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AirMaintenance UPDATE

The Magazine for Aircraft Maintenance Professionals

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Report: Not Enough Aviation Mechanics

Raising The Bar: Blame it All on the Laser

Vanquishing Vibrations

Transport Canada: Reports and Comments

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Project Transonic Truss-brace

NASA and Boeing will tackle emissions problem together

IT'S ALWAYS interesting to see what happens next when heavyweights collaborate. Example. In January NASA announced it will partner with Boeing for the agency's Sustainable Flight Demonstrator project, which aims at influencing a new generation of green single-aisle airliners.

Under a Funded Space Act Agreement, Boeing will work with NASA to build and fly a full-scale Transonic truss-braced wing demonstrator aircraft aimed at lowering emissions. The concept aircraft involves extra-long, thin wings stabilized by diagonal struts. This design theoretically results in an aircraft that is much more fuel efficient than a traditional airliner due to a shape that would create less drag – resulting in its burning less fuel.

According to NASA, the technology flown on the demonstrator aircraft, when combined with other advancements in propulsion systems, materials, and systems architecture, would result in fuel consumption and emissions reductions of up to 30 percent relative to today's most efficient single-aisle aircraft.

Over seven years, NASA will invest $425 million, while Boeing and its partners will contribute the remainder of the agreement funding, estimated at about $725 million. As part of the agreement, the agency will also contribute technical expertise and facilities.

Single-aisle aircraft are the workhorse of many airline fleets, and due to their heavy usage, account for nearly half of worldwide aviation emissions. NASA plans to complete testing for the project by the late 2020s, so that technologies and designs demonstrated by the project can be incorporated into the next generation of single-aisle aircraft that could enter into service in the 2030s. ■

— John Campbell, Editor

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Features

AirMaintenance Update

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Upcoming Events

Dream Machines return to West Coast

After three years on the sidelines, Half Moon Bay, California's **Pacific Coast Dream Machines** Show will return in 2023 with a massive celebration of mechanical ingenuity, power and style in a big 30th anniversary revival show. This year's event will be held Sunday, April 30 at Eddie Andreini Field, located in the seaside town of Half Moon Bay, about 20 miles south of San Francisco.

The show will feature some 2,000 magnificent flying, driving, and working machines from the 20th and 21st centuries. Historic military aircraft, cars of every era and style, model-T fire engines, vintage busses, custom motorcycles, tricked out trucks, sleek streamliners, one-of-a-kind antique engines and tractors will be among the displays.

Plans for this year's show include a new "Machines of Tomorrow" showcase with displays of all things to come in the next-generation of transportation — concept cars, flying cars, robotics, autonomous vehicles, EVs and more.

Additional attractions include amusements in the Kidz Super Duper Funzone, fabulous food and drink with craft beer, premium wine and custom cocktails, and live music all day.

This year's show has a new, improved event layout bringing all the attractions closer together and making it a more walkable, unified event with separate entrances for spectator parking.

To show a car, truck, motorcycle, aircraft or other machine, the pre-registration fee is $40 ($50 for entries postmarked after April 15) and includes a custom dash plaque and admission for the registrant plus one passenger (must be together in the registered vehicle). ✪

RCAF Hornet Demo schedule

June 7	North Bay, Ontario	(Tactical)
June 10-11	Barrie Airshow	Barrie, Ontario (Tactical)
July 22	Boundary Bay Airshow	Delta, BC (Tactical)
July 29-30	Red Deer Airshow	Red Deer, Alberta (Tactical)
August 5-6	Alberta International Airshow	Edmonton, Alberta (Aerobatic)
August 11-13	Abbotsford International Airshow	Abbotsford, BC (Aerobatic)
August 26-27	Air Show Atlantic	Debert, Nova Scotia (Aerobatic)
September 2-4	Canadian International Air Show	Toronto, Ontario (Aerobatic)
September 8-10	Festival Aérien Airshow	Mirabel, Quebec (Aerobatic)
September 16-17	Aero Gatineau-Ottawa	Gatineau, Quebec (Tactical)

COMING EVENTS

Sun 'n Fun Aerospace Expo
March 28-April 2, 2023
Lakeland, Florida
www.flysnf.org

Pacific Coast Dream Machines
April 30, 2023
Half Moon Bay, California
www.dreammachines.miramarevents.com

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Publications keep aircraft compliant

Information and software services provider **ATP** recently received authorization for the **Honeywell T55 Turboshaft Engine**. ATP now has the ability to offer maintenance publications through ATP's Aviation Hub platform to companies that maintain and manage the T55 engine that Honeywell manufactures. ATP has been in business for 50 years and in over 146 countries, producing publications for operators to stay compliant with regulations and keep airplanes and helicopters safe. In addition to Honeywell, ATP has several other partnerships with original equipment manufacturers, including MD Helicopters, Schweizer Helicopter and Enstrom Helicopter, among others. **www.atp.com**

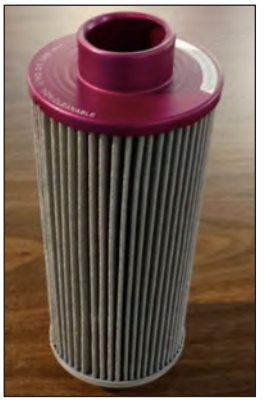
Carbon cowls resist contaminants

QT Aerospace now has Supplemental Type Certificates on its carbon graphite barrel for Gulfstream G-450, Embraer Legacy 450/500, and Praetor 500/600 STC aircraft. What this means for many Canadian operators is that QTA now has the licence to carry out inlet cowl upgrades. QTA replaces the corroding aluminum inner barrel with a one-piece carbon graphite barrel that will never corrode or fail. The QTA solution is quieter, stronger and impervious to all contaminants the aircraft may encounter, be it salt, humidity, acid rain, or any other. **www.qtaerospace.com**

High Torque starters replace old ones

Hartzell Engine Tech recently received FAA Parts Manufacturer Approval for its Sky-Tec HT (High Torque) starters for Robinson two-place R22 and four-place R44 light utility helicopters. The company's Sky-Tec HT starter for Lycoming engines features an integrated self-resetting kickback protection system to protect the powerplant and starter from an engine kickback. Hartzell Engine Tech's durable Sky-Tec HT starters are available through the company's distribution system. They replace the older starters installed by Robinson helicopters at the factory and also older competitor starter units. **www.hartzellaviation.com**

Metal fibre cartridges save millions



Global Filtration's metal fibre media is now available as a drop in replacement cartridge for existing cellulose or fibreglass media cartridges. The metal media has been proven effective by tests on the Apache and Blackhawk Helicopters, and Southwest Airlines and saved over $4,000,000 in replacement costs due to contamination, pumps, servos and actuators, and continues to save millions every 100 flight hours. Applications include helicopters, commercial aircraft hydraulic systems, heavy equipment, and many more. In 2017 Global Filtration received FAA PMA approval on the return hydraulic system filters for Boeing aircraft. **www.globalfiltration.com**

B-nut eliminates lockwire

As an advanced **B-nut** for fittings, **JPB Système's LULYLOK** solution features a unique self-locking device to ensure the sealing of pipes and tubes, thereby preventing loosening and leakage caused by severe vibration and extreme thermal conditions. Crucially, LULYLOK addresses safety concerns by eliminating the need for a lockwire or safety cable, tab washers, cotter pins or any other method of fastening to secure the threaded parts within an aircraft's engine. This eliminates foreign object damage while reducing maintenance costs and installation time. **www.jpb-systeme.com**

Hanging dividers save space

Aircraft interior products supplier **Jamco America** now offers class dividers that are highly integrable with a variety of models for customers to fit their needs. These include standard dividers, joggle dividers, attendant partitions provisioned for attendant panels and attendant seat, and unique solutions such as the Jamco America hanging soft divider. Joggled options allow for more foot space, while hanging dividers are ideal for airlines who do not want to put in a full height divider in order to save space. Jamco also offers branding solutions such as colours and logos. **www.jamco-america.com**

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ALL-FEMALE PAINT TEAM GETS JOB DONE

Alabama-based MAAS Aviation presented its first ever all-female paint team on International Women's Day 2023. Over a five-day period in late February and early March, the company's 12-member female team completed the painting of a brand-new A320 aircraft. They carried out all stages of the paint job from applications of primer through to basecoat, then finishing with clearcoat, with inspections at every stage. "This is the first time we've have had an all-female team complete an aircraft painting project, but it's important to say that female colleagues have worked within our paint teams for many years," said Geoffrey Myrick, MAAS Chief Operating Officer.

PHENOM 300 STILL RACKS UP TOP SALES

For the 11th consecutive year, Embraer's Phenom 300 series has become the world's best-selling light jet, according to the General Aviation Manufacturers Association. Embraer delivered 59 Phenom 300 series light jets in 2022 to achieve this milestone, and to date the series has accrued more than 700 deliveries. The Phenom 300 series is in operation in 36 countries and has accumulated nearly 1,800,000 flight hours. The new Phenom 300E is capable of reaching Mach 0.80, becoming the fastest single-pilot jet in production, and able to deliver a high-speed cruise of 464 knots and a five-occupant range of 2,010 nautical miles.

FACE SCAN NOW AVAILABLE AT YVR

Air Canada announced it has launched digital identification, becoming the first airline in Canada with approval to offer customers a new option to confirm identification using facial recognition technology. In a pilot project currently underway, Air Canada's digital identification is now available for customers departing from Vancouver International Airport (YVR) when boarding select flights to Winnipeg, and for eligible customers entering the Air Canada Café at Toronto Pearson International Airport. Air Canada plans to expand digital identification options to select Canadian airports and Maple Leaf Lounges as part of its pilot project phase.

TURBOPROP ISLANDER EARNS CERTIFICATION

UK aircraft manufacturer Britten-Norman has gained United States Federal Aviation Administration type certification for the Rolls-Royce model 250 powered BN2T-4S Islander turboprop aircraft. The BN2T-4S is the larger variant of the piston BN2B Islander and comes with an increased Maximum Take off Weight of 8,500 pounds. Certification is included under FAA Type Certificate reference A17EU Revision 22. This change is an important milestone for Britten-Norman and complements existing type certificates for the aircraft with the UK CAA and EASA. The new certification opens up new markets for the company in the USA and internationally.

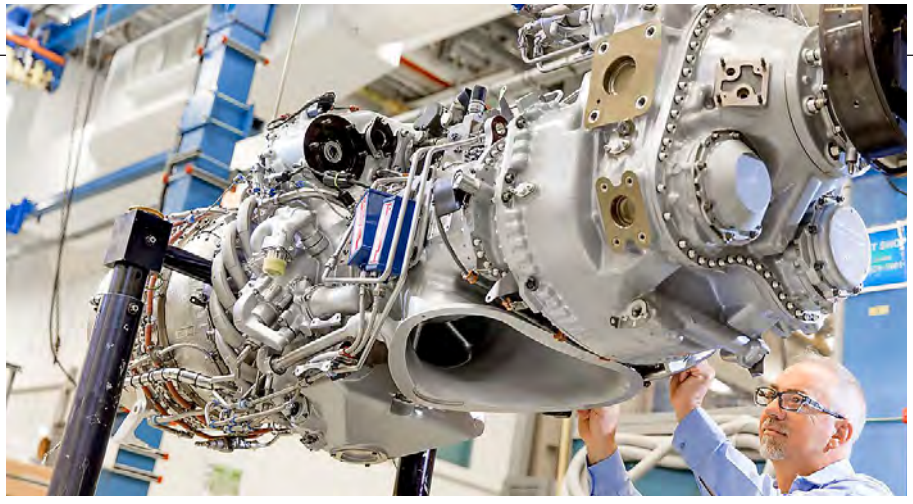
PILOT PROGRAM CHECKS CT7-8 HEALTH

GE Aerospace and PHI Aviation will launch a pilot program featuring GE's new digital engine health monitoring technology for CT7-8 engines. The objective of the program is to refine and expand the tool, eventually making it available to operators of CT7-8 and other CT7 variants.

The CT7-8 is the powerplant for Sikorsky's S-92 helicopter. PHI was the S-92 and CT7-8 launch customer and today operates 34 S-92s. GE's digital engine health monitoring tool combines engine analytics capabilities with original equipment manufacturer experience to produce actionable insights which keep customers' aircraft ready for the next mission.

MAINTENANCE KIT INCLUDES SPEC TOOLS

Pratt & Whitney Canada has announced the rollout of new remote maintenance kits comprised of strategically selected parts and tooling for helicopter engines that will support aircraft availability and maintenance autonomy. The kit is offered to customers enrolled in the company's Eagle Service Plan pay-per-hour maintenance plan as part of their investment in the program. The collection of engine parts and tooling includes specialized cables, an ignition exciter and Stabilant 22, borescope guide tools to perform engine diagnostic tests, spare parts such as fuel and oil filter elements, retaining rings, and seals.



BIG PLAYERS TACKLE HSVTOL

Bell and Pratt & Whitney are now collaborating on propulsion ideas for the development of Takeoff and Landing technology. HSVTOL technology leverages existing Bell experience with the development of high-speed vertical lift aircraft, with the Bell 360 Invictus dashing over 200 knots, and the Bell V-280 Valor cruising to over 300 knots. HSVTOL's runway flexibility provides the capability to utilize runways with conventional jet takeoff when runways are intact and independence with short field takeoff and vertical takeoff when runways are compromised.

GREY WOLF PRODUCTION NOW IN PROGRESS

Boeing will begin production on the first 13 MH-139A Grey Wolf helicopters, following the award of a $285 million U.S. Air Force contract. The MH-139A's enhanced capabilities allow it to accomplish missions more quickly, quietly and efficiently. The MH-139A team consists of Boeing as the prime contractor, and Leonardo as an original equipment manufacturer. Leonardo produces the helicopter at its plant in northeast Philadelphia, while Boeing is responsible for military equipment procurement and installation and post-delivery support of the aircraft. ■

REPORT: Not Enough Aviation Mechanics

In a report released this winter a team of analysts writing for the American management consulting firm Oliver Wyman suggests ways the industry can address this decade's shortage in aircraft maintenance workers. These are selections from their study.

Adding to the challenge of attracting younger candidates, the job isn't one where hybrid work is possible.

Top, right: AMT schools should be viable alternatives to college.

AFTER A SUMMER OF flight cancellations and delays, the pilot shortage has become an all-too-real phenomenon with which airlines and the traveling public are learning to cope. But while no one can ignore empty cockpits, behind the scenes yet another labor shortage looms — not enough aircraft mechanics.

While there were just enough to handle the maintenance, repair, and overhaul (MRO) workload on the North American fleet in 2022, the latest forecast suggests that a shortfall of somewhere between 12,000 and 18,000 is likely to be the case in 2023. That imbalance between supply and demand — including licensed and unlicensed labor working on aircraft and in the backshops — will persist through the rest of the decade and threaten aviation's ability to grow profitably if it remains unaddressed.

For our report Not Enough Aviation Mechanics, we at Oliver Wyman looked at the challenges the industry faces because of that impending shortage, and areas it can address — including recruitment, retention, training, regulation, and productivity — to help mitigate it.

The Baby Boomer Effect

Behind this future shortage is an aging workforce with baby boomers preparing to retire. Added to that are the thousands of mechanics who took early retirement during the COVID -19 pandemic. The Oliver Wyman survey and government data indicate as much as 35 percent of the current workforce is 55 to 64 years old, putting more than one-third at or near retirement. The average retirement age for a mechanic was 62 before the COVID-19 pandemic, based on Oliver Wyman's analysis. There is no mandatory retirement age for mechanics as there is for pilots.

Today, most aircraft mechanics are over 40 years old, with the percentage between 18 and 30 in the single digits. Given these projections, the number of workers expected to call it quits over

Below: Today, most aircraft mechanics are over 40 years old.

the next few years is simply too big to be offset by hiring alone. Bottom line: Over the next few years, there's little the industry can do to avoid completely the anticipated shortage.

But there are a variety of possible remedies the industry might try to mitigate it. We created three scenarios to test the impact of various approaches to solving the problem.

How to Respond: recruitment and retention

The job of the mechanic doesn't require a college degree but does entail considerable training. The course work can typically cost around $17,000 and take as much as 22 months to complete. The underlying value of the license and training needs to justify the cost and time to acquire them. Aviation Maintenance Technician (AMT) schools should be viable alternatives to the rising cost of a college education and lead to expansive careers. Pay rates from employers should allow workers to pay down student debt, or employers could subsidize the training. One program increasing in popularity is sponsorship. That's where companies "adopt" candidates in training and then find a spot for them, assuming completion of the program and a certain level of performance.

Pay and Hours

The US Bureau of Labor Statistics reported that mechanics earned a median annual wage of $65,380, or about $31.52 an hour, in May 2021. The median annual wage for avionics technicians — those maintaining and repairing an aircraft's electronics systems, such as radar, radio equipment, and navigation aids — was $69,280. Those salaries are above the average worker's pay in the US by more than $10,000 a year, based on BLS numbers.

Average entry-level hourly wages for mechanics are in the low $20s an hour. It's likely the industry will push up salaries in response to the shortage. Higher wages might attract more young workers to the profession and prevent established mechanics from leaving for other jobs. But it's doubtful that the industry can make the shortage go away at least for the next few years by simply throwing money at it.

Plus, there is also the problem of the resulting higher operating costs with which the industry would have to contend. Adding to the challenge of attracting younger candidates, the job isn't one where hybrid work is possible, and the work schedule is not particularly flexible. Hybrid/flexible work has been cited in several studies, including one done by Oliver Wyman Forum, as an important factor for Generation Z applicants in job searches. Likewise, the work environment in hangars and repair stations or on airfields is often loud, or uncomfortably hot or cold based on the weather.

A Limited Pool

Looking at the workforce, most mechanics are male and white, although the number of women and minorities pursuing A&P licenses is rising, according to a 2021 report by the Aviation Technician Education Council (ATEC). Based on the latest data, only 2.6 percent of certificated mechanics are women, according to the FAA. That's less than pilots, where 4.6 percent are women. Minorities are similarly underrepresented. Expanding the appeal of the profession to women and minorities would be one way to increase the pool of candidates from which MROs and airlines can draw.

One key to improving the outlook is engaging with prospective workers, getting them interested in aviation again.

Higher wages might attract more young workers to the profession.

Expanding the appeal of the profession to women and minorities would be one way to increase the tech pool.

But in today's highly competitive climate, targeting high school and college students is probably too late. That education campaign needs to start early with programs that introduce both children and their parents to what's possible in aviation. This approach could reap rewards, given the cost of college and the fact that most parents are encouraging children to pursue careers related to science, technology, engineering, and math where better-paying jobs are more likely.

One easy group to approach would be current mechanics who are parents. Most children look at what their parents do for a living when considering a career for themselves, which might make them easier to convince.

Keeping Workers on the Job

Another effort that could help stem the shortfall is increasing retention rates among current workers. This might include later retirement or discouraging younger workers from leaving the profession for what they think might be greener pastures.

Four primary factors affect retention rates among aviation technicians: total rewards, pathways for growth, culture, and work environment. While it always helps to look for ways to raise hourly pay, it's also important to make sure pay progression and premiums are transparent and directly aligned with experience, tenureon the job, and a worker's responsibilities.

Technicians also need to see clear pathways for professional development. This means companies need to provide access to and maybe even subsidize technical training programs that give workers new skill sets and licenses to work on different aircraft types and technical specialties, such as avionics or composite materials. It also means opportunities beyond just developing technical skills. For instance, some mechanics may be interested in pursuing leadership roles, management and business courses, professional coaching, and mentorship programs.

For some independent MROs, it may be worth considering partnerships with mainline airlines for line or heavy maintenance jobs and using operator resources to raise MRO professional development offerings for their mechanics. Smaller MROs could leverage the training resources that the airlines have in their maintenance departments, which would benefit both the airlines and MROs as mechanics will likely move on to airlines or larger MROs anyway. But to make this kind of relationship work, smaller MROs need to modernize their human resources models and processes to cater to a younger and more transient workforce.

In Need of Modernizing

This is where culture comes in. Diversifying the workforce and valuing diversity are steps in the right direction, given that Gen Z workers look for and expect diversified workforces. Gen Z workers are also apt to leave a work situation where they encounter unfair pay or uneven treatment based on race or gender.

The atmosphere at work is also important to these younger employees who work to live rather than live to work as their baby boomer elders did. Hence, the preponderance of ping-pong and foosball tables at companies with a lot of young workers — physical symbols of valuing work-life balance.

The MRO industry offers few of the amenities common at companies popular with Gen Z workers, such as free snacks, comfortable break rooms, and attractive work environments. Gen Z employees expect these extras when they come to work — especially since hybrid work situations are not available in MRO.

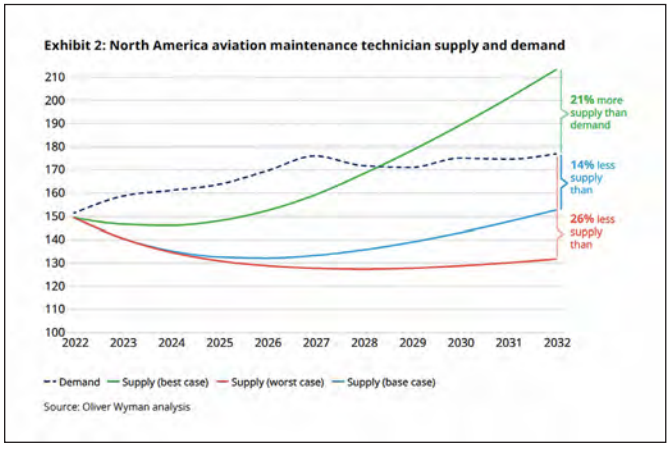
Training 2.0

Another way to attract more mechanics is to improve the training process. The FAA could help the industry by making some rule changes that would modernize the sector. Re-

vising 14 CFR Part 147, effective September 21, 2022, was a step in the right direction by removing archaic requirements from training. This was a much-needed overhaul to align curriculums with current industry standards. But the change shouldn't stop there.

The FAA and the industry could also consider ways to reduce the time mechanics spend in the academic environment through the expansion of on-the-job work study where candidates can work with A&P license holders. Among additional changes that should be considered to ease pressures from the shortage are:

- Increase government subsidies and free tuition programs for AMT schools with requirements that students then owe a certain amount of time on the job in the United States



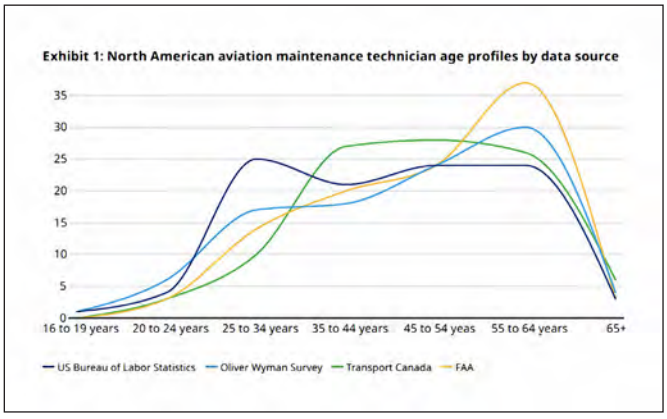
or North America, like the military requirements for Reserve Officers' Training Corps candidates

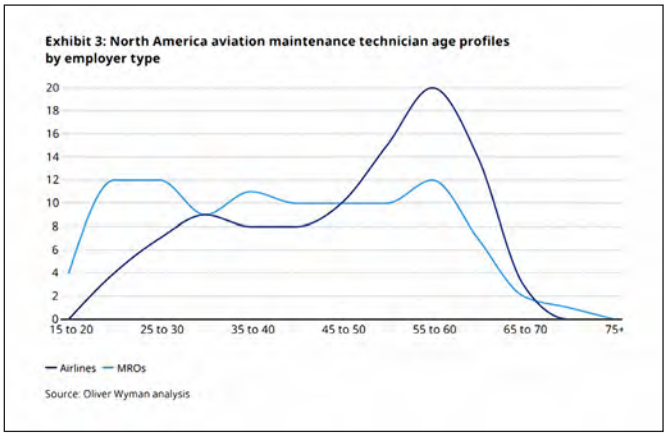
- Allow candidates to apply credits earned in other trades with similar rigor, such as apprenticeship and journeyman programs in heating, ventilation, and air conditioning and plumbing, toward A&P certificates where appropriate
- Amend the rules that require 18 full months of 40-hour weeks to allow candidates that put in the same hours over a shorter period to qualify to take the A&P exam. Right now, the rule is somewhat inflexible
- Make it easier for military-trained and foreign aircraft mechanics to get certificated as A&P-licensed mechanics in the US and make work visas available to them.

Cutting-Edge Tech

The Oliver Wyman Forum report called The New People Shaping Our Future showed that very few workers looking to upskill after COVID returned to traditional schools. They want a blended environment of in-class, online, and hands-on training. The MRO industry seems well-suited to provide that kind of experience.

Today's younger generation also grew up around technology, and they expect — and want — to utilize technology in their workplace, even for jobs that are hands-on. MRO training and operations must incorporate more modern tech-





One solution to the AMT shortfall is to make it easier for military-trained techs to find work.

nologies and experiences, not as experimental pilots but as business as usual. For instance, to ensure a unified industry focus on safety and reliability, training on the use of electronic logbooks, portable devices for work instructions, and hyperlinked content management systems should become standardized. Going further, FAA-certified schools should introduce more cutting-edge technologies, such as artificial intelligence, augmented and virtual reality (AR and VR), and drones, into the curriculum to bring training into the 21st century.

This raises the bar on the skill set of mechanics and potentially their productivity. Adding the latest tech to training programs may enable more rapid adoption of it by the industry — leading to more productivity.

Aviation also must consider trying to attract workers in industries with similar skill sets and designing training that will enable them to cross over to aviation. This would mean increasing program offerings for mid-career workers to switch into aviation.

Investment in Productivity

Given the impending shortage, maintenance organizations also need to focus on productivity more than ever. Are they making the most out of the scarce resources they have? There are tactical and structural changes that can be introduced to improve employee productivity, although companies must recognize the potential to scare away workers if they come down too hard.

The key is to make productivity programs more about improvements that make work easier or more satisfying rather than "turning the screws." One way to make such efforts more successful is to offer opportunities for worker input so they feel ownership in the changes. The company may also benefit from the different perspective.

Tactically, maintenance organizations should be looking to eliminate waste through technology, such as clocking systems and barcoding and Lean efficiency-focused principles and practices. Structurally, it's worth a company's time to ensure that aircraft are not being over-maintained and thus wasting resources.

Using data to increase maintenance intervals is an obvious benefit to airlines, but it is also vitally important for all MRO providers when resources are so limited. In the same spirit, reviewing maintenance programs to ensure that modifications and maintenance tasks are generating value is also a way of making sure resources are being deployed most effectively.

Much of that work has been done over the last several years, but there are aspects that have not been incorporated to their full potential:

- Employ Active Supervision to assist workers and keep them on task
- Increase adoption of digital tools, such as portable devices. This requires adequate on-the-job training to demonstrate their most productive uses and how they can make their jobs easier through real-time data collection, error proof records, and other required documentation
- Share data up and down the supply chain to reduce technicians waiting on parts or materials and maximize a mechanic's "time on tools" as a leading driver of labor inefficiency.

Conclusion

For aviation's aftermarket, the labor shortage projections should make it clear that new approaches to attract and retain

mechanics are needed. To accomplish that will mean pushing the MRO sector firmly into the 21st century through innovative talent practices, productivity, technologies, and values — especially if it wants to increase its appeal among Gen Z and millennial workers.

To deal with the immediate need, the focus must be on productivity: The MRO industry needs to be getting the most it can out of the limited number of mechanics it has. That means an increased emphasis on digitization, hand-held tech, and on-the-job training, as well as looking for ways to incorporate the newest tech.

Next, the industry must acknowledge the new labor landscape. It's no longer competing with only heavy industrial and manufacturing companies for young workers. It's going head-to-head with high-tech companies willing to offer higher pay, hybrid work situations, and better work-life balance.

To have a chance, MRO operations must focus on making entry-level mechanic slots more appealing by offering more competitive pay and benefit packages and an improved work-life balance. Employers must reduce barriers to entry with financial aid, work-study programs, and sponsorships — especially for underrepresented groups. By diversifying the workforce through active recruitment of women and minorities, employers will move the sector into the 21st century culturally and ease the squeeze on resources.

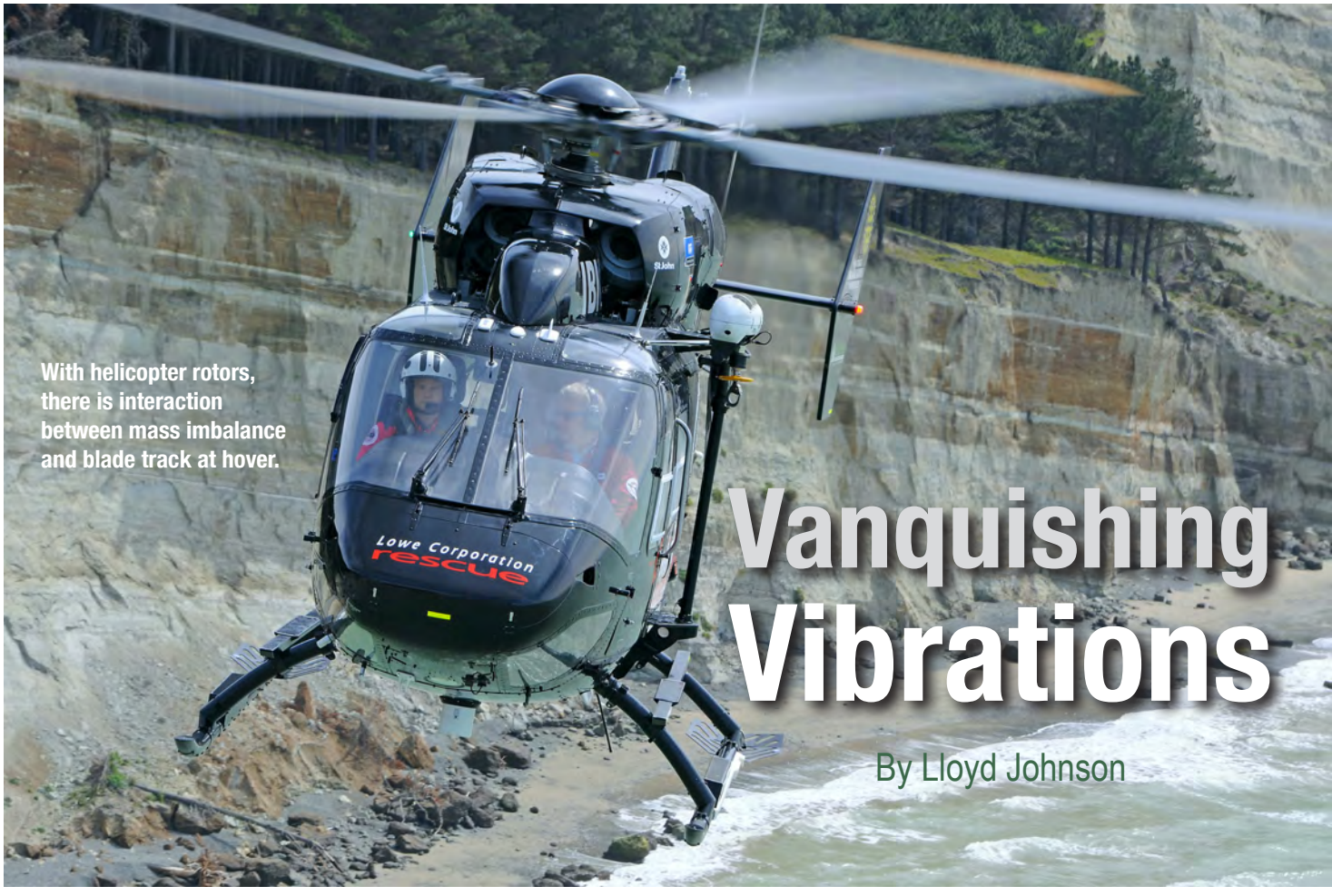
Recruiting must start earlier, at the middle school and high school levels through curriculum, internships, and scholarships. Simultaneously, there should be a dramatic expansion of sponsorships that help candidates get through training with less debt, placement opportunities, and future options to expand their skill base.

The younger generations like technology and want to be introduced to the latest like VR, AI, and drones. Airlines and independent MROs should encourage the FAA and other training programs to bring in this kind of cutting-edge tech to the classroom and should also be open to experiment in the workplace.

Mitigating the labor shortage may require companies to go a little outside their comfort zone and essentially establish a new working relationship with mechanics. We don't necessarily believe we will see the worst-case scenario and, in fact, expect the shortage to end up somewhere between our baseline and best-case.

Our expectation is that the industry will increase wages to recruit and retain more workers. In addition, we have confidence the industry will also expand sponsorships and work harder to increase women and minority recruitment. Still, numbers don't lie, and they portray an industry that needs to address its declining popularity among younger workers. Without some fundamental change, that trend may haunt the industry for more than just this decade. ■

(Not Enough Aviation Mechanics was written by Derek Costanza, Brian Prentice, Matt Poitras, Oksana Bardygula, Brian Fasano, Sam Sargent, Livia Hayes, and Carlo Franzoni. The full report can be found at www.oliverwyman.com under the Insights menu.)



With helicopter rotors, there is interaction between mass imbalance and blade track at hover.

Vanquishing Vibrations

By Lloyd Johnson

Over the decades many methods have been used to reduce vibrations produced by the main and tail rotors of helicopters. Here, California-based Dynamic Solutions Systems argues why they believe their technique is a better approach.

THEORETICALLY, main rotor blades should all fly in the same plane and maintain equidistant angular spacings during flight. Pitch links and tip tabs can be adjusted to compensate for blade differences to keep the blades in line at all forward speeds. Rotor tracking systems have focused on providing information that can be used to adjust the pitch links and tabs to coax the blades to fly "perfectly."

FLAG TRACKING

The earliest technique for rotor tracking was flag tracking, where the tip of each blade was marked with coloured chalk or crayon and a white strip of cloth mounted to a pole was pushed into the edge of the rotor blade path. The marks on the cloth gave a measure of the blade track.

ELECTRO-OPTICAL TRACKING

In the 1960s an opto-electronic method of measuring rotor track height and lead lag was developed and patented by Chicago Aerial. They built small single lens systems that could be mounted to the aircraft and measure track in flight, but the system they sold the most of was a large ground based

Left: Users found the track conditions of the rotor directly related to vibrations in the airframe.

Above: A bad damper may produce a subtle transient vibration effect during turns.

Left: If alternating blades are set to fly high and then low, each blade will have calmer air to fly through resulting in smoother flight.

dual lens/sensor system that was very accurate but could only measure track on the ground.

STROBE LIGHT TRACKING

In the late '60s, early 1970s Chadwick-Helmuth adapted a strobe light and retro-reflective tip targets to allow blade track and lead-lag to be measured in flight. This technique required the operator to manipulate a dial and visually locate a group of targets in space and remember their relative locations. This method required significant operator skill and training, often making results obtained by military units unreliable. In the early 1980s the US Army and helicopter manufacturers made it clear they were looking for a system that could measure blade track consistently and accurately without highly skilled human operators.

ELECTRO-OPTICAL TRACKING REVISITED

In the 1980s Stewart Hughes revived the method originally developed by Chicago Aerial and applied up-to-date electronics and packaging methods to make this technique practical for in-flight tracking. Helitune developed another method using a line scan video camera. Scientific Atlanta entered into a licensing agreement with Stewart Hughes to utilize their technology for blade tracking. Chadwick-Helmuth introduced a system in the early '90s that utilized the method patented by Chicago Aerial to measure track optically without using a strobe. In 1995, the company I work for—Dynamic Solutions Systems (DSS) introduced an optical tracker using a method patented in the 1970s but never produced commercially.

The DSS technique uses a hand held electronic camera that has several advantages over the methods currently in use. These are:

1. No tip targets or tape or painting blades is required.
2. The camera is hand-held, eliminating mounting problems.
3. Very little power is required, meaning aircraft power is not used.
4. The data is machine readable, making the results reliable and repeatable with unskilled users.
5. Using daylight, the system is totally passive.

TRACKING USING VIBRATION SENSORS

Users found the track conditions of the rotor directly related to vibrations in the airframe. Experimentally it was found that the vibration information could be used to adjust pitch links and tabs to produce minimum vibrations at all forward speeds. After this process was complete, the blade track could be measured optically and surprisingly the blades were not in

In the early 1980s the US Army and helicopter manufacturers made it clear they were looking for a system that could measure blade track consistently and accurately without highly skilled human operators.

perfect track! This lead to a quandary... do we want perfect track or minimum vibrations?

IS TRACKING OF ANY VALUE?

In the process of using these tracking methods and measuring the vibrations that resulted, users found that "perfect track" rarely produced minimum vibrations. Various theories have been proposed to explain this effect. One theory is that each blade has a slightly different shape, twist, flexibility etc. and only by putting them slightly out of track can these variations in lift be compensated. Another theory is that each blade produces a "turbulent wake" that the trailing blade must fly through. If alternating blades are set to fly high and then low, each blade will have calmer air to fly through resulting in smoother flight. This effect is more pronounced on aircraft with four or more blades on the main rotor.

TRACKER IS USEFUL FOR FINDING ROTOR FAULTS

This fact has lead some manufacturers to conclude that blade tracking is of little value and the only purpose of rotor smoothing should be to minimize vibrations without regard to blade track. This approach has a few drawbacks however. First, a bad blade that must be put way out of track to minimize vibrations can only be detected if a tracking system is used. Second, blade track and lag information may make finding some problems with the rotor much easier. For example, a bad damper may produce a subtle transient vibration effect during turns, but a lead lag measurement will show the damper problem as a blade obviously unstable in angular position.

ROTOR BALANCING METHODS

Early methods of balancing helicopter rotors were limited to static bubble balancing of rotor heads and weighing blades to be sure the rotor was symmetrically loaded. In the 1970s maintenance personnel began attaching vibration sensors and using spin balancing techniques that were common in industry on large industrial blowers. Using a strobe flash to establish the phase of the vibration along with a meter reading of the amplitude of the vibration, charts (nomograms) could be used to determine where to add weight and how much.

EARLY COMPLEX ALGORITHMS

With helicopter rotors, there is interaction between mass imbalance and blade track at hover. If one blade is flying high and producing more lift, it will also lag its normal position due to higher drag force. This induces an effective mass imbalance due to the blade being out of position. Due to this and other interactions, users developed procedures or algorithms that allowed the rotor to be smoothed by performing steps in a particular order.

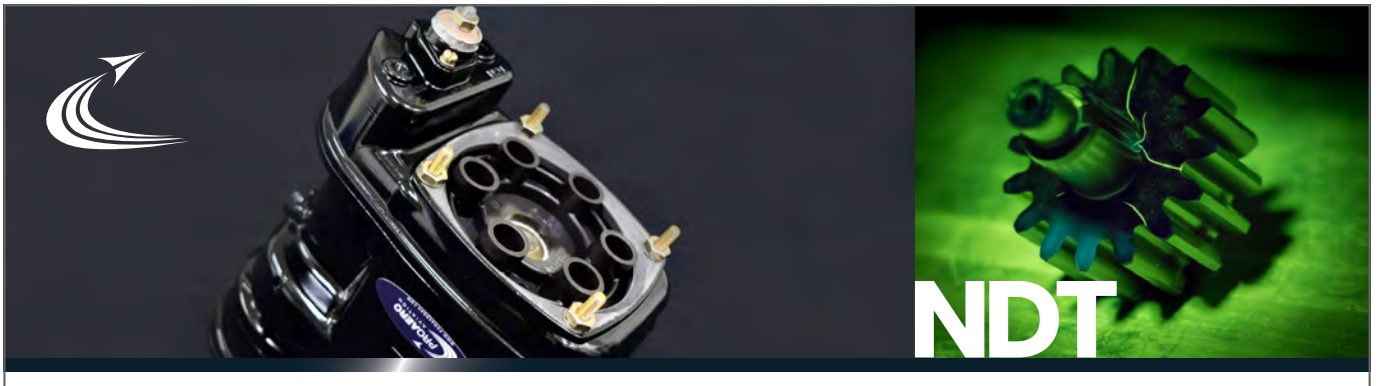
For example, **First:** track blades with pitch links on the

ground. **Second:** track the blades with pitch links based on hover and forward flight track. **Third:** adjust tabs based on track data or vertical vibration data in forward flight. **Fourth:** spin balance the main rotor at hover. These procedures required a good deal of skill and accuracy from the maintenance personnel.

Once again the military did not get consistent good results with average military personnel trying to execute these complex algorithms. The military and helicopter makers asked for automated computerized methods that eliminated the need for highly skilled users.

COMPUTER BASED ALGORITHMS

In the 1980s hand held computers were programmed to perform the rotor smoothing algorithms. In some cases, the engineers programming the new computer systems wanted to



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Users found that "perfect track" rarely produced minimum vibrations.

leapfrog the algorithms that were currently in use. A new concept became popular that theorized all interactions between pitch link, mass balance and tab were linear. If this linearity were valid a single flight to gather data at several flight regimes would be all that is necessary to make all required adjustments. Another popular concept was that all helicopters of the same type were sufficiently similar to allow a single computer math model to be used without adjustments for each individual aircraft. Equipment based on these two concepts was developed and introduced into the market by Chadwick-Helmuth in their 8500 system and Scientific-Atlanta in their RADS system.

UNRELIABLE ALGORITHM

Single flight computer based rotor smoothing algorithms based on these two concepts have proven to be unreliable. They work fine so long as the aircraft is close enough to normal conditions for linearity to hold fairly well and so long as the aircraft is a fairly good match for the math model contained in the program. The problem is: How often are these two conditions met? Experience has shown these conditions are only met 50 to 75 percent of the time. When these conditions are not met, the algorithm fails and cannot provide any further assistance in rotor smoothing. The user is stuck. Some vendors feel this method is still viable... At DSS, we do not. If your wrench only fit 50 to 75 percent of the time would you be satisfied?

ALGORITHM UNABLE TO VERIFY MOVE

Compounding this problem is that a single flight method does not lead to any method of verifying that the changes recommended were executed properly. This is because the single flight method requires the user to make several adjustments at once. Due to the interaction of these adjustments it is virtually impossible to determine if the adjustments were done correctly. **Example:** On Huey and Jet Ranger main rotors, blade sweep is used to accomplish chord wise mass imbalance of the main rotor. Field data has shown that there is

One theory is that each blade has a slightly different shape, twist, flexibility etc.

tremendous stiction in this adjustment. Quite often when the adjustment is done, no mass shift can be measured. Only by isolating this adjustment can stiction be overcome.

IMPROVED FAULT-TOLERANT ALGORITHM

The DSS rotor smoothing algorithm is the single move method. Each flight will only result in instruction to make a single adjustment. The next flight will be used to verify that the change matches the math model, if it does not match but is within a tolerance, the math model will be corrected to match the current aircraft. If it does not match and is radically different from the expected result, the user can double check that the move was as specified and if so the move can be taken back out to see if the original data repeats. This algorithm will allow the math model to learn the particular characteristics of the current aircraft. Any errors in user execution of the change will be caught. When the rotor smoothing is completed the math model can be stored and labeled with the tail number of the aircraft being worked.

Another advantage of this method will be the first flight may only be pulling the aircraft up into hover for 30 seconds. Forward flight will not be attempted until hover vertical and lateral vibration is low. This will avoid the safety hazard of trying to fly an aircraft that is badly out track or balance in forward flight conditions.The DSS algorithm will work on all rotors and will require lower skill levels on the part of the operator when compared to earlier methods using paper charts. The math model will be improved with each use to the point where it will match the aircraft in use precisely. This will save time in future track and balance operations compared to repeatedly trying to balance an aircraft with a fixed math model of a typical aircraft.

The DSS algorithm is grounded in the scientific method used in all research. Using this method all conditions are held constant except one. The true effect of changing one condition can then be accurately assessed. Only by using this method can real learning take place.

Another advantage of the DSS approach over the single flight method has to do with development cost and time.

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Development of a single flight program requires hundreds of flights on many different aircraft of the same type. This is required to arrive at a reasonable average math model of this type of aircraft. Since this method cannot learn from normal use, all this data must be gathered and averaged before the program can be written. This process is time consuming and costly.

During this process, which may take up to a year or more, the program for this aircraft is unavailable. Even when the process is complete, if the math model does not match the users particular aircraft the program will not work. The DSS approach does not have this flaw. Our algorithm will only need to know basic mechanical facts like the number of blades, number of tab stations, type of rotor, if tabs are adjustable etc. and can then be used immediately to smooth any helicopter rotor. In fact only one program will exist for this method. The data the program learns for each aircraft will be stored in a separate data file for that aircraft.

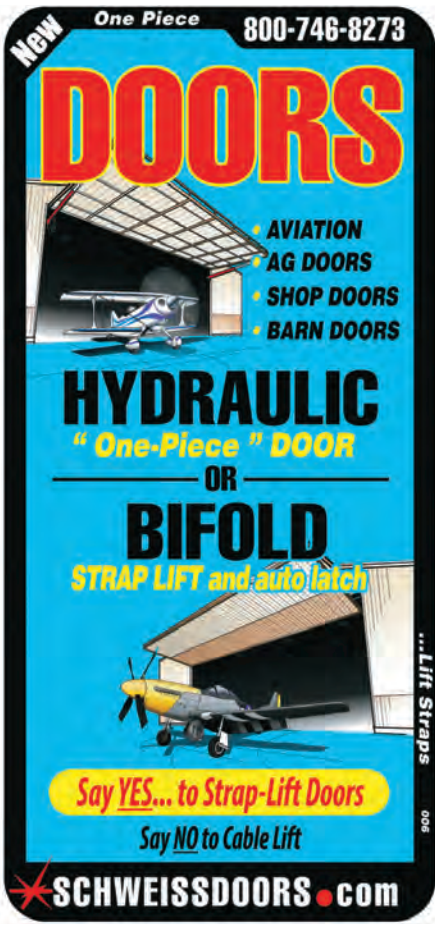
For example: after working one Huey, a user can use this data file to work a second Huey for a good head start, but each Huey will be slightly different, and the program will learn from the process. This leads to the advantage of the DSS method for working helicopter types that are new, or that are few in number, making development of a single flight program uneconomic.

Another advantage of the DSS approach is when each aircraft of a particular type is significantly different from its sister aircraft. We have found this condition to exist with the Robinson R44 for example. If the algorithm does not learn each individual aircraft, the algorithm will fail.

BASIC CAPABILITIES

Another problem with several helicopter track and balance systems on the market is their limited basic capabilities. They have become so highly specialized that they have left out several basic features found in most general purpose balancers and vibration analyzers. Some systems require a special program in order to take a simple balance measurement. Some systems cannot recall a saved spectrum back to the screen for analysis. Some systems can only print to a built-in thermal printer, limiting the quality of the hard copy record. Some systems have only one choice for the number of lines in the spectrum analysis.

Some systems have little or no spectrum averaging capabilities. Some systems cannot even make reliable and repeatable balance measurements during slight gusty winds or minor turbulent conditions due to poor measurement methods and averaging techniques. Our MicroVib is not only a powerful helicopter track and balance system, it retains all the basic capabilities of a general purpose balancer and vibration analyzer that other more expensive systems have left out. ■



PACIFIC

Pacific AME Association

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 Aircraft Maintenance Engineers of Canada (AMEC).

Mission Statement

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

We shall promote honorable practices among our Members and others in the aviation industry, while remaining non-union, non-sectarian and non-partisan.

www.amec-teac.ca/pacific

WESTERN

Western AME Association

Who We Are

The Western Aircraft Maintenance Engineers Association (WAMEA) is an organization equipping its members with the knowledge and professionalism which distinguishes the occupation of Aircraft Maintenance Engineers (AMEs) in the aviation industry.

For any inquiries email, info@wamea.com or president@wamea.com
Phone: 587-713-WAME (9263)

Website Maintenance

While the WAMEA website is undergoing maintenance, please take the opportunity to peruse the National AME Association website for your professional interests at:

http://www.amec-teac.ca

Thank you for your patience,
Greg Andersen
President
Western AME Association

www.wamea.com

CENTRAL

Central AME Association

CAMEA Outstanding AME

Previously known as the NAASCO Outstanding AME Award. This award recognizes any AME or manager holding an AME license in Manitoba, Saskatchewan, and Northern Ontario that has performed an extraordinary act of service or has shown leadership, dedicated technical service and has been active in nurturing and training other mechanics.

2023 Winner – Henri Boulanger

Henri Boulanger obtained his commercial pilot and AME licenses in the early 60s. He spent many years flying bush planes for Bearskin Lake Air Service and maintaining aircraft in Big Trout Lake, Ontario. Henri then moved to Lac du Bonnet, Manitoba, in the late 70s, where he worked as a pilot and maintenance worker for several local air services, including Silver Pine, Tall Timber, and Bluewater Aviation. He has completed contract work for Buffalo Airways and Adventure Air throughout his career.

In recent years, Henri's work has primarily involved completing annual inspections for private customers, many of whom have become his close friends. Salvage jobs are among the most challenging tasks for an AME, requiring repairing and flying the aircraft safely. Despite working in bitterly cold winters, Henri has always enjoyed his work and its challenges. He considers working in a warm hanger a treat compared to outdoor maintenance.

Women AME in Training

The CAMEA – Ninety-Nine scholarship award for Women AME in Training is a significant step towards promoting and supporting women in the Aircraft Maintenance Engineer (AME) field. Through this newly formed scholarship, we aim to inspire and attract more women into the field of AME and provide them with the resources to achieve their goals.

2023 Winner – Helene Trudeau

Hélène has been studying Aircraft Maintenance Engineering at Red River College Polytech in Winnipeg and is now an AME apprentice at Fast Air. She hopes to contribute to aviation safety and to bring people along the journey with her to encourage young girls through her volunteer efforts with various local organizations. As a member of the Friends of the 99s, she has recently helped install a winter kit on their Cessna 152 and looks forward to assisting in projects involving the organization and the aircraft. w**ww.camea.ca**

AME Association of Ontario

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ONTARIO

Association Updates

We started off the year with a busy month. A special Board of Directors Meeting was held on January 14th at the Canadian Warplane Heritage Museum to discuss our Budget and Objectives for 2023. Goals were set and plans made for improving corporate membership, ideas for training initiatives and expanding our general membership. Consensus was reached that we need help with administration and bookkeeping and that we may have to pay for these services.

The special board meeting was followed by a Team Change Management Course facilitated by the Ontario Aerospace Council. Several Ontario aviation maintenance industry guests also attended.

The regular monthly AME Association of Ontario Board of Directors meeting was held Monday evening, January 23rd using Google Meets. At the meeting the board members voted for Stephen Farnworth to fill the vacant Vice President position. Drea Reid Sneath was elected as a Director-at-Large and was then elected as the Association Secretary.

Joe Brazeau has stepped down as our Area Director for the Northern Region. We are seeking candidates to fill this Northern Area Director position. Candidates should reside in the postal code starting with the letter P and be willing to liaise with their area AMEs and AMOs, as well as meeting virtually with the board once per month.

Our Conference and Workshop committee has been hard at work preparing for our next conference. Mark your 2023 schedules for Wednesday and Thursday, November 15 & 16 (setup by vendors on Tuesday November 14) for this year's conference to be held at the Delta Hotel and Conference Centre near the Toronto Airport. Details and updates will be posted on our Conference website - https://www.ame-ont.com/cpages/conference-2023

Submitted by ***Stephen Farnworth,***
For the Board of Directors
www.ame-ont.com

Quebec AME Association

Association des Techniciens/Techniciennes d'Entretien d'Aéronefs du Québec

C.P. 34510, 3131 Côte-Vertu; CSP Place Vertu, Saint-Laurent, Qc, H4R 2P4
email: info@ame-tea.com website: www.ame-tea.com

QUÉBEC

Nous sommes l'Association des Techniciens et Techniciennes d'Entretien d'Aéronefs du Québec et nous sommes fiers de pouvoir servir et promouvoir la communauté des TEA du Québec. Membre de l'AMEC/TEAC, nous travaillons avec les différentes associations de TEA à travers le Canada sur différents dossiers, dont certains directement avec Transports Canada.

L'Association des TEA du Québec promeut la sécurité des personnes affectées par les métiers de la maintenance aéronautique, favorise des pratiques sûres sur le lieu de travail et reconnaît que la sécurité est la pierre angulaire de l'industrie aéronautique.

Faire partie d'une association régionale de TEA amène certains avantages. Outre l'accès à des rabais intéressants pour les TEA, vous recevrez plusieurs magazines dédiés au monde de l'aéronautique directement à la maison. C'est aussi un excellent moyen pour les TEA de participer à cette communauté.

Nous avons récemment été actifs à différents niveaux et avons eu le plaisir de participer à la journée Portes-Ouvertes de l'École nationale d'aérotechnique de St-Hubert le 19 novembre et avons eu la chance d'y rencontrer nombre de futurs étudiants souvent accompagnés de leurs parents. De plus, le 20 et 21 novembre derniers, les 6 associations régionales de TEA du Canada se sont rassemblées à Ottawa en présentiel pour la première fois depuis l'assouplissement de certaines restrictions relatives à la Covid-19. Nous y avons également rencontré les représentants du département de la Navigabilité opérationnelle de Transports Canada pour notre réunion annuelle avec eux. Nos membres recevront sous peu un compte-rendu complet de cette rencontre.

Finalement, nous prévoyons organiser notre assemblée générale au début de 2023. Les membres seront informés par courriel relativement à cette rencontre.

Vous pouvez en apprendre plus à notre sujet à l'adresse suivante :
www.ame-tea.com email: info@ame-tea.com

The association's mission is to represent all AMEs in Quebec regardless of the company or the contracts on which they work. Regardless of the type of aircraft on which the AME works, he/she will be welcome. We will simply recognize ourselves as a holder of an AME Transport Canada M1/2, E or S license with an attachment in Quebec.

Renewal: Annual Membership

Licenced Aircraft Maintenance Engineer: $45
Apprentice/ Student/ Retiree: $30

Here is how you can renew

Make an Interac transfer to the following email address:
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Learn more about us at :
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ATLANTIC

Atlantic AME Association

Mark your calendar
ARAMC 2023 is set to be held at the :
Delta St. John's, Newfoundland on **May 3-5, 2023**.
Info to follow as it becomes available.

Potential phishing scam alert
To our members: It's been brought to our attention that there could be Phishing emails circulating that appear to be coming from the Association President, Bob Pardy. Please be vigilant and do not open if it appears suspicious.

www.atlanticame.com

SOCAL

SoCal PAMA Chapter

Who We Are
The purpose of SoCal PAMA is to promote a high degree of professionalism among aviation maintenance personnel; to foster and improve methods, skills, learning, and achievement in the field of Aviation Maintenance; to conduct local meetings and seminars; to publish, distribute, and disseminate news, technical bulletins, journals, and other appropriate publications dealing with the trade of Aviation Maintenance; to collaborate with other organizations in aviation in the queries of governmental agencies pertaining to maintenance rules and guidelines.

Flight Safety Detectives

Yeti Air Crash Preliminary Report (Episode 157)

The Flight Safety Detectives John Goglia and Greg Feith examine the preliminary accident report from the fatal January 2023 Yeti air crash. They discuss professionalism and crew resource management as the central cause.

"Pilots needs to execute with purpose," Greg Feith says. "That means that before you do or touch anything in the cockpit you have to be clear about your purpose."

Greg, Todd Curtis, and John Goglia share possible reasons why the Yeti Airlines ATR 72 flight crew made fundamental errors that allowed the aircraft to stall and crash shortly before landing. For them, the Yeti air crash may become a great case study for the importance of paying attention and professionalism.

The flight crew included a captain getting familiarization training with a new airport and a training captain. John highlights the many tasks being covered by the training captain and makes a case for the need for a third crew member in the cockpit.

The preliminary report shows that the training captain grabbed the wrong levers during approach. Neither pilot reacted well to the resulting flight issues. Human factors and poor communication are large contributors to the resulting crash.

This episode also includes discussion of the acting FAA administrator's effort to put together a panel to study aviation safety. John, Greg and Todd talk about the types of people who need to participate to get an accurate picture of what is happening with aviation safety.

World-renowned aviation industry consultants and former NTSB investigators John Goglia and Greg Feith have 100 years of worldwide aviation safety experience between them. In the hard-hitting Flight Safety Detectives podcast series, they offer the ultimate insider view of everything aviation safety including behind-the-scenes facts on deadly air crashes and issues impacting general aviation and the commercial airline industry.

www.socalpama.org

Central Ohio PAMA

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Be a content contributor

Our members work at many airports in the Central Ohio area and may be interested in some event happening at your airport. This information might include visiting vintage aircraft or dignitaries, fly-ins, airshows, etc. If you know of some upcoming event or special interest item at your airport, pass us an email including some base information and we'll post it here for other members to view.

www.copama.org

Remember When? Some of our COPAMA Scholarship Award Recipients from 2019.

A fun look back at 2019: (Left-Right) Andrew Callendar, Pablo Lazu, Antony Sivixay, Justin Nelson and William Rioch, winners of the 2019 COPAMA Scholarship Award Recipients.

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Reports and Comments

The following are selections of Canadian Aviation Service Difficulty Reports originally published as "Feedback" by Transport Canada.

Left: Muffler as installed, adjacent to the hydraulic filter manifold, outer insulation wrapping damage is evident. Above: A Learjet 45

REPORT: LEARJET 45

Environmental Control System (ECS) Muffler Cracked

Subject:

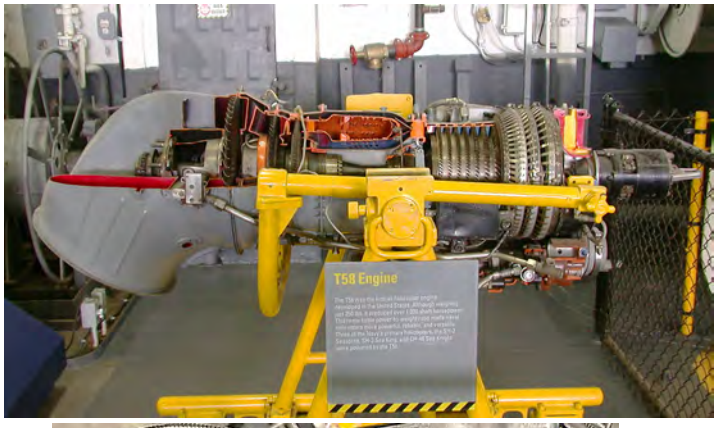
During routine maintenance, insulation was found blown into the hydraulic access panel and filter areas. Further investigation revealed that the cockpit ECS muffler assembly had cracked in two places (one crack was 2 1/8" long and the other was 3 1/8" long). No issues were noted in flight prior to the finding. This muffler was installed in 2000, in accordance with Service Bulletin 45-21-4 Modification of the Environmental Control System for Reduced Cabin Noise Levels and had accumulated 8178.0 hours since installation. The muffler was removed, inspected, and re-installed in 2020 due to other fleet muffler issues with no defects noted at that time.

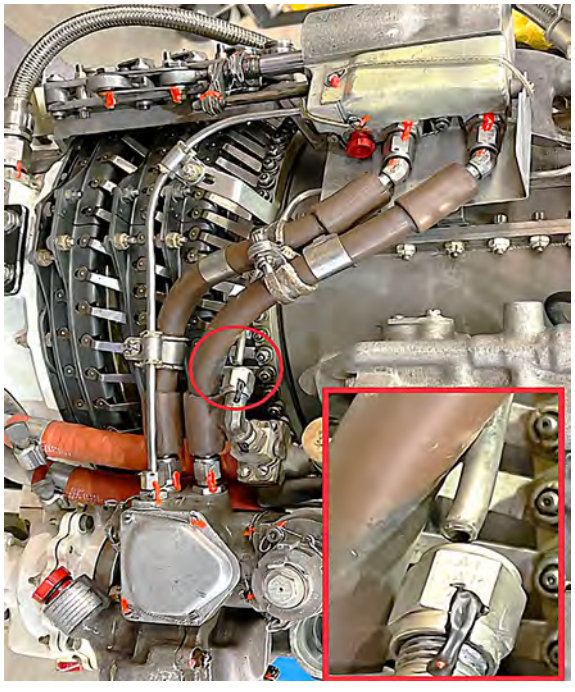
Transport Canada Comments:

Additional reports of failure have been discovered after experiencing ECS anomalies in flight. Low airflow to the cockpit, inability to maintain selected heat settings and reports of cabin pressurization loss have been described by flight crews.

Learjet has noted that adequate cabin pressurization is available regardless of a rupture in the muffler assembly. It may cause the cabin air not to be routed through the operator's desired duct locations, but it will still reach the cabin, and with additional ECS ducting through the bulkhead, safe cabin pressure levels will be maintained.

This area is routinely accessed during a 300 hour hydraulic filter replacement. Damaged or loose outer insulation wrapping around the muffler or insulation material located near the hydraulic manifold is a good indication that the cockpit ECS muffler may be cracked.





Top left: General Electric CT58 engine.
Left: General Electric CT58. Broken P3 air line.
Top right: Piper PA-44. Incorrect orientation of centering spring bracket. Bottom right: A Piper PA-44 in flight.

REPORT: GENERAL ELECTRIC CT58-140-2

Broken P3 Air Line

Subject:

During forestry fire-fighting operations, after the load of water was picked-up and the climb was initiated, Engine Number 2 was not providing the required power. When compared with Engine Number 1, the torque was 40% lower and the T5 was 120 to 130 degrees Celsius below the Engine Number 1 T5 indication. The water load was released, the checklist for the low side governor failure was completed, and the helicopter returned safely to the base. An engine inspection revealed a broken P3 air line.

Transport Canada Comments:

The root cause of the broken air line has yet to be determined, however, fatigue and stress may have played a role in this failure. The photo shows the broken air line offset from the B nut, which may suggest a side load from installation.

Due to congestion of lines and bundles on many engines, it is sometimes difficult to have proper alignment when connecting fluid lines. A slight bend of a line to achieve contact, may induce stress and lead to a failure. Another common error is securing and torquing one end of the line before connecting the other end, instead of connecting both ends and then securing and torquing.

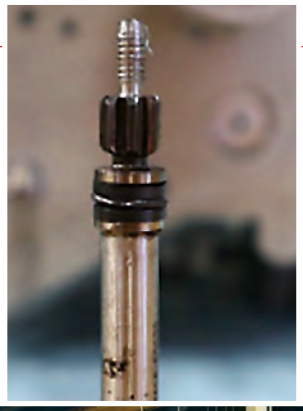
Transport Canada Civil Aviation (TCCA) would like to make operators and maintainers of this model and similar models aware of this event. It is also recommended that close attention be paid to this line when inspecting in this area.

REPORT: PIPER PA-44

Nose Landing Gear Centering Spring Bracket Installed Upside Down

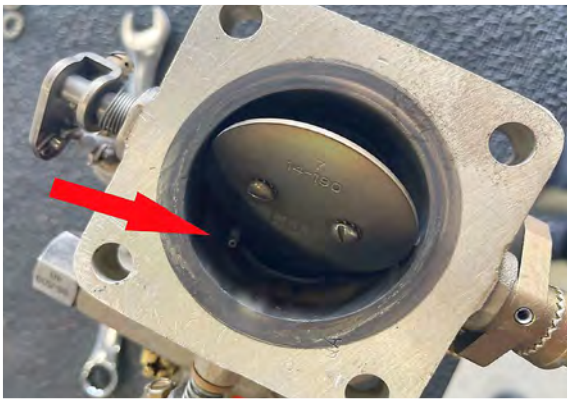
Subject:

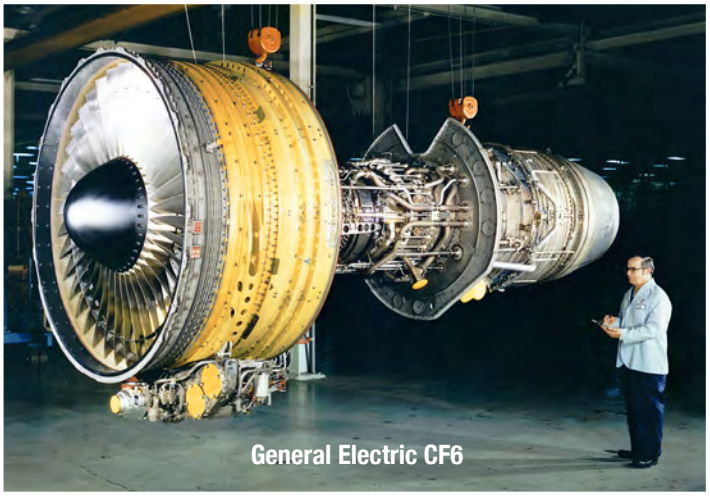
The pilot was practicing slow flight and noticed that when the landing gear extended, only the main lights illuminated. He made several attempts to deploy the landing gear with no success in getting the nose gear extended. The pilot flew by



Left: General Electric CF6. Main Engine Control driveshaft.

Right: Avco Lycoming O-320. Discharge tube lodged beside throttle fly.





General Electric CF6

Avco Lycoming O-320

the tower, which confirmed that the nose landing gear was not fully extended. Only a small portion of the tire could be seen in the wheel well. The pilot elected to burn some fuel for an hour and then land. The aircraft landed and came to rest on its nose nacelle. The pilot feathered the engines on landing. Unfortunately, the propellers struck the ground, bending back the blade tips.

Upon inspection by maintenance, it was found that the centering spring (shimmy damper) bracket was installed incorrectly, which caused the nose gear to be turned off centre, and, consequently, the gear got stuck in the wheel well. Before this flight, there was a ground handling incident where the centering spring bracket had been bent. The bracket was removed, straightened, inspected, and reinstalled. It was at this time that the bracket was reinstalled upside down, causing the nose gear to spring off centre with weight off the wheel.

Transport Canada Comments:

Owners, operators, and maintainers are reminded to always follow the appropriate instructions for continued airworthiness (ICA). In cases where clarity of assembly cannot be positively ascertained, the type certificate holder should be contacted for assistance.

Although the outcome of this occurrence was likely burdensome on many levels, it was not catastrophic. Service Difficulty Reports (SDRs) should continue to be submitted for occurrences related to assembly / installation lack of clarity. The potential for mistakes and resultant consequences are not always apparent while completing complex tasks, especially if these tasks are new to the Aircraft Maintenance Engineer.

REPORT: GENERAL ELECTRIC CF6

Main Engine Control Driveshaft Migration

Subject:

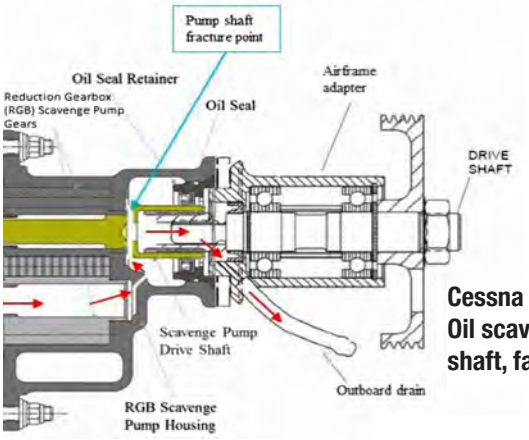
During the left engine start, a hung start condition was observed, with the power turbine speed N2 at 75% and 450 degrees Celsius Exhaust Gas Temperature (EGT), with no response to throttle movement. The engine was shut down for maintenance troubleshooting.

Troubleshooting was carried out and identified the Main Engine Control (MEC) as being at fault. Upon maintenance removing the MEC from the accessory gearbox, the driveshaft was found no longer mated to the MEC. The driveshaft had migrated towards the gearbox and was no longer rotating the MEC internal shaft. The nut, attaching the driveshaft within the MEC, had backed off to allow this migration of the shaft. The MEC was replaced, and the aircraft was returned to service.

Transport Canada Comments:

From viewing the MEC driveshaft threads photograph, it appears that the threads were worn or damaged. This condition may have been a factor contributing to the attaching nut backing off. The use of wrong hardware, cross threading or over torque of the securing nut, and thread strength, are a few possible causes of thread damage. Until an investigation is carried out, the root cause of this event remains undetermined.

Although the investigation is still ongoing, Transport Canada Civil Aviation (TCCA) would like to bring this event to the attention of maintainers and operators of the CF6-80C2B6



Cessna 208B. Oil scavenge pump drive shaft, failure location.

Cessna 208B. Alternator pulley drive shaft, bearing failure.

model or similar models. A verification of the MEC driveshaft condition and security when in this area, or before installation of the MEC, may prevent a similar or more serious incident.

REPORT: AVCO LYCOMING O-320

Liberated Accelerator Pump Discharge Tube

Subject:

While landing, the student and flight instructor noticed that they were unable to reduce the engine speed to idle, revolutions per minute (RPM) could only be controlled between 2000-2200 RPM. They declared an emergency, shut down the engine in short final and landed safely. The company's maintenance technicians inspected the engine throttle control and noticed that it could not be pulled back. The carburetor was removed, and it was found that the accelerator pump discharge tube had detached and stuck in the butterfly.

Transport Canada Comments:

The MA-3 and MA-4 series are updraft style carburetors found on Lycoming, Continental, and other normally aspirated engines. They are currently manufactured by Mavel-Schebler Aircraft Carburetors (MSA) and were previously manufactured by Precision, Facet, and Volare.

The accelerator pump discharges fuel only when the throttle fly is moved toward the open position. In MA4-5, MA-5 and MA-6 series carburetors, this additional fuel is fed through the main discharge nozzle, and in smaller carburetors such as the MA-3 and MA-4 series, a separate discharge tube is utilized. This discharge tube is bonded in the sidewall below the venturi and main discharge nozzle.

1. Possible indications of a liberated discharge nozzle could include:
2. Obstructed throttle fly, jammed throttle control
3. Fuel found in airbox
4. Cylinder Foreign Object Damage (FOD)
5. Failure to start
6. Sluggish acceleration during takeoff or other phases of flight

Accelerator pump discharge tubes are bonded in place during assembly or overhaul and undergo a specified torque check to determine serviceability. Transport Canada Civil Aviation (TCCA) recommends that a detailed visual inspection of this area be performed whenever possible to detect a disbonded accelerator pump discharge tube and that such defects continue to be reported by submitting a Service Difficulty Report (SDR).

REPORT: CESSNA 208B

Standby Alternator Drive Bearing Failure

Subject:

During a flight, the pilot noticed that the standby power inoperative (INOP) light had illuminated. He then diverted back, contacted maintenance about the issue and noted that all oil pressure, torque and power output of the engine (Ng) indications were normal. Shortly after the conversation with maintenance, the pilot observed that the oil pressure gauge started to fluctuate. The fluctuations continued to worsen as the flight continued and the pilot elected to divert to a closer airport. The pilot landed the aircraft with no major issues.

Maintenance went to inspect the aircraft and noticed a streak of oil along the right side of the fuselage. While inspecting the engine, maintenance noticed that the alternator pulley had a slight wobble. They removed the alternator pulley drive assembly and the oil scavenge pump drive shaft came out along with the alternator pulley drive assembly. The oil scavenge pump drive shaft had sheared off where it couples with the alternator drive shaft. After disassembling the alternator pulley drive assembly, the bearing on the side of the pulley had come apart and the ball bearings came out of the housing.

Transport Canada Comments:

Textron Aviation suggests removing the alternator drive belt during Manual Task 24-36-00-220 (Inspection Document 07 – 400hr / 12 month inspection). Refer to Single-Engine Turboprop Communique # SE-TP-004. "Removing the alternator belt during this inspection allows for a more thorough check of the pulley assembly, as it does for checking side-to-side play."

Transport Canada Civil Aviation (TCCA) suggests owners, operators, and maintainers pay particular attention to this area and continue to report any defects noted. ■

Transportation Safety Board of Canada | Bureau de la sécurité des transports du Canada

Blame it All on the Laser

Undetected damage to a Boeing 777's high-pressure turbine shrouds and hangers was the source of drama at Pearson International Airport.

Approximately 6 seconds after the engine failed, the crew received an EICAS engine fail warning when the N2 speed decreased below idle.

AT 1425 EASTERN DAYLIGHT TIME, the Air Canada Boeing 777-333ER aircraft (registration C-FITW, serial number 35298), operated as flight ACA 001, commenced the take-off from Runway 23 at Toronto-Lester B. Pearson International Airport, Ontario. The aircraft, with 16 crew members and 309 passengers on board, was en route to Narita International Airport in Tokyo, Japan. During the initial climb-out, at approximately 1590 feet above ground level, the number 2 engine failed (GE 90-115B, serial number 906-456).

The flight crew followed the Quick Reference Handbook procedures and secured the engine. Air traffic control was notified of the event, and the flight crew declared an emergency. After jettisoning fuel to reduce the aircraft weight down to the maximum landing weight, an uneventful landing was carried out at Toronto-Lester B. Pearson International Airport. Emergency services stood by for the landing and escorted the aircraft back to the gate. There were no injuries, but the underside of the right wing received minor damage from engine debris ejected through the exhaust. Several automobiles on the ground were also damaged from the falling debris. There were no reported injuries.

HISTORY OF THE FLIGHT

The aircraft arrived at Toronto-Lester B. Pearson International Airport (CYYZ) after a seven-hour flight from Frankfurt, Germany. There were no reported engine defects. Air Canada line maintenance completed the pre-departure checklist and added 1.5 litres of oil to the number 2 engine. Normal oil consumption for this model engine is 0.34 litres per hour. Boarding was completed, and the aircraft was given taxi instructions for Runway 23. All engine parameters were normal when the aircraft commenced its take-off from Runway 23.

At 1427, with the aircraft at an altitude of 2160 feet above sea level (asl) and travelling at a computed airspeed of 206 knots, the number 2 engine lost power. Engine Indicating and Crew Alerting System (EICAS) parameters displayed rapid decreases in fan speed (N1), compressor speed (N2), fuel flow, and oil pressure. The exhaust gas temperature (EGT) increased and peaked at 1252°C within 2 seconds of the engine failure. EICAS indications for the number 2 engine included a discrete signal corresponding to the EGT redline being exceeded, accompanied by a rise in engine vibration levels.

Approximately 6 seconds after the engine failed, the crew received an EICAS engine fail warning when the N2 speed

decreased below idle. The captain selected the autopilot to on and levelled the aircraft at 3000 feet asl. The crew followed the engine severe damage checklist in the Quick Reference Handbook and secured the engine by moving the thrust lever to idle, the fuel control switch to cut-off, and then pulling the engine fire switch. Since there was no fire warning or indication, the crew decided not to activate the fire extinguishing bottles. The flaps were retracted, and the auxiliary power unit was started.

The aircraft then climbed to 7000 feet asl. After the aircraft was levelled off, the fuel jettison nozzle valves were opened and remained open for approximately 38 minutes. The aircraft subsequently climbed to and levelled off at 12 000 feet asl. The total fuel load was reduced by 86,600 kg to bring the aircraft down to its maximum approved landing weight.

Upon its return to CYYZ, the crew reviewed the landing procedures when 1 engine is inoperative. Autobrake 4 was selected, and the flap lever was selected down to the 20 detent. Shortly after touching down on Runway 23, the crew activated partial thrust reverser on the operating engine, and the aircraft came to a stop on the runway. Emergency services personnel chocked the main landing gear wheels, and the brakes were released to reduce the temperature prior to the aircraft taxiing to the gate. The aircraft had been airborne for approximately 1 hour and 26 minutes. After the passengers were deplaned, the aircraft was towed to the hangar, where the engine was examined.

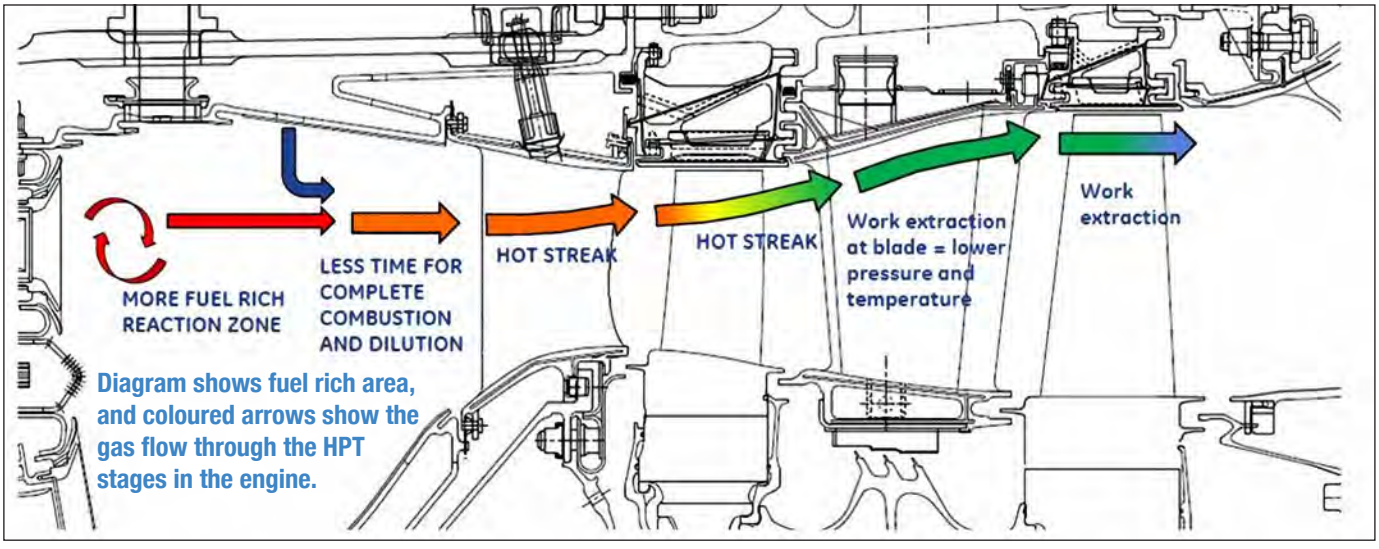
PRELIMINARY ENGINE AND PROPULSOR INSPECTION

The propulsor core was seized by several HPT stage 2 nozzle fragments jammed in different locations, which prevented the core from rotating freely. There was no indication of a bird strike or component failure forward of the HPT module. A borescope inspection (BSI) was performed before the propulsor was shipped to Air France's overhaul facility in Orly, France, one of the only 2 overhaul facilities available for this type of engine. This inspection was performed by Air Canada maintenance personnel, and a video was produced for General Electric (GE) Product Support Engineering for evaluation of the internal damage.

The damage was observed on the HPT stage 1 stator shrouds and appeared to be more prevalent at the 11 o'clock position. Approximately 1 ½ of the stator shroud segments at this position were burnt, and the remainder were missing. HPT stage 1 blades were found in place; however, they displayed substantial damage to the leading and trailing edges, and to the blade tips. Three holes were located in the HPT casing, which appeared to have been created by excessive heat exposure. There was no damage observed to the combustor, which was located directly forward of the HPT.

ENGINE SERIAL NUMBER 906-456 SERVICE AND MAINTENANCE HISTORY

Engine S/N 906-456 had been on wing at the number 2 position on Boeing 777-333ER (registration C-FIUW) when it was delivered to Air Canada. On 04 April 2009, it was removed and shipped to Air France due to leaf-seal liberation. On 12 May 2009, the LPT stage 6 blades were modified as per GE 90-100 Service Bulletin 72-0279. When the engine returned to Air Canada, it was installed in the number 2 position of C-FITW, the event aircraft. It remained in this position until it was removed following the occurrence. The engine had accumulated a total time since new of 19 216 hours and 2303 cycles. The engine had 96 cycles remaining before the next scheduled BSI of the HPT stage 1 shrouds as per Service Bulletin 72-0401.



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HIGH-PRESSURE TURBINE STAGE 1 AND 2 DAMAGE

In March 2010, another Boeing 777-300 series aircraft experienced a similar engine failure (S/N 906-435) during the take-off roll, which resulted in an aborted take-off. The disassembly of that engine revealed that the initial distress was located at the HPT shroud position number 33.

This was verified when the most significant heat distress downstream from this location was in alignment with the shroud 33 position. In addition to this engine, there have been 3 other engines examined during scheduled in-shop visits that have displayed similar heat distress in this area. The reason for these shop visits was unrelated to the HPT shroud condition.

The disassembly of S/N 906-456 was performed by Air France personnel with guidance and supervision from GE, and in the presence of the TSB.

The HPT stage 1 had extensive burn damage surrounding shroud number 33. Flame propagation (secondary flame) was suspected aft of the combustor location, in line with shroud number 33. The inspection also determined that damage to shrouds number 26 and number 27 was a long-term effect rather than the result of this single event, and may have been present during the previous BSI.

The fuel nozzles were removed from the engine and identified by serial number in accordance with their position on the engine. The manufacturer then func-

After jettisoning fuel to reduce the aircraft weight down to the maximum landing weight, an uneventful landing was carried out at Toronto-Lester B. Pearson International Airport.

tionally tested these nozzles. The test results revealed no abnormalities that would have contributed to this event.

The information downloaded from the electronic engine control (EEC) non-volatile memory (NVM) was basically a replication of the information obtained from the DFDR and did not provide any indicator of engine performance degradation prior to the event.

All of the damage to stage 2 of the HPT was a result of failure in the HPT stage 1 region.

APPLICABLE SERVICE BULLETINS TO ENGINE SERIAL NUMBER 906-456

GE categorizes its service bulletins (SB) by assigning each one with a number between 1 and 9; the lower the number, the higher the priority for compliance. For the GE 90-115B engine, GE issued 3 SBs that were related to the HPT stage 1 stator shroud.

GENERAL ELECTRIC SERVICE BULLETIN 72-0348

SB 72-0348 was first issued by GE on 11 May 2009 and revised on 19 August 2010. This SB was assigned a category 5

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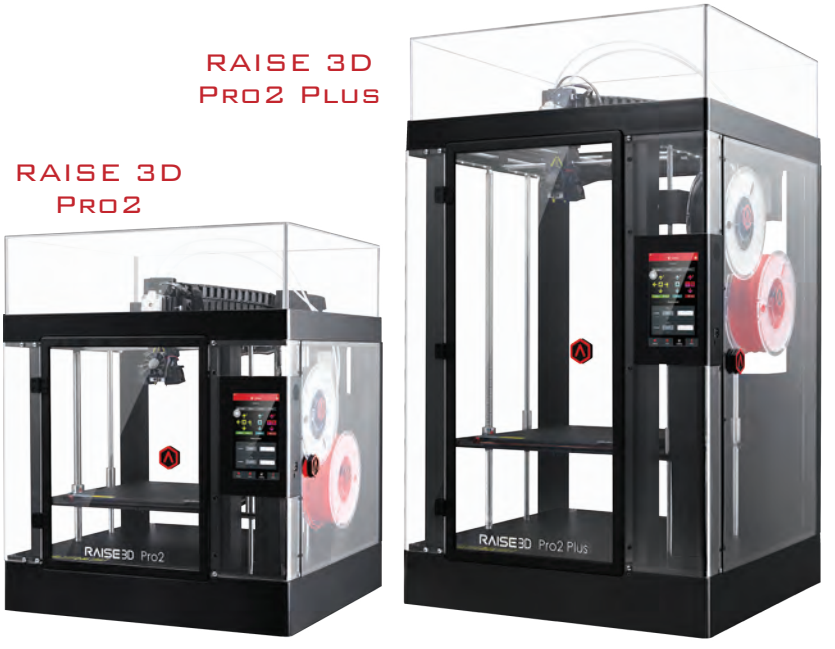

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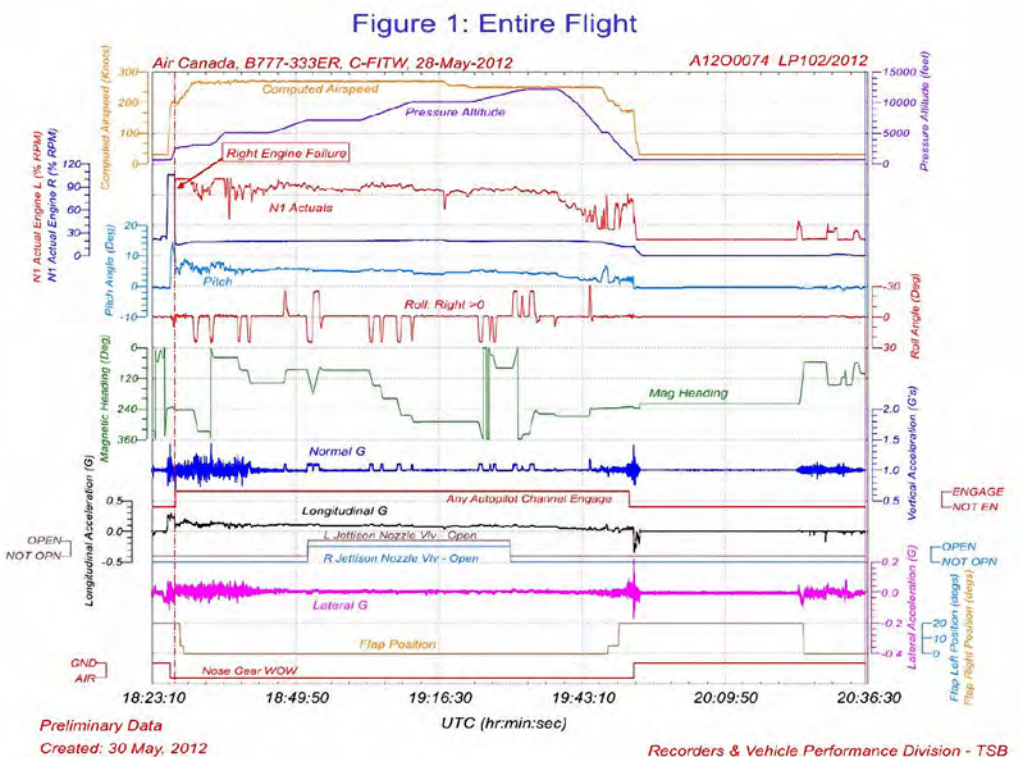
Pro2 (WxDxH)		Pro2 Plus (WxDxH)	
Single Extruder Print	Dual Extruder Print	Single Extruder Print	Dual Extruder Print
305x305x300 mm	280x305x300 mm	305x305x605 mm	280x305x605 mm

Slicing Software: ideaMaker. File Types: STL, OBJ, 3MF, OTLP. Machine code: GCODE. Supported OS: Windows, macOS, Linux. Network: Wi-Fi, Ehernet. Power-loss Recovery. Print Tech: FFF. Head System: Dual-head w/ elec. lifting system. Filament Diameter: 1.75mm. Filament Run-out Sensor. Print Head Travel Speed: 30-150 mm/s. Layer Height: 0.01 - 0.25mm. Nozzle Diameter: 0.4mm (Default) and 0.2/ 0.6/ 0.8/ 1.0 mm. Max Nozzle Temperature: 300 °C. Max Build Plate Temperature: 110 °C. Connectivity: Wi-Fi, LAN, USB port, Live camera. Filter: HEPA with activated charcoal. Certifications: CB, CE, FCC, RoHS. ISO 9001 & ISO 14001.



Left: Flight data recorder data.

compliance number on the GE scale. GE recommends that a category 5 SB be complied with when the affected part is removed from the engine. The SB was applicable to GE 90-110B1 and GE 90-115 engines and was introduced into production on GE 90-100 engines after S/N 906-657. The SB was titled HPT Stage 2 Nozzle Assembly (72-52-00) - Stage 1 HPT Stator Shroud and Stage 1 HPT Stator Shroud Hanger – New and Rework. The reason for this SB was to introduce an HPT shroud that addressed a manufacturing issue that caused the cooling flow at the leading edge of the shroud to be lower than design intent.

The new shroud also introduced a new optimized cooling pattern to further improve durability. The SB introduced a modified version of the shroud, which required either a new or a reworked HPT stage 1 shroud hanger. The old P/N for the shroud was 1847M52P10, and the hanger P/N was 2086M35G03. These had been installed on the occurrence engine since it was new. SB 72-0348 recommended replacing the old parts with HPT stage 1 shroud P/N 1847M52P15 (P15) and hanger P/N 2086M35G04. The SB also gave the option to rework the old hangers to fit the new shrouds rather than replace them with the new hangers. One condition for SB compliance was that all 40 shrouds had to be replaced along with the 20 corresponding hangers, with no intermixing of old and new parts.

GENERAL ELECTRIC SERVICE BULLETIN 72-0363

SB 72-0363 was issued on 03 September 2009 and assigned a category 8 compliance, which is a spare parts release. The engines affected by this SB were the GE90-110B1 and the GE90-115B. The SB identified new parts that were interchangeable with parts they are replacing. Parts being replaced included the shroud, HPT stage 1 stator (P/N P15), which was introduced in the previous SB. The new P/N 1847M52P16 (P16) had a different shroud base material, hence the new part number.

It should be noted that by introducing P15 and P16 as replacement shrouds, GE introduced a different procedure for drilling the cooling holes, procedure known as electric-discharge machining (EDM). The EDM drilling procedure, which included an improved shroud cooling hole pattern, restored the shroud cooling flows to design intent.

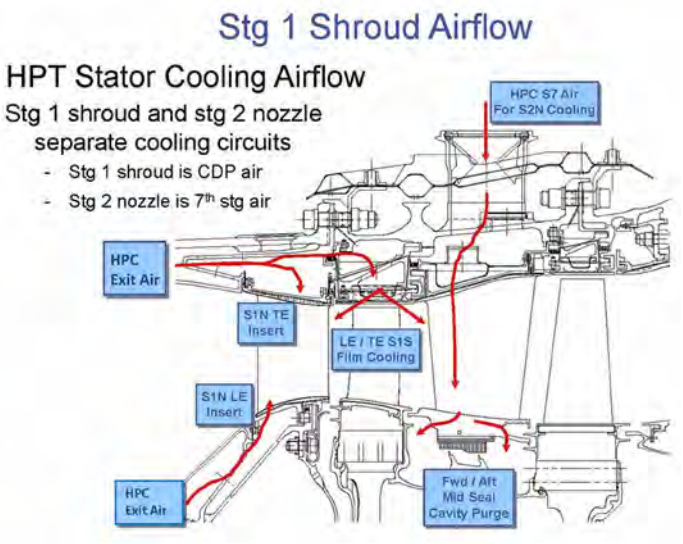
GENERAL ELECTRIC SERVICE BULLETIN 72-0401

SB 72-0401 was developed by GE after the March 2010 event involving engine S/N 906-435. Similarities to the Air Canada event included the damage signature to the shrouds, blades, and turbine centre frame (TCF). There were also no prior indicators of a deteriorating condition. GE issued this SB on 10 May 2010, and revision 5 was issued on 10 November 2011 as a category 2. A category 2 SB recommends to the operator that the SB be carried out as soon as possible, without affecting operator service, but before a specified number of hours and/or cycles. SB 72-0401 recommends that the inspection be performed at 500 cycles since new, and repeated at 250-cycle intervals thereafter. The SB is applicable to GE 90-110B1 and -115B engines that have HPT stage 1 stator shroud P/Ns 1847M52P10 (P10) and 1847M52P11 (P11). It also applies to engines that had these shrouds installed during a shop visit after September 2007.

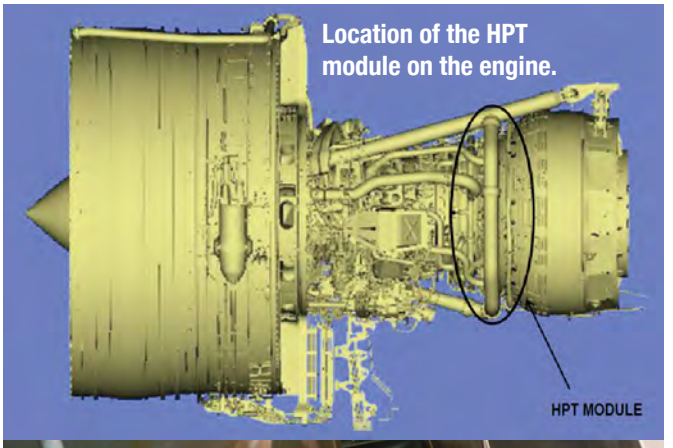
Compliance with either SB 72-0363 or SB 72-0348 are closing actions for SB 72-0401 and its inspection requirements. Scheduling for engine shop visits to comply with either of these SBs depends on the current shroud condition, operational requirements, and spare engine availability.

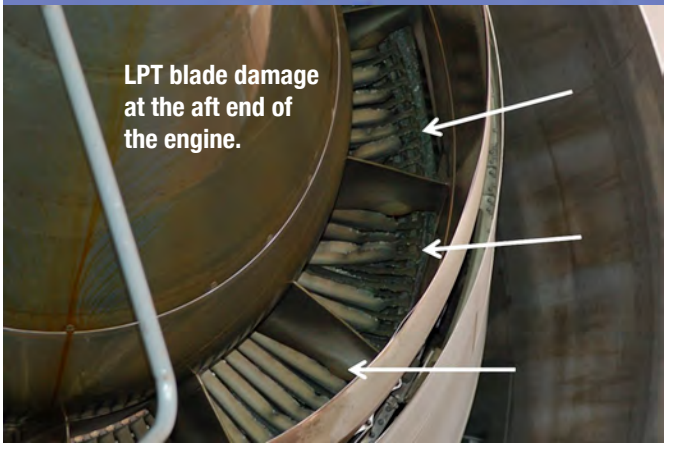
REASON FOR SERVICE BULLETIN 72-0401

Field experience had shown an unexpected accelerated rate of deterioration that could result in engine failure. GE recommended a shroud control program to monitor shroud deterioration for this specific batch of engines with HPT stage 1 P10 and P11 shrouds. Through compliance, SB 72-0401 provided



High-pressure turbine stator cooling airflow.





feedback information to GE on shroud and hanger deterioration rates. GE suspected that shroud failures were attributable to the machining process used to drill the cooling holes in the shrouds. The holes were laser-drilled into the shrouds, and during production, a new laser with a higher-intensity lamp was used, which resulted in a variation in the cooling hole shape and diameter.

GENERAL ELECTRIC SERVICE BULLETIN 72-0522 FOR NON-SUSPECT ENGINES

Engines in service manufactured prior to the suspect engines are affected by SB 72-0522. The inspection requirements are similar to SB 72-0401, but apply to engines that have recorded over 3000 cycles since new. The shrouds in this group of engines were manufactured with cooling holes drilled prior to the change to a high-intensity laser lamp, and fleet experience indicates that they have a higher resistance to deterioration. However, some deterioration has been reported during recent shop visits. Therefore, SB 72-0522 was issued.

GENERAL ELECTRIC SHROUD DISTRESS INVESTIGATIONS

After the engine S/N 906-435 failure, another investigation was initiated by GE. The engine teardown revealed that the initial distress was located between shroud number 31 and number 33. Testing of the fuel nozzles did not provide any findings that would directly contribute to the shroud distress. It is believed that, under the right operating conditions, a fuel-rich zone can exist downstream of the igniter. In normal hardware conditions, this fuel-rich zone would pass through the HPT and into cooler temperatures, following work extraction in the turbine stages, with no effect on engine operation.

However, if a hole greater than 0.3 inches in diameter develops in an HPT stage 1 shroud, the hot fuel-rich air can be ingested in the region behind the shroud. The larger volume of air in this region can mix with the fuel-rich air and become a super-heated zone. The temperatures of this super-heated air mixture would be well above the melting point of the surrounding materials, which would quickly lead to rapid deterioration of the shroud hanger and stage 2 nozzle outer bands. This would lead to the release of a stage 2 nozzle and cause the resultant downstream hardware damage.

GE performed an investigation on engine S/N 906-449 in an attempt to recreate the flame propagation phenomenon. Because this engine had similar damage on shroud number 33, it was deemed to be a suitable engine for the planned testing.

Testing on this engine was designed to create a profile of contributing factors leading to the flame propagation and the subsequent HPT stage 1 shroud failure. Probes were placed at various locations on the engine to collect temperature information under different operating conditions. After completion of these and several other tests, there were no reported findings that could definitively explain how the flame propagation developed.

This phenomenon is most likely to occur at HPT stage 1, as temperatures are higher than anywhere within the engine. As the gas continues to flow aft, energy is extracted by the different turbine stages. Temperatures are relatively lower, reducing the possibility of a super-heated zone developing further aft of HPT stage 1. The condition that started the shroud deterioration was identified to be related to the laser-drilled cooling holes in the shroud. The subsequent shroud deterioration decreased the effectiveness of the shroud cooling and increased the rate of material loss.

FINDINGS AS TO CAUSES AND CONTRIBUTING FACTORS

During shroud production, a change to a higher-intensity laser resulted in a variation in the shape and size of the shroud cooling holes. Over a period of time in service, these cooling holes eroded, which resulted in both degraded shroud cooling and a super-heated zone. This, in turn, increased the rate of erosion until the shroud integrity was reduced to the point of failure.

Damage to high-pressure turbine shrouds and hangers, which was likely present during the last borescope inspection, went undetected prior to the occurrence. As a result, the engine was not removed from service. The number 2 engine shut down during the initial climb-out due to a failure of the high-pressure turbine stage 1 shroud.

SAFETY ACTION TAKEN BY AIR CANADA

Air Canada has taken a proactive approach in an effort to establish a baseline for all of its engines, regardless of their current cycle position in the inspection schedule. All borescope inspections (BSI) were performed using a four-metre flex scope. After the fleet inspection, Air Canada identified 15 engines currently in service with shrouds that would qualify for the re-inspection program in accordance with service bulletin (SB) criteria. Three engines displayed sufficient shroud deterioration and were placed on a reduced cycle inspection interval. Two other engines displayed unserviceable shroud damage and were removed from service in order to implement either SB 72-0348 or SB 72-0363.

Air Canada performed its own risk assessment to evaluate the condition of the remaining engines affected by SB 72-0401 in order to assist with the prioritization of their removal and repair. The assessment considered engine time in service, current conditions of the high-pressure turbine (HPT) stage 1 shrouds, engine modification status and the pairing of affected engines on an aircraft, in an effort to reduce the probability of a double engine failure. After completing the risk assessment procedure and evaluating the results, Air Canada reduced the amount of cycles between inspections by 50% or more from the inspection schedule cycles documented in SB 72-0401, depending on its assessment of the shrouds. ■

(These were excerpts from the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 6 November 2013. It was officially released on 13 December 2013.)

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Wrap-up: HELI-EXPO 2023

Vertical aviation conference and trade show knocks 'em out in Atlanta.

THE INTERNATIONAL vertical aviation community gathered March 6-9 for HAI HELI-EXPO 2023 in Atlanta, Georgia, where more than 12,400 industry professionals from 97 countries attended the four-day show produced by Helicopter Association International. The show featured 639 exhibitors and 49 aircraft on display, and HAI estimates that roughly $2 billion in business occurred during the event. Aircraft on the floor ranged from small but capable personal aircraft to some of the largest helicopters in operation. Several companies displayed Advanced Air Mobility mock-ups, un-crewed aircraft system models, and other emerging technologies.

Safety was the literal centrepiece of the show, as presentations and demonstrations covered a variety of safety-related topics. A highlight was the US Coast Guard's newest variant, an Airbus MH-65E Dolphin multi-mission helicopter, from the USCG Aviation Training Center in Mobile, Alabama. Attendees could also test virtual-reality simulators and meet with representatives from safety-focused organizations to learn how to fly and work more safely. HAI also offered an extensive slate of free safety education sessions in its Rotor Safety Challenge, providing opportunities for everyone in the industry to learn or improve their skills to achieve safer operations.

"Networking and workforce development are always a huge part of this show," said Jeff Smith, chair of the HAI Board of Directors. "Our Helicopter Industry Career Fair hosted more than 15 companies that were actively seeking new employees as well as several thousand job seekers." The show also featured the popular Mil2Civ workshop, where military veterans shared the lessons they learned when transitioning from the military to successful careers in the civilian sector.

The conference portion of the show included several events focused on AAM, including a three-part AAM Showcase and a forum that featured senior leaders from the organizations working to make AAM a reality. HAI also released the Roadmap of Advanced Air Mobility Operations, a white paper describing the next steps necessary for AAM development in areas such as regulations, infrastructure and airspace use, and vehicle development.

The show's education and training sessions also drew large numbers of attendees, with 2,194 people attending 116 courses and sessions. The Professional Education Courses provided in-depth professional development for pilots, maintenance technicians, and other aviation professionals. And with a focus on supporting its small-business members, HAI again held its Communications U for Small Businesses, which offered free sessions in digital marketing, social media, crisis communications, and building better relationships with elected officials.

With the theme of "Building Tomorrow," next year's show will be held at the Anaheim Convention Center, February 26–29, with exhibits open February 27–29. ■

(With HAI Rotor Media files)

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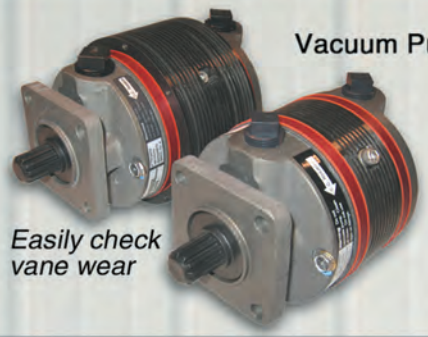

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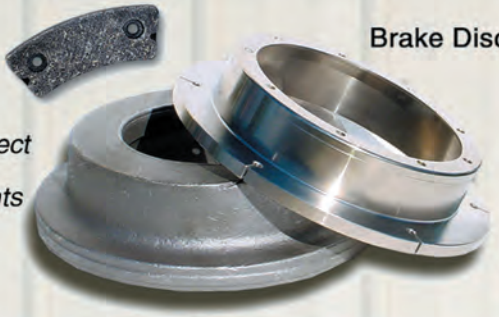

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