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AirMaintenance UPDATE

The Magazine for Aircraft Maintenance Professionals

The Pipeline Report: AMT workforce trends

Today's rotorcraft: a global perspective

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Boeing statement on 737 MAX software enhancement

As we went to press with this issue, the crash of Ethiopian Airlines Flight 302 in March and Lion Air Flight 610 in October 2018 dominated global headlines. It became clear something was very wrong with the airworthiness of Boeing's 737 MAX 8 — a software glitch that over-rode the pilot's manual inputs. In early March, Boeing issued the following statement:

"For the past several months and in the aftermath of Lion Air Flight 610, Boeing has been developing a flight control software enhancement for the 737 MAX, designed to make an already safe aircraft even safer. This includes updates to the Maneuvering Characteristics Augmentation System (MCAS) flight control law, pilot displays, operation manuals and crew training. The enhanced flight control law incorporates angle of attack (AOA) inputs, limits stabilizer trim commands in response to an erroneous angle of attack reading, and provides a limit to the stabilizer command in order to retain elevator authority. Boeing has been working closely with the FAA on development, planning and certification of the software enhancement, and it will be deployed across the 737 MAX fleet in the coming weeks. The FAA says it anticipates mandating this software enhancement with an Airworthiness Directive (AD) no later than April.

"A pitch augmentation control law (MCAS) was implemented on the 737 MAX to improve aircraft handling and decrease pitch-up tendency at elevated angles of attack. It was put through flight testing as part of the certification process prior to the airplane entering service. MCAS does not control the airplane in normal flight; it improves the behavior of the airplane in a non-normal part of the operating envelope. Boeing's 737 MAX Flight Crew Operations Manual (FCOM) already outlines an existing procedure to safely handle the unlikely event of erroneous data coming from an angle of attack (AOA) sensor. The pilot will always be able to override the flight control law using electric trim or manual trim. In addition, it can be controlled through the use of the existing runaway stabilizer procedure as reinforced in the Operations Manual Bulletin (OMB) issued on Nov. 6, 2018." ■

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Upcoming Events

Legend Skip Koss will be missed

A page was turned late this winter as Concorde Battery Corporation announced the passing of Edward "Skip" Koss, long time vice president of marketing and great friend of the aviation Industry. Skip was surrounded by family at his Redlands, California home March 19, 2019 at the time of his passing.

Skip, a legend in aviation and the industry's battery authority, started his aviation career at Detroit City Airport in the summer of 1949. He went on to attend Aero Mechanics High School the following Septembe. At 17, Skip passed his written exams for his FAA Airframe & Powerplant Mechanic certification but he had to wait until 18 to take his Practicals.

Skip went on to work for General Motors Air Transport section for 13 years as a licensed A&P before moving on to act as the director of maintenance for Midwestern Airlines, Omni Aircraft Sales and Sunstream Jet Center. Skip chose to accept a position as sales manager with Aero Quality Sales in 1973. There he became the industry's battery authority and helped develop the first charger analyzer.

In 1980, Skip joined Teledyne Battery Products as the Manager of OEM Sales. He then worked for Marathon Power Technology from 1983 to 1987. He ultimately joined Concorde Battery Corporation in 1987. Skip's enthusiasm for Concorde's new AGM technology led to him joining the Concorde team.

As is often the case with new technology, getting the industry to accept RG batteries was no small task because no operator wanted to be the first to prove the reliability, dependability and safety of the new technology. His longstanding relationship with Lockheed's Burbank Skunk Works facility allowed him to present lead acid batteries for a "vehicle" to replace the high maintenance nickel cadmium batteries they were using.

Lockheed emphasized their lack of interest in Concorde's batteries but, soon after, Navy batteries began to disappear from the depot and Skip had a hunch that the USAF was borrowing the stock for use on the "vehicle." The Persian Gulf War started and the F-117A Stealth became world famous. After the war, Lockheed sent Skip a letter stating that Concorde batteries were on the Stealth and thanked Concorde for the support. The US Military had found Concorde batteries to be 100 percent reliable in F-4, F/A-18, C-130, KC-135 and the renowned F-117A aircraft during the war.

This success led to additional military certifications on the T-1A and BeechJet 400A and allowed Concorde to enter into the commercial market when Skip facilitated Beechcraft's KingAir's switch from nickel cadmium to Concorde's sealed lead acid battery as original equipment. Skip's business prowess and aircraft knowledge propelled Concorde into designing drop-in replacement batteries that provide pilots and mechanics a low maintenance solution. Skip made significant developments in sales and marketing over more than 30 years of dedication to Concorde.

Skip was an active member of the International Electrotechnical Commission (IEC) and the FAA Aerospace Committee for the development of US aircraft battery specifications. Skip's contributions to the industry were recognized in 2009 when he was awarded the Charles Taylor "Master Mechanic" Award by the Federal Aviation Administration.

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www.nbaa.org

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Rivet-working tools are designed for MRO

Chicago Pneumatic has launched a new series of rivet squeezers and hammers developed exclusively for the aerospace maintenance, repair and operations (MRO) market. The CP42 series comprises ergonomic squeezers and lightweight rivet hammers, which are ideal for key tasks in the metal structure repair of aircraft. The CP42 series includes six models of squeezers. A swivel air inlet provides added flexibility so the user can easily maneuver the squeezer into the right position. There are seven models of compact rivet hammers in the CP42 series starting from just 2.3 pounds (1 kg) in weight and they are available in a wide range from 1X for the smallest rivets up to 9X for the larger rivets. **For information visit** www.cp.com

New battery reduces cost per flight

FAA STC SR00917DE has been approved to install Concorde Battery Corporation's Platinum Series RG-292-102 (17Ah) or RG-292-103A (24Ah) on Sikorsky Aircraft S-92A helicopters. Concorde developed the RG-292 batteries as a replacement for the original Ni-Cd battery. Upgrading to the Concorde lead acid battery reduces cost per flight hour and reduced maintenance requirements. Concorde's RG-292-102 and RG-292-103A do not require watering and pose no risk of thermal runaway. The advanced lead acid technology of Concorde batteies facilitate instant spooling of the engines upon starting. **For information visit** www.concordebattery.com

Warranty doubled on new windshield installs

Twin Commander Aircraft is offering owners significantly extended factory warranty on replacement windshields purchased and installed through a Factory Authorized Service Center. Effective immediately, all new windshield purchases and installations completed at one of 14 Factory Authorized Service Centers worldwide will come with a 36-month pro-rata warranty. This coverage is almost double the amount of the previous warranty. The extended warranty is only applicable if the windshield was installed by a Factory Authorized Twin Commander Service Center. **For information visit** www.twincommander.com

Turbine oils meet new specification

Eastman Aviation Solutions offers a complete range of standard and high-performance turbine oils, including Eastman Turbo Oil (ETO) 2197 (MIL-PRF-23699 HPC), ETO 2380 (MIL-PRF-23699 SPC), and ETO 2389 (MIL-PRF-7808). They also offer high-load engine/transmission Eastman Turbo Oil 25 (DOD-PRF-85734). The latest advanced helicopter transmission oil Eastman HALO 157 is approved to meet the needs of the new MIL-PRF-32538 specification.

For information visit www.eastman.com

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The Page Industries P400K 400 Hz power cable test kit is a comprehensive kit every GSE professional needs. This kit allows for verification of the 400 Hz cable's retention force on each power and control pin, surface temperatures, accurate no-load testing and confirming E&F safety interlock, voltages and phases are correct.

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BOMBARDIER LAUNCHES NEW 50-SEATER

Early this winter Bombardier launched its new CRJ550 aircraft, which the company says is the first triple-class 50-seat aircraft in the world and is based on the CRJ700. United Airlines is the launch customer of this new model. The CRJ550 features a self-serve beverage and snack station and more overall legroom per seat than any other 50-seat aircraft flown by any U.S. carrier, says Bombardier.

HARTZELL ADDS TO TOP PROP PROGRAM

Hartzell Propeller has added replacement propellers for twin-engine Piper Navajo and Navajo Chieftains to the company's Top Prop lineup. The program covers Piper PA31 Navajo aircraft with TIO-540-A2 series engines, Piper PA31-325 Navajo C/R, and PA-31-350 Navajo Chieftains. As part of the Top Prop program, these propellers carry a warranty that covers 2,400 hours or six years, whichever occurs first.

P&WC APPOINTS PORTAGE AIRCRAFT AS DMF

During February's Canadian Aerial Applicators Association (CAAA) Conference & Tradeshow, Pratt & Whitney Canada announced it has appointed Portage Aircraft Maintenance Ltd. as its first Designated Maintenance Facility (DMF) in Canada. Based in Portage la Prairie, Manitoba, this new DMF will offer line maintenance and Mobile Repair Team (MRT) services for PT6A-11AG, -15AG, -34AG, -60AG, -65AG, -67AG and -140AG engine models, which power the world's most popular agricultural aircraft.

Portage Aircraft Maintenance provides a range of maintenance and repair services through its 8,400 square foot, climate-controlled maintenance facility. Portage Aircraft Maintenance also has a 3,100-foot paved runway for the convenience of its customers.

BOEING 727 JET ALSO HAD A TERRIBLE START

News agency Reuters says that as Boeing and global airlines work to restore public confidence in the 737 MAX after two deadly crashes, they will have a playbook they can use. This is not the first time that Boeing has faced a crisis after launching a new plane with innovative technology. In 1965, three Boeing 727-100 passenger jets crashed in less than three months in the United States while coming into land, killing a total of 131 people. Like the 737 MAX, the three-engined 727 was billed as one of the most advanced aircraft of its time. Boeing introduced the 727 in 1964 and portrayed it as a more efficient alternative to the standard four-engine jets of the day, with new features designed to make the 727 easier to operate from short airfields.

The 727's wing flap system, which provides extra lift at low speeds, was unusually large and sophisticated, which allowed the plane to descend more quickly than other rivals and avoid buildings and other obstacles close to runways. Investigators looking into the crashes discovered that some pilots did not fully understand the flap system and were therefore allowing the planes to descend at too great a speed.

Boeing made some modifications to the flight manual and to the procedures for flying the airplane on final approach. In the case of the 737 MAX 8, Boeing is working on software and training updates.

BELL 525 ENGINE RECEIVES FAA CERTIFICATION

The newest member of GE's CT7 engine family, the CT7-2F1, achieved type certification by the Federal Aviation Administration. This milestone is a big step forward for entry into service of the CT7-2F1-powered Bell 525 Relentless, the world's first fly-by-wire commercial helicopter, designed to operate safely and reliably in austere environments and with decreased pilot workload.

The CT7-2F1 engine incorporates GE's CT7/T700 engine family, with more than 100 million flight hours of experience on civil and military turboshaft and

turboprop aircraft. The 2000 SHP-class turboshaft will provide the Bell 525 Relentless with up to 2129 SHP for emergencies and 1979 SHP for takeoff. The aircraft is designed to support customers in various mission configurations including oil & gas, search & rescue, helicopter emergency medical services and VIP/corporate transport.

SIKORSKY INTRODUCES S-92A+ AND S-92B HELICOPTERS

In early March, Sikorsky, announced new plans for its S-92 helicopter line that will re-designate fielded helicopters as the S-92A+ after modification, and newly produced aircraft as the S-92B. The two variants will share a nearly identical configuration, with S-92B helicopters also featuring enlarged cabin windows and plans for a common cabin door suitable for offshore and SAR configurations. The announcement came at the 2019 Helicopter Association International Heli-Expo show.

These changes to the S-92 helicopter will introduce new technology that is focused on reliability, operating cost reduction, and time-delivering increased capabilities. Changes will increase commonality of the aircraft between the offshore, SAR, and utility configurations and allow for speedier reconfiguration between roles. Sikorsky expects to launch an hourly aftermarket support program concurrent with deliveries. General Electric's CT7-8A6 engine, capable of producing more power in higher altitudes and hotter temperatures, also will be available as an option for both the S-92A+ and S-92B products.

BOMBARDIER CONCLUDES SALE TO CAE

Bombardier has now concluded the sale of its flight and technical training activities to CAE, for an enterprise value of $645 million. Net proceeds are expected to be approximately $500 million after the assumption of certain liabilities, fees, and closing adjustments.

Bombardier and CAE also agreed to continue their Authorized Training Provider (ATP) relationship pursuant to which CAE carries out the training activities for Bombardier Business Aircraft, including from the training centres located in Montréal and Dallas.

CITATION'S MOST DELIVERED MIDSIZE BUSINESS JET

Textron Aviation's Citation aircraft were the most-delivered business jets of 2018 according to the annual shipment and billings report published by the General Aviation Manufacturers Association (GAMA). Textron Aviation delivered 188 business jets – including 57 Cessna Citation Latitude aircraft – winning the midsize segment for the third consecutive year and outselling its closest competitor four to one. Textron Aviation's Citation aircraft were the most-delivered business jets of 2018 according to the annual shipment and billings report published by the General Aviation Manufacturers Association (GAMA). Textron Aviation delivered 188 business jets – including 57 Cessna Citation Latitude aircraft – winning the midsize segment for the third consecutive year and outselling its closest competitor four to one.

In 2018, the midsize jet earned certification in Australia and China and today, the aircraft is certified in 43 countries. The worldwide fleet has amassed more than 150,000 flight hours since entering service in 2015. The jet's takeoff field length of 3,580 feet provides greater access to airfields usually reserved for smaller aircraft. ■

The Pipeline Report:

It's no secret there's a shortage of new talent entering the aircraft maintenance profession. A recent American study (with Canadian implications) reports on the issue.

Opposite page and above: Demand estimates intensified by the anticipated replacement deficit suggest AMTS will need to increase production by 30 percent in the next 20 years. The workforce bleed appears to be clotting.

an industry shortfall

Each year the Aviation Technician Education Council (ATEC) compiles information about Federal Aviation Administration (FAA) airframe and powerplant (A&P) mechanic certificate holders, the aviation maintenance technician schools (AMTS) that prepare the majority of those individuals for careers in aviation maintenance, and the companies that employ maintenance professionals.

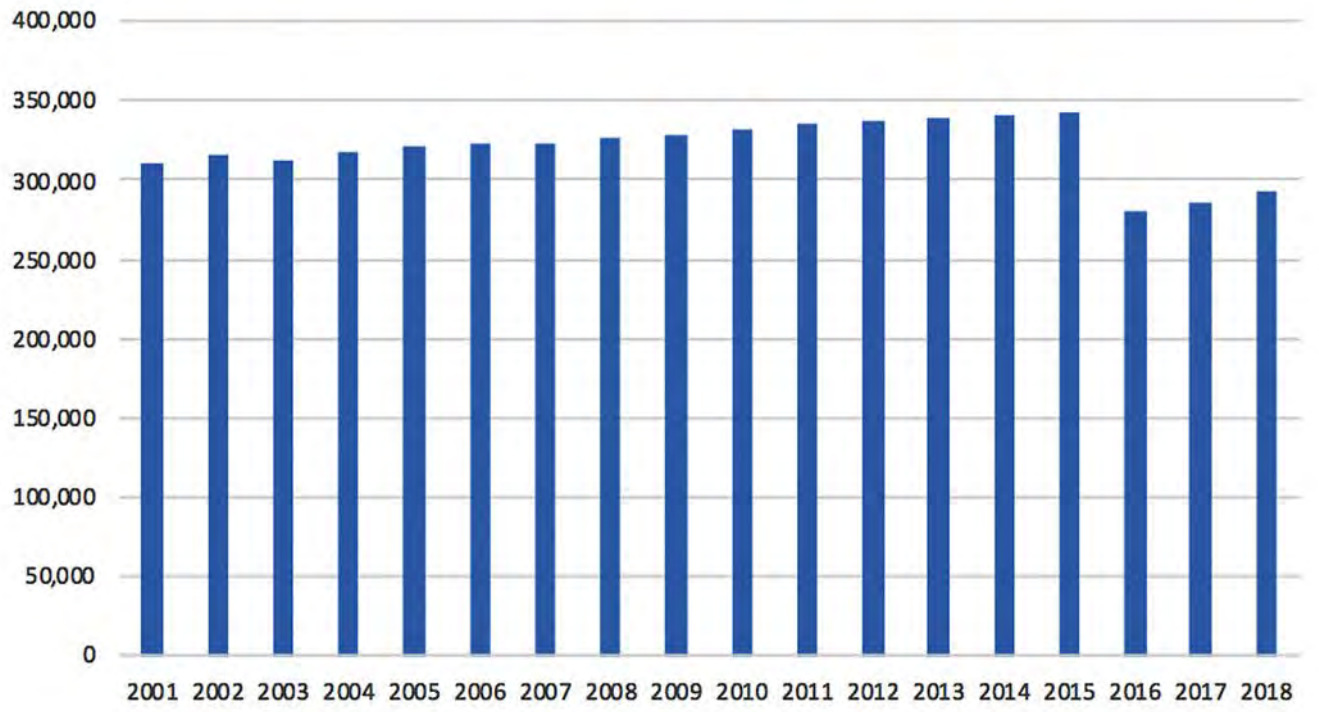
These compilations are published annually as "The Pipeline Report." The purpose of the report is to identify workforce trends and propose some solutions to help meet the growing workforce demand.

Although the report is based on the American workforce, there are numerous similarities to the Canadian model (relative to the respective populations of the two countries) to which Canadian AMEs will be able to identify.

AMTS data was gathered through an ATEC-conducted survey of educational institutions holding an FAA certificate. In total, 57 percent of all FAA-certificated AMTS participated in the questionnaire. Ninety-four percent of respondents submitted complete answers used to compile this report.

The information in this report is based on data available as of November 15, 2018.

Figure 1: Active FAA Mechanic Certificates



The report's key conclusions

1. Mechanics continue to retire faster than they are being replaced. ATEC's model projects that the mechanic population will decrease 5 percent in the next 15 years. New entrants make up 2 percent of the population annually, while 30 percent of the workforce is at or near retirement age.
Meanwhile, forecasts by the U.S. government and Boeing project a need for thousands of additional mechanics in the next 10-20 years.

2. Schools have the capacity to help close this gap. Right now, only 1 in 2 seats in technical schools are taken, meaning that an additional 17,000 students can be accommodated without any school expansion. While institutions are ramping up recruitment activities and expect enrollment to increase, there is significant opportunity for industry employers to help define career paths and attract more students into the pipeline.

3. In 2017, the number of students choosing non-aviation jobs over their aviation counterpart dropped by nearly half over the previous year. More good news: seventy percent of A&P students are taking the FAA mechanic exam upon graduation, a 10-point increase over the previous two years.

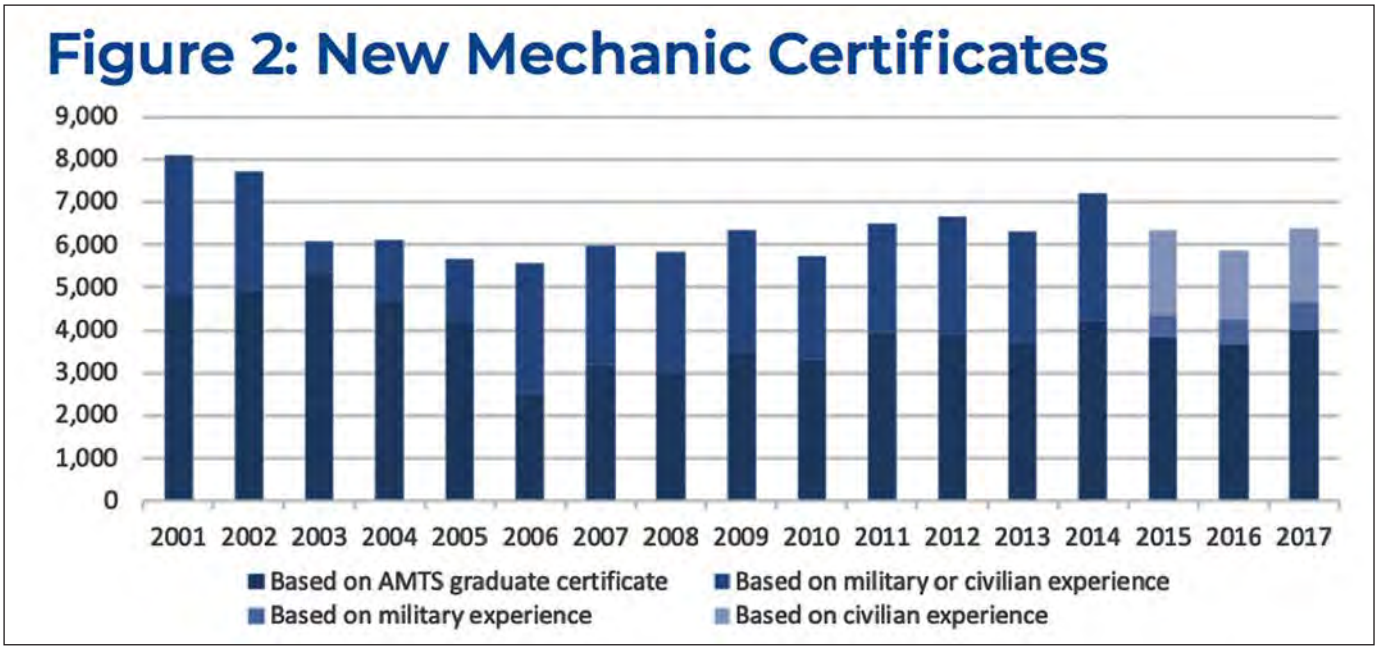
4. AMTS are facing their own workforce challenges. Hiring and maintaining qualified instructors is the number one threat to increased enrollments. Negative perceptions and a lack of career awareness is also adversely impacting student recruitment efforts, suggesting the time is ripe for development of a national campaign to increase knowledge and understanding of aviation technical careers.

Mechanic Population

The FAA airman database includes 292,730 certificated mechanics. Females make up 2.4 percent of the population, a statistic that has barely moved in the last 15 years.

The FAA does not track whether mechanic certificate holders are working within the U.S. or actively performing maintenance. Certificated mechanics are removed from the airman database only when the agency receives notification of death, the certificate is suspended or revoked, or the mechanic turns 90 years of age. Therefore, the number of active mechanics is likely significantly lower than the number derived from the data source.

Factoring out administrative adjustments made in 2016, the number of certificated mechanics has steadily increased 1-2 percent a year since 2001. The trend is not expected to continue with an anticipated exodus of seasoned maintenance professionals fast approaching. Of the 6,401 mechanics certificated in 2017, 63 percent obtained certification based on completion of an AMTS program, 10 percent based on military experience, and 27 percent based on civilian experience. That distribution has been fairly consistent since the FAA started tracking the breakdown in 2015.



Employer Personnel Demographics

While the airman database is an important source of information for identifying and analyzing mechanic population and pipeline trends, a more accurate representation of the current workforce may be derived from analysis of air agency employee reports. Forty-one percent of all FAA mechanic certificate holders — 121,290 individuals — are accounted for in FAA databases reporting employees that work in general aviation, or for repair stations, air carriers, or AMTS. Certificated mechanics make up 33 percent of the aviation technical personnel working in these segments. Of the certificated mechanic subset, half are employed by repair stations. Certificated mechanics make up 82 percent of the air operator maintenance workforce, 21 percent of the repair station workforce, and 88 percent of the general aviation workforce.

The Gray Wave

The average age of an FAA mechanic is 51, nine years older than the median age for a U.S. worker as reported by the Bureau of Labor Statistics. Thirty percent of the mechanic population is age 60 or above — up 3 percent from a year ago.

Figure 3: Reporting Segment Personnel Demographics

SOURCE: FAA DATA DOWNLOAD FOR REPAIR STATIONS AND AIR OPERATORS

New entrants are not keeping pace with retiring personnel. Year-over-year, newly certificated mechanics make up only 2 percent of the entire population. Using the 10-year average rate of change for new mechanics (1.1 percent), and assuming an average retirement age of 65, departing mechanics are expected to outpace entering mechanics 4:3 through 2037. Using this model, the mechanic population is expected to decrease 4.25 percent by the year 2037.

Population and enrollment

FAA-certificated AMTS produce the majority of new mechanics. There are 177 active part 147 certificates listed in the FAA maintenance school database; of those, approximately 172 schools are enrolling students. The number of certificated schools has trended up, increasing 6 percent over the last ten years.

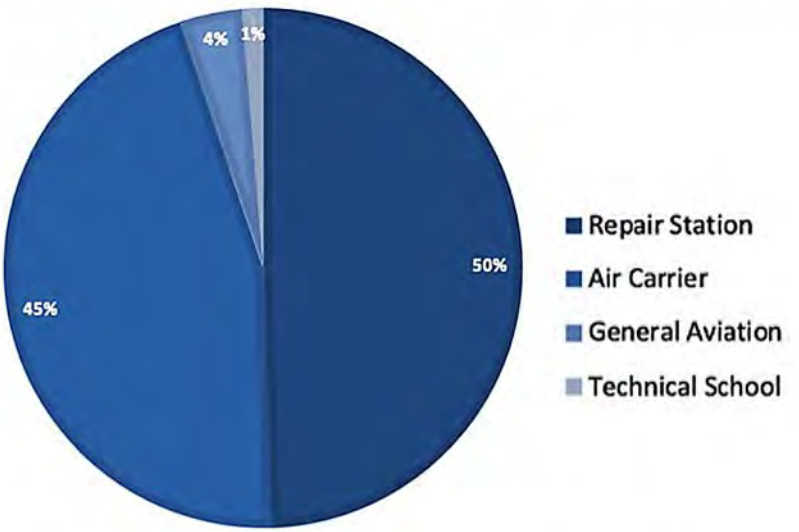
According to FAA data, total AMTS enrollment capacity is 34,769, up 4 percent since 2014. The agency reports total current enrollment for all A&P programs at 17,872, a decline of nearly 2 percent since 2014. Using FAA numbers, the AMTS student enrollment load factor is 51 percent.

Schools responding to the ATEC survey reported 7 percent higher enrollment than what is reflected in agency databases, suggesting the actual AMTS load factor is closer to 55 percent. Even with the adjustment, enrollment and capacity has remained relatively flat over the last five years.

The majority of respondents anticipate 2018 graduate output to increase 10 percent over the previous year, and another 11 percent in 2019. Anticipated enrollment is also expected to grow—87 percent of participating schools said as much, estimating new entrants would increase by an average of 40 percent.

When asked about the driver for enrollment predictions, the majority of respondents pointed to changing market demands and increases in student-recruitment activities. Those that selected "other" cited program capacity limitations. When asked about the most concerning threat to their technical programs, AMTS pointed first to hiring and retaining qualified instructors,

Figure 4: Certificated Mechanic Employers



SOURCE: FAA DATA DOWNLOAD FOR REPAIR STATIONS AND AIR OPERATORS

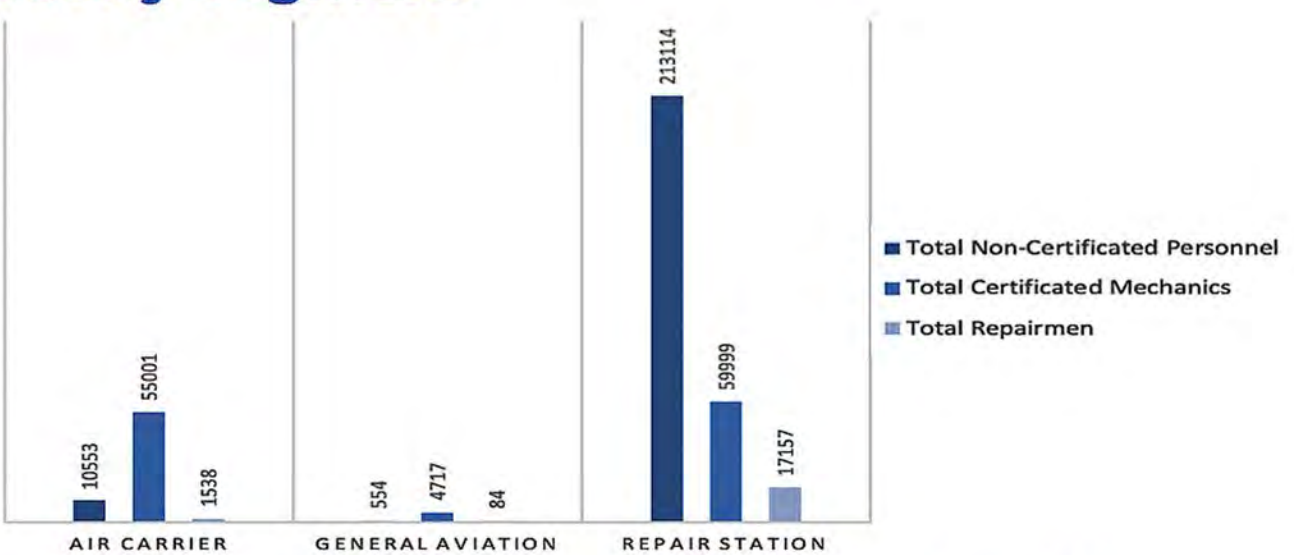
then to limited access to training equipment. What was historically the top threat—inaccessible program funding—came in fourth.

The number one reported challenge to recruit, accept, retain or graduate technical program students is insufficient student soft skills (i.e., attitude, communication, work ethic, time management, etc.). Second on the list of recruitment challenges: more than half of respondents cited program awareness, and nearly a third pointed to negative public perception about aviation maintenance careers

Demographics

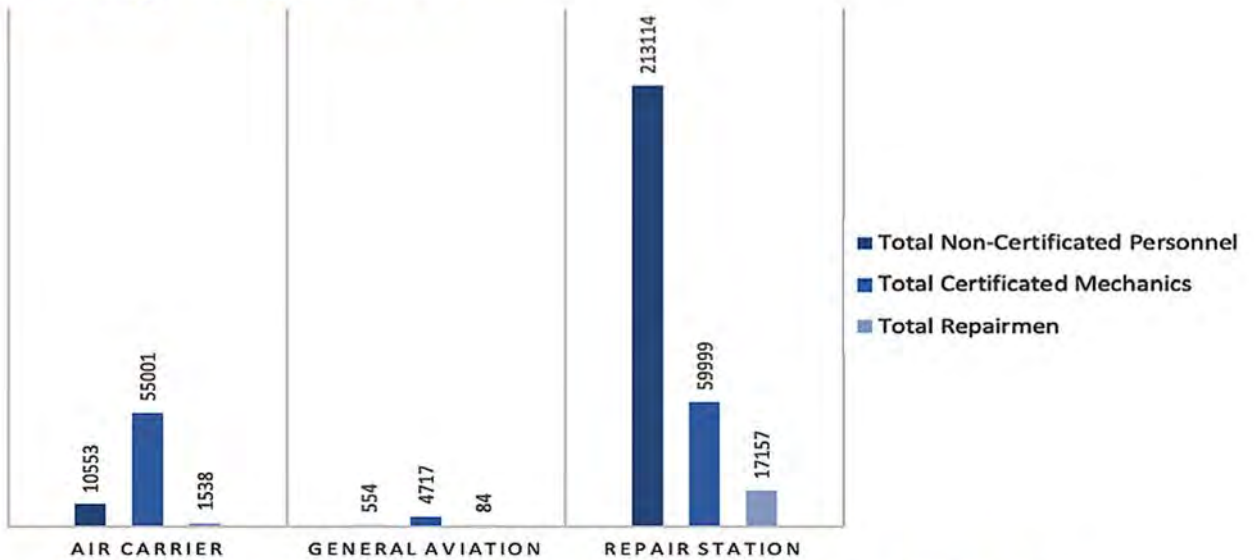
The vast majority of educational institutions with A&P programs—nearly 80 percent—are public institutions. While private schools make up only 21 percent of the population, they enroll 36 percent of all A&P students. A few schools dominate overall enrollment. Thirty-four percent of all A&P students are enrolled at the 10 largest institutions. The AMTS community is therefore composed

Figure 5: Personnel Demographics by Industry Segment



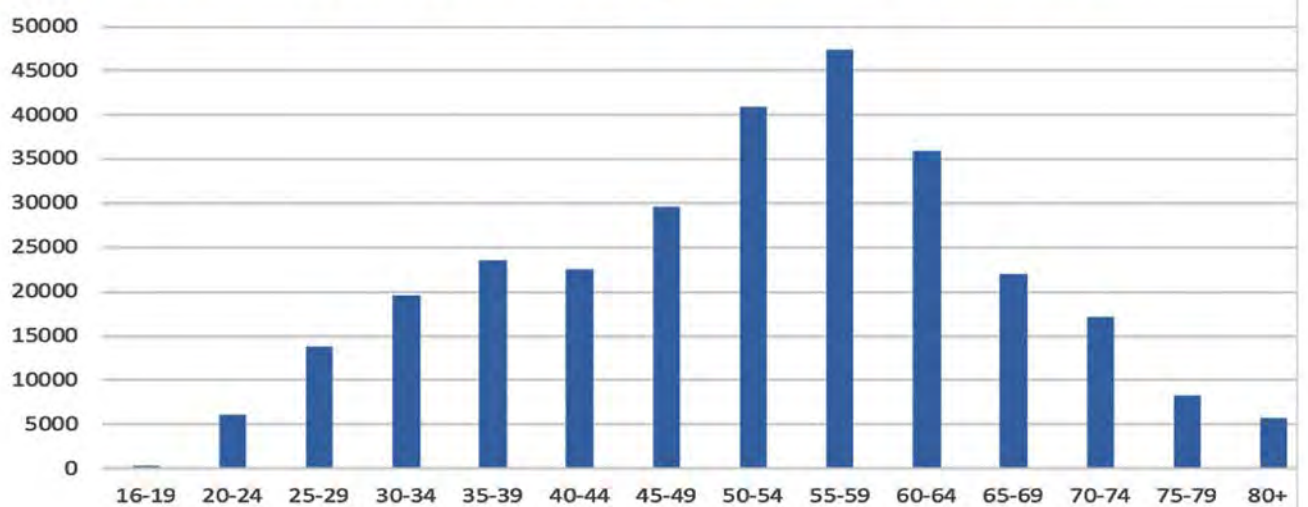
SOURCE: FAA DATA DOWNLOAD FOR REPAIR STATIONS AND AIR OPERATORS

Figure 5: Personnel Demographics by Industry Segment



SOURCE: FAA DATA DOWNLOAD FOR REPAIR STATIONS AND AIR OPERATORS

Figure 6: Mechanic Age Distribution



SOURCE: FAA AIRMEN CERTIFICATION BRANCH

mostly of smaller institutions, with half of AMTS reporting 50 or fewer enrollments. Forty-eight percent of A&P students reside in New York, Florida, Texas or California.

Programs, Degrees Offered, and Graduates

To meet the growing demand for specialized services, more than a third of AMTS provide stand-alone, aviation-related programs outside its A&P program, including avionics, unmanned aircraft systems, composites, welding, non-destructive testing, and sheet metal.

While almost all schools offer graduating AMTS students a diploma or certificate, nearly 70 percent of institutions couple the program with an Associate's degree. Survey respondents reported an average graduation rate of 73 percent for A&P students. The average age of an A&P graduate is 25. Twenty-two percent of graduates are veterans and 8 percent are female. Of those eligible for placement, 63 percent of graduates had a job offer upon graduation. New AMTs are willing to relocate for their careers. Of those with a job offer upon graduation, nearly 35 percent moved outside the school's geographic location. The number of students securing employment in other industries continues to decrease; AMTS respondents estimate that only 13 percent of 2017 graduates took jobs outside aviation.

When asked what the most significant barrier was for a graduating student to obtain a mechanic certificate, 50 percent of respondents cited testing costs. Another testing deterrent was the lure of opportunities that do not require a mechanic certificate as a condition of employment. Respondent comments suggested that in many instances, jobs not requiring an A&P had more competitive compensation packages.

Conclusions and Projections

The overall mechanic population is expected to drop over the next two decades. Even if an anticipated increase in enrollments comes to fruition, supply will not meet projected demand. The Bureau of Labor Statistics estimates aviation maintenance career opportunities will grow 5 percent in the next decade, amounting to 12,400 new job openings.

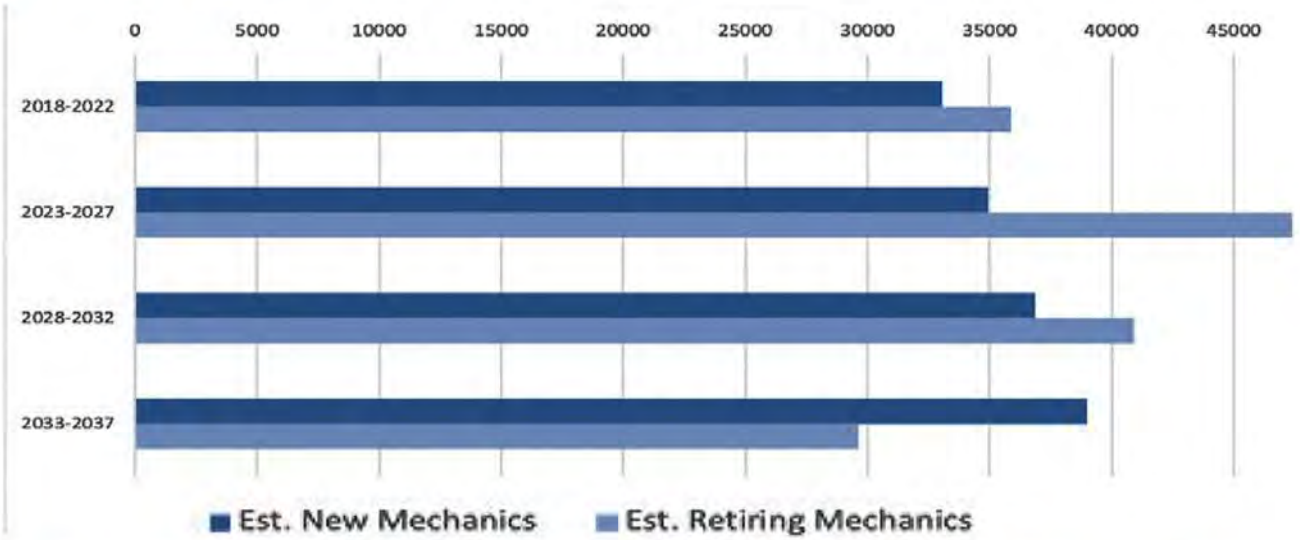
The Boeing Company estimates are more drastic; the company predicts that the commercial, helicopter and business aviation industries combined will require 189,000 new technicians by 2037 in North America alone.

Demand estimates intensified by the anticipated replacement deficit suggest AMTS will need to increase production by 30 percent in the next 20 years.

Eighty-seven percent of participating schools said they expect enrollment to increase next year, by an aggressive 40 percent. The optimism has markedly increased since the 2015 survey, when only 55 percent of respondents shared that same expectation.

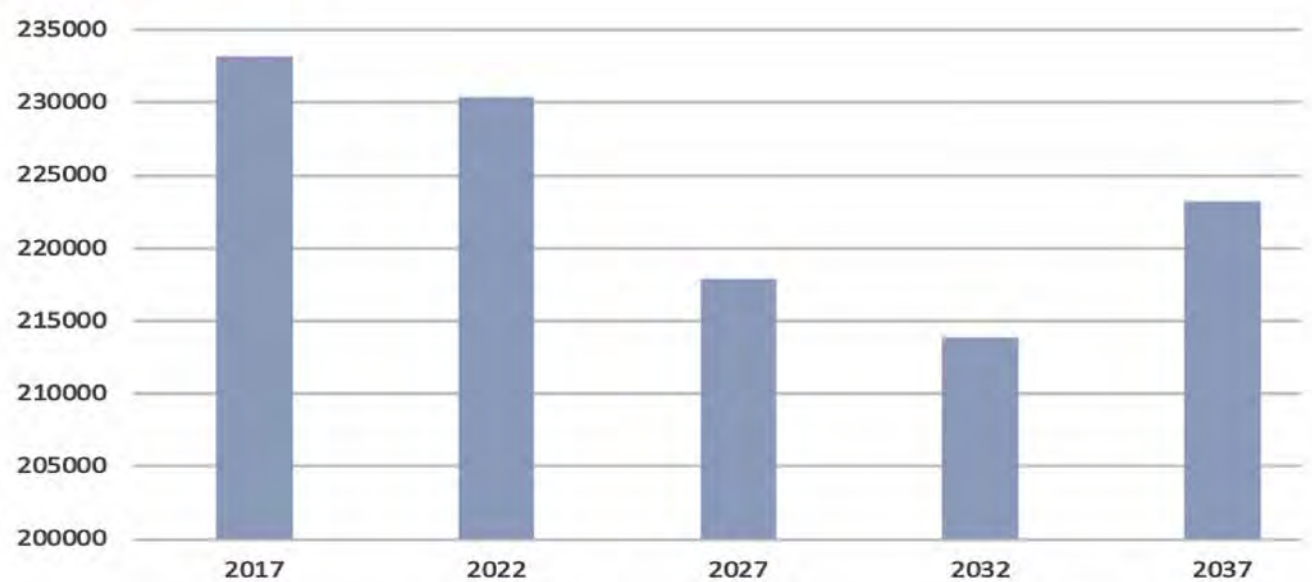
In 2017, 83 percent of respondents said they expect enrollment to increase. While it appears, based on FAA authorized enrollment numbers, that A&P programs have the capacity to almost double enrollment, that possibility is largely

Figure 7: Estimated New vs. Retiring Mechanics



SOURCE: FAA AIRMAN CERTIFICATION

Figure 8: Estimated Mechanic Population (Age < 65)



dependent on the community's ability to overcome limiting factors, such as keeping pace with an anticipated increase in demand for instructors.

The workforce bleed appears to be clotting. For the last two years, the number of A&P students taking jobs outside aviation has dropped. This year, schools report that of those with offers upon graduation, only 13 percent took a job outside aviation. The percentage is much improved over the 25 percent reported in 2015 and 2016, and 20 percent in 2017. Partnership programs between AMTS and industry are on the rise, suggesting that the community is doing a better job of defining career paths for students, and consequently, retaining future aviators already in the pipeline.

Among the takeaways from previous reports was the stat that only 60 percent of A&P candidates — those already in the aviation career pipeline — pursue a mechanic certificate. That number was consistent in 2016 and 2017, but in 2018, schools reported an uptick: 70 percent of A&P grads elected to take the FAA test for mechanic certification. Combatting top deterrents — including testing costs and access to mechanic examiners — should be the focus of industry-education partnerships looking to capitalize on the momentum.

When asked about challenges impacting a school's ability to recruit students into its program, more than half of respondents cited program awareness, and nearly a third pointed to negative public perception about aviation maintenance careers. Smaller schools—which make up the majority of AMTS — are less likely to implement their own marketing campaign to sell aviation technical programs and post-graduation career opportunities. A national campaign to support local recruitment efforts could alleviate some of these barriers.

ATEC survey results support the common assertion that industry-education partnerships are one of the best recruitment tools for careers in maintenance. The trade association will therefore continue to support development of strategic partnerships.

In 2019, ATEC will hold its third employer-educator networking event in conjunction with the annual conference. The Employer Link provides an opportunity for recruiters and workforce development personnel to network with instructors and administrators and forge new relationships. The reception (which follows ATEC's first ever student career fair) supplements an annual conference agenda chock-full of best practices, tools and resources to support industry-education partnerships.

ATEC is also facilitating a new industry-led initiative, Choose Aerospace. The campaign is a partnership of aerospace stakeholders joined together to address one of the biggest threats to continued industry growth: the availability of a diverse, qualified technical workforce.

The initiative aims to unite companies, associations, labor unions, and educational institutions; to spur interest in aerospace careers; and to identify and implement solutions to the aerospace workforce shortage. To get involved, visit www.chooseaerospace.org.

For more information about ATEC activities and initiatives addressing several other issues identified in this report, visit www.atec-amt.org. ■

ATLANTIC

Atlantic AME Association

Aviation labour market information

CCAA released an Aviation Labour Market Study in March 2018. The market study was derived through Aviation Industry surveys and company interviews. In the survey that was conducted in 2017, there were 132 respondents, representing 39,000 workers or 40 percent of the Air Transport sector — which is about 25 percent of the total industry. The results of the survey indicated a projected shortage of 55,000 people for all sectors of the industry by 2025.

AMEs and Technicians
The industry will need a minimum of 5,300 new aircraft maintenance mechanics by 2025 to keep up with the current industry growth (30 percent) and retirements (70 percent). The present specific college programs graduate ap- proximately 600 maintenance technicians per year plus 150 from Avionics program and 130 from the Struc- tures Technician program.

Wages
The annual average starting hourly wage is $23.80 and the annualized wage is $49,504 per year.

New technology and skill sets
The CCAA and a consortium of companies are developing an innovative training program, which combines skills for maintenance technicians with those of Avionics and Interior Technicians, together with soft skills and business skills to deliver a "Multi Disciplinary Technician."

Education
Employees with post-secondary education make up the majority of the Aviation and Aerospace industry with 72.3 percent, compared to 53.4 percent in the average Canadian workforce.

Gender distribution
The industry gender distribution is 69.8 percent male and 30.2 percent female. (The average for the Canadian workforce is 48.8 percent male.) Occupations with critical shortages have even fewer women, with only 6 percent of the mechanics and 7 percent of the pilots being female.

Age distribution
6.5 percent of the Aviation and Aerospace industry are 25 years or younger, 47.9 percent are between 25 to 45 and 45 and older is 44.4 percent.

Occupations most in demand
It is expected that 7,300 air pilots, flight engineers and flying instructors and 5,300 aircraft mechanical persons will be needed in the next five years.

Drivers of employment demand
It is expected that the National Aviation industry will expect to see a 9 percent growth rate in Air Transportation and 8 percent in support activities. Air Transportation refers to transportation of freight and persons via aircraft by scheduled or non-scheduled service.

Equipment growth
Airbus and Boeing continue to rise and expect an annual rate of close to 2 percent growth until 2024. On the other hand, Bombardier rose in 2017 and is expected to decline afterwards.

www.atlanticame.ca

CENTRAL

Central AME Association

About CAMEA

The Central Aircraft Maintenance Engineer Association is an organization dedicated to maintaining and enhancing the standards, rights and privileges of all AME members in the central region of Canada. Our chapter is one of six similar associations across Canada that collectively supports the national body CFAMEA (Canadian Federation of Aircraft Maintenance Engineers Association). Our organization works with Transport Canada in the formulation of new rules and regulations and provides a collective viewpoint for all AMEs. CAMEA is a not-for-profit organization run by a volunteer group of AMEs. We elect members of our organization to be part of our Board of Directors. Members of CAMEA are comprised of AMEs, AME apprentices, students, non-licensed persons working in the industry and corporate members.

www.camea.ca

Western AME Association

Summary of 2018 Enforcement Findings

June 2018

- A Company operated an aircraft when it was not maintained in accordance with a maintenance control system which was described in the air operator's maintenance control manual (MCM) required by section 706.08 Penalty $5,000
- A Company, without authorization by the Minister in writing, failed to comply with the policies and procedures contained in its Maintenance Control Manual. Penalty: $1,688
- Another Company, without authorization by the Minister in writing, failed to comply with the policies and procedures contained in its Maintenance Control Manual. Penalty: $5,000

July 2018

A person failed to ensure that the required maintenance details were entered in the appropriate technical record. Penalty: $5,000

August 2018

A person conducted a take-off in an aircraft when maintenance performed on the aircraft had not been certified. The person also failed to record, at the required time, the required particulars in the aircraft journey log in violation of CAR 605.85(1) and CAR 605.94(1) Penalty: $8,000

September 2018

- A person knowingly made false representation for the purpose of obtaining a Canadian aviation document or any privilege accorded thereby. Penalty: 30 days license suspension.
- Another person knowingly made false representation for the purpose of obtaining a Canadian aviation document or any privilege accorded thereby.

Penalty: 60 days licence suspension

November 2018

A company failed to implement a training program to ensure that persons authorized to perform or supervise the performance of any function under Subpart 573.06(1) are trained in respect of the regulations, the standards and the AMO procedures applicable to that function. Penalty: $3,750

www.wamea.com

AME Association of Ontario

c/o Skyservice F.B.O. Inc., PO Box 160, Mississauga, Ontario L5P 1B1
tel: 1-905-673-5681 fax: 1-905-673-5681
email: association@ame-ont.com website: www.ame-ont.com

AMEC/TEAC: The first steps

The presidents and some senior members of the regional AME associations have been getting together by telephone conference and email to continue the process of transforming the Canadian Federation of AME Associations (CFAMEA) into the new AMEs of Canada (AMEC/TEAC) organization. The process is important to ensure that the national organization can become a strong united voice for AMEs, while ensuring that the regional associations will continue at the "grass roots" level to serve AMEs throughout the country. Word of the initiative is spreading through several aviation magazines as well as through internet connections. A video addressed to AMEs across the country from President Sam Longo is available at https://ame-ont.com/new-page.

There has been a sudden realization that the shortage of workers in aviation is not just for pilots. The training and the associated experience requirements for maintenance personnel takes considerably longer and is more intensive than the other positions in aviation. Filling these positions is a high priority for any company seeking to expand or even to maintain status quo.

With this increased demand for quality professional aircraft maintenance personnel comes an increased anticipation for a greater respect for our profession. The formation of a strong association will help achieve this requirement. The association will also be able to attract young people to an occupation that should be seen as that of a highly skilled professional.

Save the Date for the 2019 AME Association of Ontario Conference

This year's conference dates will be Wednesday, September 11 to Friday, September 13.

Our turnout from last year's conference was great and we are looking forward to seeing you all again! We also encourage you to spread the word to friends, mentors and peers within the aviation community to let them know that everyone is welcome to attend, not only AMEs.

We are, as always, excited to be putting together another great show with a variety of technical presentations that will appeal to everyone, no matter their expertise.
If you have any suggestions or questions regarding the upcoming conference, or feedback from the 2018 conference, please send us a note! Our email is: association@ame-ont.com

— Submitted by Stephen Farnworth
For the Board of Directors

PACIFIC

Pacific AME Association

www.pamea.ca

About Us

PAMEA is a non-profit association comprised of aircraft maintenance engineers, aircraft maintenance personnel and aviation industry corporate members. PAMEA is an active member of the Canadian Federation of AME Associations (CFAMEA).

Mission Statement

The Pacific AME Association promotes and protects the professionalism of the AME, while developing, maintaining and improving our relations with regulatory bodies affecting our industry. We represent the views and objectives of our members, while promoting proficiency through educational collaboration with other groups on matters of mutual interest.

CENTRAL OHIO

Central Ohio PAMA

COPAMA Board Meeting

www.copama.org

The Board met at the C.S.C.C. Aviation Maintenance Technology facility at Bolton Field and selected to following officers for 2019:

- President - Joe Lippert
- Vice President - Charles Jenkins
- Treasurer - Earl Redmond
- Secretary - Gene Sprang

Board Member Dave Fragale asked to be replaced on the board and Stephen Brown was asked to be nominated, accepted and was elected to serve the final year of Dave's term. Stephen was included in the 2016 Election Ballot and we thank him for his willingness to serve on the COPAMA board. Many thanks to Dave for his time on the COPAMA Board, and his many years of service as the COAGO Chairperson.

Scholarship Report

There are five applicants for the 2019 COPAMA Scholarships and the board agreed to fund all those requests. There are still a few 2018 and 2017 awards to be paid out as those technicians complete their training and complete their FAA testing.

2019 Maintenance Symposium

The Ohio Aviation Maintenance Symposium (OAMS) will again be held at the Columbus State Community College downtown camps on Thursday, March 14th. Notices will go out for the 23 Vendor Booths during January and the price will not change from last year ($175.00).

Central Ohio Aviation Golf Outing 2019

Friday September 6, at the Willow Run Golf Course, Rt 161 and 310 near Pataskala, Ohio.

SOCAL

PAMA SoCal Chapter

2019 Chapter Scholarships

(www.SoCalPAMA.org)

A&P Student Scholarship A&P/IA Continuing Education Scholarship
Deadline: April 1, 2019

Awards Presentation: June 11, 2019
Open to all Southern California residents currently enrolled in good standing in an accredited A&P or IA Training School/Program.

www.socalpama.org

PAMA Dallas – Fort Worth

About us

The DFW Chapter of PAMA is a non-profit association dedicated to promoting professionalism and recognition of the Aviation Maintenance Technician through communication, education, representation and support, for continuous improvement in aviation safety.

Since 1997 we have been coming together for a day of golf and fun in support of our local aspiring Airframe & Powerplant mechanics! Our annual PAMA DFW Golf Classic is a charitable event whose proceeds benefit scholarships for students pursuing a career in Aviation Maintenance at Tarrant County College. The chapter partners the Tarrant County College Foundation to offer a full scholarship to at least one student every year.

However, this goes beyond just the classes leading to the Airframe and Powerplant certificate. The scholarship pays for the tuition, student fees, textbooks, and all of the FAA examinations (written, oral and practicals). These are all accomplished at Tarrant County College Northwest Campus, Aviation Department.

The cost for a full scholarship is approximately $6,500. A selection committee set up by the college chooses the winner of the merit-based scholarships. The scholarship is open to anyone who meets the criteria.

Since the Foundation began administering this scholarship in 2009 we have collected over $97,000 and awarded 16 full scholarships. These successes are possible with the support of our aviation community, so we are always looking for hole sponsors and major raffle donors to support this just cause.

Our mission to educate, train, and provide encouragement to our industry's aviation technicians does not waiver.

www.pamadfw.com

Today's rotorcraft:

Honeywell forecasts 4,000 new civil helicopter deliveries over next five years.

Opposite: In North America, helicopter purchase plans are stronger from law enforcement and oil and gas operators in this year's survey, but significantly lower from corporate operators. Above: Latin American respondents favored light single-engine models.

a global perspective

In its 21st annual "Turbine-Powered Civil Helicopter Purchase Outlook" published in early March of this year, Honeywell forecasts 4,000 new civilian-use helicopters will be delivered from 2019 to 2023, marginally lower than the 4,200 cited in the five-year forecast from 2018.

"Despite positive impacts of U.S. tax reform on new helicopter purchase plans in North America, an inconsistent economic outlook for international markets has resulted in lower purchase plans worldwide from fleet managers when compared with a year ago," said Heath Patrick, president, Americas Aftermarket, Honeywell Aerospace. "Honeywell remains focused on bringing innovation to the market by delivering avionics, monitoring systems and Connected Helicopter technologies that boost a platform's efficiency and availability."

Key survey findings this year include:

1. About 20 percent of survey respondents in North America said their helicopter fleet utilization is expected to increase over the next 12 months — higher than the global rate of 14 percent.

2. Purchase plans are stronger from law enforcement and oil and gas operators in this year's survey, but significantly lower from corporate operators.

Above: Close to 70 percent of planned new helicopter purchases in Africa and the Middle East were medium twin-engine models.

Above: Close to 65 percent of planned North American purchases were identified as light single-engine models.

3. A greater proportion of planned new helicopter purchases are for intermediate/medium twin-engine models in this year's survey compared with 2018. The proportion is lower for light twin-engine. The proportion of light single-engine and heavy twin-engine planned purchases are about the same as last year.
4. When choosing make and model for a new aircraft, the top three factors operators consider are brand experience, aircraft performance and cabin size.

Despite respondents having a slightly less positive view of the global economic outlook in this year's survey compared with 2018, new helicopter platforms will support an expected three to four percent annual growth rate in overall deliveries. The predicted increase in deliveries signals an overall healthy helicopter market poised for moderate growth.

Regional Overview

North America: Purchase plans have risen by five percentage points over a year ago, with 18 percent of respondents saying they would either replace or expand their fleet with a new helicopter over the next five years. North America is home to more than 40 percent of the world's helicopter fleet.

Close to 65 percent of planned North American purchases were identified as light single-engine models, while roughly 22 percent of new planned purchases were for intermediate and medium-twin product classes.

Europe: Compared with 2018 results, purchase plans were lower in this year's survey. Nearly 15 percent of respondents said they would either replace or expand their fleet with a new helicopter over the next five years. The figure was 22 percent a year ago. Intermediate and medium twin-engine classes captured roughly 30 percent of total mentions for new helicopters. Meanwhile, 25 percent of respondents indicated plans to purchase light single-engine helicopters, down 12 percentage points from last year.

The sample of Russian operators responding in the 2019 survey remains small, which continues to add some uncertainty to the overall European results.

Latin America: Results for 2019 show significantly lower fleet replacement and growth expectations compared with 2018. Purchase plans are well below the global average of 15 percent, and the region's purchase plans decreased by 26 percentage points from last year.

Latin America had the lowest rate of new aircraft purchase plans globally, with only 9 percent of respondents saying they would either replace or expand their fleet with a new helicopter over the next five years. Purchase plans in Brazil decreased to only five percent, reflecting higher political tensions and lower expectations for long-term economic growth.

Latin American respondents favored light single-engine models, which represent about 70 percent of their planned purchases, an increase of 20 percentage points when compared with 2018 survey results.

Above: Nearly 15 percent of European respondents said they would either replace or expand their fleet with a new helicopter over the next five years.

Middle East and Africa: This region had the second highest new purchase rate globally, with 15 percent of respondents' fleets expected to get a new helicopter replacement or addition. Purchase plans were five percentage points higher compared with 2018 survey results Close to 70 percent of planned new helicopter purchases were medium twin-engine models.

Light single-engine models were the second-highest mentioned product class in the survey by operators.

Asia Pacific: Overall buying plans were down five percentage points when compared with 2018. Close to 13 percent of respondents said they would either replace or expand their fleet with a new helicopter over the next five years.

Light single-engine and medium twin-engine helicopters were the most popular classes, both capturing near 30 percent of mentions for new helicopters. Despite limited inputs, new helicopter purchase plans were stable in China, showing that about 21 percent of the fleet would be replaced or expanded by a new helicopter over the next five years. Plans were up by about 10 percentage points in India.

Methodology

The 2019 outlook presents a snapshot of the helicopter business at a given point in time and reflects the current business and political environment. This year's data comes from a survey of more than 1,000 chief pilots and flight department managers of companies operating 3,334 turbine and 321 piston helicopters worldwide.

The survey excluded large fleet or "mega" operators, which were addressed separately. Input received from large oil and gas support and emergency medical service fleet operators is factored into the overall outlook in addition to the individual flight department responses.

The survey detailed the types of aircraft operated and assessed specific plans to replace aircraft or add new helicopters to the fleet.

Honeywell is a Fortune 100 technology company that builds aircraft engines, cockpit and cabin electronics, wireless connectivity systems, mechanical components and more. ■

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the arrival and departure of Concorde

Concorde was an engineering marvel and styling icon. This spring marks the 50th anniversary of Concorde's maiden flight, when commercial aviation took a supersonic leap into the future.

The roar of the engines is deafening as the flight crew pushes them to maximum power. After a long wait, cheers of encouragement and rippling applause reach fever pitch and Concorde 001 thunders majestically into the skies above Toulouse.

It's 3:38 p.m. on March 2, 1969, and the first page in the history of supersonic commercial aviation has just been written.

As Concorde's four Olympus 593 turbines carry the aircraft into the distance the joy of the technicians, engineers, employees and onlookers witnessing the moment is plain to see. Six hundred journalists from around the world are on hand to report how 'old Europe' has met the challenge of melding speed and technology in service of passenger transport.

The maiden flight, described by captain André Turcat as "a trip around the runway" lasted just 29 minutes and did not exceed 480 kmh. Alongside Turcat the crew consisted of flight mechanic Michel Rétif, flight engineer Henri Perrier and co-pilot Jacques Guignard.

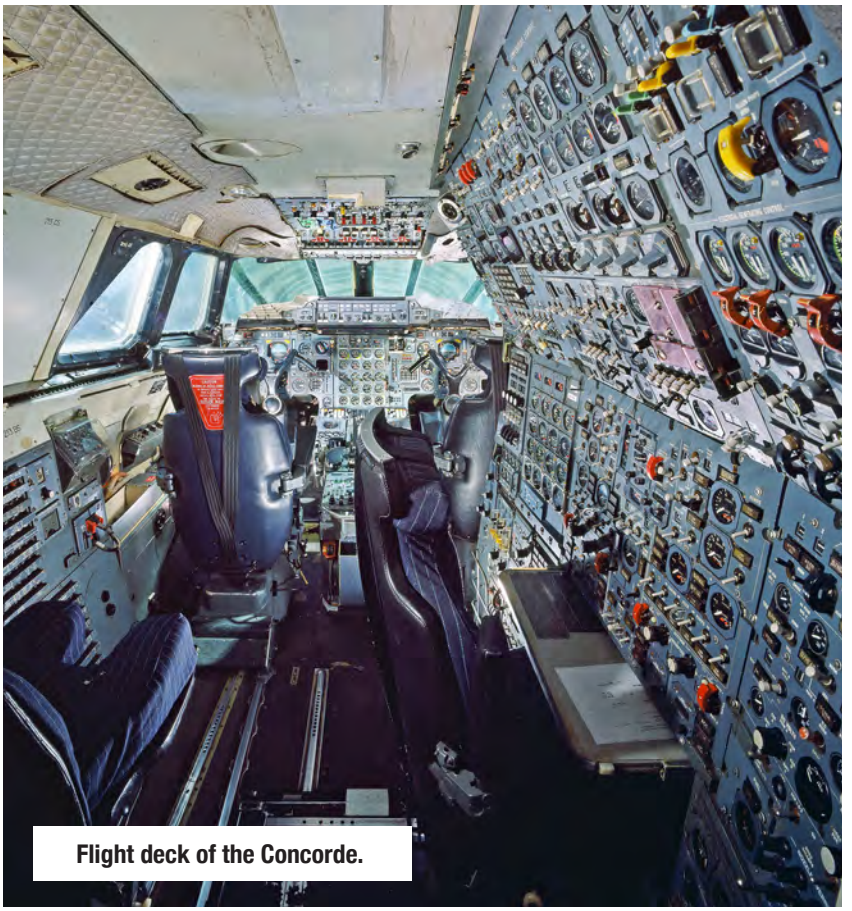
On the other side of the English Channel captain Brian Trubshaw, co-pilot John Cochrane and flight mechanic Brian Watts coaxed Concorde 002 into the skies between Filton and Fairford for its first flight, even shorter at 22 minutes, on April 9, that same year.

Concorde 001 first broke the sound barrier in October 1969 and reached Mach 2 during its 102nd test flight, with its English 'brother' achieving the same one week later.

French ambassador Geoffroy de Courcel and British aviation minister Julian Amery had signed the Franco-British cooperation program on November 29, 1962, confirming the industrial agreement between Sud Aviation and the British Aircraft Corporation outlined a month earlier. The agreement committed the two countries to a 50:50 share of Concorde's research and assembly costs.

It took seven years to arrive at the first flight that March afternoon. Many innovations resulted, from electronic flight controls and the first cockpit

Above: The Concorde-SST Concorde in production.



Flight deck of the Concorde.

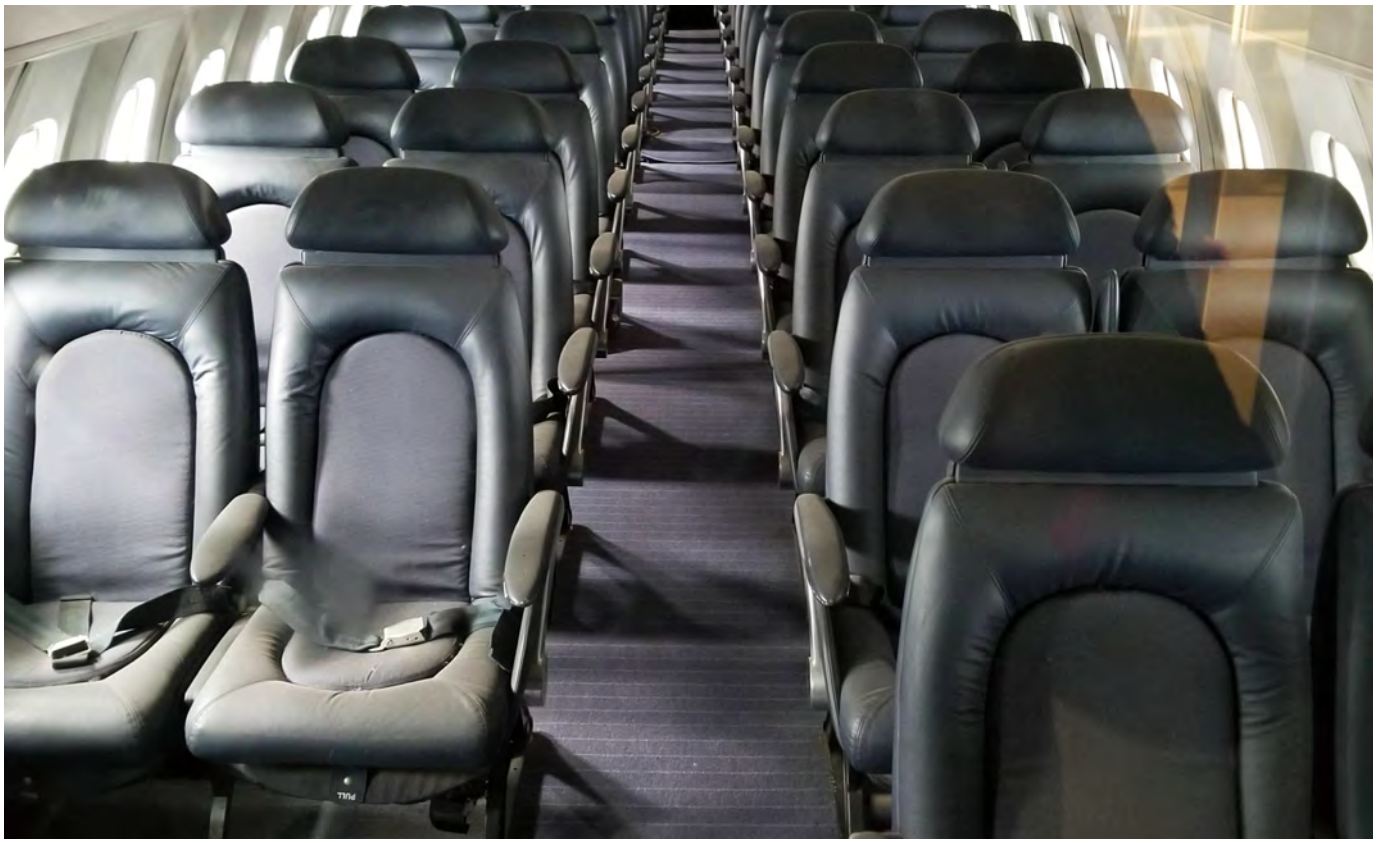
sidestick to anti-skid braking systems and the movement of fuel around the aircraft in flight to adjust its centre of gravity.

British Airways Concorde made just under 50,000 flights and flew more than 2.5 million passengers supersonically. With a take off speed of 220 knots (250 mph) and a cruising speed of 1,350 mph – more than twice the speed of sound – a typical London to New York crossing would take a little less than three and a half hours as opposed to about eight hours for a subsonic flight.

In November 1986 a British Airways Concorde flew around the world, covering 28,238 miles in 29 hours, 59 minutes.

Concorde's four engines took advantage of reheat technology, adding fuel to the final stage of the engine, which produced the extra power required for take-off and the transition to supersonic flight. Concorde's fastest transatlantic crossing was on February 7, 1996, when it completed the New York to London flight in two hours 52 minutes and 59 seconds.

Concorde measured nearly 204 feet in length and stretched between six and 10 inches in flight due to heating of the airframe. It was painted in a specially developed white paint



Above: Concorde passengers enjoyed a variety of luxury appointments.

to accommodate these changes and to dissipate the heat generated by supersonic flight. Concorde was subjected to 5,000 hours of testing before it was first certified for passenger flight, making it the most tested aircraft ever.

The experience the French and British gained during Concorde's development meant some pitfalls were avoided when Airbus was created – such as the politically-motivated dual assembly lines, one in each country. Concorde entered commercial service in 1976. In all, 16 aircraft were built and were operated only by Air France and British Airways. The type's only crash at Gonesse near Paris in 2000 marked the end of operations, three years later.

(With files from Airbus and British Airways.)

Top Ten Most Interesting Facts About Concorde

1. Concorde flew to 60,000 feet, a height of over 11 miles. Passengers were able to see the curvature of the earth. Due to the intense heat of the airframe, the aircraft used to stretch anywhere from six to 10 inches during flight. Every surface, even the windows, was warm to the touch by the end of the flight.
2. Concorde had a take-off speed of 220 knots (250 mph) and a cruising speed of 1,350 mph – more than twice the speed of sound. Its landing speed was 187 mph.
3. Two companies merged into one during the expansion (British Aircraft Corp and France's Aerospatiale) and began work on planes. French and British engineers built a proto-

Fifty years have passed since Concorde's first flight.

type, and the first successful flight occurred in October 1, 1969. In both French and English, "Concorde" means agreement.

4. Flights consisted of nine crew members: two pilots, one flight engineer and six flight attendants. Concorde used to fly 100 passengers (40 in the front of cabin and 60 in the rear cabin).

5. The last commercial Concorde flight was from New York to Heathrow on October 24, 2003. It was the last aircraft to carry flight engineers as part of the crew.

6. A version of the Concorde featured a special white paint to adapt to temperature changes and dissipate the heat generated by supersonic flight.

7. Concorde not only carried passengers but was also used to transport diamonds and human organs.

8. During its lifespan, Concorde made more than 50,000 flights, carrying a total of 2.5 million passengers including the most senior passenger, 105-year-old Eva Woodman.

9. One of the most noteworthy Concorde moments was the first round-the-world flight by a BA Concorde on November 8, 1986: a total of 28,234 miles in 29 hours 59 minutes.

10. The worst day in Concorde history was July 25, 2000. A flight departing Paris ran over a piece of titanium that had fallen from another aircraft. It burst the tire and resulted in the fuel tank igniting. The plane crashed killed everyone on board.

(With files from www.aviationcv.com) ■

History of Failure

The age of a cylinder and time-in-service can factor in material fatigue and ultimately engine power loss and a forced landing. That's the story here.

On 6 July 2008, the float-equipped Gogal Air Services Limited Noorduyn Norseman Mark V (registration C-FECG, serial number N29-43) departed Burntwood Lake Lodge, Manitoba, on a 20-minute flight to Snow Lake.

Approximately 10 minutes into the flight, the engine began to sputter and lose power. The pilot attempted but was unable to restore engine power. At 0900 central daylight time, the pilot made a forced landing 15 nautical miles north of Snow Lake into a sparsely wooded marshy area.

The pilot and seven passengers exited the aircraft without injury. The aircraft sustained substantial damage; however, the impact forces were low and the emergency locator transmitter did not activate. The pilot radioed another company aircraft that was flying in the area and informed the other pilot of the accident. A company helicopter was dispatched to the site and the pilot and passengers were flown to Snow Lake.

Other factual information

The aircraft was to be flown from the company's Snow Lake water base to the Burntwood Lake Lodge situated 37 nautical miles to the north and return with seven passengers and their baggage. The pilot completed the

pre-flight inspection and added 159 pounds of fuel to the left tank, bringing the total fuel on board to approximately 500 pounds. The planned fuel usage for the 40-minute round trip was 150 pounds. The flight to Burntwood Lake was uneventful and the aircraft performed normally. At Snow Lake, the passengers and baggage were loaded. The aircraft's total weight was estimated to be at or near its maximum authorized gross weight of 7540 pounds.

The aircraft took off from Burntwood Lake and the pilot leveled the aircraft at 1,000 feet above ground level. Approximately 10 minutes into the flight, the engine began to sputter and lose power. The pilot pushed the engine mixture control to the full rich position, applied carburetor heat, and switched fuel tanks. Engine performance did not improve and the aircraft began to lose altitude. The pilot attempted to reach a lake situated approximately three miles away. Approximately one mile from the lake, the pilot realized that he would not be able to reach it and aligned the aircraft with a marshy area that lay below. The aircraft touched down on the marsh grass, travelled approximately 200 yards through the reeds before entering a stand of trees at about 30 mph. The wings and floats absorbed the brunt of the impact and the aircraft came to a gradual stop. The right float ended up beneath the fuselage, causing the aircraft to tilt to the right. The pilot exited through the left door and assisted the passengers out of the cabin. No injuries were reported. The aircraft was examined on site and a clean and bright flow of fuel was found present at the main airframe fuel strainer. The engine cowling was removed and an initial examination of the Pratt & Whitney (P&W) R1340 AN-1 engine (serial number 18620) revealed that the exhaust ear on the number 2 engine cylinder had cracked and split open. The engine was removed from the site and taken to the TSB Central Region wreckage facility for further examination.

This examination found some minor chafing in several areas, but identified no major discrepancies other than the failure of the number 2 cylinder. The engine was rotated and it was observed that the number 2 cylinder exhaust valve did not move from the closed position. It was determined that the separation of the ear caused an increase in clearance between the exhaust valve push rod and the valve rocker arm to the point where the valve would not open. During engine operation, a closed exhaust valve can result in the hot pressurized exhaust gases being forced back into the common induction system through the normal opening of the intake valve. Small glowing carbon deposits in the hot exhaust gases can induce pre-ignition of the fuel/air mixture in the induction system and result in a disruption in the normal air/fuel mixture to the remaining cylinders. This, in turn, can lead to engine roughness and loss of engine power.

The cylinder was removed from the engine and sent to the TSB Engineering Laboratory for analysis. The valve operating mechanism, bearing clearances, and valve pushrods were examined and found to be within acceptable serviceability limits. The crack on the number 2 cylinder was found to extend from the oil drain hole on the inboard side through to the oil drain hole on the outboard side and up into the valve cap flange area.

The cylinder fracture was examined under a scanning electron microscope (SEM). Casting porosity and heavy oxidation were found in several areas of the fracture surface and in the origin area of the failure. Beach marks were found that indicated that the fracture and failure occurred as a result of fatigue. The origin of the fatigue was co-located in an area of geometric stress concentration, at the corner where the cooling fin attaches to the cylinder.

The normal operation of the pushrod provided the cyclic tension load needed to promote the growth of the fatigue crack. The cluster of casting porosities at the corner of the cooling fin was most probably present since the cylinder was first cast, indicating that the fatigue process started when the cylinder was first put into service.

The majority of the crack's fatigue lifetime occurred at lengths below the threshold of detectability and did not reach detectability until late in the fatigue lifetime. The severe extent of the corrosion, staining, and rub on the fracture surface indicated that the fatigue crack had been present for a considerable time prior to failure. Due to pounding of the surfaces nearest to the origin, however, it was not possible to quantify the time it took to grow from detectability to failure.

An examination of the aircraft technical records indicated that the aircraft had been maintained in accordance with the Gogal Air Services-approved maintenance schedule. The aircraft last underwent a 100-hour inspection on 07 August 2007, 51 hours prior to the occurrence. The engine had accumulated 1031 hours time-in-service since its last overhaul. The engine overhaul life is 1200 hours with a 50-hour tolerance. The engine received a top overhaul on 16 August 2002 at 436 hours time since overhaul (TSO). Nine overhauled chrome-barrelled P&W cylinders were installed.

On 26 July 2003 at 555 hours TSO or 119 hours since top overhaul, the number 1 cylinder was replaced due to a cracked exhaust ear. On 14 June 2008 at 992 hours TSO or 556 hours since top overhaul, the number 3 cylinder was replaced due to a failure of the intake valve seat. On 06 July 2008 at 1031 hours TSO or 595 hours since top overhaul, the number 2 cylinder failed on the occurrence flight due to a cracked exhaust ear.

The cylinders are not subject to an overhaul time limit and tracking of cylinder life and overhaul cycles is not maintained. The cylinders are overhauled when the engine is overhauled or when the cylinders are removed prematurely due to a cylinder problem. During overhaul, the cylinders are subjected to an inspection, including liquid penetrant inspection of the head area and, in some cases, ultrasonic testing on the barrel threads. Some overhaul facilities mark the cylinder skirt with the overhaul date and coding particular to the facility or put a serial number on the valve ear for tracking purposes. There are no requirements to track cylinder life or repair information. Some cylinders have accumulated high-time usage while others have not.

High-time usage can lead to material failure under certain conditions. While the complete history or total time in service of the failed number 2 cylinder could not be established, numerous and overlapping overhaul shop markings were noted on the cylinder skirt and both valve ears.

Above: P&W manufactured the R1340-series engine between 1925 and 1960. It has a history of cylinder failures.

P&W manufactured the R1340-series engine between 1925 and 1960. After 1960, no new cylinders were made, but a large quantity of unused spare stock remained in the civil and military markets. A prototype heavy head cylinder was produced by a vendor in the late 1990s that was supposed to be stronger across the dome, on the sides, and in the rocker box area. Production of these cylinders was stopped due to technical difficulties, which are being addressed by the vendor. The P&W R1340 is used extensively in the Norseman and DHC-3 Otter aircraft, which are still in common use today. The P&W R1340, like many piston engines, has a history of cylinder failures. Most cylinder failures are rectified during engine overhaul or routine maintenance.

A review of the aircraft's history revealed two documented forced landings. On September 12, 1989, the aircraft was forced to land on Mawdesley Lake (15 nm east of the The Pas, Manitoba) due to a failure of the number 3 exhaust valve. The cylinder had accumulated 586 hours TSO.

On June 14, 1990, the aircraft was forced to land on Emerald Lake (25 nm northeast of Flin Flon, Manitoba) due to a failure of the number 2 cylinder exhaust valve. That cylinder had accumulated 625 hours TSO. The major factor in a successful forced landing is the availability of a suitable landing area. These forced landings occurred in an area of extensive open water and neither of the forced landings resulted in an accident or aircraft damage.

Transport Canada issued Service Difficulty Advisory AV-2007-02 that discussed concerns regarding cylinder head and cylinder flange failures on the Pratt & Whitney R985-series engine. The advisory contains inspection information that may be useful or interchangeable with the R1340-series engine cylinders.

Analysis

The number 2 engine cylinder exhaust ear failed under fatigue in an area of casting porosity and geometric stress concentration. The casting porosity was likely introduced during manufacture of the cylinder some 50 to 80 years prior. The time in service of the cylinder could not be established because there is no requirement to track the cylinder's total accumulated usage. Numerous repair shop markings on the cylinder skirt and ear area suggest that the cylinder had high-time hours in service. The area of fatigue was subject to normal operational loading that took years to initiate and manifest the crack.

The severe extent of the corrosion, staining, and rub on the fracture surface indicated that the fatigue crack had been present for a considerable time prior to failure. Because the crack was not detected by liquid penetrant inspection during cylinder overhaul 595 hours prior to the occurrence flight, the development of the crack to the detectable stage likely occurred after that time. The cast-

ing porosity, age of the cylinder, and its high time in service were major contributing factors in its eventual failure. The failure and separation of the number 2 cylinder exhaust ear prevented the exhaust valve from opening. The hot exhaust gases migrated back into the induction system through the opening of the intake valve, causing a disruption in the fuel/air mixture to the remaining cylinders and resulting in a loss of engine power.

Records indicated that three of the engine's nine cylinders failed within 600 hours of cylinder overhaul or within one-half of the engine's overhaul life. The number 1 cylinder failed at the exhaust ear less than 120 hours after cylinder overhaul. The three failed cylinders were all located near the top of the engine, which could indicate a thermal stress problem associated with airflow, but this was not proven. The last cylinder failure resulted in a forced landing and the occurrence accident. Past cylinder failures on this aircraft have also occurred in the top cylinder positions and have resulted in two documented forced landings. These forced landings, however, did not result in accidents or aircraft damage. On the occurrence flight, the engine power loss occurred in an area where a successful damage-free landing was improbable. The pilot controlled the landing and put the aircraft down in an area where damage to the aircraft and injury to the occupants would be minimized. The following TSB Engineering Laboratory report was completed: LP 148/2008 – Cylinder Failure, Noorduyn Norseman MK V, C-FECG. This report is available from the Transportation Safety Board of Canada.

Findings as to Causes and Contributing Factors

1. The number 2 engine cylinder exhaust ear failed in fatigue in an area of casting porosity and geometric stress concentration. The casting porosity was likely introduced during manufacture of the cylinder some 50 to 80 years before the occurrence.

2. The failure of the number 2 cylinder exhaust ear prevented the exhaust valve from opening. The hot exhaust gases migrated back into the induction system through the intake valve, causing a disruption in the fuel/air mixture to the remaining cylinders, resulting in a loss of engine power.

3. The engine power loss occurred in an area of flight in which a damage-free forced landing was improbable.

Finding as to Risk

The growing age and time in service of some of the originally manufactured P&W R1340-series cylinders has increased the risk of material fatigue leading to a premature failure of the cylinder. Some cylinder failures can then put the aircraft at risk of an engine power loss resulting in a forced landing or accident.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 07 April 2009. ■

Aviation Services

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Standing in the Wake

Perspective: Boeing and the FAA stand to lose big from the B737 Max disaster

BY DIOGENIS PAPIOMYTIS

In the nearly immediate aftermath of the crash of Ethiopian flight ET302 that cost the lives of 157 passengers and crew, the global fleet of Boeing's B737 Max 8, aside from a few exceptional cases, was grounded. Regulatory authorities went on standby waiting for Boeing, the accident investigation teams and the FAA to provide more information and confirm measures to ensure flight safety.

Until this is done, fleets will remain grounded, which is something reminiscent of the B787 Dreamliner entry into service in 2013. Back then there was no tragic accident, but numerous incidents with overheating Lithium batteries on the new aircraft. At the time, the FAA had been proactive and taken the decision to ground all US 787 aircraft, prompting aviation authorities around the world to follow their lead. This time around, it is the world that has been proactive in grounding the 737 Max and the FAA had to capitulate. It was inevitable that they would follow suit, partially because the world of aviation is built upon the principle of trust in safe operations. Although we don't know if 737 Max aircraft are unsafe, the public's perception is that they are not, until proven wrong. It is this perception of safety that is particularly important for regulators and airlines worldwide; after all aviation is one of the highest profile consumer markets.

A few questions that we can answer now

What will be the impact of grounded fleets on Boeing and its supply chain?

The impact is huge. Boeing was late in announcing and marketing the 737 Max, the newest version of its most popular aircraft program, back in 2011. This gave Airbus a jumpstart of over a year, with their A320 NEO, and it has not looked back since. In 2019 the NEO had 5,700 aircraft orders against Max's 3,700. The Lion Air and Ethiopian Airlines 737 Max disasters will, undoubtedly, push this gap even wider.

Longer-term, the role of Boeing in the duopoly of commercial narrow body aircraft is at stake. With the introduction of the Chinese Comac C919 and the Russian Irkut MC-21 in 2021, airlines will have more choice.

Another side effect is that the aviation industry is now seeing the first signs of overcapacity amidst slowing air traffic growth, driven by a slowdown in the global economy and rising fuel prices. Many airlines may take the opportunity and cancel orders for the 737 Max in light of a possible downturn. Simply put, the business case for new aircraft in 2019 is completely different from 2015 or 2016, when the airlines placed their orders. Of course, when we are talking about Boeing we have to consider the whole supply chain; from Tier 1 manufacturers of aircraft systems and airframes such as GE Aviation, Collins Aerospace and Spirit Aerosystems down to component manufacturers from Boeing's global supply chain. All of them will be affected as Boeing and the 737 program make up a significant part of their business.

What will be the impact of grounded fleets on airlines and their networks?

Prior to the latest disaster, there were 370 Boeing 737 Max aircraft flying worldwide. Two thirds of the global fleet is now grounded and we estimate that the impact to all airlines adds up to more than $10 million dollars daily. If the grounding applies to all aircraft, coupled with a deferral of the more than 400 deliveries planned for 2019, the bill will amount to more than $4 billion in 2019. Airlines, of course, will seek compensation from Boeing, but the impact on their profitability and operations cannot be underestimated. It is enough to push many of the smaller and financially struggling airlines to the brink of bankruptcy.

What should Boeing do next?

Boeing will have to put all its efforts on finding the cause of the latest accident, and rectify. If it is a simple software issue related to the MCAS (Manoeuvring Characteristics Augmentation System) then it can be solved with next month's planned software upgrade. If it is a human issue, related to pilots not trained to override the MCAS when needed, then training and an added pilot certification are needed. If, however, this is a major aircraft structural issue, then the 737 program's future is at risk.

But aside from its engineers and aircraft mechanics, the onus is on the Boeing corporate communications, marketing and sales teams to minimize the impact on Boeing's brand. In mid-March and at the time of this writing, Boeing was supposed to roll out its B777X aircraft at a special ceremony in Seattle. This has been postponed indefinitely. The manufacturer is also due to make a decision on a new midsize airplane in the next 12 months. Ultimately, the 737 Max troubles may impact Boeing's sales across all of its aircraft programs.

Diogenis Papiomytis is with business consulting firm Frost & Sullivan. ■

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