically been a long and costly process for both civilian and military pilots. For military pilots, the cost is measured in the time invested to repay initial active duty training commitments; currently a minimum of eight to eleven years is normally required. The cost of training a military pilot is estimated to be approximately $750,000 for 55 weeks of training (Thomas 2009) and $5 million to train a pilot up to an "experienced pilot level" of between 3 and 5 years (GAO).

For civilian pilots, the cost is measured both in money and time; the amount of each depending on the chosen training path pursued (See Chart 1). Civilian pilots can generally seek employment with a major carrier several years earlier than a military pilot who must fulfill a military obligation. However, this early entry capability comes at a high price. Military pilot training is paid for by the service, but a civilian pilot must obtain college scholarships, take out student loans, or pay the training expenses out of pocket. Acquiring all the certificates and/or ratings required to be an airline pilot takes years (three to six years) and may require incurring a debt comparable to that normally associated with attending medical school.

Using an average rental rate of $90.00-$150 per hour, one source has estimated that a pilot will be required to spend approximately $112,500-$187,000 to acquire sufficient total flight time to qualify for an ATP certificate unless they are able to find an instructor position or other entry level position that will cover the cost of the aircraft and provide modest compensation. Unfortunately, the flight time hours can be gained in a simple aircraft with little relevance and exposure to complex Part 121 aircraft and crew operating procedures (Collogan, 2010). If the pilot were able to fly non-commercially on average 60 hours per month, it would take a minimum of 25 months to meet the 1,500-hour required.

The new ATP Certified Training Program (CTP) requirements must be completed with an approved provider before taking the ATP written examination. The CTP must be taught by instructors who hold an ATP and have at least two years of airline experience. As of January 2016, there were 14 certificate holders authorized to conduct the ATP CTP. Some of these

Chart 1 - Career Paths for U.S. Civilian Pilots

Education and/or Training Provider			Certificates & Ratings	Additional Jobs to Build Flight Time & Experience
Part 141 University Program	**Part 142 Large Commercial Training Provider**	**Part 61 Small Training Provider**		
Attend University/ College Aviation program (2 to 4 years) ↓ Fight Instruct or other position to build flight hours (2 to 3 years) ↓ 1,000 to 1,500 hours flight time and ATP CTP ↓ Corporate Flying (2 to 3 years) and/or ↓ Regional Airlines (5 to12 years) ↓ Major Airline (Generally requires a four year degree)	Attend University/ College (2 to 4 years) ↓ Attend Part 142 school (18 months to 2 years) ↓ Fight Instruct or other position to build flight hours (2 to 3 years) ↓ 1,500 hours flight time and ATP CTP ↓ Corporate Flying (2 to 3 years) and/or ↓ Regional Airlines (5 to12 years) ↓ Major Airline (Generally requires a four year degree)	Attend University/ College (2 to 4 years) ↓ Receive Part 61 training *(18 months to 2 years) ↓ Fight Instruct or other position to build flight hours (2 to 3 years) ↓ 1,500 hours flight time and ATP CTP ↓ Corporate Flying (2 to 3 years) and/or ↓ Regional Airlines (5 to12 years) ↓ Major Airline (Generally requires a four year degree)	**Certificates:** Private Commercial Instructor (optional) Airline Transport Pilot (ATP) **Ratings:** Instrument Multi-engine Instrument Instructor (optional) Aircraft Type Ratings	Flight Instructor -First Officer for Foreign Carrier Crop Dusting Power Line Inspection Traffic watch Fire watch Fish spotting Law Enforcement Civil Air Patrol Research grants Sightseeing Small business support

providers, i.e., Embry-Riddle, commercial aviation training schools, and regional airlines, offered the CTP training at multiple locations. Embry-Riddle was the only university authorized to provide the CTP training as of January 2016. The new ATP CTP requirements are estimated to add $15,000 to $20,000 to the costs of obtaining an ATP certificate (Durden, 2014). This pilot flow model assumes an annual 2 percent increase in training costs.

Retirements. There is general agreement that the mainline airlines will experience an increase in the number retiring ATP certified pilots over the next 20 years. The reasons given include the expansion of the airlines and passenger traffic and the resulting spurt in hiring in the late 1990's; the rehiring of furloughed pilots in recent years; and the increase in the retirement age from 60 to 65 in December 2007. The Air Line Pilots Association expects 21,000 ATP certified pilots to retire during the 2015-2024 period while Flightpath Economics projected 18,000 would be retiring at the "Big Four" airlines between 2014 and 2022 (Pilot Career Center, 2016). Professor Swelbar at M.I.T. has estimated retirements increasing from 1,000 a year in 2015 to 2,500 by 2022 (Pilot Career Center, 2016). Other industry consults have indicated that approximately 1,400 per year would be retiring 2013-2017, and approximately 2,200 per year for the period 2017 to 2022 (Barton and Adkins, 2013). This pilot flow model uses a retirement rate of 1400, for the two years 2016-2017, and 2200 per year during the period of 2018-2022, and 2.5 percent per year thereafter for airline pilots. For the general aviation and air taxi portion, a retirement rate of 2.5 percent per year is used.

Attrition.

The annual attrition of airline pilots is due to changes in career goals, promotions out of active flying, and inability to meet the medical requirements for Class 1 and 2 medicals. The estimated annual attrition rate is 0.57 percent of airline pilots. This pilot flow model has used an annual attrition rate of 0.57 percent of the active airline pilots of the previous year for the period of 2016-2035.

The Number of Military Pilots.

Until the 1990s, roughly 80 percent of the pilots hired by major U.S. carriers came from the U.S. military with only 20 percent being drawn from civilian aviation. Today however, hiring percentages have nearly reversed due to military active duty training commitments rising from six to almost twelve years. "Stop-loss" programs preventing military pilots from leaving the service and incentive programs (Aviation Career Incentive Pay and Aviation Continuation Pay) to retain experienced pilots have also contributed to this trend. The average military pay in 2014 for pilots was $97,376 (My Future, 2016).

In 2015, the U.S. Air Force indicated a shortage of 520 pilots in its manning requirements with the expectation that it would get worse in the future (Everstine, 2015). The cut in active duty fighter squadrons, fighter training squadrons, available flying hours, and working conditions have contributed to the shortage. To retain pilots, the Air Force offers Aviation Retention Pay of up to $225,000 for those agreeing to serve for an additional nine years, and bonuses of up to $125,000 for fighter pilots signing up for five or more years (Everstine, 2015).
In the summer of 2014, 840 airmen were eligible for the bonuses, and 615 or 73 percent extended their service for five to nine years.

One study, with access to the RAND studies of military pilots, found that the number of pilots that were leaving the service was highly related to the demand for pilots by the major airlines. McGee's analysis of the Air Force, Navy, and Marine military pilots situations is the most detailed in the literature; he has estimates that approximately 1,100 military pilots a year up

to 2019 and 900 per year after 2019 will leave the services before retirement (75%) and at retirement (25%) for positions with major airlines (McGee, 2015, p.71).
There is also an indication that the need for drone pilots is impacting the military's supply of trained pilots (Reis, 2015). This pilot flow analysis assumes that 1,100 military pilots per year will start new careers with the major airlines during the 2016-2019 period, and 900 per year from 2020-2035 (McGee, 2015).

International Demand.

The foreign demand for U.S. ATP pilots has increased in recent years. The advertisements of pilot positions is dominated by foreign carriers; the Pilot Career Center website on March 31, 2016, reported 40 of the top 50 pilot jobs were for foreign carriers (Pilot Career Center, 2016). Nevertheless, the FAA documented number U.S. ATP pilots flying for foreign carriers continue to be a relatively small number ( ).
With the change in the required flight hours to serve as First Officer in the U.S., the opportunity to start with fewer hours with a foreign carrier may be attractive to low-time pilots. In addition, the first year salaries are reported to be almost double the starting salaries at the U.S. regional airlines.

Many of the foreign carriers require a training bond for the first three to five years. This bond requires the pilot to repay the initial training cost if they elect to leave prior to completing the three to five year period agreed to by contract (McGee, p. 53).
Cropper notes, "With fleet growth rates in Asia and the Middle East nearly eight times that of the U.S., and over half of aspiring pilots in the U.S. open to the idea of relocating overseas, international competition for U.S. airline pilot supply is a serious reality" (Cropper, p. 23).
This model has assumed no foreign demand and a 1 percent per year attrition of total ATP certified pilots.

Hiring Practices of Airlines.

Some of the concern over commercial pilot availability stems largely from the past two-step predatory hiring practices used by major and regional airlines. When major airlines, both domestic and international, need pilots, they routinely target senior regional pilots to meet their flight deck needs. During the last round of pilot hiring in the early 2006 -07, this practice resulted in some regional airlines having annual cockpit turnover rates in excess of 50 percent. In turn, at that time, regional airlines target Certified Flight Instructors (CFIIs) from Federal Air Regulations (FAR) Part 61 and 141 training organizations (especially those qualified to conduct both instrument and multi-engine training) to man their flight decks. Unfortunately, by hiring CFII s away from "Ab Initio" (Latin for "from the beginning") training providers, the production of new pilots was adversely impacted. At that time, the demand for pilots by major carriers had forced regional carriers to reduce their hiring minimums to all-time lows; in some cases, from 1000 total flight hours with 500 being in multi-engine aircraft, down to 350 total flight hours with less than 40 hours in multi-engine aircraft. This entry of low-time pilots into the cockpits of regional jet aircraft had some government regulators questioning the adequacy of existing Ab Initio training programs. In anticipation of the 1,500 flight time rules, some of the regional airlines rushed to hire a number of low-hour pilots in anticipation of the impact on available, qualified pilots over the next three to five years.

More recently, the regional airlines have been "squeezed" by: 1) the need to raise pilot compensation; 2) increasing training costs; 3) schedule changes to accommodate new rest requirements; 4) union contract negotiations; and 5) fixed contracts with the major airlines. There is some indication that pilots have already started moving away from the regional airlines with smaller aircraft to regional airlines with larger jets (Schaal, 2014). Republic Airways Holding filed for bankruptcy in February 2016 blaming a pilot shortage for some of its problems. Republic was, allegedly, particularly, hard hit because of its outdated pilots contract (Cameron, 2016).

The long-term impact of the new laws will undoubtedly force the regional airlines to find ways to raise salaries in order to attract a pool of qualified applicants, or reduce routes and increase the size of aircrafts in service thereby cutting the number of pilots needed. Conversely, in order to protect their feed, many major airlines are engaging in or considering "grow-down" expansion plans where they add smaller rather than larger aircraft to their fleet. This will require additional pilots to man these aircraft and increase airline operating costs which will impact ticket prices.

Results

The impact of the above assumptions are shown in Table B-1. The preliminary results of the pilot flow model indicate that there will be an increase shortage of ATP certified pilots exceeding 5,000 annually by 2021 unless there are major changes made in the training pipeline. Additionally, in order to ensure that new aviators have the requisite knowledge and skills sets (technical and human factors) necessary to sustain the desired levels of safety in global aviation, training programs will have to:

- Train pilots to focus on energy management throughout all phases of flight instead of trying to identify the specific components of an approach to stall, stall, or loss of control event set maneuver delaying their ability to apply time critical corrective actions.
- Teach pilots about the physiological and psychological impact of hyper arousal or rapid onset acute stress on their critical thinking skills and ability to react to unusual aircraft attitudes or performance parameters in a timely manner.
- Provide pilots with a rationalized operational policy that emphasizes automation as a tool to enhance rather than replace their airmanship skills.
- Invest the time and resources in training necessary to produce aviators capable of meeting the challenges of actual airline operations, not just "test-takers" capable of passing the minimum standards of an FAA certification/qualification check.

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Table A-1
FAA Forecast of Mainline Passenger Jets, Mainline Cargo Jets, Regional Airline Aircraft, and General Aviation and Air Taxi Turbine Aircraft in Service, 2015-2035

As of Dec 31	Mainline Passenger Jets	Mainline Cargo Jets	Regional Airlines Passenger Jets	General Aviation and Air Taxi Turbine Only
Historical				
2001	4488	1064	2274	18874
2005				
2006				
2007	3897	1008	2732	26697
2008	3982	970	2780	26327
2009	3784	871	2682	26808
2010	3694	822	2653	27367
2011	3722	850	2613	27844
2012	3730	870	2566	28860
2013	3733	838	2340	27884
2014	3774	740	2213	28085
Forecast				
2015	3804	738	2202	28410
2016	3853	748	2185	28810
2017	3918	764	2166	29265
2018	3973	777	2156	29750
2019	4003	801	2140	30265
2020	4018	821	2140	30840
2021	4087	833	2130	31455
2022	4160	843	2137	32130
2023	4235	859	2142	32840
2024	4291	877	2134	33625
2025	4340	901	2130	34450
2026	4413	923	2122	35350
2027	4483	948	2115	36320
2028	4530	976	2109	37330
2029	4587	1007	2108	38395
2030	4665	1033	2115	39525
2031	4753	1064	2125	40695
2032	4837	1092	2126	41925

2033	4926	1124	2132	43205
2034	5009	1151	2139	44535
2035	5112	1182	2141	45905

Source: FAA(Forecast 2015), U.S. Mainline Carrier Passenger Jet Aircraft, Table 21, Regional Carriers Passenger Aircraft, Table 27, Air Cargo, Table 22, General Aviation and Air Taxi Aircraft Total Turbines only, Table 28.

Table A-2
Scheduled Airline Pilots, Copilots, and Flight Engineers
Employment and Earnings, 2008-2015

Year	Employment	Mean	Median
2008	77,090	$119,750	$111,680
2009	74,420	117,060	106,240
2010	68,580	115,300	103,210
2011	68,350	118,070	105,580
2012	66,270	128,760	114,200
2013	73,030	129,600	115,190
2014	75,760	131,760	118,140
2015	81,350	136,400	117,290

Source: Bureau of Labor Statistics, Occupational Employment and Wages, 53-2011, Airline Pilots, Copilots, and Flight Engineers, Scheduled Airlines.

Table A-3
Major Airline Pilot Hiring by Year
1990-2015

Year	Major Airline Hiring	Year	Major Airline Hiring
1990	3567	2004	1199
1991	2406	2005	2301
1992	1720	2006	2443
1993	547	2007	2766
1994	1359	2008	1299
1995	2369	2009	30
1996	2604	2010	408
1997	3414	2011	748
1998	3511	2012	553
1999	4721	2013	1084
2000	5105	2014	3053
2001	3408	2015	3429
2002	851		
2003	854		

Source: Future and Active Pilot Advisors, Major Airline Pilot Hiring by Year, 1990-2000 and 2000-Present.

Table A-4
Airline Fleet and Active Pilots

Airline	Fleet Count	Active Pilots	Ratio
Major			
Alaska	236	1700	
American	943	15268	
Delta	810	12896	
United	717	12505	
Hawaiian	52	627	
Total	2758	42996	15.59
Low Cost			
Jet Blue	213	3204	
Southwest	692	8235	
Spirit	79	1335	
Virgin	58	630	
Allegiant	81	711	
Frontier	58	944	
Total	1181	15059	12.75
Cargo			
FedEx	336	4288	
UPS	237	2538	
Air Transport Int.	14	115	
Southern	10	253	
Total	597	7194	12.06
Regional			
Air Wisconsin	70	750	
Compass	62	991	
Express Jet	291	3610	
GoJet	54	510	
Horizon	52	653	
Mesa	108	1077	
Piedmont	41	449	
PSA	100	1195	
Republic	230	2871	
Silver	27	208	
SkyWest	350	3874	
Trans States	81	700	
Endeavor	113	1457	
Envoy	136	2000	
CommutAir	21	203	
Total	1736	32862	18.93
Fractional			
FlexJet	70	361	
NetJet	516	2658	
XOJet	43	177	

Exec.AirShare	31	90	
Flight Options	127	318	
PlaneSense	38	150	
Total	825	3754	4.55
Atlas Air	52	1257	
Omni Air Internat.	11	230	
World Airways	4	179	
Miami Air	6	58	
Xtra Airways	6	45	
Total	79	1769	22.39

Source: Airline Pilot Central, " Airline Profiles", April 3, 2016.

Table B-1
Part II: Pilot Flow Detail

Year	Estimated Airline Pilots	Airline Hiring	Cost of Training	New CFII	New CFII	Military	Retire-ment Airlines	Other retire-ment	Attrition	Net Addition to Pilots	Net Diff from Manning
2010		408			0.87			2.50%	0.57		
2011		748									
2012		553									
2013		1084									
2014		3053									
2015	135065	3429	2	4437	3860	1100	1400	1975	770	815	0
2016	135880	4960	2	4447	3869	1100	1400	1980	775	815	106
2017	136695	4969	2	4441	3864	1100	2200	1987	779	-2	538
2018	136693	4964	2	4457	3878	1100	2200	1998	779	0	1803
2019	136693	4978	2	4516	3929	1100	2200	2011	779	39	2747
2020	136732	5029	2	4527	3939	900	2200	2031	779	-172	3745
2021	136560	4839	2	4573	3979	900	2200	2046	778	-145	5504
2022	136415	4879	2	4574	3979	900	2200	2069	778	-167	7654
2023	136248	4879	2	4573	3979	900	2200	2094	777	-191	9924
2024	136056	4879	2	4574	3979	900	2200	2115	776	-211	11791
2025	135845	4879	2	4575	3981	900	1599	2141	774	366	13763
2026	136211	4881	2	4570	3976	900	1626	2166	776	307	15487
2027	136518	4876	2	4571	3977	900	1652	2195	778	252	17351
2028	136770	4877	2	4571	3977	900	1669	2226	780	202	19026
2029	136972	4877	2	4571	3977	900	1690	2261	781	145	21084
2030	137117	4877	2	4571	3977	900	1719	2300	782	76	23665
2031	137192	4877	2	4571	3977	900	1751	2344	782	-1	26620
2032	137192	4877	2	4571	3977	900	1782	2383	782	-71	29445
2033	137120	4877	2	4571	3977	900	1815	2428	782	-148	32608
2034	136972	4877	2	4571	3977	900	1846	2473	781	-223	35768
2035	136750	4877	2	4571	3977	900	1884	2517	779	-304	39290