United States Government Accountability Office

Report to Congressional Requesters

February 2014

AVIATION WORKFORCE

Current and Future Availability of Aviation Engineering and Maintenance Professionals

GAO-14-237

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GAO Highlights

Highlights of GAO-14-237, a report to congressional requesters

Why GAO Did This Study

Maintaining a safe and robust aviation system requires qualified aviation professionals—including aerospace engineers, aircraft mechanics, and avionics technicians—to design, manufacture, and repair more than 225,000 aircraft. Aviation stakeholders have expressed concerns that an insufficient supply of personnel could develop because of imminent retirements and a perception that fewer people enter these professions.

GAO was asked to review the supply and demand of aviation professionals. This report discusses (1) what available data and forecasts reveal about the need for and potential availability of aerospace engineers, aircraft mechanics, and avionics technicians, and (2) what actions industry and the federal government are taking to help attract and retain these professionals. GAO (1) collected and analyzed data from 2000 through 2012, employment projections from 2012 through 2022, and literature relevant to the aviation professionals' labor markets; (2) reviewed agency documents; and (3) interviewed agency officials about programs that support training. GAO also interviewed 10 aviation industry associations (5 representing employees and 5 representing employers) and selected a non-generalizable sample of 23 private sector employers, based on size and location, to understand any actions used to attract their workforce.

GAO is not making recommendations. GAO received technical comments on this report from Education, DOL, and DOT, which were incorporated as appropriate. DOD did not have any comments on this report.

View GAO-14-237. For more information, contact Gerald L. Dillingham at (202) 512-2834 or dillinghamg@gao.gov

What GAO Found

GAO analysis found mixed evidence about a current or possible future shortage of aviation professionals. Aerospace engineers have experienced a low unemployment rate—the most direct measure of a labor shortage—and increases in employment suggesting a shortage may exist; however, earnings for the occupation have stayed about the same. Data provide less support for a shortage of aircraft mechanics; while the occupation has had a low unemployment rate, both employment and earnings have stayed about the same, suggesting that demand for this occupation has not outstripped supply. GAO was unable to analyze information on avionics technicians because of insufficient data. In addition, the Bureau of Labor Statistics' employment projections indicate slower than average or no growth for these three occupations over the next 10 years. Data also suggest the number of people who have received training related to these aviation professions is increasing; however, several other industries compete for these individuals and not all will pursue aviation careers.

Examples of Tasks Performed by Selected Aviation Professionals

Source: GAO.

Industry and government are taking some actions to attract and retain qualified individuals in these occupations, but employers GAO interviewed remain concerned about future needs. GAO found that most of these employers had some challenges hiring personnel with the skills employers were seeking at the wage they offered. According to economic literature, employers may take several actions in response to a perceived labor shortage—including increasing recruiting efforts and raising wages. Employers reported taking a variety of actions, but few were raising wages. Several agencies—the Federal Aviation Administration (FAA) and the Departments of Defense (DOD), Education, Labor (DOL), and Veterans Affairs—maintain programs that assist individuals interested in aviation careers. For example, in academic year 2011–2012, Education disbursed approximately $1.6 billion in federal grants to students majoring in related fields. Still, most employers and stakeholders stated that maintaining a qualified workforce will be difficult, in part because of a perception that fewer people are interested in aviation careers. GAO was unable to verify these concerns with available data. It could be expected that employers would continue to take actions at their disposal—such as adjusting wages or changing recruiting and training practices—if a labor shortage were to develop. While such actions would be considered typical market responses to a potential shortage, it does not mean such actions are costless or might not affect the industry.

Contents

Abbreviations

A&P	airframe and power plant
AMT	aviation maintenance technician
AVSED	Office of Aviation and Space Education
BLS	Bureau of Labor Statistics
Boeing	Boeing Company
CIP	Classification of Instructional Programs
CPS	Current Population Survey
DOD	Department of Defense
DOL	Department of Labor
DOT	Department of Transportation
Education	Department of Education
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
IPEDS	Integrated Postsecondary Education Data System
JSAMTCC	Joint Services Aviation Maintenance Technician Certification Council
Manufacturer	original equipment manufacturer
NASCAR	National Association for Stock Car Auto Racing, Inc.
NDAA	National Defense Authorization Act
NPSAS	National Postsecondary Student Aid Study
Repair Station	maintenance, repair, and overhaul facility
STEM	science, technology, engineering, and math
SOC	Standard Occupational Classification
VA	Department of Veterans Affairs
WIA	The Workforce Investment Act of 1998

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
Washington, DC 20548

February, 28, 2014

Congressional Requesters

The aviation industry is vital to the U.S. economy, generating billions of dollars in revenue each year, providing employment, bolstering economic growth, and improving the quality of people's lives. In 2011, air transportation contributed almost $70 billion to the U.S. economy and accounted for over 450,000 jobs, according to the Bureau of Economic Analysis. Maintaining a safe and robust aviation system requires a sufficient number of qualified aviation professionals to design, manufacture, repair, and ensure the airworthiness of more than 225,000 civilian aircraft. While unforeseen events—including the terrorist attacks of September 2001 and the 2008 economic downturn—contributed to a downsizing of more than 100,000 jobs in the industry throughout the past decade, employment has increased in more recent years, and the industry is projecting a growth in demand for air travel and the number of aircraft manufactured.

Aviation stakeholders have expressed concern that an insufficient supply of certain types of aviation professionals–aerospace engineers, aircraft mechanics, and avionics technicians–could develop because of imminent retirements and a perception that fewer people are choosing to enter certain aviation professions. You asked that we review the current and projected future status of the professional aviation workforce. This report examines (1) what available data and forecasts reveal about the need for and potential availability of aerospace engineers, aircraft mechanics, and avionics technicians and (2) what actions industry and the federal government are taking, if any, to help attract and retain these professionals.[1]

This report looks specifically at three professions in the aviation industry—aerospace engineers, aircraft mechanics, and avionics technicians—which are involved in the design, manufacture, and repair of aircraft and have been the subject of concerns voiced by industry stakeholders. To examine current labor market conditions for these

[1]GAO recently conducted similar work looking at the supply and demand of commercial airline pilots. See GAO, *Commercial Aviation: Information on the Supply and Demand of Airline Pilots*, GAO-14-232 (Washington, D.C: Feb. 28, 2014).

aviation professions, we analyzed data from the Bureau of Labor Statistics' (BLS) Current Population Survey (CPS) for years 2000 through 2012 on unemployment rates, employment numbers, and median weekly earnings (earnings)–referred to as "labor market indicators." We reviewed economic literature that describes how to evaluate labor market conditions that might indicate a labor shortage.[2] To understand the available workforce, we reviewed and analyzed data from the Department of Education (Education) on completion rates for degree or certificate programs that might prepare individuals to work in these professions from academic years 2000-2001 through 2011-2012; from the Department of Defense (DOD) on service members working in aviation maintenance separating from the military from fiscal year 2000 through 2012; and from the Federal Aviation Administration (FAA) on mechanic certificates issued from 2000 through 2012.[3] To assess the reliability of Education, DOD, and FAA data we reviewed documentation related to these data sources from our prior reports, agencies' websites, and interviewed knowledgeable government officials about the quality of the data. We determined the data to be sufficiently reliable for our purposes. We interviewed officials from seven select engineering, aviation maintenance technician (AMT), and avionics schools to understand training requirements and changes in demand for graduates. We selected training programs that varied based on location, size, and program specialty; our findings from these interviews should not be used to make generalizations about all training programs, but provide us with insights. We also reviewed studies that projected future demand for these professions and interviewed representatives of labor unions and industry associations. We did not verify the underlying data that these organizations collected and used in developing their projections of future demand. To understand the extent to which select employers have had difficulty attracting or retaining workers and any steps they have taken often to mitigate perceived shortages, we interviewed representatives and reviewed data from selected private companies that employ these professionals–including original equipment manufacturers (manufacturers); air carriers; and maintenance, repair, and overhaul

[2]See, for example, Malcolm Cohen, *Labor Shortages as America Approaches the Twenty-first Century* (Ann Arbor, MI: University of Michigan Press, July 1, 1995).

[3]DOD could not provide data on the number of service members separating from all branches of the military for fiscal year 2000. To allow for comparisons across all years, we only reported data since fiscal year 2001.

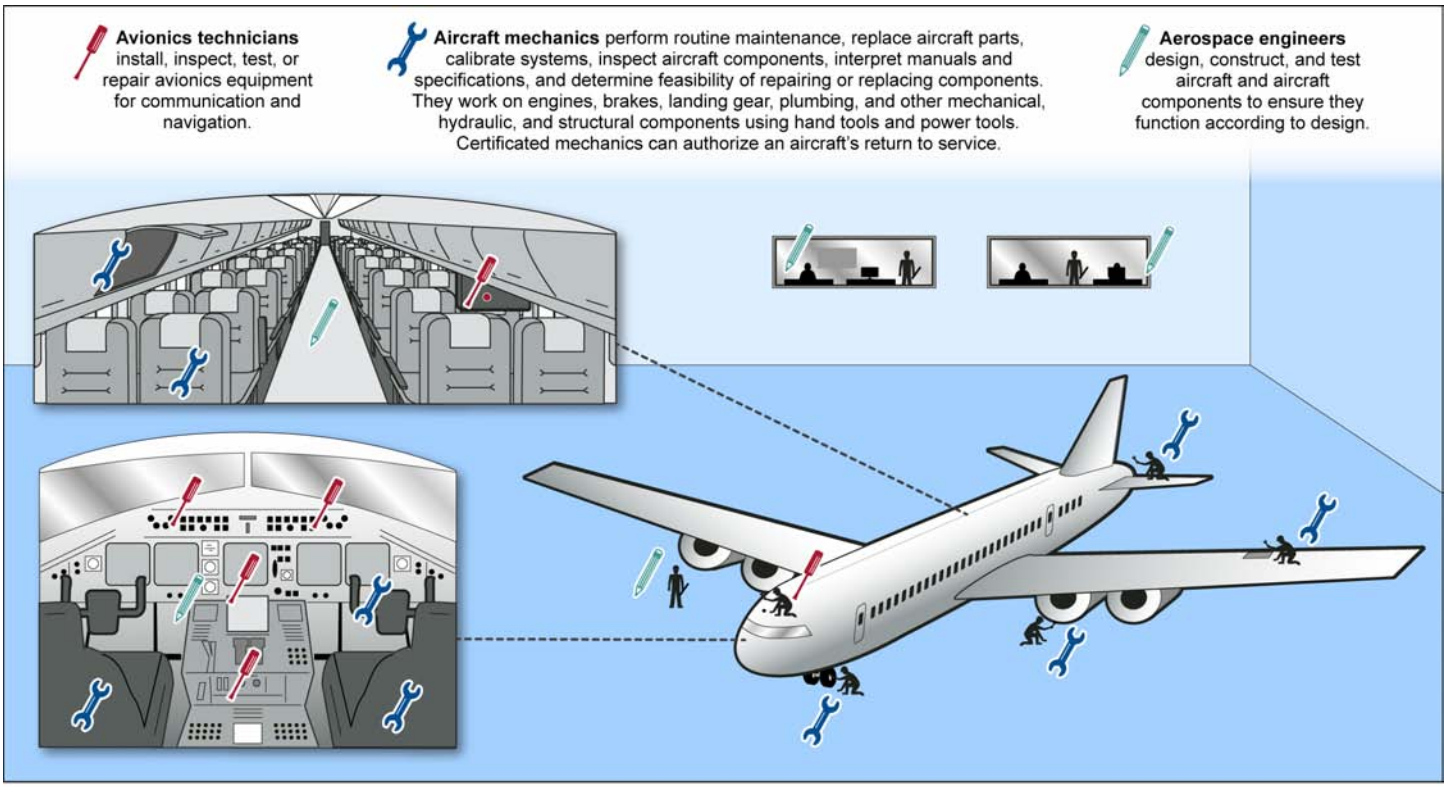
facilities (repair stations). We selected 23 employers that ranged in size, geographic location, and type of work performed. Our findings from these interviews should not be used to make generalizations about all employers of these professionals, but provided us with insights. We also met with and reviewed documents from government officials, various industry groups that represent these professionals, and experts in labor economics to identify any actions taken or analyses that have been performed concerning these issues. See appendix I for more information about our scope and methodology and a listing of the employers we interviewed.

We conducted this performance audit from February 2013 through February 2014 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

As noted, various aviation professionals are involved in the design, maintenance, and repair of aircraft and aircraft components (see fig. 1).

Figure 1: Examples of Tasks Performed by Selected Aviation Professionals



Source: GAO.

These professionals are commonly employed by commercial air carriers, corporate flight departments, repair stations, or manufacturers of aircraft or aircraft components.

- Aerospace engineers working in aviation design aircraft and components, and test prototypes to make sure that they function according to design.[4] The vast majority of aerospace engineers have at least a bachelor's degree, according to BLS's Occupational Outlook Handbook.

[4]In addition to aerospace engineers, mechanical and electrical engineers, among others, are employed by the aviation industry.

- Aircraft mechanics inspect, service, and repair aircraft bodies (airframe) and engines (power plant). Aircraft mechanics can earn a mechanic certificate from FAA with either an airframe (A) rating, power plant (P) rating, or combined airframe and power plant (A&P) ratings, and are referred to as certificated mechanics. According to FAA data, almost all certificated mechanics (92 percent) hold A&P ratings. Applicants for a mechanic certificate must pass written and oral exams and demonstrate competence through a practical test. Certification is not necessary to work as an aircraft mechanic; however, without it, a mechanic cannot approve an aircraft for return to service and must be supervised by a certificated mechanic. Certificated mechanics that hold A&P ratings generally earn a higher wage and are more desirable to employers than mechanics who are not certificated, according to BLS.

  For an applicant to be authorized to take the mechanics examination for the combined A&P ratings, the applicant must either (1) complete an FAA-certificated AMT school; demonstrate and document relevant A&P work experience gained through on-the-job training, or (2) demonstrate and document work experience or some combination of work experience and education gained through the military working with airframes and engines.[5] Mechanics trained at an FAA-approved AMT school complete, at a minimum, 1900 curriculum hours of training: 750 curriculum hours in airframe subjects, 750 curriculum hours in power plant subjects, and 400 curriculum hours in general education subjects. Applicants seeking to take the mechanics examination for A&P ratings based on qualifying on-the-job training must provide documentary evidence of 30 months of practical experience concurrently performing the duties appropriate to the A&P ratings.[6]

- Avionics technicians test and troubleshoot aircraft instruments and components, install electronic components, and assemble switches or electrical controls. Avionics technicians receive training either through

[5]Military applicants may have supplemented work experience with training through the Joint Services Aviation Maintenance Technician Certification (JSAMTCC) program. Military applicants who have not completed the JSAMTCC program must be able to demonstrate experience in 50 percent of curriculum subject areas for the ratings sought. The JSAMTCC program is discussed in additional detail later in this report.

[6]In addition to education and training requirements, individuals must be at least 18 years of age and be able to read, write, speak, and understand English to be eligible for certification.

schooling, on the job, or in the military. Though some avionics technicians may hold a mechanics certificate, there is no FAA exam or certification specific to avionics technicians. However, some technicians seek certification from the Federal Communications Commission in the form of, for example, a General Radiotelephone Operator License.

Some avionics technicians may hold an A&P certificate or an FAA-issued repair-person certificate.[7] A repair-person certificate allows individuals to perform specific tasks at an FAA-certificated repair station, commercial operator, or air carrier that is authorized to perform those tasks.[8] Eligibility for a repair-person certificate requires employment by and recommendation from the FAA-approved employer. If an individual who holds a repair-person certificate leaves employment at that entity, he or she does not retain that certification.

Table 1 shows the employment levels, wages, and the largest type of employer for the aviation professions discussed in this report, as reported by BLS.

Table 1: Employment Levels and Salary Information for Selected Aviation Professions (2012)

Occupation	Total employment	Average hourly wage rate	Largest employer type
Aerospace engineer	80,420	$50.39	Manufacturing
Aircraft mechanic	119,160	$26.78	Air transportation support services[a]
Avionics technician	16,810	$26.65	Manufacturing

Source: BLS's Occupational Employment Statistics

[a]Air transportation support services include airport operation, servicing, repairing (except factory conversion and overhaul of aircraft), maintaining, and storing aircraft.

No single federal agency is tasked with developing the aviation workforce, but FAA is responsible for a variety of tasks related to developing and

[7]Repair-person certificates may be issued for a variety of tasks including, among others, welding and painting.

[8]Unlike an A&P certificate that is issued to an individual, a repair-person certificate is issued to a person through an FAA-approved repair station and, as a result, is only valid while that person is performing the specific task at the issuing station.

maintaining a qualified workforce. For example, FAA sets the minimum requirements for the academic curriculum and certifies and oversees AMT schools across the country.[9] With regard to certification of individual mechanics, FAA developed and administers the written A&P mechanic examination; certifies instructors (known as designated mechanic examiners) to administer the oral and practical tests to candidates; oversees the examiners; and issues A&P certificates to mechanics who successfully pass the examination. FAA also certifies and oversees repair stations within and outside of the United States and oversees maintenance performed by air carriers.[10] Several other federal agencies, including DOD, the Department of Veterans Affairs (VA), Education, and the Department of Labor (DOL), play a role in developing and maintaining a qualified aviation professional workforce, as shown in table 2.

Table 2: Examples of Agencies' Roles and Responsibilities Regarding Various Aviation Professionals

Agency	Role
FAA	FAA sets requirements and oversees the AMT schools and testing; issues certificates to mechanics and repair stations; and performs outreach on behalf of the profession.
DOD	DOD administers a training program meant to supplement work experience, which upon completion makes service members eligible to take the mechanic certification exam.
VA	VA administers several programs to provide financial assistance for higher education.
DOL	DOL-supported workforce-training programs can fund engineering, mechanic, or avionics training programs.
BLS	BLS collects employment and wage data and makes long-term employment projections.
Education	Education provides financial assistance to support training in aviation-related fields.

Source: GAO analysis of government information.

The demand for air travel is highly sensitive to the state of the economy and to political, international, and even health-related events. As a result, despite periods of strong growth and earnings over the past decade, the industry has at times suffered substantial financial distress resulting in the industry contracting. For example, in response to the 2008 economic

[9]There are no current or historical data available on the number of enrollees and graduates of those schools, and FAA does not require the schools to report this information.

[10]FAA does not approve air carrier's maintenance programs; it issues carrier operations specifications that authorize the carrier to use a maintenance program and the air-carrier maintenance manual required by FAA regulations. Advisory Circular 120-16F.

downturn and resulting decrease in demand for commercial air travel, airlines cut capacity and reduced their workforce. However, as demand for air travel has rebounded, the number of aircraft in operation and the size of the workforce are expected to grow. Representatives of the aviation industry are concerned there will not be a sufficient number of certain aviation professionals to support this growth—that is, the industry is concerned that the demand will exceed the available supply and that a labor shortage will result. While no agreed-upon definition for a labor shortage exists, it is commonly described as a sustained period during which the demand for workers in a geographic area exceeds the supply of workers available, qualified, and willing to work at a particular wage and under particular working conditions.

Data and Forecasts Provide Mixed Evidence for a Current or Future Workforce Shortage

Our analyses of labor market data indicate that a shortage of aerospace engineers may exist, but our analysis found less support for a shortage of aircraft mechanics.[11] For example, while both have low unemployment rates, neither employment nor earnings have increased for aircraft mechanics suggesting that employers' demand for this occupation has not outstripped supply. Stakeholders representing these groups also varied in their overall assessment of the labor market. Further, while some of these individuals will pursue other careers, the number of people completing degrees in these or related fields has increased in recent years, and BLS employment projections indicate slower than average or no growth through 2022.

Evidence Is Mixed for a Current Shortage of Selected Aviation Professionals

While no single metric can be used to identify whether a labor shortage exists, labor market data can be used as "indicators" —in conjunction with observations from stakeholders.[12] According to economic literature, one can look at historical unemployment rates, as well as trends in employment and earnings.[13] If a labor shortage were to exist, one would

[11]We were unable to analyze information on avionics technicians because the sample size for the data was too small.

[12]As mentioned, a labor shortage occurs when demand for workers for a particular occupation is greater than the number ("supply") of workers who are qualified, available, and willing to do the work at a certain wage rate.

[13]All data presented in this review on the unemployment rate, employment, and earnings are from BLS's CPS data unless otherwise noted. Data from BLS on earnings have been adjusted for inflation.

expect a low unemployment rate signaling limited availability of workers in a profession; increases in employment due to demand for that occupation increasing; and increases in wages offered to draw more people into the industry.[14] Of these three indicators, the unemployment rate provides the most direct measure of a labor shortage because it estimates the number of people who are unemployed and actively looking for work in a specific occupation.[15] The other indicators can be affected by factors unrelated to a labor shortage; for example, wages may be determined by union contracts rather than market demand. Results of these indicators can be analyzed in relation to other occupations and by using absolute scales defined by benchmarks that we identified in the economic literature.[16]

Two of the three labor market indicators we examined for aerospace engineers suggest that the profession may be experiencing a labor shortage (see table 3). From 2000 through 2012, the unemployment rate for aerospace engineers has averaged 2.3 percent—much lower than the economy as a whole—and employment has increased by about 50 percent.[17] Both the unemployment rate and employment could be suggestive of a labor shortage relative to other occupations and based on the scale we identified in the economic literature. For example, over this period, aerospace engineers had the 38th (out of 295) lowest unemployment rate and 45th (out of 490) largest growth in employment.[18] Similarly, according to the 7-point scale we identified in economic literature, the unemployment rate and employment growth would receive a 5, which is not the highest rating, but still provides some support for a

[14]Cohen, *Labor Shortages*.

[15]Cohen, *Labor Shortages*. This assumes that unemployed individuals will likely seek work in the same occupation in which they were previously employed.

[16]Cohen, *Labor Shortages*. Cohen developed an absolute scale with seven categories to more easily synthesize results from the indicators. Each indicator is assigned a numerical value from 1 to 7 based on benchmarks that were derived by examining distributions of results and identifying natural groupings (e.g., distinguishing between positive and negative employment growth). A rating of "7" means than an indicator is most consistent with a labor shortage and a "1" means that the indicator is most consistent with a labor surplus.

[17]For the economy overall, since 2000, the average unemployment rate has been 6.3 percent, earnings and employment has stayed about the same, according to BLS.

[18]For this time period unemployment rates ranged from 0.6 percent to 22.2 percent across the different occupations.

labor shortage.[19] Median earnings for aerospace engineers, however, have stayed about the same over that time period, a statistic that does not appear consistent with a labor shortage.[20] Specifically, if employers were experiencing difficulty hiring aerospace engineers, one would expect earnings to rise to attract new workers to the industry. However, other factors can also account for a lack of growth in earnings even during a labor shortage. For example, earnings may be slow to adjust to other labor market trends, or certain aspects of an industry may prevent wages from increasing (e.g., a highly competitive industry with slim profit margins). Furthermore, over our analytical time period, wages were stagnant through much of the economy as a result of two economic downturns.

Table 3: Unemployment, Employment, and Earnings for Selected Aviation Professions, 2000–2012

	Unemployment		Change in full-time employment (as a percentage per year)		Change in median weekly earnings (as a percentage per year)	
Occupation	**Rate (average)**	**Rank (total 295)**	**Rate (yearly)**	**Rank (total 490)**	**Rate (yearly)**	**Rank (total 250)**
Aerospace engineers	**2.3**[a]	38	**4.6**[a]	45	0.3	60
Aircraft mechanics and service technicians	**3.0**[a]	70	-0.25	265	-0.07	127
All occupations	6.3	N/A	0.1	N/A	0.06	N/A

Source: GAO analysis of BLS's CPS data.

Notes: Data are from unpublished CPS tables.

[19]Cohen, *Labor Shortages*. Growth rates for the change in employment, and earnings were calculated by fitting a time trend using a log linear regression, for which we computed statistical significance. As such, our calculations yield different larger annual changes compared to calculating the percentage change over the same time period and annualizing the percentage change because our method does not include the effect of compounding. While results show larger changes than an annualized analysis would, both values were within the range to receive a 5. Further, calculating the data this way allowed us to calculate the significance of any trends.

[20]In Cohen's book, the indicator levels for earning growth are presented in nominal terms, without accounting for inflation. They were developed using years 1983-1993. In order to use them for the period 2000 through 2012, when inflation has been lower, we adjusted them using the average inflation rates for the earlier period. Based on the adjusted scale, both occupations would receive a 4 (out of seven), although the real rate of growth in wages is close to zero.

Average annual unemployment rates were ranked from lowest to highest. Yearly rates of change in full-time employment were ranked from highest to lowest. Yearly changes in earnings were ranked from highest to lowest.

BLS adopted the Standard Occupational Classification (SOC) titles in 2010. As a result, some occupations were combined and others were phased out. While this did not affect the occupations relevant to our analysis, it affected the total number of occupations. We excluded any occupation for which the name changed. We also excluded occupations for an indicator if BLS did not report unemployment, or median weekly earnings, or employment for any year. We excluded avionics technicians since the workforce included fewer than 50,000 people and BLS did not report unemployment in many years.

In the table, growth rates for the change in employment and earnings were calculated by fitting a time trend using a log linear regression, for which we computed statistical significance. As such, our calculations yield different larger annual changes compared to calculating the percent change over the same time period and annualizing the percent change, because our method does not include the effect of compounding. For example, the 51 percent change over the 12 year period for aerospace engineers would result in a 3.6 annual rate of change, as opposed to the 4.6 reported in the table. This would be the largest difference of any numbers reported in the table.

[a]Denotes that the indicator would be suggestive of a labor shortage, although not at the highest level.

Data for aircraft mechanics provide less evidence of a labor shortage. From 2000 through 2012, the average unemployment rate for aircraft mechanics has been 3 percent—about half the rate for the entire workforce—which could be suggestive of a labor shortage.[21] However, earnings for aircraft mechanics remained static and employment decreased.[22] Industry stakeholders varied in their assessment of the labor market. Some industry officials we spoke with, representing companies that employ aircraft mechanics across the United States, told us that the industry was currently experiencing a labor shortage; however, others believed that there were enough people to perform the work, but companies were competing to hire the most experienced personnel. According to one industry stakeholder we spoke, the major airlines are not having difficulty attracting workers. As another stakeholder explained, if difficulty existed attracting workers, smaller businesses, and general aviation—particularly in rural areas—would most likely be affected first. The low unemployment rate suggests that with few available people to hire, employers may have difficulty finding people with specific skill sets, certifications, or work experiences.

[21]From 2000 through 2012 aircraft mechanics had the 70th lowest unemployment rate (out of 295 occupations).

[22]The growth rate for aircraft mechanics was negative and was the 265th highest out of 490 occupations.

Our analysis of labor market data has a number of limitations given the nature of the CPS data from BLS and the scope of our analysis. SOC titles are broad, and may not take into account specific requirements an employer seeks. For example, many employers may require employees to hold an A&P certificate. However, BLS's occupational classification for aircraft mechanics includes both certificated and non-certificated mechanics. As a result, labor market data may overestimate the number of available mechanics for certain employers. Moreover, BLS only publicly reports annual employment data for occupations that have at least 50,000 people; as a result, we were unable to analyze data for avionics technicians. We identified the following other limitations of the labor market indicators:

- Data are collected through a household survey and are subject to sampling and response errors. Often, one individual will identify occupation, employment, and wage data for all household members; individuals may report incorrect or inconsistent information.
- Survey results of unemployment rates are based on the person's last job, rather than the longest job held or occupation in which a person is trained or looking for work: the data, therefore, can miss individuals who are seeking work in a particular occupation. For example, an A&P mechanic who lost a job, worked temporarily in the automotive industry, and was then seeking employment as an A&P mechanic, would be classified as an automotive mechanic not as an A&P mechanic, when surveyed by BLS.
- BLS reports data on median earnings for aviation professionals in all stages of their careers, so we could not examine whether starting earnings have increased, an examination that would be more likely to indicate if wages were rising to attract entry-level workers.
- The data were collected at a national level; while not all indicators were consistent with a labor shortage, our analysis would not identify any regional shortages.
- Research by BLS and others suggests job vacancy data as another potential indicator for identifying labor shortages. However, BLS does not collect information on job vacancies at the occupational level. Job vacancy data are collected by some states and private companies,

but the data are limited. We could not obtain complete and sufficiently reliable occupational-level job-vacancy data from these sources.[23]

Finally, as mentioned above, no single measure can provide definitive evidence as to whether a labor shortage exists. Rather, these data can indicate the extent to which employers may have difficulty attracting people at the current wage rate. Moreover, even if perfect data existed, the term labor shortage is sometimes used to describe a variety of situations, some of which are generally not considered to be shortages.[24] For example, during periods of economic recession, employers may become accustomed to hiring a high caliber of candidate with specific training or levels of experience at a prescribed wage rate. In these cases, employers can be more selective when hiring candidates and could, for example, look for individuals with niche skills or more experience. However, during an economic expansion, where companies may be increasing the size of their workforce, it is likely that the number of job applicants will shrink and employers may have difficulty finding the same caliber of candidate. Under these circumstances, the employer's challenge may become one of quality of available people, not necessarily quantity of people willing and able to do the job.

Data Suggest That the Number of Individuals in the Selected Professions Is Increasing, but Several Industries Compete for These Workers

From 2000 through 2012, the number of people identifying as aerospace engineers and aircraft mechanics and service technicians–both certificated and non-certificated–has increased, according to BLS data (see fig. 2).[25] For example, the size of the aircraft-mechanic and service-technician workforce in 2012 had increased 5 percent since 2000. Moving forward, a couple stakeholders that represent training programs and members of the armed services noted that they expect an increase in the number of available mechanics due to an increase in the number of

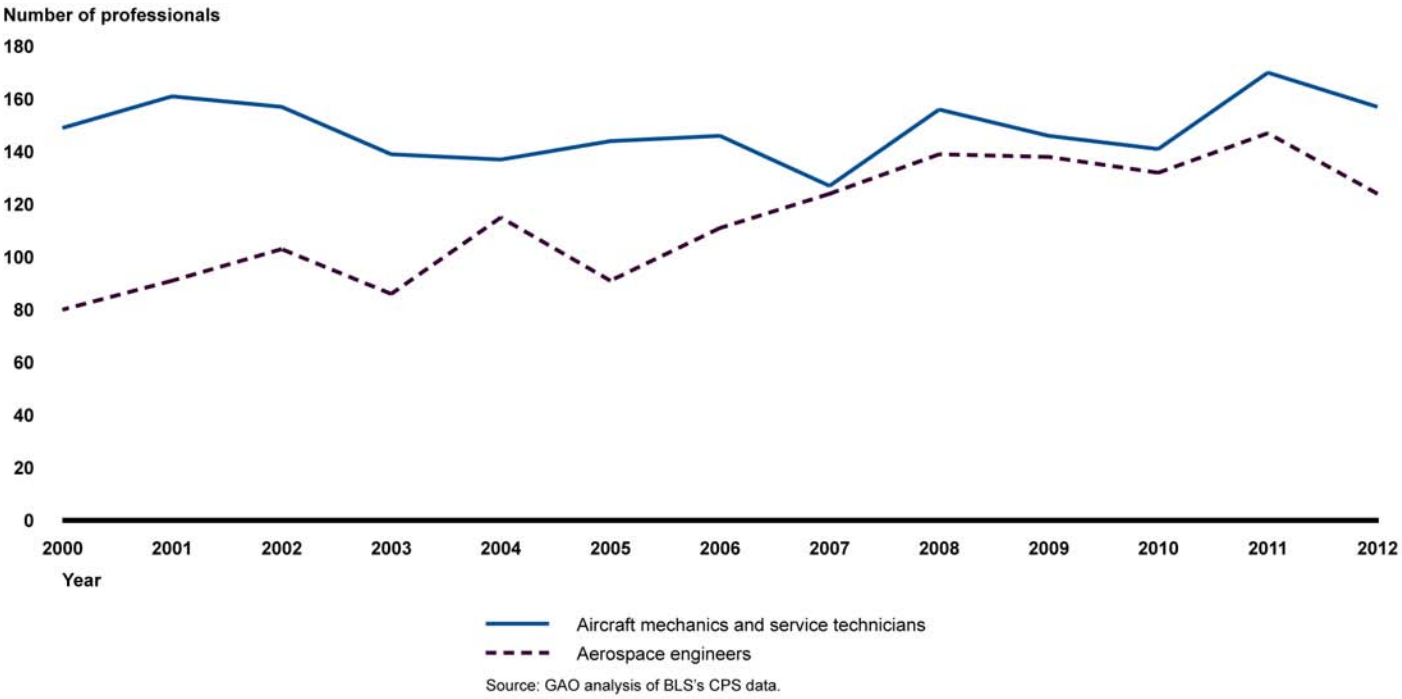
[23]BLS collects a Job Openings and Labor Turnover Survey that provides a broad measure of job vacancies, but not by occupation.

[24]Carolyn Veneri, "Can Occupational Labor Shortages be Identified Using Available Data," *Monthly Labor Review* (March 1999) 15-21.

[25]Data are not available for avionics technicians because the workforce is too small and BLS did not publicly report data for all years. Further, these data for aerospace engineers and aircraft mechanics are from the CPS survey and represent the number of people, both employed and unemployed that either are or were most recently employed in these occupations. BLS uses the term aircraft mechanics and service technicians to describe individuals that repair, maintain, and service aircraft.

completions in aircraft maintenance related degrees and people separating from the armed services, respectively.

Figure 2: Number of Aerospace Engineers and Aircraft Mechanics, 2000–2012 (in thousands)



Source: GAO analysis of BLS's CPS data.

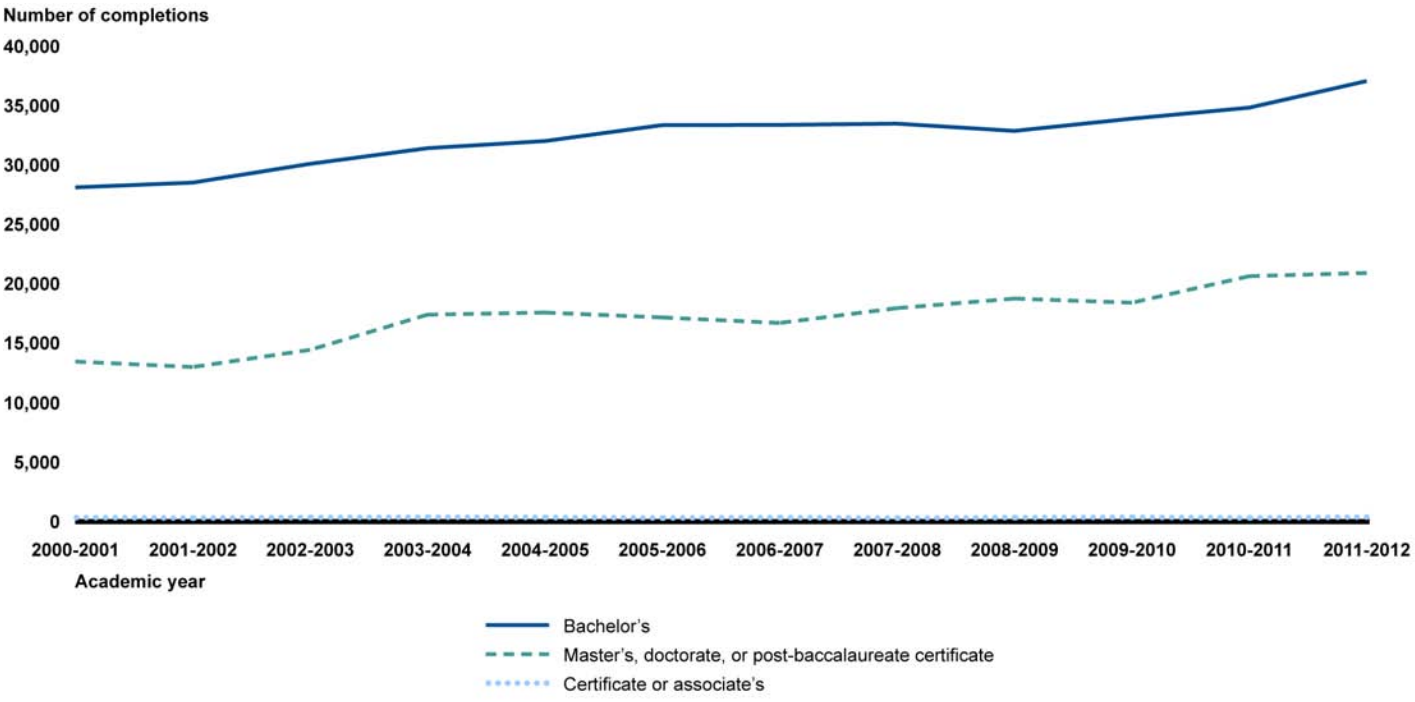
Note: Data are not available for avionics technicians because the survey sample size is too small for data to meet the reporting threshold.

The number of completions in aerospace-engineering-related fields has generally increased, according to data from Education.[26] For example, from academic years 2000–2001 through 2011–2012, there has been a 39 percent increase in the number of completions (see fig. 3).

[26]Education categorizes all degree programs through a Classification of Instructional Programs (CIP); each CIP code is then matched to the SOC. This relationship indicates that programs classified in the CIP category prepare individuals directly for jobs classified in the SOC category. For our analysis of Education data, we included CIP programs that prepare individuals directly to our occupations of interest. For aerospace engineers, this included the following degree programs: aerospace, aeronautical and astronautical/space engineering engineering (CIP code 14.0201), mechanical engineering (CIP code 14.1901), and electrical and electronics engineering (CIP code 14.1001).

Representatives from engineering programs we spoke with generally suggested that the number of completions from engineering programs will be sufficient to meet demand given future BLS employment projections. Therefore, they suggested that it is unlikely that a labor shortage will develop in the near future. For example, one representative told us he would expect demand to be met given the increase in the number of completions combined with the projected slow growth in government projections for selected employment in the aviation field. The same stakeholder noted that the vast majority of engineers are getting employment offers, but are receiving, on average, fewer offers than in past years. A union representative we spoke with echoed a similar sentiment, saying that aerospace engineering needs will be met given the number of engineers entering the workforce.

Figure 3: Completions in Aerospace-Engineering-Related Fields by Level of Degree, 2001–2012



Source: GAO analysis of Education data.

Note: Analysis includes degree programs that train individuals for work as aerospace engineers.

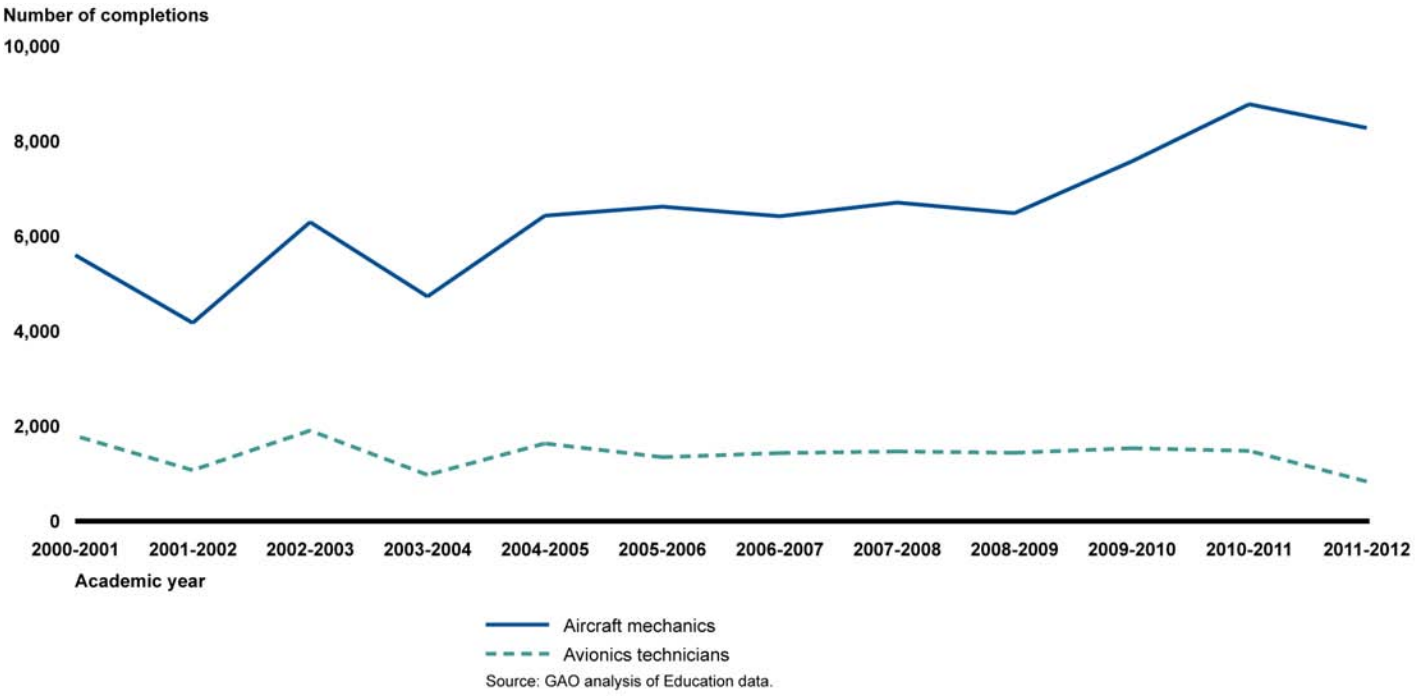
Numbers of aerospace engineering completions, however, are not a direct reflection of the number of individuals entering the aviation

workforce. According to FAA, the industry also uses civil, software, and chemical engineers, among others. For example, the aviation industry requires electrical and software engineers to design airplane motors or electrical circuits and design programs to make air travel faster, respectively. Further, other industries, such as financial services and information technology, compete for aerospace and other types of engineers and often offer less career uncertainty and more exciting job prospects, according to one industry stakeholder representing aerospace companies. Officials we spoke with both at engineering training programs and within industry attributed this to the fact that the aviation industry is highly cyclical, offering less job security than other industries.

In terms of the other aviation occupations, the number of completions of AMT-related programs has also increased; however, the number of completions in avionics related programs has not.[27] Over the past decade, the number of students receiving degrees in aircraft maintenance has increased by 48 percent (see fig. 4), while the number of students receiving degrees in avionics has decreased by 53 percent. However, data on degrees granted in avionics may not be a good indicator for the number of people gaining training to be an avionics technician. For example, according to officials from one school, a sizeable portion of avionics technicians received training in other fields, including electronics technology or electrical engineering, which is not captured in these data. Similarly, some AMT schools offer avionics specialties; though students may go on to be avionics technicians, according to this data source, they are classified as aircraft mechanics. According to officials from a couple selected AMT schools, based on the number of students enrolled in avionics specialties in their schools, interest in avionics has increased in recent years.

[27]The related CIP codes for aircraft mechanic included airframe mechanics and aircraft maintenance technology (CIP code 47.0607), aircraft power-plant technology (CIP code 47.0608), and agricultural mechanics and equipment technology (CIP code 01.0205), whereas avionics technicians only included avionics maintenance technology/technician (CIP code 47.0609).

Figure 4: Aircraft-Mechanic and Avionics-Maintenance-Related Completions, 2001–2012



Source: GAO analysis of Education data.

Note: Analysis includes degree programs that train individuals for work as aircraft mechanics or avionics technicians.

Nevertheless, we heard from education officials at selected AMT and avionics schools and others that not all graduating students received job offers or go to work in the aviation industry upon completion. For example, officials at the majority of AMT schools we visited told us that graduates on occasion pursue other fields of work. According to these officials, some graduates from AMT schools pursue other occupations that offer higher wages or better working conditions—such as the industrial heating industry—or occupations that are likely considered more exciting such as working for amusement parks and NASCAR (National Association for Stock Car Auto Racing, Inc.). Some officials suggested this could be a result of students not yet earning an A&P certificate. However, this also could suggest there are more students entering the field than jobs available in a particular location or that employers are hesitant to hire A&P mechanics directly out of school.

Enrollments at AMT schools have generally been increasing and, if demand existed, AMT schools could train more people to become aircraft

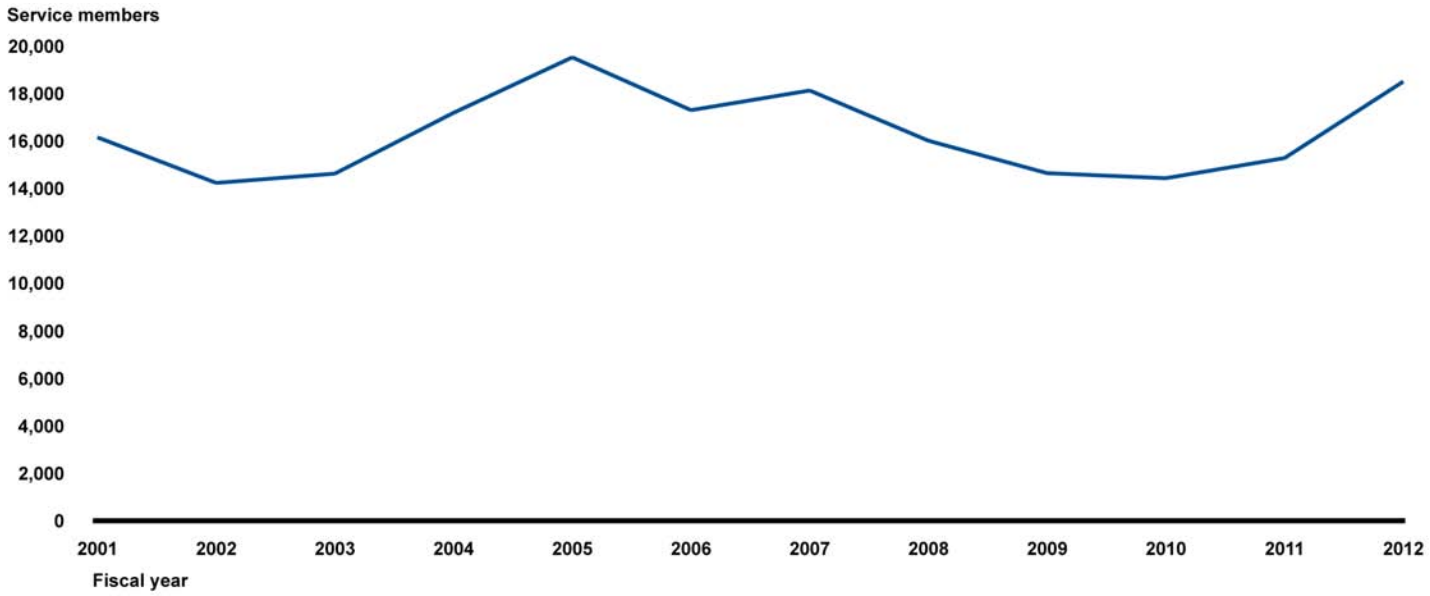
mechanics and avionics technicians. According to the Aviation Technician Education Council, an organization that represents more than 100 AMT schools, 10 of those reported that they were, on average, utilizing about half of their training capacity.[28] This is similar to what we were told by 3 of the 5 schools we interviewed, which reported that they could or planned to increase capacity.

The number of aircraft mechanics and avionics technicians separating from the military—another main source of supply—and entering the civilian workforce has stayed relatively constant since fiscal year 2001, but will likely increase in the future, according to DOD officials.[29] From fiscal year 2001 through 2012, about 16,000 workers trained in aviation maintenance related occupations separated from the military annually, according to DOD data (see fig. 5). However, it is unknown how many of these individuals stayed in aviation maintenance upon completion of their military service. Further, according to DOD officials, the vast majority of these individuals will not hold an A&P certificate when entering the civilian workforce, a factor that can make them less desirable to employers. Nevertheless, DOD officials told us that they expect separations for aviation maintenance workers to increase in the future given planned workforce reductions.

[28]FAA does not require approved AMT schools to provide data on enrollments or graduation rates.

[29]DOD data for aircraft mechanics include avionics technicians. DOD was unable to provide data for engineers.

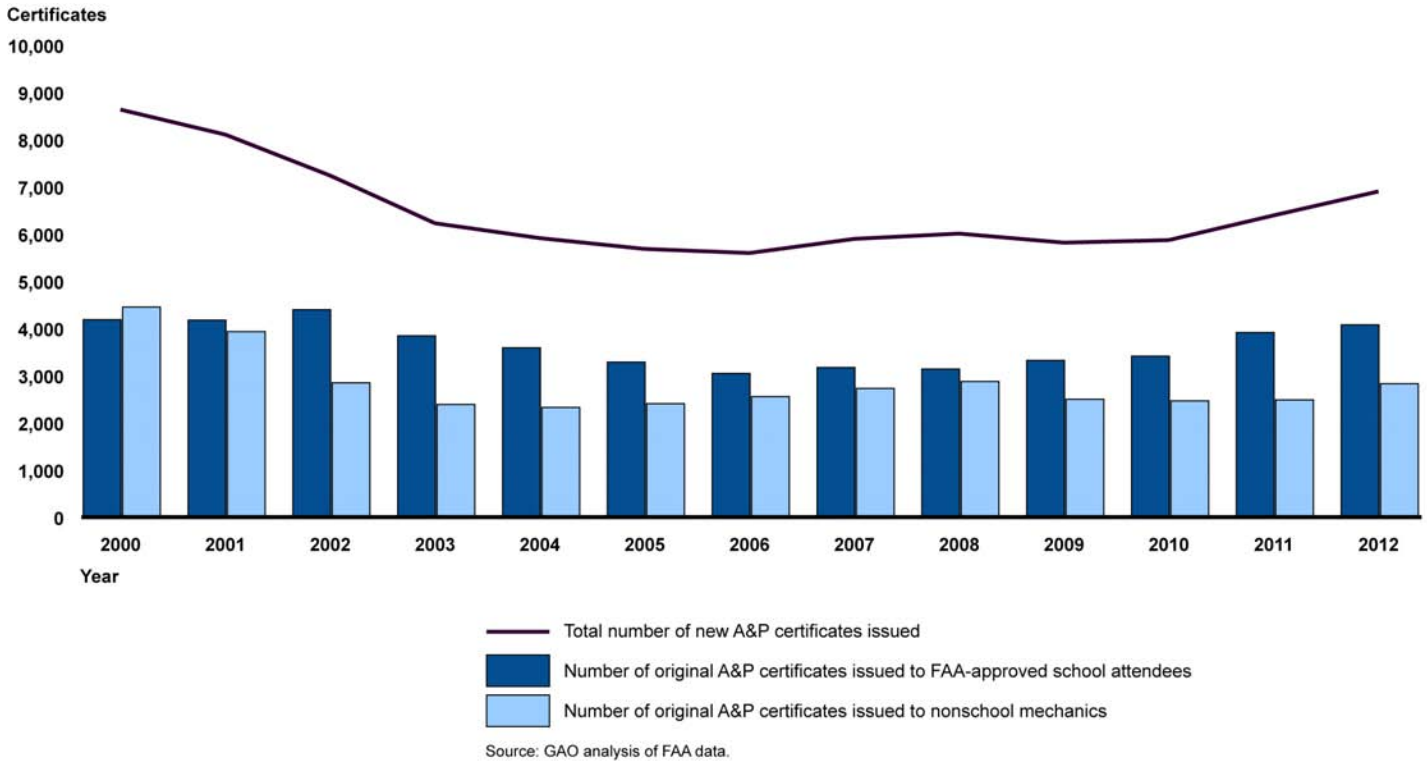
Figure 5: Aviation Maintenance Personnel Annually Separating from the Military, Fiscal Years 2001–2012



Source: GAO analysis of DOD data.

The annual number of newly issued A&P certificates, while declining in the early 2000's and staying relatively constant at about 6,000 new certificates annually from 2003 to 2010, has increased in recent years (see fig. 6). About 7,000 individuals were issued their certificates in 2012. These individuals met the requirements either through attending AMT schools (4,072) or through on-the-job training or military service training (2,824). Over this same period, the pool of certificated A&P mechanics has stayed roughly the same, according to FAA—ranging from roughly 313,000 to 338,000 individuals. In 2013, there were over 335,000 certificated A&P mechanics age 70 or younger.

Figure 6: The Number of New A&P Certificates Issued by Training Type, 2000–2012



Source: GAO analysis of FAA data.

Projections Suggest Slower Than Average or No Growth for the Selected Aviation Professions

BLS's employment projections suggest slower than average or no growth for our selected professions over the next 10 years.[30] From 2012 to 2022, according to BLS, the U.S. economy is projected to add more than 15.6 million new jobs as total employment grows from nearly 145.4 million to more than 161 million (an overall 10.8 percent growth rate or an annualized growth rate of 1.0 percent per year). According to BLS, the number of aerospace engineers employed in the United States is projected to increase to 89,100 by 2022, an overall 7.3 percent increase over the 83,000 employed in 2012.[31] Alternatively, employment for aircraft mechanics and service technicians and for avionics technicians employed in the United States is projected to show little or no change through 2022. Employment for aircraft mechanics and services technicians and avionics technicians is expected to increase by about 2.5 percent (or 3,000 jobs) and 2.9 percent (or 500 jobs) over the same 10-year period, respectively.[32] While air traffic is expected to increase over the coming decade, according to BLS, it is likely that airlines' continued outsourcing of maintenance overseas and the introduction of newer aircraft that require less maintenance will affect demand for these occupations. While projections show slower than average or no growth for these occupations, BLS also provides forecasts of the number of job openings to accommodate both industry growth and the replacement of workers

[30]We also reviewed two industry studies that projected maintenance employment within the aviation industry worldwide and by region–one published by The International Civil Aviation Organization (ICAO) and one by the Boeing Company (Boeing). The ICAO study forecasted future employment demand and the available supply of maintenance personnel based on existing training capacity, but did not produce a projected rate of growth. The Boeing study projected employment for personnel employed to maintain commercial aircraft and found that to meet future anticipated demand, including the effects of anticipated retirements and attrition, approximately 97,900 new aviation maintenance workers will be need to be hired in North America by 2032. We were unable to assess the reliability of these studies due to a lack of sufficient information about their methods and assumptions. For more information on these forecasts see the International Civil Aviation Organization, *Global and Regional 20-year Forecasts: Pilots, Maintenance Personnel, and Air Traffic Controllers* (2011) and the *Boeing Company Current Market Outlook, 2013-2032*.

[31]This would result in an annualized growth rate of about 0.71 percent per year. Employment growth in this area is relatively low because aerospace engineers are typically employed in manufacturing industries that are projected to grow slowly or decline. Demand for aerospace engineers will be greatest in areas related to national defense and the design of civilian aircraft, according to BLS.

[32]Employment for aircraft mechanics and service technicians is projected to be 124,700 in 2022 (an annualized growth rate of about 0.24), and employment of avionics technicians is projected to be 17,600 in 2022 (an annualized growth rate of about 0.29).

leaving these jobs.[33] According to BLS data, most of the demand for new workers in these three occupations will be to replace those retiring or leaving the profession.

BLS's future employment demand for an industry or occupation is influenced by the projected demand for goods and services produced by an industry. For example, the projected employment of aircraft mechanics and service technicians is influenced by the projected demand for air travel and various manufacturing industries. To estimate future employment in the various occupations, BLS uses historical economic and employment data and forecasts of key economic factors, such as economic growth by sector of the economy, to estimate the number of jobs that will result in those industries.

While BLS's projections are helpful in gaining a sense of the expected growth in aviation employment, developing long-term occupational employment projections is inherently uncertain for a variety of reasons. Specifically, these projections rely on a set of assumptions about the future, some of which may not come to fruition. For example, BLS's projection assumes a full-employment economy in the target year, but if a recession occurred, for example, projections for employment are likely to be overstated. That said, projecting occupational employment is reasonably feasible because there are often historical data showing employment trends that can be compared to, for example, economic growth and factors affecting the airline industry—including trends in passenger travel and the cost of key inputs, such as fuel. On the other hand, analyzing whether a shortage might arise in an occupation would require an understanding of both the supply and demand characteristics of the market and an ability to project each of these relationships independently. The factors underlying those relationships require information that is more detailed and likely difficult to develop based on past data, a challenge exacerbated when projecting into the future. For example, forecasting the labor supply requires understanding how the number of people who might choose to work in an occupation varies at different wage rates or working conditions. In the case of the three selected professions, we have past data on the trends in the number of degrees or certifications awarded—which tend to show a growing number

[33]Specifically, during the 2012 to 2022 timeframe, BLS estimates there will be 25,400 job openings for aerospace engineers, 35,600 job openings for aircraft mechanics and service technicians, and 4,000 job openings for avionics technicians.

of people entering the professions—but these data do not provide a forecast of future supply. Nonetheless, with employment growth projected to be slower than average or not to grow and recent trends indicating a stable or growing supply of personnel, there is little reason to believe that a significant shortage is likely to arise in the United States over the next several years.

Industry and Government Are Taking Some Actions to Facilitate Entry into the Aviation Workforce, but Employers Remain Concerned about Future Needs

Most of the employers we interviewed reported some challenges hiring individuals in the selected professions; often this was not an issue of an insufficient number of candidates seeking employment, but rather an insufficient number of candidates with the experience and skills employers sought available to work at the wage being offered. Certain employers, for example those seeking niche or craft skills or those located far from metropolitan areas, cited particular difficulty attracting workers. Almost all employers we spoke with reported taking some actions that economists associate with responding to a labor shortage, but few were raising wages to attract workers. Federal agencies have programs in place that support training for the selected aviation professions, but employers of all sizes, including those that are not currently experiencing hiring challenges, were concerned that young people are losing interest in aviation careers and that future employment needs may go unmet.

Employers Reported Varying Levels of Difficulty Filling Vacancies and Attracting Individuals in the Selected Aviation Professions

Most of the employers we interviewed—particularly the small and medium-sized firms—cited some challenges hiring individuals in the selected aviation professions with the skills they were seeking at the wage they offered. Of the 23 employers we interviewed, 16 expressed some degree of difficulty hiring, though often the issue was not due to an insufficient number of workers, but rather an insufficient number of workers with the experience levels employers desired. Employers also reported challenges hiring mechanics with certain niche or craft skills, such as upholstery, welding, and cabinetry—skills that are not unique to aviation. Similarly, employers seeking aerospace engineers, as well as mechanical and electrical engineers, reported difficulty filling vacancies. According to some employers and stakeholders we interviewed, attracting engineers is made difficult by the lack of job security that results from the cyclical nature of the aerospace industry and the volatility of demand for aircraft and air travel related to the economy.

Certain employers also cited location as a challenge to attracting individuals in our selected professions. For example, employers located

farther from metropolitan areas or those considered to be “aviation hubs” explained that they had difficulty attracting people for engineering and mechanic positions. Employers seeking to hire mechanics added that in more rural areas, they would have the most success hiring and retaining employees from the surrounding areas, but have found it difficult to do so if there is not a local AMT school to support training needs.

Smaller employers—those with less than 100 employees—often considered themselves to be at a disadvantage in attracting workers relative to larger companies. According to 5 of these 13 employers, large air carriers and major manufacturers are considered more desirable, offering employees a sense of stability and an air of prestige, often at higher wages. Employment with an air carrier also offers attractive fringe benefits, such as the ability to fly on standby or for a discounted fare. One employer we interviewed, which is collocated at an airport with a repair station for a large manufacturer, said that despite its offer of comparable wages, it has a hard time competing with the brand-name recognition of larger employers. Consistent with this assessment, more than half of the large employers we interviewed said that they were not currently experiencing difficulties attracting and retaining workers.

Employers who reported challenges hiring A&P mechanics often expressed a reluctance to hire recent graduates or recently certificated A&P mechanics. While the A&P certificate may signal an aptitude and a level of general knowledge, many employers felt that recent graduates lack on-the-job experiences to supplement their education. According to employers, it generally takes between 1 and 3 years to become fully proficient as a mechanic. As a result, according to 5 of the 23 employers who provided their opinions, preferred employment candidates were generally certificated A&P mechanics with at least 2 to 5 years of experience working with the specific aircraft types that the employer maintained and repaired because these individuals could make an immediate contribution with limited supervision.

While employers found the A&P curriculum to generally be well-aligned, overall, with their needs, some employers we interviewed said that the curriculum’s focus is on out-dated technologies—such as aircraft built with dope and fabric—at the expense of more relevant topics, such as composite materials. We previously reported similar concerns from

industry stakeholders in 2003.[34] Specifically, at that time stakeholders indicated that the core curriculum at AMT schools provided mechanics with a solid understanding of basic repair principles, but that some parts of the curriculum were obsolete and covered aspects of aviation repair that are rarely needed or used by A&P mechanics.[35] At least two of those areas—soldering and welding—have been identified by researchers as subjects that could be deleted or condensed because of infrequency of use. However, employers we interviewed indicated skills in these areas were lacking among the current workforce, especially recently certificated A&P mechanics. Given the diversity in the type and age of aircraft in the civilian fleet, satisfying the needs of all employers would be difficult. For example, while dope and fabric aircraft are less common, some certificated aircraft are still produced with those materials; and while composite materials are being used in new airframe construction, aluminum airframes are still the most common.

In addition to challenges hiring workers, 7 of the 23 companies we interviewed reported that while they had some difficulties retaining employees, overall retention was not a major issue. That said, according to representatives of these companies, most of the employees who resign leave for similar positions at companies that offer higher wages, that are located in places with a lower cost of living, or that are considered to be employers that are more attractive. Nevertheless, some leave for other industries. According to some employers and stakeholders we spoke to, mechanics have relevant skills for working at a variety of occupations, including at amusement parks or on oil rigs, which were stated to be either higher paying or have characteristics employees found more favorable.

[34]GAO, *Aviation Safety: FAA Needs to Update Curriculum and Certification Requirements for Aviation Mechanics,* GAO-03-317 (Washington, D.C.: Mar 6, 2003).

[35]Partly in response to previous GAO work (GAO-03-317), FAA convened an Aviation Rulemaking Advisory Committee (ARAC). In 2007, FAA assigned the ARAC a new task: to review and recommend revisions to certain requirements for operation of AMT schools. In 2009, the ARAC submitted recommendations to FAA that included: (1) creating a curriculum review board to biennially review and recommend changes and (2) changing the distribution of training hours between subjects to 450 hours for general knowledge, 800 hours for airframe, and 650 hours for power plant. According to FAA, it implemented the recommendation to create the review board, chaired by the Aviation Technical Education Council, which began operation in fiscal year 2014.

Employers Are Taking a Variety of Actions to Attract and Retain Individuals in the Selected Aviation Professions

According to economic literature we reviewed, employers—who first identify a shortage when they encounter difficulty filling vacancies at the current wage rate—may take a variety of actions in response to a perceived labor shortage.[36] Their actions vary in desirability for the employer based on resources required and their permanency. For example, increasing recruiting requires fewer resources than investing in technologies that could replace labor; further, recruitment efforts could be halted if labor market conditions changed, whereas investing in new technologies cannot be easily undone. Employers may also choose to take some of these actions for reasons other than filling vacancies—for example, to improve morale among current employees or to increase profitability.

In response to difficulties filling employment vacancies, employers may:

- *Increase recruiting efforts.* Increasing recruiting efforts includes such activities as increasing advertising, using public or private employment agencies, and paying recruiting bonuses to employees who refer new hires.
- *Increase the use of overtime.* Employers may choose to have current employees work additional hours in place of hiring additional workers, especially if they do not expect hiring difficulties to last for a substantial period of time.
- *Reduce the minimum qualifications for the job.* Employers may have set minimum qualifications higher than necessary and may choose to reduce those qualifications when hiring becomes difficult. Though employers cannot reduce the requirements for earning A&P certification, they may choose to hire non-certificated mechanics or lower required years of experience necessary for consideration for employment.
- *Restructure the work to use current or new employees in other occupations.* In some cases, complex jobs can be decomposed into simpler tasks, allowing less-skilled and perhaps cheaper labor to be used in place of other occupations. For example, employers may

[36]Burt S. Barnow, John Trutko, and Jaclyn Piatak, "Conceptual Basis for Identifying and Measuring Occupational Labor Shortages." In *Occupational Labor Shortages: Concepts, Causes, Consequences, and Cures* (Kalamazoo, MI: W.E. Upjohn Institute for Employment Research, 2013) 1-34.

choose to use less-skilled workers to begin the repair process by pulling panels from aircraft, freeing A&P mechanics for other tasks.

- *Substitute machinery and equipment for labor.* Employers may sometimes be able to use machinery or equipment in place of labor. For example, a die-cut machine can precisely cut sheet metal, a task that was previously done by hand.
- *Train workers for the job.* In a difficult labor market, an employer that traditionally relied upon colleges or vocational or trade schools to train its workforce may choose to offer or sponsor training.
- *Improve working conditions.* Improving working conditions—such as changes in hours worked, equipment or facility upgrades, training, and job recognition efforts—may be a means to attract and retain workers.
- *Offer bonuses to new employees.* Employers may offer new employees a "signing" bonus, such as, covering moving expenses for agreeing to join a company.
- *Improve wages and fringe benefits.* Increasing wages will help increase the number of workers willing to work in a particular position or occupation. However, employers are reluctant to do this because they may be forced to raise the wages of current employees as well. Further, unlike some other actions, once wages are raised, it is unlikely that they will be reduced later if hiring becomes less difficult.
- *Contract out the work.* If employers cannot fill vacancies for employees in certain occupations, it may contract out those tasks to another firm.
- *Turn down work.* If a firm has exhausted other means to mitigate its hiring challenges and vacancies persist, it may choose to turn down work.

Companies we interviewed took some of the above actions in direct response to a perceived labor shortage. For example, 10 of the 16 companies that reported hiring difficulties increased recruiting efforts—including using social media and attending career fairs. Many companies also made use of specialty websites that advertise aviation jobs as well as staffing and recruiting agencies that offer short-term contract workers and contract-to-hire options. Almost half of the companies we interviewed—including those that did not cite challenges hiring—also developed and leveraged relationships with local schools as a means to recruit workers. According to one company, its location made attracting employees difficult and there were no local schools from which to recruit. In response, it built a relationship with a local technical college with an

automotive-maintenance-training program and hired and trained its students—with aptitude in painting and certain machinery—for related aviation tasks.

Almost all companies we interviewed reported training workers for the job, though few reported providing the initial training to become a mechanic, instead many offered A&P mechanics they employed the opportunity for training in areas specific to the work they were doing for the company. For example, 18 of the 22 companies that reported providing training to its employees sent employees to training courses specific to the make or model of aircraft that the company repaired, or to courses that would build company capabilities on topics such as composites or non-destructive testing. Only one company we interviewed reported hiring individuals without formal training, training them on-the-job, and paying for their A&P testing. Another company reported hiring former military members and sending them for refresher courses to prepare them for the A&P certification exam.

Approximately one-third of companies reported reducing their minimum standards for employment. For example, three companies lowered the number of years of experience it required of applicants and another said that it would like to do so in the future to expand its hiring pool. However, 10 of the companies we interviewed said they would not lower standards; they reasoned that doing so might reduce the quality of their work and they were not willing to expose themselves or their clients to those risks, or that doing so would, in the end, be more expensive for them because non-certificated mechanics need to be under the supervision of a certificated mechanic. Nine of the companies we interviewed that had challenges attracting workers also reported having to turn down work because of staffing constraints, though the frequency varied. According to some of these companies, turning down work was a last resort. In addition, in some instances, companies described receiving requests for services that they could not accommodate in the customer's desired time frames, and as a result, the customer went elsewhere.

Few companies we interviewed reported raising wages, improving benefits, or offering bonuses to attract employees. Five of the 16 companies that reported difficulties filling vacancies also raised wages. However, only one did so explicitly to attract additional mechanics; two did so to remain competitive with other employers, one did so following a multi-year pay freeze, and the last raised wages after it was acquired by a larger entity. Four companies that reported difficulties filling vacancies offered bonuses to new employees. Though raising wages and offering

bonuses would be obvious ways to increase the number of workers willing to work in a particular occupation, doing so could have implications in the market for air travel or aircraft repair if those costs are passed on to the customer. The inability to pass those costs on was the reason that officials from at least one company we interviewed provided for why the company could not afford to raise wages; according to that company, its clients—air carriers—paid a fixed amount, leaving no margin for increased labor costs. In other situations, companies facing competition from repair stations abroad where labor is cheaper may also find it difficult to increase wages.

Officials from many of the companies we interviewed were taking some of the actions we identified for reasons unrelated to difficulty filling vacancies. For example, 17 of the companies we interviewed indicated that they used overtime but not necessarily in place of hiring additional workers. According to those employers, the nature of their business is such that there are peaks and valleys in workflow. At times, the amount of work that must be completed is in excess of what can be completed in a normal workweek; however, it is not a sustained level of work and hiring additional employees would mean layoffs or having to cut hours at other points in the year. Eighteen companies also indicated that they improved working conditions—such as by improving the tools available to employees, updating safety mechanisms, and installing fans or lighting to making working in hangars more comfortable—in efforts to improve morale and retention.

Some actions were taken largely in response to business needs. For example, almost all of the companies we interviewed reported contracting out some tasks that were more economical than building the capabilities to complete them internally. These tasks included non-destructive testing and parts plating. In addition, approximately half of companies we interviewed discussed restructuring their work as a means to maximize efficiency. According to those companies, they did not necessarily restructure their work in an effort reduce the number of mechanics or engineers required in response to or because of hiring challenges. Instead, they sought to maximize the efficiency of their current workforce by using more experienced mechanics to do work that is more complicated. Further, while approximately one-third of the companies we interviewed reported introducing technologies to improve efficiency in the workplace—for example, automating the troubleshooting part of repair work—only one company substituted the use of machinery (a die-cut machine) for positions previously held by people.

The Federal Government Maintains Several Programs and Initiatives That Can Help Attract People to Aviation-Related Fields

As mentioned previously, while no single agency is tasked with developing the aviation professional workforce, several maintain programs that help promote and train people for aviation-related careers. At the time of its creation in 1958, the FAA was tasked with regulating, promoting, encouraging, and developing civil aeronautics. In 1996, following criticism of its response to the ValuJet crash in the Florida Everglades and to address concerns about its dual role, FAA's mission was amended to make ensuring the safety of the national air-space system the agency's top priority.[37] According to FAA, it remained responsible for promotional tasks, but specific references were deleted from its mandate.

Currently, FAA's Office of Aviation and Space Education (AVSED) is tasked with increasing the public's knowledge of aviation and the key role air transportation plays in the U.S. economy, and serves to help recruit new workers into the field. AVSED collaborates with federal, state, and local agencies, as well as private sector entities, to promote aviation-related science, technology, engineering, and math (STEM) skills and grow the pipeline of students seeking to work in aerospace-related fields or aviation maintenance. To this end, AVSED produced a DVD and developed a brochure on aviation maintenance careers that it shares with college recruiters and high school guidance counselors and distributes at career fairs, and that has been shown on public television. AVSED also ran a national poster campaign called, "Yes I Can Do That." In partnership with other organizations, AVSED is involved in a variety of activities, including the *Real World Design Challenge*, a high school-level engineering competition; the *Build-a-Plane* program which provides schools with aircraft to be used as teaching tools; and the *Walk in my Boots Program*, which offers students the opportunity to observe aviation mechanics in the hangar for a day. In addition, AVSED works with the

[37]On May 11, 1996, a ValuJet DC-9 crashed into the Florida Everglades shortly after take-off from Miami International Airport, killing all 110 people aboard. Earlier that year, FAA had initiated a special review of the rapidly growing low, cost carrier following a series of incidents and non-fatal accidents. In June 1996, FAA announced that the carrier would cease operations pending safety improvements to address serious deficiencies it had found in ValuJet's airworthiness, maintenance, quality oversight, and engineering capabilities. This sparked renewed criticism of the Department of Transportation and FAA because it appeared to contrast with statements, made following the accident, assuring the public that the airline was safe. The next day, the Secretary of Transportation committed to urge Congress to make safety FAA's single primary mission. The change was codified in the Federal Aviation Reauthorization Act of 1996, Pub.L. No. 104-264, § 401, 110 Stat. 3213, 3255.

Centers of Excellence, which award aerospace research grants to colleges and the National Coalition of Certification Centers, a network of education providers and corporations that supports and advances technology skills in the aviation industry, among others, and promotes aviation-maintenance technical degrees and careers. Further, AVSED maintains national partnerships with various groups with shared interest in growing the aviation workforce, including the Organization of Black Aerospace Professionals, Women in Aviation International, Youth Aviation Adventure, and the Experimental Aircraft Association.

AVSED tries to track the number of events it organizes and individuals who participate; however, it does not have a mechanism to evaluate the effectiveness of those programs or if the participants pursue an aviation-related career. Without a measure of effectiveness or feedback mechanism to determine if the materials are reaching AVSED's target audience and if that audience is responsive to its efforts, FAA may be missing opportunities to improve performance.[38] However, according to AVSED officials, efforts to track program participation and outcomes would be difficult from a privacy perspective given the ages of its target audience and would be prohibitively costly to execute. AVSED's outreach efforts are done with limited funding as the office does not have a dedicated budget; instead, AVSED relies on transfers from other offices for its activities. For example, the DVD and brochures it produced were made with funds transferred from Flight Standards.

Other agencies also administer programs that could encourage entry into aviation careers.

- *DOD* trains and employs over 114,000 individuals working in occupations that are comparable to the aviation professional occupations discussed in this report. However, while in the military, mechanics are not mandated to hold A&P certificates. Further, their training may be for specific tasks or duties and, as a result, does not necessarily qualify them for eligibility to take the A&P exam. As previously mentioned, though certification is not required for civilian employment either, certificated A&P mechanics can command higher wages and have better promotion potential.

[38]GAO, *Managing for Results: Critical Actions for Measuring Performance*, T-GGD/AIMD-95-187 (Washington, D.C.: June 20, 1995).

In an effort to help separating service members find civilian employment and to promote a more professional military workforce, DOD has undertaken several actions to facilitate A&P certification of its members. For example, since 2002 the Community College of the Air Force has run the FAA-approved JSAMTCC bridge program that, upon completion, confers a certificate of eligibility—equivalent to a training program diploma—to take the A&P exam. The JSAMTCC program is available to members of all services who have attained minimum requirements in aviation maintenance—typically after 3 years of experience in a related position—and includes three self-paced courses taken online in addition to on-the-job training. According to DOD officials, depending on individual circumstances, the time to complete the program varies. According to DOD, several thousand service members have enrolled in the program (see table 4). However, the numbers who have completed the program are much smaller, likely because deployments and other activities interrupt coursework. Once eligible for the exam, service members can complete the written portions of the A&P exam free at testing facilities located on base. In addition, the Navy, for example, subsidizes the cost of the practical and oral exams for its members and the Army awards promotion points for attainment of the certification. In coordination with the FAA, the services have also standardized their forms to facilitate proving eligibility to take the exam.

Table 4: Aircraft-Maintenance-Technician Certification Program Enrollments and Completions by Service, 2002–2013

	Air Force	Army	Marine Corps	Navy	Coast Guard
Enrolled	5,911	1,916	145	1,274	16
Completions	193	39	7	39	14

Source: DOD.

In the last year, DOD also completed a pilot program aimed at streamlining credentialing and licensing for military members that included aircraft mechanics.[39] The Navy and Air Force, which employ the largest number of aircraft mechanics, participated by designing efforts to increase participation in the technician certification program. DOD found that though it would be ideal for service members to start the program early in their military careers, service members lacked an appreciation for the differences between the military and civilian requirements for aircraft mechanics, and for the value of FAA certification, resulting in many choosing not to participate.[40] The services also found that the cost of taking the A&P exam—on average $1,750—was prohibitively expensive for some who completed the JSAMTCC program. As part of the pilot program, the Air Force made arrangements to pay the fee. The Navy, which already had a program in place to meet the cost of certification exams, focused on better marketing for the program. Based on the outcomes of their efforts, the Navy plans to continue outreach and the Air Force plans to pay for all exam costs, funding permitting.

In coordination with DOL, VA, and other federal partners, DOD also administers the Transition Assistance Program (TAP)[41] for eligible separating service members. TAP consists of a 5-day core curriculum with segments on translating military skills to civilian job requirements, financial planning, and individual counseling and assessment with the goal of each service member's developing an individual transition plan. It also includes a process that "crosswalks" military jobs to civilian occupations by evaluating the transferability of skills from the individual's military occupational specialty to civilian occupations. In

[39]Section 558 of the National Defense Authorization Act (NDAA) for Fiscal Year 2012, Pub. L. No. 112-81, 125 Stat. 1298, 1418 (2011), as amended by section 543 of NDAA for Fiscal Year 2013, Pub. L. No. 112-239, 126 Stat. 1632, 1737, required DOD to carry out a pilot program to assess the feasibility and advisability of permitting enlisted members of the Armed Forces to obtain civilian credentialing or licensing for skills required for military occupational specialties or qualification for duty specialty codes. In addition to aircraft mechanics, the pilot included automotive mechanics, healthcare support, logistics and supply, and truck drivers.

[40]As previously noted, military aircraft mechanics are not required to hold an A&P certification and may not understand the additional autonomy tasks—such as returning a plane to service—and career opportunities available to civilian mechanics who hold a certificate as compared to those who do not.

[41]National Defense Authorization Act, Fiscal Year 1991, Pub. L. No. 101-510, § 502(a)(1), 104 Stat. 1485, 1553 (1990).

addition, participants may attend one or more 2-day tracks, including tracks focused on entering a technical skills training program. Moving forward, DOD has said that it plans to shift to a Military Life Cycle Transition Model by October 2014, a more proactive approach intended to integrate transition preparation—counseling, assessments, and access to resources to build skills or credentials—throughout the course of a service member's military career. Federal laws, as well as DOD policy, generally require that eligible transitioning service members participate in many components of TAP; DOD's annual goal is for 90 percent of eligible separating service members to attend the mandatory TAP components.[42]

- *The Post 9/11 GI Bill*, established in 2008 and available through VA, provides full tuition and fees for all public school in-state students and reimbursement for private institutions of higher learning for up to $19,198 per academic year.[43] It is currently VA's largest education program. Financial support provides up to 36 months of education benefits, which are generally payable for 15 years following release from active duty. Though the program distributed more than $8.5 billion in tuition, housing, and other payments in fiscal year 2012, we have previously found that problems with its administration and delays in payment create financial challenges for student veterans.[44] We made recommendations to VA to address these problems, and VA has taken steps to respond to those recommendations, including efforts related to educating student veterans about education benefits prior to enrollment and working with postsecondary schools to identify information to facilitate timely access to other sources of federal financial aid while VA benefits were processed. Additional benefits are also available to veterans with higher expenses through the "Yellow Ribbon Program."

[42]In 2011, the Administration redesigned TAP—the first major re-design of the program since its inception over 20 years ago. As part of the redesign, all service members are required to meet career readiness standards—the completion of a set of tasks that demonstrate their readiness for a civilian career. In response to a congressional mandate, GAO is in the process of assessing DOD's implementation of the program redesign. Pub. L. No. 112-56, § 226, 125 Stat. 711, 719 (2011).

[43]Amount is for academic year 2013-2014 for individuals who are eligible for the full benefit level.

[44]GAO, *VA Education Benefits: VA Needs to Improve Program Management and Provide More Timely Information to Students,* GAO-13-338 (Washington, D.C.: May 22, 2013).

- *Education* offers grants, work-study funds, and low interest loans to help cover expenses such as tuition and fees, books and supplies, and room and board, as well as other related expenses. Schools that offer training in aviation-related fields are eligible for this funding. (See table 5 for information on the number of students majoring in aviation-related fields receiving aid and the total amount of aid received.) We did not identify any funding sources that specifically targeted the selected aviation professions discussed in this report.

Table 5: Number of and Amount of Aid Disbursed to Students Majoring in Aviation-Related Fields Receiving Federal Aid, 2011–2012

	Mechanical, electrical, and aerospace engineering		Aircraft mechanics and avionics	
	Recipients	Total Amount	Recipients	Total amount
Federal grants	90,581	$724 million	142,708	$918 million
Federal work study	30,583	$180 million	6,438	$47 million
Federal loans	120,740	$1.6 billion	114,564	$1.3 billion

Source: GAO analysis of Education data.

Notes: Federal loans do not include Plus Loans.

Education categorizes all degree programs through a CIP code which can be matched to a SOC code. This relationship indicates that educational programs classified in the CIP category prepare individuals directly for jobs classified in the SOC. For this data source, the National Postsecondary Student Aid Study (NPSAS), only 4 of the 6 digits of the CIP code are used. As a result, programs may be classified at a higher level and include related programs. With regard to aircraft mechanics and avionics, the CIP code used (47.06) includes programs related to vehicle maintenance and repair, such as automotive mechanics and engine mechanics. For electrical engineering, the CIP code used (14.10) includes programs related to telecommunications and optical engineering. The CIP codes used for mechanical (14.19) and aerospace (14.02) engineering did not have any additional programs associated with them.

- *DOL:* Under the Workforce Investment Act of 1998 (WIA) administered by DOL[45], training services are available to eligible individuals who meet requirements for services—including training to become an aerospace engineer, aircraft mechanic, or avionics technician. To be eligible for training support, individuals must first participate in what are considered core services—job search and placement assistance—and intensive services—individual

[45]Pub. L. No. 105-220, 112 Stat. 936 (1998).

employment and career plans. WIA does not specify an amount of time one must spend or the number of attempts one must make to gain employment before moving to the next level in the sequence of services, and the state-level administrators of the moneys have discretion on how much is spent on training relative to other services. Due to the limited sum of money available, WIA requires that individuals receiving training funds be unable to obtain grant funding from other sources to pay the cost of training.[46] According to DOL, workforce counselors encourage those interested to seek support from other sources (including VA and Education) prior to seeking WIA training funds. WIA funds were used in whole or in part to support training in aviation-related fields for more than 2,000 individuals from 2010 through 2012.[47]

DOL also provides grant moneys to various entities that support aviation-related training. For example, since 2011, through its Trade Adjustment Assistance Community College and Career Training Grant Program, DOL has provided more than $55 million to community colleges in California, Idaho, Kansas, Michigan, and Washington to support training in aviation manufacturing and machining, composites, and engineering technology. Through DOL's H-1B Technical Skills Training and Job Accelerator Innovation Challenge Grant Programs, DOL has provided more than $14.5 million to universities and localities to provide aerospace and aviation-related education, training, and job placement assistance directly related to high-growth occupations for which employers are currently using the H-1B nonimmigrant visa program to hire foreign workers and to support regional development.

[46]As part of the eligibility conditions for WIA-supported training services, individuals must be unable to obtain grant assistance from other sources to pay the costs of such training, including Welfare-to-Work, state-funded training funds, Trade Adjustment Assistance, and Federal Pell Grants established under title IV of the Higher Education Act of 1965, or require WIA assistance in addition to other sources of grant assistance, including Federal Pell Grants. 20 C.F.R. § 663.310(d). DOL does not collect information on the total amount of WIA resources expended on training.

[47]From 2010 through 2012, 269 individuals received funding for avionics technician training, 1,527 for aircraft mechanics and service technician training, 134 for aerospace engineering training, and 296 for aerospace engineering and operations technician training. During that time, a total of 691,343 individuals with associated information on occupation of training received training supported, in whole or part, by WIA funds.

Despite the availability of these programs, most employers and stakeholders we interviewed told us that maintaining a qualified aviation professional workforce will be more difficult in the future due to changes in K-12 education, a perceived emphasis on earning a 4-year degree, and the perceived decreased desirability for working in aviation, particularly aviation maintenance. Several employers cited the absence of vocational and "shop" classes in high school as a reason interest and critical knowledge in maintenance are waning. Several employers and stakeholders we interviewed also said that with parents and counselors insisting that a college degree is needed for every job, students may not be aware that there are well-paying professions that do not require a 4-year degree. FAA echoed this sentiment in describing the challenges of AVSED. According to AVSED, it can be difficult to interest students in aviation maintenance careers because it is mistakenly perceived to be a low paying, low skilled occupation. To combat this perception, according to stakeholders, AVSED and industry must find a means to convince parents and guidance counselors that not all well-paying careers require a bachelor's degree. Several employers and stakeholders also noted that aviation used to be a more "exciting" industry, which attracted people even though wages were often lower than other, similar industries. Events of the last decade—including September 2001 and airline bankruptcies and mergers—also have resulted in the aviation industry being viewed as unstable, compared to other industries.

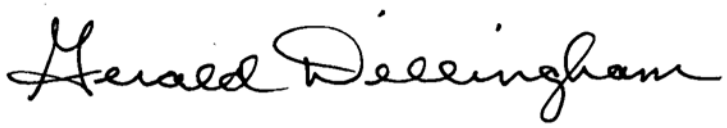
Employers and stakeholders we spoke with did not agree about how to encourage entry into aviation occupations. Some suggested that FAA should do more to champion the industry and increase its outreach and educational efforts. Others suggested that by providing subsidies or tax credits, government could incentivize students to enter aviation fields and businesses to hire them. However, others maintained that government should not have a role and that it was an issue for industry to address. One company suggested that companies could sponsor students in exchange for an agreement that, upon graduation, they would work for a specified period of time for that company. Aerotek, a staffing solutions company that focuses on aviation, recently instituted a similar program when it collaborated with two aviation maintenance schools in Canada to train workers. According to Aerotek, it participated in the curriculum design to include topics its clients seek and guaranteed the classes would be full. Students who complete the program are then guaranteed employment. Aerotek estimated that it trained between 600 and 700 employees in this way.

Agency Comments

We provided a draft of this report to the departments of Defense (DOD), Education (Education), Labor (DOL), and Transportation (DOT) for review and comment. We received technical comments on this report from Education, DOL, and DOT which were incorporated as appropriate. DOD did have any comments on the report.

We are sending copies to the appropriate congressional committees, the Secretaries of Defense, Education, Labor, Transportation, and interested parties. In addition, this report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me on (202) 512-2834 or at dillinghamg@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix II.



Gerald L. Dillingham, Ph.D.
Director, Physical Infrastructure Issues

List of Requesters

The Honorable John Thune
Ranking Member
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Bill Shuster
Chairman
Committee on Transportation and Infrastructure
House of Representatives

The Honorable Frank A. LoBiondo
Chairman
Subcommittee on Aviation
Committee on Transportation and Infrastructure
House of Representatives

The Honorable John L. Mica
House of Representatives

The Honorable Thomas Petri
House of Representatives

Appendix I: Objective, Scope, and Methodology

Our report focuses on the supply of and demand for individuals in three selected aviation professions–aerospace engineers, aircraft mechanics, and avionics technicians–which are involved in the design, manufacture, and repair of aircraft and have been the subject of concerns voiced by industry stakeholders. In this report, we examined: (1) what available data and forecasts reveal about the need for and potential availability of aerospace engineers, aircrafts mechanics, and avionics technicians and (2) what actions industry and the federal government are taking, if any, to help attract and retain these professionals.

To determine what available data reveal about the current need for and availability of these professionals, we reviewed relevant economic literature that describe labor market conditions,[1] developed a summary of the general economic principles for evaluating labor market conditions, and identified relevant data sources. Economic literature states that no single measure exists to determine whether a labor shortage exists; however, one can look at multiple indicators— including unemployment rates, employment numbers, and earnings—that might converge to suggest either the presence or absence of a shortage.[2] We obtained these data from the Bureau of Labor Statistics (BLS) Current Population Survey for years 2000 through 2012.[3] In 2010 BLS adopted the updated Standard Occupational Classifications (SOC) titles and, as a result, some occupation's names changed during the time period we examined. We used SAS, a statistical software application, to connect data for 2000–2010 and 2011–2012 by the SOC titles and did not include occupations for which no exact job title match existed between the two time periods;

[1]See Burt S. Barnow, John Trutko, and Jaclyn Piatak, "*Conceptual Basis for Identifying and Measuring Occupational Labor Shortages,*" in Occupational *Labor Shortages: Concepts, Causes, Consequences, and Cures. (*Kalamazoo, MI: W.E. Upjohn Institute for Employment Research, 2013) 1-3;4 and Malcolm S. Cohen *Labor Shortages: As America Approaches the Twenty-First Century* (Ann Arbor, MI: University of Michigan Press, 1995).

[2]In the absence of a universally agreed upon definition we have defined a labor shortage in the same terms that have been used in economic literature, including a Bureau of Labor statistics (BLS) publication.

[3]The Current Population Survey, a monthly household survey conducted by the Bureau of the Census for the BLS, provides a comprehensive body of information on the employment and unemployment experience of the nation's population, classified by age, sex, race, and a variety of other characteristics.

this did not affect our occupations of interest.[4] We analyzed how these indicators have changed over time, and whether these indicators suggest a labor shortage–that is, whether there appears to be an imbalance between the labor supply (i.e., available people) and demand (i.e., available jobs). We analyzed each occupation relative to all other occupations and using an absolute scale with benchmarks developed in previous economic analysis.[5] For the unemployment rate we looked at the average unemployment rate for each occupation from 2000 through 2012.[6] For both employment and earnings we analyzed any change from 2000 through 2012.[7] To verify our results, we discussed them with Malcolm Cohen, PhD, labor economist and author of the original indicator analysis.[8] We incorporated his comments as appropriate. Finally, we summarized limitations with the data with respect to how we used them. To assess the reliability of BLS's CPS data we reviewed documentation related to the data sources from prior GAO reports and BLS's technical documentation about the quality of the data. We determined the data were sufficiently reliable for the purposes of our indicator analysis to provide context on the labor market.

[4]BLS adopted the modified SOC titles in 2010 and as a result, some occupations were combined and others were phased out. While this did not affect our occupations, it affected the total number of occupations. We excluded those occupations for which the name changed. We also excluded occupations that had any years where the sample size was too small (i.e., under 50,000 observations) to report unemployment, median weekly earnings, or employment. This resulted in 288, 490, and 250 occupations in unemployment rate, employment, and earnings, respectively.

[5]Cohen developed a scale with seven categories to more easily synthesize results from the indictors. Each occupation's indicators were assigned a numerical value from 1 to 7. Categories were developed by looking at the distribution of the results and setting natural groupings (e.g. distinguishing between positive and negative employment growth). A rank of "7" designates the indicator is consistent with a labor shortage and a "1" designates the indicator is consistent with a labor surplus.

[6]As part of a sensitivity analysis we also compared data since 2003, in addition to developing a regression line for both time periods. Performing multiple analyses with different comparison years allowed us to ensure that a year with unique results would not impact our analysis.

[7]Similar to the unemployment rate we also looked at data since 2003 as well. Finally, we adjusted earnings for inflation and only included full-time non-farm workers.

[8] Malcolm S. Cohen, President of Employment Research Corporation, received his PhD in economics from the Massachusetts Institute of Technology in 1967. He has directed numerous labor market research and forecasting studies for the U.S. Department of Labor. He testifies as an expert witness in various court proceedings on economic loss, discrimination and other employment issues.

To identify future demand for, supply of, or employment projections for individuals in our selected aviation professions, we performed a literature review of scholarly material, government reports, and books, among others; identified any projections for aviation professional occupations; and analyzed results that projected demand in the United States (or North America) using databases that included ProQuest, WorldCat, and LexisNexis. We identified three studies—one performed by the federal government (BLS) and two performed by industry (the Boeing Company and the International Civil Aviation Organization (ICAO))–and obtained the most recent analysis for each.[9] To understand these projections, we reviewed the processes, methodologies, and sources of information used to make the projections. We also discussed the projections with the staff that performed each study. We did not verify the data that the companies collected and used in making their projections. We also described, based on economic literature, why forecasting these factors generally includes a great deal of uncertainty.

To identify trends in sources of supply for individuals in our selected aviation professions we obtained data through 2012 from sources that supply such professionals. We analyzed the Department of Education's (Education) data on annual completions by major since academic year 2000–2001; data from the Department of Defense (DOD) on service members separating from the military since fiscal year 2000; and the Federal Aviation Administration's (FAA) data on the number of people annually obtaining airframe and power plant (A&P) certificates since 2000.[10] Specifically:

- *Education:* To describe national trends in number of completions in aviation-related majors we analyzed data from Education's Integrated

[9]For BLS we summarized employment projections from 2012 through 2022. The ICAO study forecasted future employment demand and the available supply of maintenance personnel based on existing training capacity, but did not produce a projected rate of growth. The Boeing study projected employment for personnel employed to maintain commercial aircraft. We were unable to assess the reliability of these studies due to a lack of sufficient information about their methods and assumptions. For more information on these forecasts see the International Civil Aviation Organization, Global and Regional 20-year Forecasts: Pilots, Maintenance Personnel, and Air Traffic Controllers (2011) and the Boeing Company Current Market Outlook, 2013–2032 (Boeing, 2013).

[10]DOD could not provide data on the number of service members separating from all branches of the military before fiscal year 2000. To allow for comparisons across all years, we only reported data since fiscal year 2001.

Postsecondary Education Data System (IPEDS). We used Education's Classification of Instructional Programs (CIP) and matched degree codes to our SOC codes to identify the relevant degree programs. Specifically, the CIP-SOC relationship indicates that programs classified in the CIP category prepare individuals directly for jobs classified in the SOC category. Our analysis of IPEDS data included all schools that reported enrollment data in these fields.

- *DOD:* To better understand the role of the U.S. military as a source for our selected professions, we obtained data on service members separating from the armed forces (i.e., the Navy, Army, Air Force, and Marine Corps); the current number of aviation maintenance workers in the military; and forecasted rates of separation for maintenance workers. [11] We also interviewed military officials at the Pentagon to understand how separation trends in the future might compare to past trends. Data for aircraft mechanics includes avionics technicians. DOD was unable to provide data on aerospace engineers.
- *FAA:* To better understand trends in the number of new A&P certificates issued and age distribution of current certificate-holders, we obtained data from FAA on A&P certificates issued from 2000 through 2012, by the type of training the certificate-holder received. We also obtained data from FAA on A&P certificate-holders as of July 2013 and, using STATA, developed descriptive statistics, including the distribution of certificates held by age and the total number of certificates held by those age 70 or younger. The database in which certificate-holder information is stored maintains records on individuals until FAA is informed of their death. To better estimate the number of active A&P mechanics, we excluded individuals over the age of 70.

To assess the reliability of Education, DOD, and FAA data we reviewed documentation related to these data sources from our prior reports, and agencies' websites, and interviewed knowledgeable government officials about the quality of the data. After analysis, we determined that the data were sufficiently reliable to provide general trends in the sources of supply of individuals in the selected aviation professions. [12] We

[11] Data from DOD are current as of June 17, 2013.

[12] Due to concerns regarding how DOD calculates its rate of workers leaving the military and how rates varied across each branch we did not report this information. Rather we reported the number of people instead.

supplemented data with interviews from government, industry, 7 select aviation engineering, maintenance, and avionics training programs, and unions representing aviation professionals. Schools were selected to provide a range of perspectives in location, size, and type of program. Where possible we selected schools in cities where we interviewed employers. Information collected from these interviews is not generalizable.

To supplement these broader trends, we selected 23 employers from FAA's list of certificated repair stations and air carriers—including original equipment manufacturers (manufacturers), air carriers, and maintenance, repair, and overhaul facilities (repair stations)—across the United States to understand the extent to which specific employers experienced difficulty attracting and retaining workers and any actions that have been taken. (For a complete list of employers, see table 6.) We selected companies based on consideration of several factors, including the total number of mechanics and repairpersons employed, the ratio of A&P–certificated mechanics to non-certificated mechanics, type of work performed, and geographic location. We limited our scope to employers located within the United States. To develop our list of actions that employers may take to mitigate labor shortages, we reviewed economic literature and interviewed the authors.[13] Using semi-structured interviews, we asked all employers whether they had used each action mentioned in economic literature to attract and retain personnel and, if they had taken that action, the purpose for doing so.[14] We also asked employers about the extent to which they expect hiring and retention to improve or become more difficult in the future. We then performed a content analysis of our interviews to summarize the extent to which these actions were taken across companies. We completed 19 of the 23 interviews in person during site visits to 7 states—California, Georgia, Maryland, North Carolina, Oklahoma, Texas, and Virginia. The findings from our interviews with selected employers should not be used to make generalizations about the views of all employers; however, employers' observations

[13]Barnow, Trutko, and Piatak, "Identifying and Measuring Occupational Labor Shortages."

[14]Barnow, Trutko, and Piatak, "Identifying and Measuring Occupational Labor Shortages." These actions include increasing recruiting efforts, increasing the use of overtime, reducing the minimum qualifications for the job, restructuring the work to use current or new employees in other occupations, substituting machinery and equipment for labor, training workers for jobs, improving working conditions, offering bonuses to new employees, improving wages and fringe benefits, contracting out the work, and turning down work.

related to their ability to fill job vacancies are a component of analyses that seek to corroborate the existence of an occupational labor shortage. As such, the information gathered in these interviews sought to supplement analyses of national-level labor market data with employer experiences.

Table 6: Selected Employers, Location, Type of Interview, and Type of Employer

Employer	Location selected	Type of employer	Method of interview
AAR Aircraft Services, Incorporated	Indianapolis, IN	Repair station	Phone
Aviation and Defense, Inc.	San Bernardino, CA	Repair station	In person
Capital Aviation Instrument Corporation	Manassas, VA	Repair station	In person
Century Flight Systems, Inc.	Mineral Wells, TX	Repair station	In person
Certified Aviation Services	Ontario, CA	Repair station	In person
Delta Airlines	Atlanta, GA	Repair station and airline	In person
Epps Air Service	Atlanta, GA	Repair station	In person
Excel Aviation	Gainesville, TX	Repair station	In person
FedEx Express	Los Angeles, CA and Memphis, TN	Repair station and airline	Phone
Gulfstream Aerospace Corporation	Long Beach, CA	Repair station and manufacturer	In person
Hawker Beechcraft	Atlanta, GA	Repair station and manufacturer	In person
Jet Works Air Center Management, LLC	Denton, TX	Repair station	In person
King Aerospace	Ardmore, OK	Repair station	In person
Lockheed Martin Aircraft Center	Greenville, SC	Manufacturer	Phone
Piedmont Airlines, Inc.	Salisbury, MD	Airline	In person
Precision Electronics	Atlanta, GA	Repair station	In person
Rockwell Collins Inc.	Atlanta, GA	Repair station	In person
Signature Flight Support	Dulles, VA	Repair station	In person
Southwest Airlines	Dallas, TX	Airline	In person
Texas Pneumatic Systems, Inc.	Arlington, TX	Repair station	In person
TIMCO Aviation Services	Greensboro, NC	Repair Station	In person
The Boeing Company	Renton, WA	Manufacturer	Phone
West Coast Aircraft Maintenance	Long Beach, CA	Repair station	In person

Source: GAO analysis of FAA data.

Note: Many of the companies we interviewed have repair stations in multiple locations. When possible, we sought to gather information about each of their locations or differences between locations during our interviews.

To understand the federal government's role, including funding provided for aviation-related training, and any actions government has taken to support the aviation industry and our selected aviation professions, we identified the relevant federal agencies through interviews with stakeholders, analysis of our prior reports, and a literature review. The identified agencies were: FAA, DOD, Veterans Affairs, and DOL. We interviewed officials to understand the programs each agency operates that either target the specific occupations or could be used to support the occupations. We also examined relevant programs, laws, and regulations. For DOD's aircraft–maintenance certification program and for DOL's Workforce Investment Act-supported training, the respective agencies provided us with the number of individuals that participated in or completed the program. To describe federal student aid awarded to students enrolled in aviation-related majors we analyzed data from Education's National Postsecondary Student Aid Study (NPSAS) 2011-2012—a survey of a nationally representative sample of students. NPSAS is a comprehensive study that examines how students and their families pay for higher education; data are based on administrative records and student interviews and include students who received financial aid and those who did not. Similar to our analysis of IPEDS data, we used Education's CIP categories and matched degree programs to our SOC codes of interest to identify the relevant degree programs. Unless noted, all estimates from NPSAS are within 5 percentage points.

We conducted this performance audit from February 2013 through February 2014 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: GAO Contacts and Staff Acknowledgments

GAO Contact

Gerald L. Dillingham, Ph.D., (202) 512-2834 or dillinghamg@gao.gov

Staff Acknowledgments

In addition to the contact named above, the following individuals made important contributions to this report, Andrew Von Ah, Assistant Director; Amy Abramowitz; Melissa Bodeau; Benjamin Bolitzer; Russ Burnett; Leia Dickerson; David Hooper; John Mingus; Susan Offutt; Joshua Ormond; Melissa Swearingen; and Jessica Wintfeld.