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# AirMaintenance UPDATE

The Magazine for Aircraft Maintenance Professionals

Transport Canada Approved for R/T

## 2018 Recurrent Training Exam

## Coatings as an alternative to hard chrome

## PAMA and AME news

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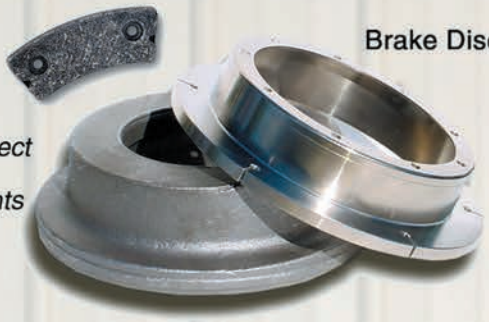

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# Under pressure: AMEs and used parts

Early this spring, Saskatchewan reader John Wilson contacted us to express his concerns on the topic of used parts and how AMEs are pressured to install them. Mr. Wilson wrote:

"I am an AME and find the regulations concerning 'as removed' parts to be lacking. In this day, owners and operators are always looking to cut costs, and one way is by wanting used parts to be installed rather than new or overhauled. I find myself being pressured to 'just install' these parts, even though they haven't been tested and certified.

"I have been expected to treat them the same as any other certified part. I have seen these parts stored right next to certified parts, and it would be very easy for an AME to grab an 'as removed' part and just install it, unknowingly taking on a huge amount of liability for the work. The differences between certified used, non certified used, new, overhauled, as removed, etcetera would be helpful for all involved in aircraft maintenance."

The debate between what is and is not a genuine certified part is a recurring one. According to estimates by Management & Excellence, a financial consultancy specializing in human capital return on investment in aviation, airlines could save an added $711 billion in operating expenses through maintenance training for the period 2017-2036.

Their estimate is based on the projection that 648,000 new commercial airline technicians will be added by 2036 and that each of them will undergo only one high-quality OEM line & base training in their career. It also considers operating costs saved only up to 12 months following the training. Thus, total savings from their training could produce yields of at least $1 trillion. The M&E calculation is based on engine maintenance, which currently constitutes 40 percent of MRO costs; frame MRO costs are 14 percent. A 2014 study of 51 airlines reports maintenance costs of $295 million per airline annually. In 2018 the commercial aviation industry is projected to spend $88 billion on MRO, increasing to $115 billion by 2016. This suggests a need for maintenance training. But in a perfect world "training" would also include bringing owners and operators to understand that cost-cutting can be the most expensive measure they'll ever take. ■

## Departments




## Features



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# Upcoming Events

## Big-buck boost for 'How Things Fly' exhibit


The Smithsonian's National Air and Space Museum received a $1 million gift in early May from AAR Corp. to support the construction of the new Design Hangar in the transformed "How Things Fly" exhibition at the flagship building in Washington, D.C., scheduled to open in 2024. The gift will also provide funding for programming in advance of and during construction, and will expand educational opportunities to students and teachers across the country with the creation of an online teacher portal.

"The support of AAR is crucial to expanding the footprint of our interactive space and programs by building on the success of the Design Hangar as a makerspace where visitors can create or build something with their own hands," said Ellen Stofan, the John and Adrienne Mars Director of the National Air and Space Museum. "This gift will help fuel the passions and imaginations of the next generation of aerospace visionaries and explorers."

Since opening in 2014, almost 62,000 visitors have engaged in hands-on learning experiences in core STEM topics in the Design Hangar. With a high average visit time of 30 minutes, this unique makerspace deepens visitors' understanding of concepts in physics and engineering.

The immersive activities in the exhibition motivate visitors to ask questions, make observations and collaborate with each other, making "How Things Fly" one of the museum's most popular exhibitions.

Construction on the exhibition is scheduled to begin in 2021. For more information about how the museum is transforming all of the exhibitions and revitalizing the building, visit https://airandspace.si.edu/reimagining-air-and-space.

**CFB Borden Airshow**
June 2 – 3, 2018
Borden, Ontario
www.bordenairshow.ca

**Great Lakes International Air Show**
June 16 – 17, 2018
St. Thomas, Onatario; www.glias.ca

**Farnborough International Air Show**
July 11 – 17, 2018
Farnborough, Hampshire, England
www.farnborough.com

**Great New England Airshow**
July 14 – 15, 2018
Westover, Massachusetts
www.greatnewenglandairshow.com

**Cold Lake Air Show**
July 21 – 28, 2018
Cold Lake, Alberta
www.coldlakeairshow.com

**AirVenture Oshkosh**
July 23 – 29, 2018
Oshkosh, Wisconsin
www.eaa.org

**Wings over Springbank**
Springbank, Alberta
July 29 – 30, 2018
wingsoverspringbank.com

**Abbotsford International Airshow**
August 10-12, 2018
Abbotsford, British Columbia
www.abbotsfordairshow.com

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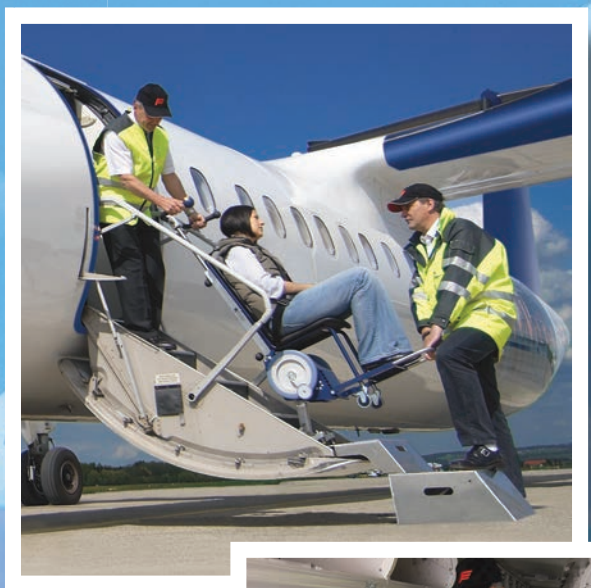

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# STCs & new products

## New aircraft hoist fits narrow aisles


**Microcranes, Inc's** new M1 Global model is designed to fit through 36-inch doorways, narrow aisles and inside elevators, yet expands to boom up to a 22-foot tip height for installation and repairs of control surfaces, wings, flaps, tails, helicopter engines, rotor gear heads, rotor blades and other components. The new M1 Global hydraulic pick & carry portable crane is rated at 2,000 lbs. (905 kg) and has a hook height of 20 ft, 3 in. (6.1m). It is only 30 in. (762mm) wide and weighs 1,800 lbs. (816 kg) with 300 lbs. of removable counterweights to reduce weight while transporting. **For information visit** www.microcranes.com

## Concorde announces upgrade validation


**Concorde Battery** has announced EASA validation for its RG-390E/30 battery to be installed on the Cessna 510 Mustang. EASA STC 10065246 and FAA Approval (STC SA02653LA) replaces the original equipment battery with a 30-ampere hour drop-in replacement that is five pounds lighter. Mustang operators will benefit from the replacement of the original battery with the prolonged service life and extended maintenance intervals of the RG-390E/30, which features enhanced plate design and a proprietary PolyGuard separator system. **For information visit** www.concordebattery.com

## Clamp collars adjust without tools

**A line of quick-release clamp collars** offered in three designs that provide clamping options by hand without tools for a wide range of applications have been introduced by Stafford Manufacturing Corp. of Wilmington, MA. The clamp collars provide easy attachment and fully adjustable clamping by hand without tools. The Staff-Lok Shaft Collar has a mounting flat with a countersunk drilled and tapped hole and two mounting holes on the face. The Flip-Lok clamp collar has a cam lever for clamping and a knurled nut to create a preset. The Grip & Go Quick-Release handle can convert any standard shaft collar into an adjustable locating device and comes in steel, stainless, and aluminum in two sizes. **For more information visit** www.staffordmfg.com

## Woven materials provide strength and lightness

**Bally Ribbon Mills** has announced its line of woven webbing for aerospace and aviation applications. The specialized narrow fabrics, 2D and 3D thermoset and thermoplastic fabrics, and innovative E-WEBBINGS narrow woven fabrics are ideal for meeting specific strength requirements for structural components. The materials are widely used in such critical applications as parachutes, cargo restraint systems, seating and interior applications, flight suits, air slides, seatbelts, and flotation devices. BRM provides advanced designs using enhanced weaving technologies and materials woven from high-performance fibers like Kevlar, Technora, Vectran, Zylon, and UHMWPE. **For information visit** www.ballyribbon.com

## New system provides welding fumes extraction

**Lincoln Electric's** new Mobiflex 400-MS is a self-cleaning welding fumes extraction and filtration system designed to extend filter life and reduce maintenance for users. Ideal for smaller manufacturing facilities, this system provides light to medium duty welding fume extraction in variable locations. The Mobiflex 400-MS base unit includes a plastic housing, two-foot flexible hose, and choice of MERV 14 or MERV 16-rated filter.

**For more information visit**
www.lincolnelectric.com

## Handheld instrument inspects tough areas

**Zetec's** MIZ-21C is a handheld eddy current instrument with surface array capabilities, delivering detailed, accurate, NDT inspections of metal and CFRP aircraft structures and components. The ergonomic form factor, intuitive touchscreen, and embedded software let users set up and inspect hard-to-reach areas faster, more easily, and with less fatigue. When combined with Zetec Surf-X Array Probes, the MIZ-21C is a powerful NDT solution for aircraft MRO and OEM-level inspections.

**For information visit** www.zetec.com

**To announce your STC or new product, email a JPG photo and a product description to amu.editor@gmail.com or amumag2015@gmail.com**

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## WESTJET UNVEILS BOEING 787-9 DREAMLINER

WestJet has unveiled its new Boeing 787-9 Dreamliner livery, logo and cabin interior including the airline's first-ever business class cabin featuring touch-screen service, on-demand dining, lay-flat mattresses, bedding and turn-down service. The reveal is part of WestJet's lead-up to the arrival of its Boeing 787-9 Dreamliners in early 2019. Meanwhile, Economy section passengers will make-do with oversized, self-dimming windows, in-flight entertainment and connectivity with in-seat device charging.

## NEW FACILITY TO FOCUS ON AEROSPACE SUB-SYSTEM TESTING

Drive System Design Inc. says its new facility in Michigan will offer a unique approach to the design, test and development of various sub-systems in the aerospace industry. The facility will initially house a loaded gearbox efficiency test rig and will be developed throughout the year to finally include three pieces of gearbox test equipment.

The current rig, which is fully operational, is suitable for various applications, such as layshaft and planetary gearboxes for auxiliary power units and landing gear applications. Further expansion throughout the year will include a hydraulic test stand for hydraulic valve body development and a dynamic tilt rig, which provides enhanced lubrication flow analysis capability.

"...we have seen an increase in demand for specialist testing expertise," says Jon Brentnall, President DSD Inc. "Our parent company has developed what we believe is Europe's most advanced, commercially-available development center for gearbox efficiency, with many test systems designed in-house to ensure that areas that have not previously received sufficient attention can now be investigated. It is our intention to build similar test capability tailored to the North American market."

## A350 XWB COMPLETES MAIDEN FLIGHT

The Ultra Long Range version of the A350 XWB, MSN 216 successfully completed its first flight in early May. The latest variant of the A350 XWB Family will be able to fly further than any other commercial airliner and will enter service with launch operator Singapore Airlines in second half 2018.

The aircraft powered by Rolls-Royce Trent XWB engines has embarked on a short flight test program to certify the changes over the standard A350-900 that will extend its range capability to 9,700 nautical miles. With a maximum take-off weight (MTOW) of 280 tonnes, the Ultra Long Range A350 XWB is capable of flying over 20 hours non-stop.

The A350 XWB is an all-new family of widebody long-haul airliners featuring new fuel-efficient Rolls-Royce engines operating with a claimed 25 percent reduction in fuel burn and emissions, and significantly lower maintenance costs. At the end of March 2018, Airbus has recorded a total of 854 firm orders for the A350 XWB from 45 customers worldwide, already making it one of the most successful widebody aircraft ever.

## WTO : AIRBUS RECEIVED ILLEGAL SUBSIDIES


The World Trade Organization has found that the European Union failed to honour multiple previous rulings and has provided more than $22 billion of illegal subsidies to European aircraft maker Airbus. After examining this case for more than a decade, the WTO determined the EU must end its unfair business practices and remedy the ongoing harm caused by the illegal subsidies.

This landmark ruling by the WTO Appellate Body in mid-May is the final decision in this case, which was initiated in 2006. The decision ends the dispute and clears the way for the United States Trade Representative (USTR) to seek remedies in the form of tariffs against European imports to the United States.

The authorized tariffs are likely to total billions in duties per year, unless and

until Airbus addresses the illegal subsidies it received from European governments for its most recently launched airplanes. It is anticipated that U.S. tariffs will be authorized up to the amount of annual harm this market-distorting tactic is causing. Tariffs could be scheduled as early as 2019. This is expected to be the largest-ever WTO authorization of retaliatory tariffs.

## COLUMBUS ENGINE CENTER OPENS NEW TEST CELL

The Pratt & Whitney Columbus Engine Center recently unveiled its new engine test cell that will double the facility's engine test capacity. Pratt & Whitney continues to make investments in its maintenance, repair and overhaul (MRO) facilities around the world to better support customers and their engines through EngineWise.

"The new 10-meter engine test cell, which is adjacent our existing test cell, will allow us to significantly increase our throughput of engines, including the Geared Turbofan (GTF) engines," said Tom Bode, general manager, Columbus Engine Center. "Over the last few years, our facility has transformed significantly to prepare for the historic GTF engine ramp up and ensure we are able to meet customer demands. We're excited about the growth of our facility and look forward to a bright future in Columbus."

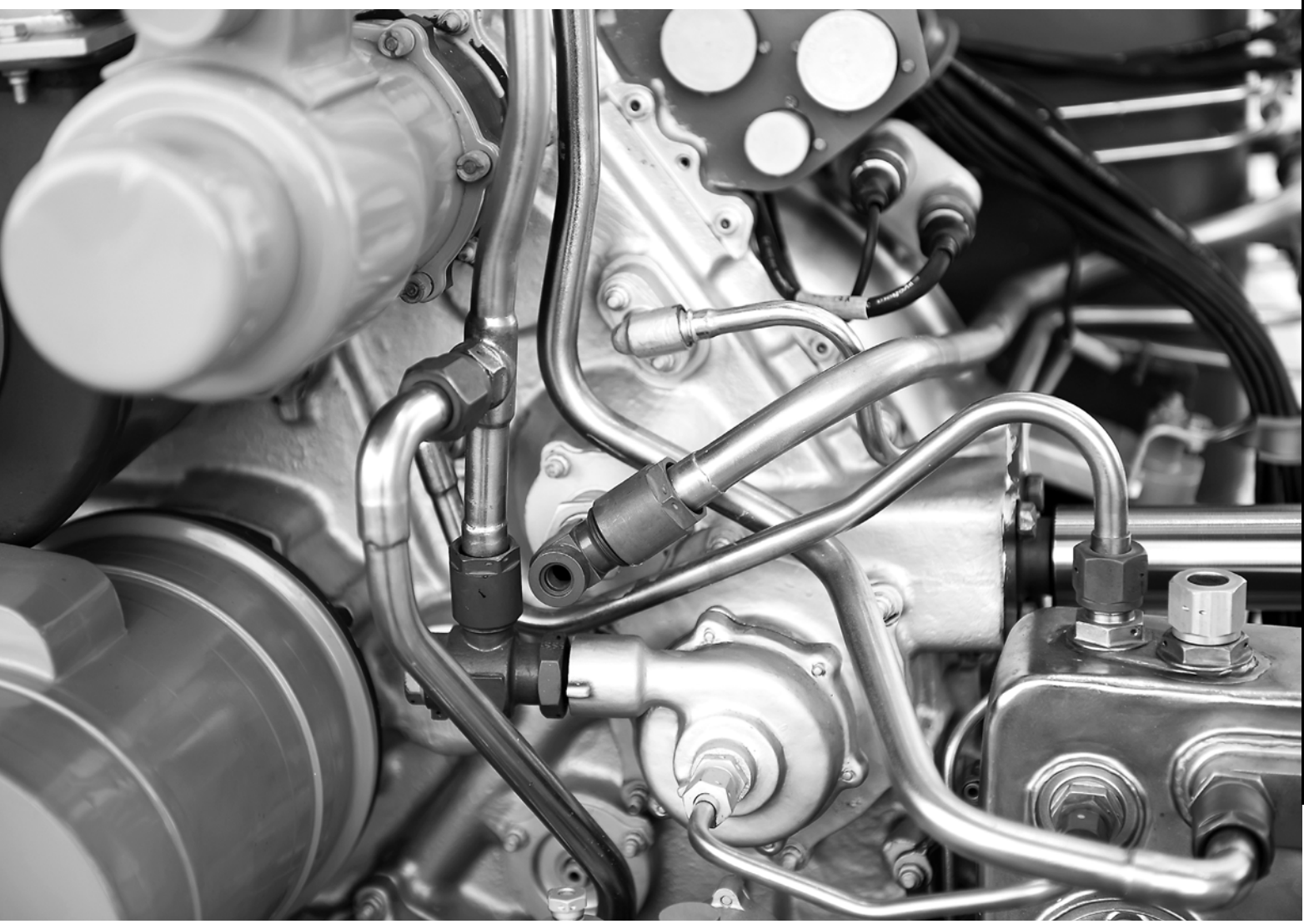
The Columbus Engine Center, which was the first facility in the world to maintain PW1000G engines, is at the heart of GTF MRO. Recent investments in the Columbus facility have included new GTF engine facilities to support disassembly, inspection, assembly and test capabilities as well as a 200,000-square-foot facility to overhaul GTF engines, expected to open in mid-2018.

## SHOWCASE THE BRAND AT NBAA 2018

Companies looking for an opportunity to showcase their brand should consider joining more than 25,000 industry professionals for the most important three days of business aviation. Ranked as the third largest trade show in the United States, the NBAA Business Aviation Convention & Exhibition (NBAA-BACE) will be held October 16–18, 2018, in Orlando, Florida, bringing together current and prospective aircraft owners, manufacturers and customers into one meeting place to get critical work accomplished.

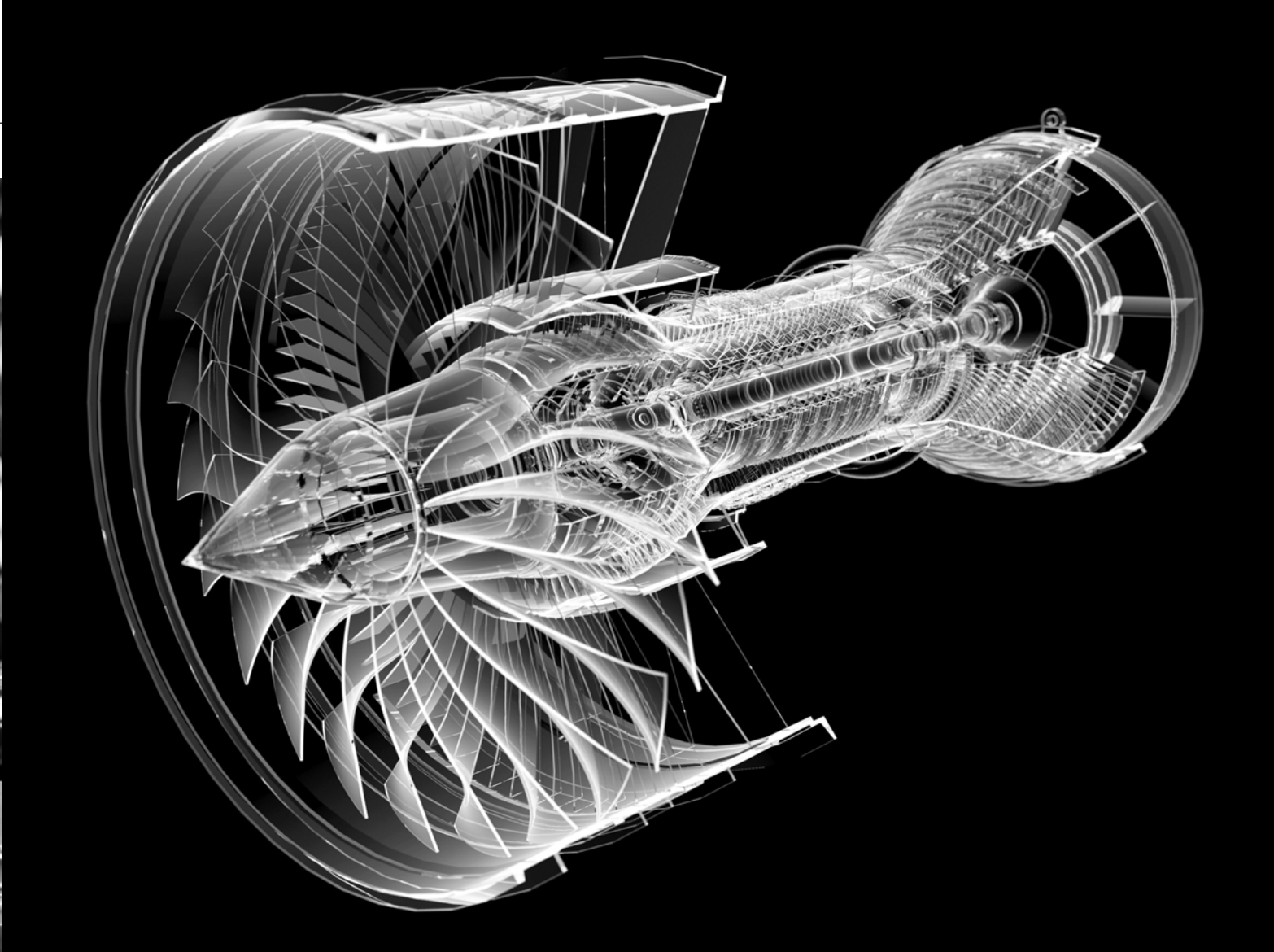
## EMBRAER DEBUTS EVTOL IN LOS ANGELES

Embraer X, an Embraer organization dedicated to developing "disruptive businesses," has unveiled its first electrical Vertical Take-Off and Landing (eVTOL) aircraft concept. Embraer X is engaged in several projects, including the development of eVTOL concepts through cooperation with Uber and other companies to explore business opportunities within the Uber Elevate ecosystem. eVTOL represents an aircraft that serves passengers in an urban environment, based on the key design drivers of safety, experience, affordability and a low footprint for the community, in terms of noise and emissions. ■



# Improving the life of

**The aerospace industry is increasingly turning to PVD and PACVD coatings to increase the durability, performance and service life of components – and as an alternative to hard chrome.**



**Opposite: In the aircraft industry, the goal is to reduce fuel use as much as possible. Above: One PVD coating, called BALINIT Turbine Pro from Oerlikon Balzers, is specifically geared towards protecting engine compressor blades, vanes or integrated bladed rotors.**

# critical components

Aerospace OEMs and MROs are continually seeking new ways to improve the performance and longevity of critical components such as those used in turbines, flight control systems, landing gear and hydraulic systems. To achieve this, these components must be designed and manufactured to withstand erosion, corrosion, extreme temperatures, high loads and even metal-on-metal contact.

However, there are additional challenges to consider beyond extending component life — namely, the more immediate goal of finding new ways to increase the operational performance and fuel efficiency of aircraft through refinements in component and system design, materials and coatings. Even seemingly minor factors such as the surface finish of compressor blades, for example, play a key role in increasing the fuel economy of high bypass ratio turbofan engines.

Today, this is putting renewed attention on coating, plating or nitriding options that modify the surface of critical components to improve wear and corrosion resistance while providing the required coefficient of friction for metal-on-metal contact or the erosion resistance necessary to maintain surface finish requirements for optimum airflow in gas turbines and therefore engine efficiency. This comes at an opportune time, given the industry's transition away from chromium plating to more environmentally friendly alternatives.

**Above: Components must be designed and manufactured to withstand erosion, corrosion, extreme temperatures, and high loads.**



For many years, hard chrome plating was the standard for achieving wear and corrosion protection, but due to the European REACH regulations the application of hard chrome plating is now highly regulated.

Now these challenges are increasingly being met by thin film coatings applied by physical vapor deposition (PVD) and plasma-assisted chemical vapor deposition (PACVD) as well as with other techniques such as nitriding, which can provide even greater durability than hard chrome plating while still providing similar functional properties.

### Aerospace-specific PVD coatings

Approved and field-tested in the aerospace industry, PVD and PACVD can be used to deposit thin film coatings to harden the surface of components. This can significantly increase the lifespan of components, reducing maintenance and downtime.

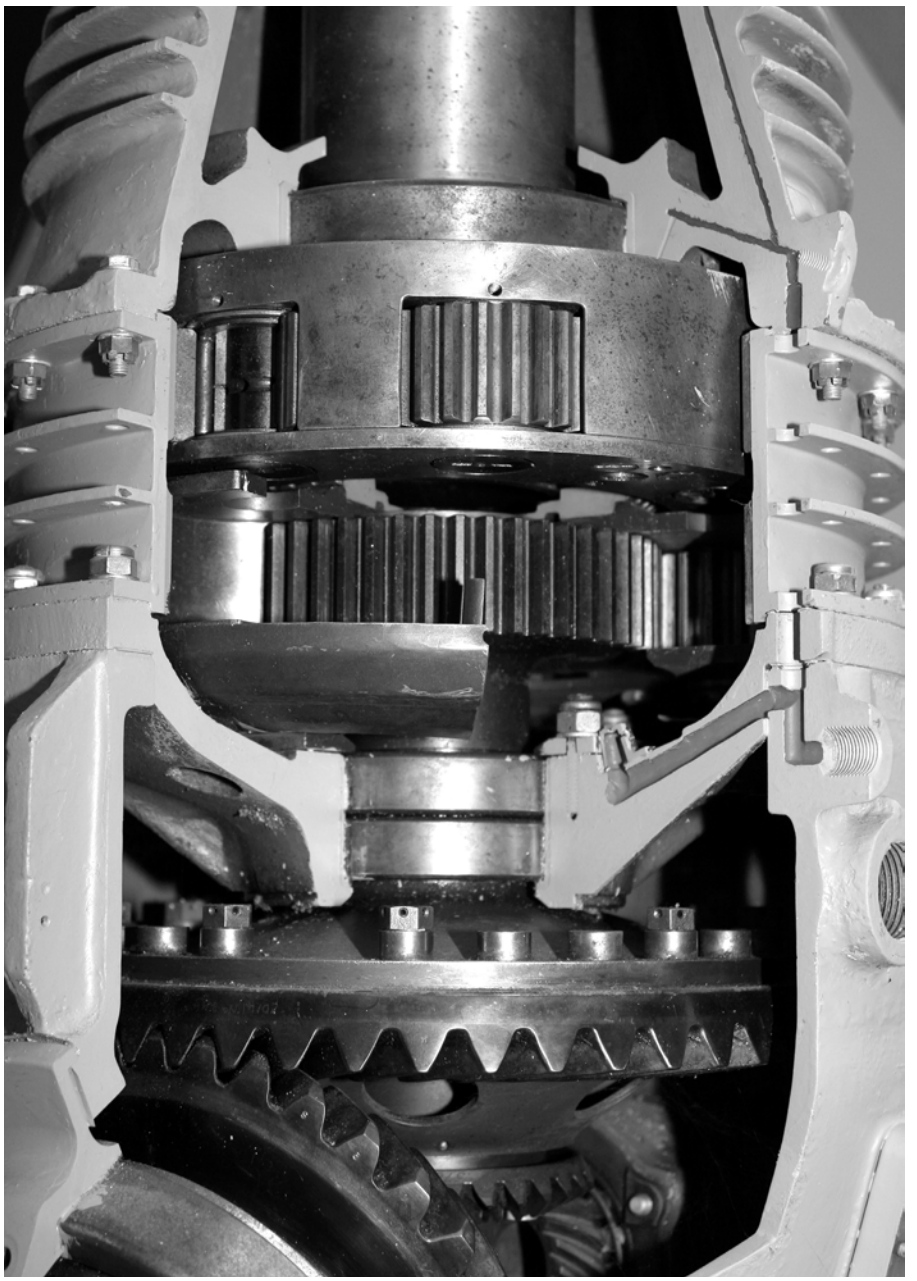
**Above: Due to new regulations the application of hard chrome plating is now highly regulated.**

The coatings also have the advantage of being thin, typically 1-5 micrometres (µm) in thickness but can be up to 25µm for specific erosion resistant properties. Coating tolerances can be as low as +/-0.5 µm over a surface. This feature, in conjunction with close tolerancing, means that the component retains its form, fit and dimensions after coating without the need for re-machining.

One PVD coating, called BALINIT Turbine Pro from Oerlikon Balzers, is specifically geared towards protecting engine compressor blades, vanes or integrated bladed rotors (blisks) from erosion, pollution and corrosion. Often, previously these blades are left unprotected. Oerlikon Balzers, a long time coating provider working in the aviation industry for over 20 years, recently achieved NADCAP accreditation at its facility in Guelph, Ontario, which serves the US and Canadian aerospace markets. The company also operates NADCAP accredited customer centres in France, the UK and Luxembourg.

"In the aircraft industry, the goal is to reduce fuel use as much as possible," explains Oerlikon Balzers Global Aerospace Segment Manager Toby Middlemiss. "To do this, manufacturers often polish the compressor blades and blisks to mirror finishes. This increases the airflow through the engine, which ultimately increases fuel efficiency."

However, Middlemiss says that as blades foul in service, the efficiency of the compression system eventually drops.



**Above: There is now renewed attention on coating, plating or nitriding options that modify the surface of critical components.**

"The debris particles in the air erodes the surface finish of the blades, they begin to get a matte finish and ultimately lose performance," says Middlemiss. "By applying the [BALINIT Turbine Pro] coating, you can maintain the highly polished surface finish and retain the efficiency gain."

BALINIT Turbine Pro utilizes a metal aluminum nitride (MeAIN) structure that results in an optimal relation of high hardness to residual compressive stress even under high thermal conditions. It can be applied to steels, super alloys and titanium components and has an extremely low surface roughness (down to 0.05Raμm) once the process is applied. The high hardness of BALINIT Turbine Pro has already been proven in solid particle, liquid droplet, liquid cavitation, waterjet and other erosion tests with the coating on various substrates (steel, Inconel and titanium) in different coating thickness and high temperatures. In the solid particle erosion test in which materials were evaluated based on mass loss, for example, BALINIT Turbine Pro demonstrated more than four times higher erosion protection than other PVD coatings, including titanium nitride (TiN). That value increased to more than 40X when compared to uncoated titanium and even more for steel.

### Alternative to chrome plating

PVD and PACVD coatings provide a viable alternative in replacing hard chrome plating. Hard chrome plating has been consistently used in the aerospace industry to protect components from fretting, corrosion and wear. However, due to the carcinogenic hexavalent chromium salts used in the hard chrome plating process, the US OSHA and the EU REACH have imposed tight restrictions on chromium and cadmium plating.

> "A better option is BALINIT C, a WC/C ductile carbide carbon of the DLC family (a-C:H:Me) coating that provides excellent wear . . .

Therefore, existing parts made with chromium and cadmium plating will need to be replaced and new parts will need to be manufactured using environmentally safe materials.

According to Middlemiss, some OEMs have attempted to replace hard chrome plated steel with uncoated, hardened stainless steel. The problem with this method is that stainless steel has poor low-frictional wear and sliding properties.

Another option that has been adopted is the use of tungsten carbide based thermal sprays. However, these coatings often require quite a bit of post-coating processing and time consuming grinding, which drive up the costs. On thin walled parts the relatively thick thermal spray coatings can also result in unwanted stresses and distortions of the components.

A better option is BALINIT C, a WC/C ductile carbide carbon of the DLC family (a-C:H:Me) coating that provides excellent wear and scuffing resistance

**Above: Increasing the airflow through the engine ultimately increases fuel efficiency.**

while simultaneously reducing wear and friction for bearings, shafts and pins using in landing gear and engine mounts.

The BALINIT C coating has a high load-bearing capacity even under conditions of deficient lubrication or dry contact. Due to its low friction coefficient, it reduces pitting and fretting corrosion on sliding or moving parts on an aircraft, such as those found in actuators, compressors and pumps.

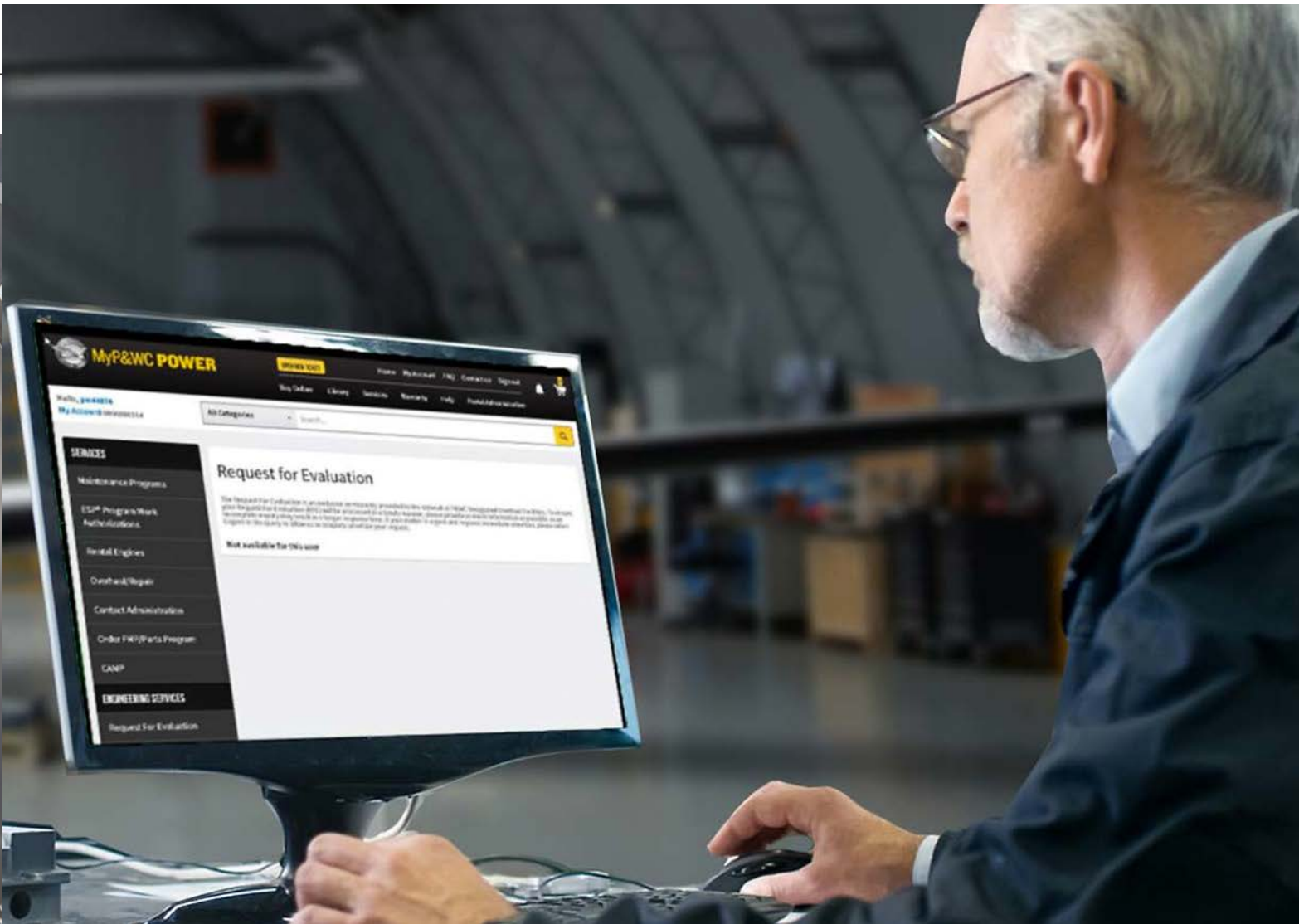
Bearings are another component that suffer from severe and disproportionately distributed abrasive wear. BALINIT C is particularly suitable for case-hardening as well as ball- and roller-bearing steels because it can be applied at temperatures below 200 °C.

The PVD coating can be applied not only to inner and outer races and cylinders but also to the balls in ball bearings in a highly uniform coating thickness of 0.5-1 µm. The slight increase in roughness is offset by the good burnishing qualities of the coating, which smoothes the raceway of the inner and outer rings, providing additional protection against scuffing and pitting.

"Given the ever-increasing performance requirements and lighter construction for the next generation of aircraft, along with the environmentally friendlier concepts for operation and maintenance, there are greater requirements on the components and tools," says Middlemiss. "PVD and PACVD coatings are an effective means to improve operational performance, reduce operational costs, extend operating hours and reduce maintenance intervals." ■

# P&W's service portal:

Extensive digital and online reference documents such as Pratt & Whitney Canada's MyP&WC Power mean hardcopy tech manuals will become obsolete in the not-to-distant future. For the busy AME, that could be a good thing.




**Opposite: Users who once had to browse through catalogues to find parts can now just point and click.**
**Above: P&WC recently surveyed customers about their experience with MyP&WC Power.**

# providing constant updates

Pratt & Whitney Canada's customer service portal, MyP&WC Power, hosts more than 460 technical manuals that guide aircraft engine maintenance and repair: nearly 16,000 users access them, and some use them daily. "Our customers need updated information at all times," says Eric Longpré Manager, Technical Information Services, Customer Service at P&WC. "There's no way to operate the engine without it."

Ensuring the technical manuals are current and accessible is all-important. "Mechanics are using tablets and phones to leverage electronic manuals more and more. All the time as internet access becomes increasingly ubiquitous in the hangar and in the field," says Eric.

## Technical manuals always current

With over 325,000 pages of online documentation to maintain, updates are constantly underway. Current versions, revised as often as twice a year, are now more accessible than ever. "Operators never have to ask themselves if it's the latest information or not. This data is as important as the engine itself," says Eric.

**Above: AMEs no longer need to bring a scratchpad of notes, and heavy volumes of aircraft parts catalogues onto a jobsite.**



"The likelihood of having an expired publication has been eliminated," says Michael Da Silva, Director of Maintenance Training at FlightSafety International. "That makes a big difference to the mechanic in the hangar."

Michael says that another advantage of the new portal is that digital publications are optimized for various devices. "You can view them on a laptop or tablet, and new colour integration makes them easier to read, which is great."

He also likes the fact that publications can be downloaded. "That's a big advantage in a real-world scenario where you don't have internet access."

### Survey reveals user satisfaction with new customer portal

P&WC recently surveyed customers about their experience with MyP&WC Power. The completely redesigned customer portal launched less than a year ago, with a roll out of several new e-commerce capabilities, not previously available online, to more than 20,000 users. Capabilities included the ability to buy parts and technical publications, and to initiate engine rentals and returns, to name just a few.

Nearly 1,200 users of the portal responded — the vast majority favourably — providing valuable feedback on their experience using 19 functionalities in MyP&WC Power, and on what they would like to see in future portal updates. Users ranked tasks like purchasing parts and publications, renewing subscriptions, viewing and printing technical publications, and assigning licenses.

"We are pleased to know we're on the right track, and we continue to make improvements to the user experience as well as to build in new features." explains Marc Turcotte, Senior Manager, Customer Portal & Commercial Technical Publications, Customer Service at P&WC. "We're also working on solutions for offline access to manuals, for example, for customers working in remote locations or off-ramp."

### One-click parts ordering

In the current version of the manuals, users can automatically order parts with a hotlink to the illustrated parts catalogue (IPC), which has been fully integrated. "This really streamlines the order process for the mechanic with an iPad," says Jean-Marie François, Assistant Director of Programs at FlightSafety.

"It simplifies their job, makes them lighter on the ramp and more independent. They don't need to bring a scratchpad of notes, and drag volume number 24 of the aircraft parts catalogue onto the snowbank."

"Our customers can do more on the same platform now," Eric adds. "We wanted to save the mechanic from having to pick up the phone." Before, users would have to browse through the catalogue to find the part, and cross-reference with the manual, "now they can just point and click."

### Ninety years of documenting engines

Eric says it's a far cry from the way access to documentation has been done. "Back in the early days of the company, manuals were handwritten and pictures of the engines were made on a drawing table. Everything has changed; the switch to digital started in the mid-1990s when P&WC converted all manuals to their first digital format." Eric adds that as the interface continues to be enhanced, more dynamic digital services will be integrated. "We want to continue to modify it to make it easier to support video and 3D animation."

What's coming up? "Many new features and enhancements. We're also hard at work on multilingual versions," concludes Eric. ■

WESTERN

# Western AME Association

## President's Message

**By Jarrah Elhalabi**
**President, WAMEA**

As another symposium and trade show ends, so begins the WAMEA fiscal year 2018-2019. With a new board voted in, and a new year ahead of us, the focus is again the future of WAMEA and the direction we take. At the AGM, we heard first-hand the voices from members who are concerned about the future as well as the present state of WAMEA and similar associations nation-wide.

## What do we need to go forward?

Western AME Association relies on membership to stay afloat. When it comes to having a collective voice, securing our financial well-being, and our ability to fulfill our mandate and grow, power is in numbers. To be a beneficial organization, we need members. To attract members, we need to provide benefit. Each fact precedes the other.

When the question is asked "What do I get for my membership right now?" or "Why should I ask someone to join?" we are not yet in the position to give the answer we would like. However, with memberships available now for the year, I have complied a list of some benefits we can offer, while we strive to add more.

**Member benefits include:**

- Attendance in monthly board meetings and voting rights at the AGM
- Access to the WAMEA newsletter
- Inclusion in online membership directory
- Email notifications of Transport Canada announcements and press releases
- Exclusive event invitations
- Education access
- Discounted rates for:
- Symposium admission
- Other events throughout the year
- Courses and seminars
- Newsletter advertisements
- Opportunity for input to and consultation with Transport Canada, CARAC, CFAMEA
- Networking and opportunities to get involved in the industry

Memberships are valid for a one-year period until March 31, 2019. To apply for membership, or to direct someone who is interested in becoming a member, go to www.wamea.com/membership and follow the prompts.

## AEA Canada Connect Conference

The annual AEA Canada Connect Conference is a two-day event that personally connect general aviation industry professionals. Formerly known as the AEA Regional Meetings, the AEA Connect conferences have grown beyond simply receiving regulatory updates and technical training via a classroom-style lecture — attendees are now more engaged than ever in the educational environment with interactive discussions and analysis. Avionics repair stations, manufacturers, regulators and educators show an increasing desire to come together, network and personally conduct serious business — they want to connect in person.

**Where: Sheraton Cavalier Calgary Hotel, Calgary, Alberta**
**When: September 6-7, 2018**

## ATAC Canadian Aviation Conference & Tradeshow

The Canadian Aviation Conference and Tradeshow has been the national gathering for operators, suppliers to the industry, and government stakeholders involved in commercial aviation and flight training in Canada for over 80 years!

**Where: Westin Bayshore Hotel, Vancouver, BC**
**When: November 13-15, 2018**

**www.wamea.com**

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 Canadian Federation of AME Associations (CFAMEA).

**www.pamea.ca**
**pamea@telus.net**

# Central AME Association

## CAMEA 2018 Outstanding AME Award Winner – William Grassick

Bill Grassick started his career in aviation by taking aircraft maintenance at the Southern Alberta Institute of Technology (1959-1961).

For 12 years, he worked doing sheet metal, starting with Field Aviation in Calgary (1961), Bristol Aerospace in Winnipeg (1963-1966), Trans Canada Airlines (1966-1969), CAE (1969-1971), and finally Saunders Aircraft in Gimli (1972-1975). While working at Saunders Aircraft, Bill was instrumental in setting up the sheet metal training center and worked as a sheet metal instructor training employees for work at Saunders Aircraft.

On leaving Saunders Aircraft, he wrote and passed the AME licence exams before going to work for Perimeter Aviation as Chief Engineer (1975-1979)

After leaving Perimeter he went to work for Air Canada, doing overhauls on the air force Boeing 707 fleet. In 1981 Bill was promoted to heavy maintenance supervisor with a crew of fifty to eighty personnel working on Boeing 727, Douglas DC-8, DC-9 and L1011 aircraft. At its peak, the Air Canada overhaul facility employed 56 sheet metal personnel that had been trained at Saunders Aircraft. At that time, Air Canada encouraged the employees to suggest improvements or changes that would save the company money. Bill earned several thousand dollars through the suggestion program saving Air Canada the equivalent of his wages each year.

In 1984, when working at Air Canada Bill became very allergic to a component in polyester paint and was off work for two years. Being unable to work at Air Canada because of the paint dust in the hangar Bill went back to Perimeter Aviation as Quality Assurance Manager (1986-1998).

In 1998 Bill left Perimeter and started his own incorporated business as an aviation consultant, which Bill continues to do to the present time. His consulting has also included being an Instructor for various aviation courses. Bill has trained hundreds of aviation technicians, in human factors training and ten or more other training courses. Bill has worked hard to improve local aviation safety by helping companies improve their quality assurance programs.

Many of us have had the privilege of being associated with Bill over the years and have a tremendous amount of respect for him. Bill truly had a passion for life and the aviation industry as a whole. Bill has been involved with aviation for a staggering 61 years and has inspired and influenced many of us! Bill you are a most deserving recipient of the Outstanding AME Award

## About CAMEA

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

**www.camea.ca**

CENTRAL

# Atlantic AME Association

## Our Job Description

To promote and protect the profession of the Aircraft Maintenance Engineer, in the Atlantic Region.

## ARAMC 2019

At one point there was some thought regarding the possibility of having the 2019 ARAMC in PEI. It was, however, determined that the 2019 Conference will again be held in Moncton, NB. Jacques Richard will again chair this conference with the assistance of Gerald Mallon (Display Chairperson at the Halifax event). It is intended to reach out to Association members from PEI to become involved in the presentation in Moncton and be part of the ARAMC 2019 committee.

## Membership

Our membership currently shows 109 AMEs, six Technicians, 20 Apprentices and 11 Corporate members. These numbers are consistent for AMEs and Technicians in previous years. The growth of apprentice members bodes well for the Association, as they are future AMEs and future members.

**www.atlanticame.ca**

ATLANTIC

ONTARIO

# AME Association of Ontario

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

## Dangers on the Job

In January the Canadian government "Gazetted" some of the new rules and regulations regarding asbestos. This has been a topic that some of our members here in Ontario have discussed due to recent articles in the automotive industry news. Although the motor vehicle and construction industries receive most of the attention, within our aircraft industry we know that many aircraft and parts have contained asbestos. This is a factor especially for those of us who work on older aircraft or are involved with restorations.

Aircraft maintainers are at risk of developing mesothelioma, a rare cancer caused from asbestos exposure that can take 20-50 years to develop. Asbestos was commonly used in aircraft equipment for its heat and friction resistant properties. These parts include the brakes and insulation around the engine and electrical components.

Asbestos exposure is considered to be Canada's leading cause of workplace death. The Canadian Cancer Society has called on the federal government to ban the manufacture, use, import and export of asbestos and asbestos-containing materials and products. So far more than 50 countries worldwide have banned the use of all forms of asbestos, including Australia, France, Germany and the United Kingdom, most of whom implemented bans decades ago. The World Health Organization has declared that 'the most efficient way to eliminate asbestos-related diseases is to stop the use of all types of asbestos.'

Worldwide an estimated 107,000 people died from asbestos-related diseases each year. The International Agency for Research on Cancer (IARC) classified all forms of asbestos as carcinogenic to humans in 1987 and reaffirmed this classification in 2009. It is the leading cause of mesothelioma and also causes lung, laryngeal and ovarian cancers. Studies show that asbestos may also increase the risk of pharyngeal, stomach and colorectal cancers. In addition to cancer, exposure to asbestos causes asbestosis, a severe and debilitating condition due to lung-tissue scarring.

Asbestos is the top on-the-job killer in Canada. New cases of mesothelioma have more than doubled in the past two decades. Each year, more than 2,000 people are diagnosed with asbestos cancers and other diseases, according to Cancer Care Ontario. The number of new mesothelioma cases rose to a record 580 in 2013, according to Statscan. Mesothelioma has a long latency period, of 10 to 50 years, and researchers expect new cases will continue to climb.

Asbestos was the most common source in workplace death claims in 2014, cited in 388 cases, most-recent data from the Association of Workers' Compensation Boards of Canada show. In that year, mesothelioma was the No. 1 cause of death in accepted fatality claims.

Canada was once one of the world's top producers of asbestos, and shut its last mine in 2011. The federal government in the past had defended the industry and maintained a position of "safe and controlled use," a stand that was harshly criticized by doctors, scientists, advocates and those affected by asbestos-related diseases.

## 2018 AME Conference & Trade Show

Our annual conference and trade show will take place November 7-9, 2018 at the Hilton Meadowvale Hotel and Conference Centre in Mississauga. Please save the dates to your calendar/agenda.

*Submitted by Stephen Farnworth for the Board of Directors*

CENTRAL OHIO

# Central Ohio PAMA

## About Us

COPAMA is an affiliated chapter of the Professional Aviation Maintenance Association (PAMA) a national association of aviation maintenance technicians. Membership requirements in COPAMA are simple. You must have an interest in aviation maintenance. Our membership includes Aviation Maintenance Technicians (AMTs) from the airline, corporate and general aviation communities as well as pilots, vendors, students and companies, all with the goal of aviation safety.

Some of the opportunities of membership in our organization are:

1. Monthly meetings with presentations — many approved for IA renewal and FAA, AMT Awards
2. A forum for discussing current aviation events
3. An opportunity for AMTs to network with other professionals
4. Opportunities for students to shadow technicians on the job; take tours and discuss the aviation maintenance profession
5. Scholarships for students of the Aviation Maintenance Technology Programs
6. Social gathering opportunities such as the Central Ohio Aviation Golf Outing (COAGO) and the Holiday Dinner
7. District Science Day and Youth Aviation Adventures participation and sponsorship

## Be a content contributor!

If you know of any upcoming events, pass us an email including some basic information and we'll post it here for other members to view.

**www.copama.org**

# AirMaintenance Update

## open book exam 2018

# open book exam 2018

AirMaintenance Update is Transport Canada-approved for recurrent training. This is our 14th exam, published annually in our June-July anniversary issue, in accordance with our agreement with Transport Canada. The exam consists of questions based on articles appearing in all six issues from the past year: June-July 2017, Aug.-Sept. 2017, Oct.-Nov. 2017, Dec.-Jan. 2018, Feb.-March 2018, and April-May 2018. You will require all six issues in order to write the exam. If you are missing any issues, call us at (604) 214-9824 or email us at amumag2015@gmail.com, and we will mail them to you at a cost of $7.95 per magazine postpaid.

A 75% pass rate is required in order to qualify for your 16 hours toward RT. The questions in the exam are arranged in order of their appearance in AirMaintenance Update according to issue and individual article. The exam can also be downloaded as an Adobe Acrobat PDF file via our website: www.amumagazine.com. Answers should be printed in the spaces provided and must be drawn directly from the text of the articles in order to be considered correct. All questions requiring a longer answer than the space allowed must be typewritten on a separate sheet of paper. Completed exams should be submitted to: AirMaintenance Update, Unit 7, 11771 Horseshoe Way, Richmond, BC, V7A 4V4. The exam must be postmarked no later than October 31, 2018. We will mark your test and return it along with documentation supporting your submission. We will keep a copy of your written test and results on file for future reference, and a copy will be forwarded to Transport Canada. Once again, good luck to all participants!

**Your Contact Information**

**For a prompt and accurate response to your 2018 Exam answers, please fill in the following information (print clearly)**

**Name** .....

**Address** .....

.....

.....

**Phone** .....

**Email** .....

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## June - July 2017 (Volume 16/Issue 1)



### *An SAE Success Story*

**Finish the following sentences:**

**1)** ...under SAE G22 AESQ auspices, aircraft engine makers are coming together to develop a special training program intended to help aircraft engine parts suppliers reduce...

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**2)** Probitas Authentication is an aerospace Auditor Authentication Body that operates within...

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### *The Grand Old Factory*

**3)** The hub of widebody factories is home to the 747-8, 767, 777, 787 Dreamliner, the KC-46 Tanker and...

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**4)** Today, Boeing's Current Market Outlook forecasts 9,100 new widebody airplanes will be needed over...

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## *Raising the Bar*

**5)** The Metro SA227 is a low-wing pressurized turboprop aircraft configured to carry...

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**6)** The aircraft is powered by...

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**7)** N1 speed is directly proportional to propeller speed (rpm) and displayed in the cockpit by...

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**8)** The engine rpm is maintained, in response to the load, by varying the fuel flow through...

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**9)** The serviceability of the internal engine components is controlled by inspection criteria, time and/or...

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**10)** The NTS system senses negative torque on the engine if...

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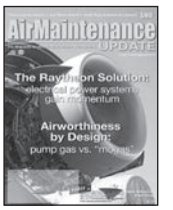
## Aug. - Sept. 2017 (Volume 16/Issue 2)





## *The Raytheon Solution*

**Finish the following sentences:**

**1)** The Dreamliner product line broke with tradition and adopted systems that rely more on electrically generated power than pneumatic and hydraulic solutions that...

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**2)** To meet the technological challenges associated with MEA, Raytheon has demonstrated a...

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**3)** ...devices mounted adjacent to very high temperatures, such as for taking measurements beside an engine, could bring...

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**4)** In regard to HiTSiC weight reduction benefits, the higher the power density, the lighter the solutions could be, further reducing thermal stresses and...

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### *Airworthiness by Design*

**5)** ...the "workhorse" aircraft that drive our industry's economics are mostly designed around...

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**6)** ...the fleet that we fly today — both workhorse and recreational — is about 50 times larger than annual new aircraft production and is based on technology designed around...

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**7)** Lycoming limited vapor pressure to...

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### *Raising the Bar*

**8)** According to the manufacturer, the Turbomeca Arriel 2B gas-turbine engine consumes about...

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**9)** If the engine inlet (approximately 5.75 inches in diameter) becomes blocked, it could cause...

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**10)** ...as a result of the airflow speeds entering the plenum and engine intake, a reduction of air temperature takes place as the air moves through the engine's intake air plenum toward...

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## Oct. - Nov. 2017 (Volume 16/Issue 3)



### *Homework*

**Finish the following sentences:**

**1)** Aircraft, including those supplied in kit form, will be designated as amateur-built aircraft, where the major portion of the aircraft (more than 50 percent) is fabricated from raw material and assembled...

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**2)** Under FAA regulations, if an individual builds at least 51 percent of an aircraft, the aircraft is eligible to be registered in...

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**3)** The term "Experimental" is actually a bit of a misnomer; it refers to the FAA category in which the airplane is registered, not...

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### *Crosshole Deburr*

**4)** In many applications, cross-drilled holes act as...

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**5)** Failing to remove burrs can cause blockage of these critical passages or create...

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**6)** ...the ball-style hone is a highly specialized abrasive tool that is instantly recognizable by...

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### *Raising the Bar*

**7)** The Bell 206B Jet Ranger is equipped with a...

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**8)** When the engine is not producing power, the sprag clutch of the freewheel assembly provides an automatic disconnect from the engine and allows the rotation of the main rotor during autorotation to drive the transmission, tail-rotor and...

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**9)** The main-rotor transmission oil lubricates...

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**10)** The restrictor must be inspected during a transmission serviceability check, which is required when...

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## Dec. - Jan. 2018 (Volume 16/Issue 4)



### *The Weakest Link*

**Finish the following sentences:**

**1)** High speed machining in excess of 20,000 RPMs is often utilized in aerospace when...

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## *Raising the Bar*

**2)** The Cessna 206 was initially certified in the United States, in 1964, with a...

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**3)** ...a STOL conversion kit made by Sierra Industries normally includes...

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**4)** Vortex generators are intended to improve control at low airspeeds and high angles of attack by controlling...

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**5)** Most light aircraft in Canada, including commercially operated light aircraft, are maintained by smaller approved maintenance organizations with limited capability for...

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## Feb. - Mar 2018 (Volume 16/Issue 5)



## *Advisory Circular*

**Finish the following sentences:**

**1)** If the parts to be removed are essential to the rigidity of the complete structure, support the structure prior to disassembly in such a manner as to prevent...

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**2)** When rivets are removed, undercut rivet heads by...

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**3)** On thin or unsupported metal skin, support the sheet metal on the inside with a...

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**4)** Removal of rivet heads with a cold chisel and hammer is not recommended because...

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### *Blown to Pieces*

**5)** ... the more important reason to suppress engine torsional excitation is to eliminate the pulse excitations fed through the gearbox, multiplied by the gear ratio, and applied to...

**6)** Metal prop blades are especially susceptible to destructive vibration if they are...

**7)** ...certain direct-drive aircraft engines have a band (2,200-2,400 RPM, for example) where continuous operation...

### *Mature Engines*

**8)** A typical turbine blade pulls on the disk with 25,000 pounds of force – a force equivalent to...

**9)** Turbine blade cooling air is introduced through...

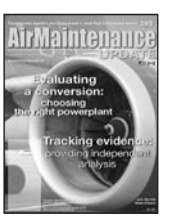
### *Raising the Bar*

**10)** A caution message in section 21-40-00 of the Maintenance Manual informs maintenance personnel that the bleed air lines must be installed a minimum of 0.5 inches from any electrical wiring aft of the heat exchanger, and that there must be at least two inches of space between...

**11)** This minimum distance may be reduced to 0.5 inches if...

**12)** Pneumatic de-icer boots on the wings and on the horizontal and vertical empennage prevent...

## April - May 2018 (Volume 16/Issue 6)





### *Tracking Hard Evidence*

**Finish the following sentences:**

**1)** Cockpit controls are designed based upon...

**2)** Controls such as the fuel cutoff and heater can be coded for...

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.....

.....

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### *Evaluating a Conversion*

**3)** The CG of a V8-Gearbox powerplant will typically be quite a bit further forward than...

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4) The combination of greater weight and greater overhung moment applies proportionately larger tensile, compressive and shear forces to the support structure behind...

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### *The Big Four*

**5)** Whenever you change a fuel nozzle, you need to check...

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**6)** ...the guide tubes for inserting the borescope into various engine ports can vary depending on...

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**7)** Over time, the seals on a turbofan engine's accessory gearbox could show...

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**8)** If there's a change in your engine's oil pressure, one of the first things to do is...

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### *Raising the Bar*

**9)** The spalling was smooth, meaning that...

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**10)** The No. 2 bearing assembly, located in the diffuser aft of the compressor, is used as a thrust bearing — it absorbs the axial thrust load generated by the compressor impellers. This means that...

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**11)** The No. 2 bearing assembly in the engine broke down due to the fatigue failure of its cage. Because this bearing served as a thrust bearing, its failure caused...

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**12)** The breaking of a gearbox stud, the crack in the compressor scroll and the fatigue failure of three fingers in the vibration damper may suggest that...

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**13)** Operating an aircraft outside of the weight and balance limits set by the manufacturer can reduce aircraft performance and cause a power surge, in turn causing...

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# PAMA SoCal Chapter

## February 2018 Meeting Wrap: aircraft window repairs

The SoCal Chapter thanks Mr. Bob Curpery, Founder, Kathi Cupery and all at Aircraft Window Repairs for their time and expert technical presentation on "Aircraft Window and Lens Inspections: The Good, Bad and Ugly Windows" on February 13, 2018 at the 94th Aero Squadron Restaurant in Van Nuys, California. For more product and service information from this world-class product and service provider: Info@AWRepairs.com or (310) 212-7173.

**www.socalpama.org**

# Sort of a made a BANG!

**Compressor surge is a rare event, but it does occur, at times to the fear and bewilderment of flight crew, who might simply have no idea what just happened. A little basic knowledge would come in handy, especially when relating events to the AME. With that in mind, here's a primer for you to share with them.**

Of course we know that turbofan engines power many aircraft. These engines are generally quite reliable, but because of the rarity of turbofan engine malfunctions, and the limitations of simulating those malfunctions, many flight crews have felt unprepared to diagnose engine malfunctions that have occurred. This complicates matters for AMEs who are tasked with maintenance and repair but must also play the role of forensic detective as they try to diagnose a flight crewmember's statement when that person says something vague such as, "We heard a bang from somewhere."

In the event of a critical system failure, the problem will likely be immediately obvious to everyone involved. But in the case of, say, compressor surge, vague statements may not be much help, especially in the instance of a single self-recoverable surge where there will indeed be a loud noise the source of which causes instruments to fluctuate quickly, but perhaps go unnoticed. Then it's a game of "Let the Confusion Begin," especially as crewmembers try to recreate the event to the best of their abilities.

At this point it's up to you, the AME, to decipher what's being said. To help smooth out the conversa-


**Above: NTSB investigators examine damage to the CFM International 56-7B turbofan engine belonging Southwest Airlines Flight 1380.**

tion's rough edges, and to get you both speaking the same language it might help if crew had some prior basic tech knowledge. With the topic here being the rare compressor surge, the following is a primer on the subject for you to share with crew.

The turbine engine in an airplane has the various sections stacked in a line from front to back. As a result, the engine body presents less drag to the airplane as it is flying. The air enters the front of the engine and passes essentially straight through from front to back. On its way to the back, the compressor section compresses the air. Fuel is added and burned in the combustion section; then the air is exhausted through the exit nozzle.

The laws of nature will not let us get something for nothing. The compressor needs to be driven by something in order to work. Just after the burner and before the exhaust nozzle, there is a turbine that uses some of the energy in the discharging air to drive the compressor. There is a long shaft connecting the turbine to the compressor ahead of it.

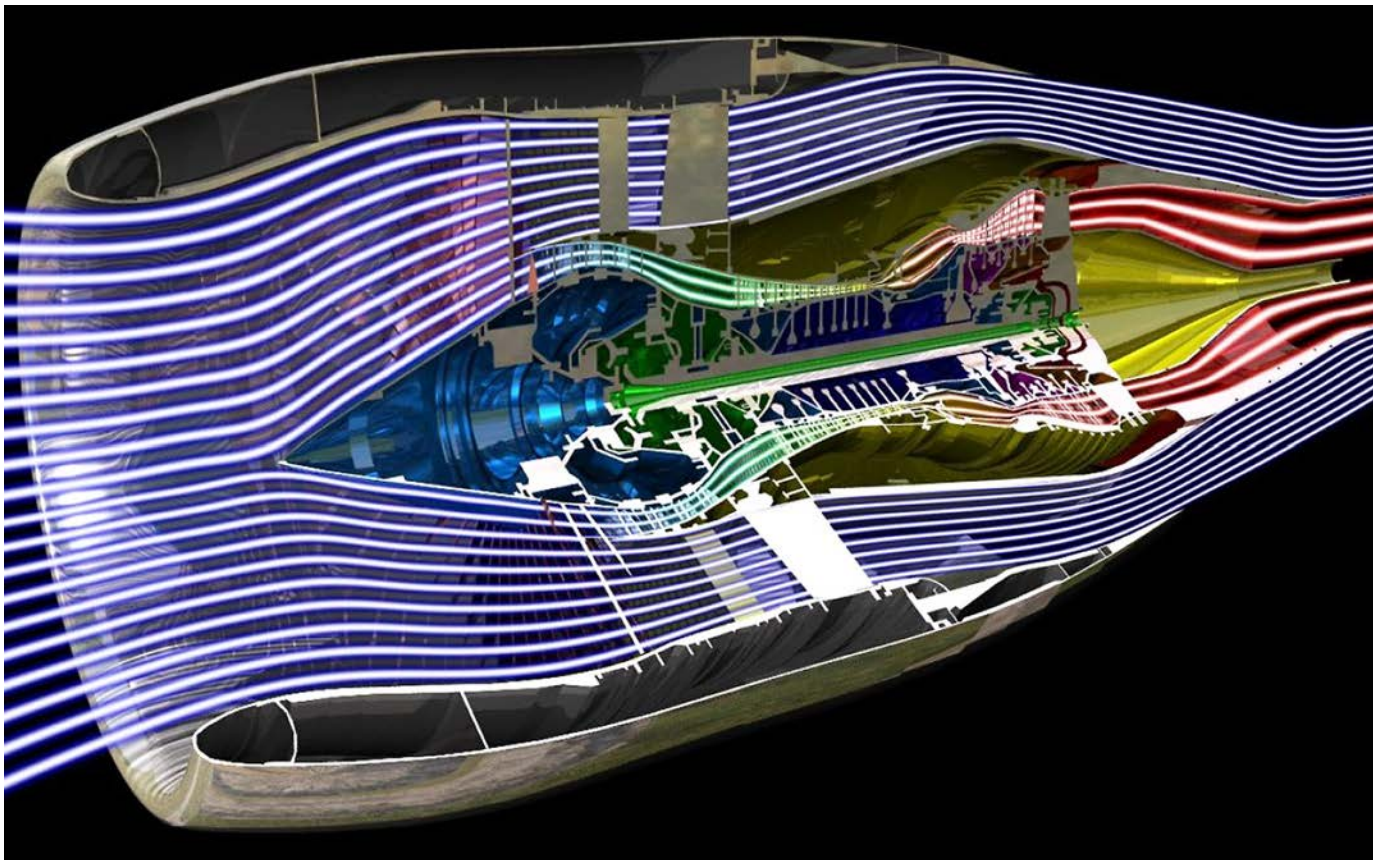

**Above: Jet Engine Combustion Chamber and Turbine Wheel.**



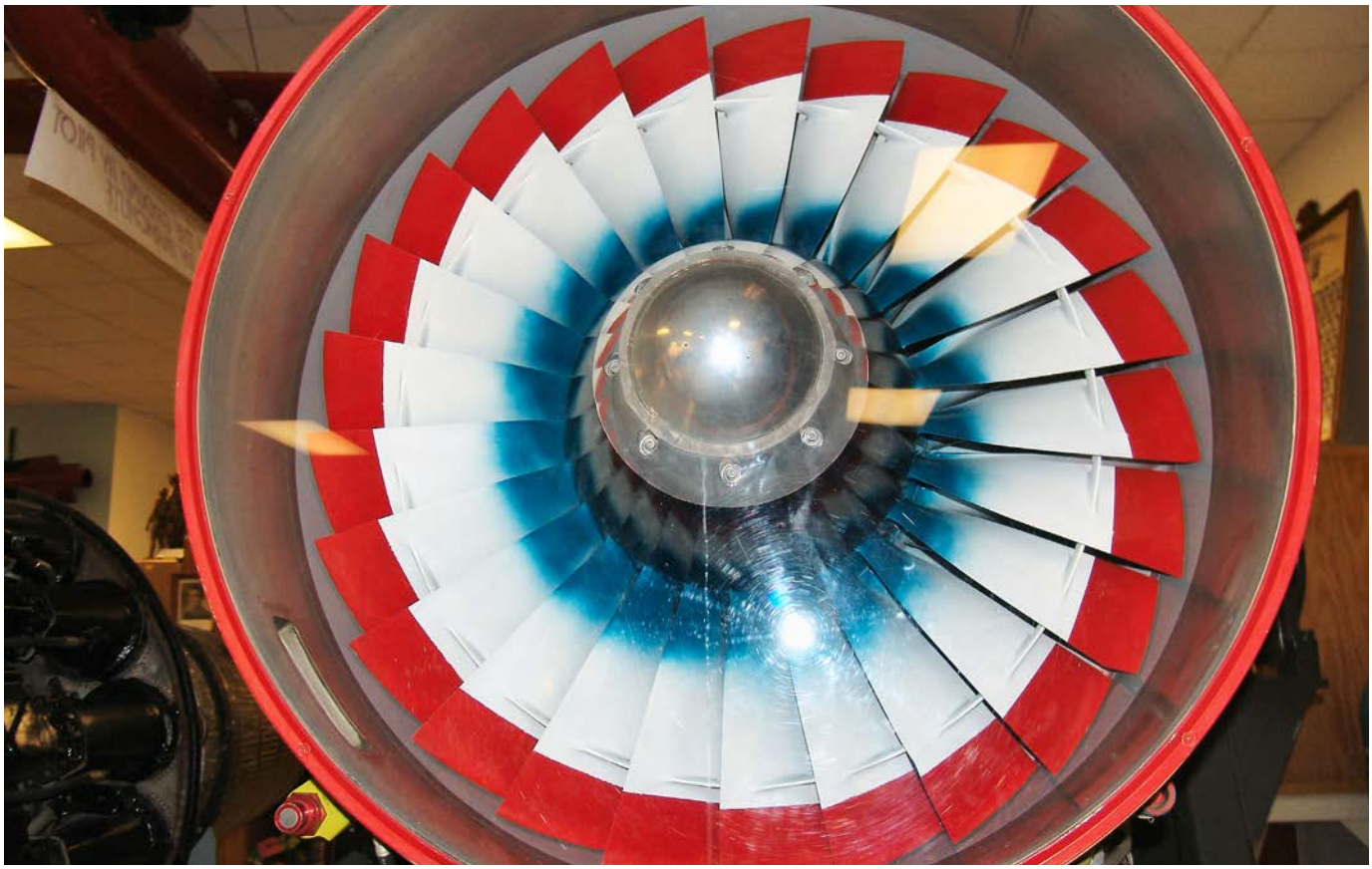
To provide an effective understanding of and preparation for the correct responses to engine in-flight malfunctions, we will now describe 'Compressor Surge.' This description, however, does not supersede or replace specific instructions that are provided in the Airplane Flight Manual and appropriate checklists.

In modern turbofan engines, compressor surge is a rare event. If a compressor surge (sometimes called a compressor stall) occurs during high power at takeoff, the flight crew will hear a loud bang accompanied by yaw and vibration. The bang will likely be louder than any engine noise or other sound the crew has previously experienced in service.

Compressor surge has been mistaken for blown tires (or even a bomb in the airplane!). The flight crew may be quite startled by the bang, and, in many cases, this has led to a rejected takeoff above V1 (the speed selected for each takeoff, based upon approved performance data and specified conditions). High-speed rejected takeoffs have sometimes resulted in injuries, loss of the airplane, and even passenger fatalities.



**Above: The blue streamlines show where cold air enters and bypasses the engine. Green streamlines are shown through the compressor stages. The red streamlines show where hot gas exits the burners and turbine stage.**



**Above: Allison TF-41 Turbofan Engine.**



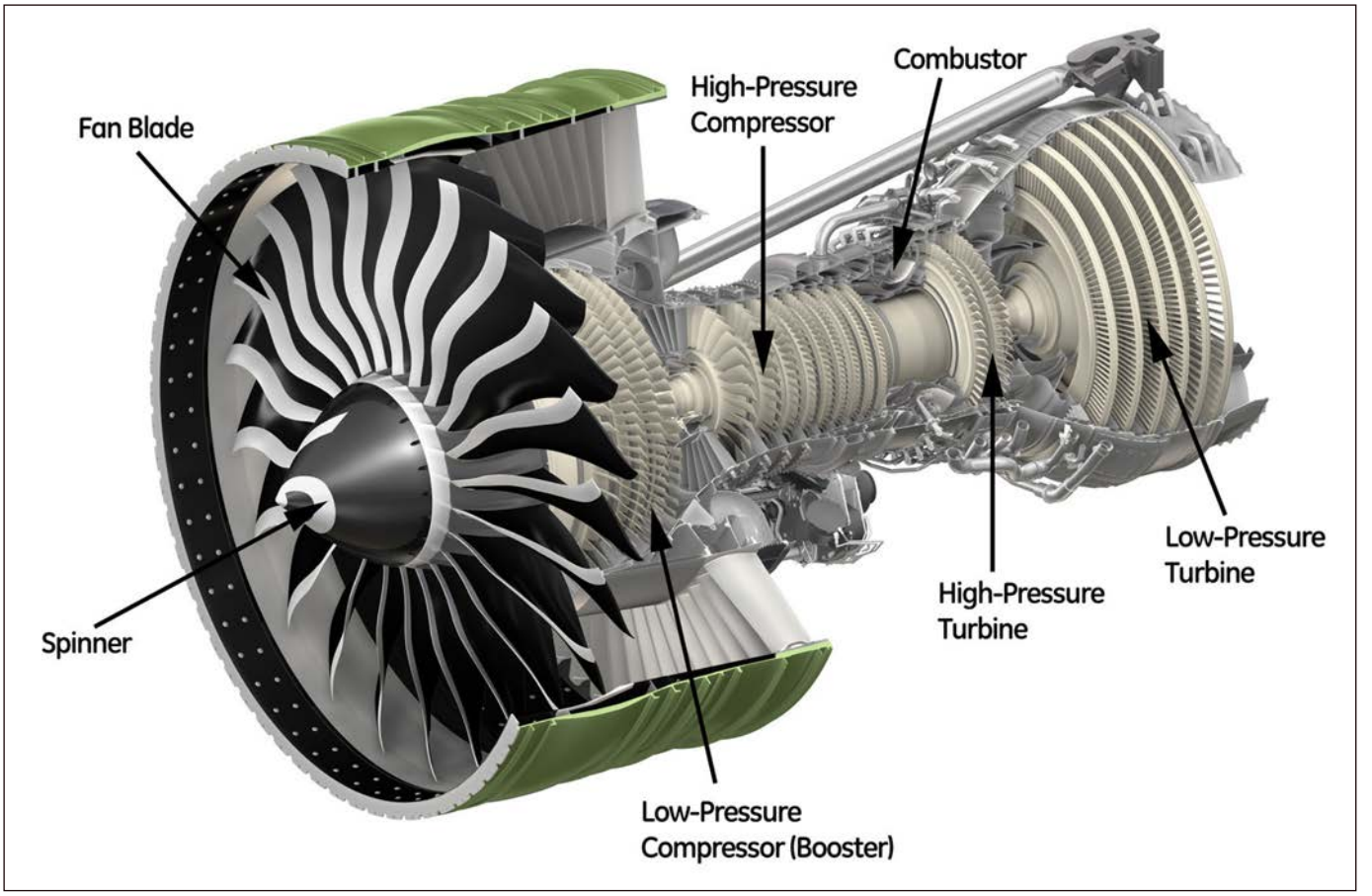
The actual cause of the loud bang should make no difference to the flight crew's first response, which should be to maintain control of the airplane and, in particular, continue the takeoff if the event occurs after V1. Continuing the takeoff is the proper response to a tire failure occurring after V1.

A surge from a turbofan engine is the result of instability of the engine's operating cycle. Compressor surge may be caused by engine deterioration, it may be the result of ingestion of birds or ice, or it may be the final sound from a "severe engine damage" type of failure. The operating cycle of the turbine engine consists of intake, compression, ignition, and exhaust, which occur simultaneously in different places in the engine. The part of the cycle susceptible to instability is the compression phase.

In a turbine engine, compression is accomplished aerodynamically as the air passes through the stages of the compressor, rather than by confinement, as is the case in a piston engine. The air flowing over the compressor airfoils can stall just as the air over the wing of an airplane can. When this airfoil stall occurs, the passage of air through the compressor becomes unstable and the compressor can no longer compress the incoming air. The high-pressure air behind the stall further back in the engine escapes forward through the compressor and out the inlet.

This escape is sudden, rapid and often quite audible as a loud bang similar to an explosion. Visible flames can accompany engine surge forward out the inlet and rearward out the tailpipe. Instruments may show high exhaust gas temperature (EGT) and engine pressure ratio (EPR) or rotor speed changes, but in many stalls the event is over so quickly that the instruments do not have time to respond.

Once the air from within the engine escapes, the reason (reasons) for the instability may self-correct and the compression process may re-establish itself. A single surge and recovery will occur quite rapidly, usually within fractions of a second. Depending on the reason for the cause of the compressor instability, an engine might experience:




**Above: 3-dimensional cutaway diagram of a Turbofan engine.**

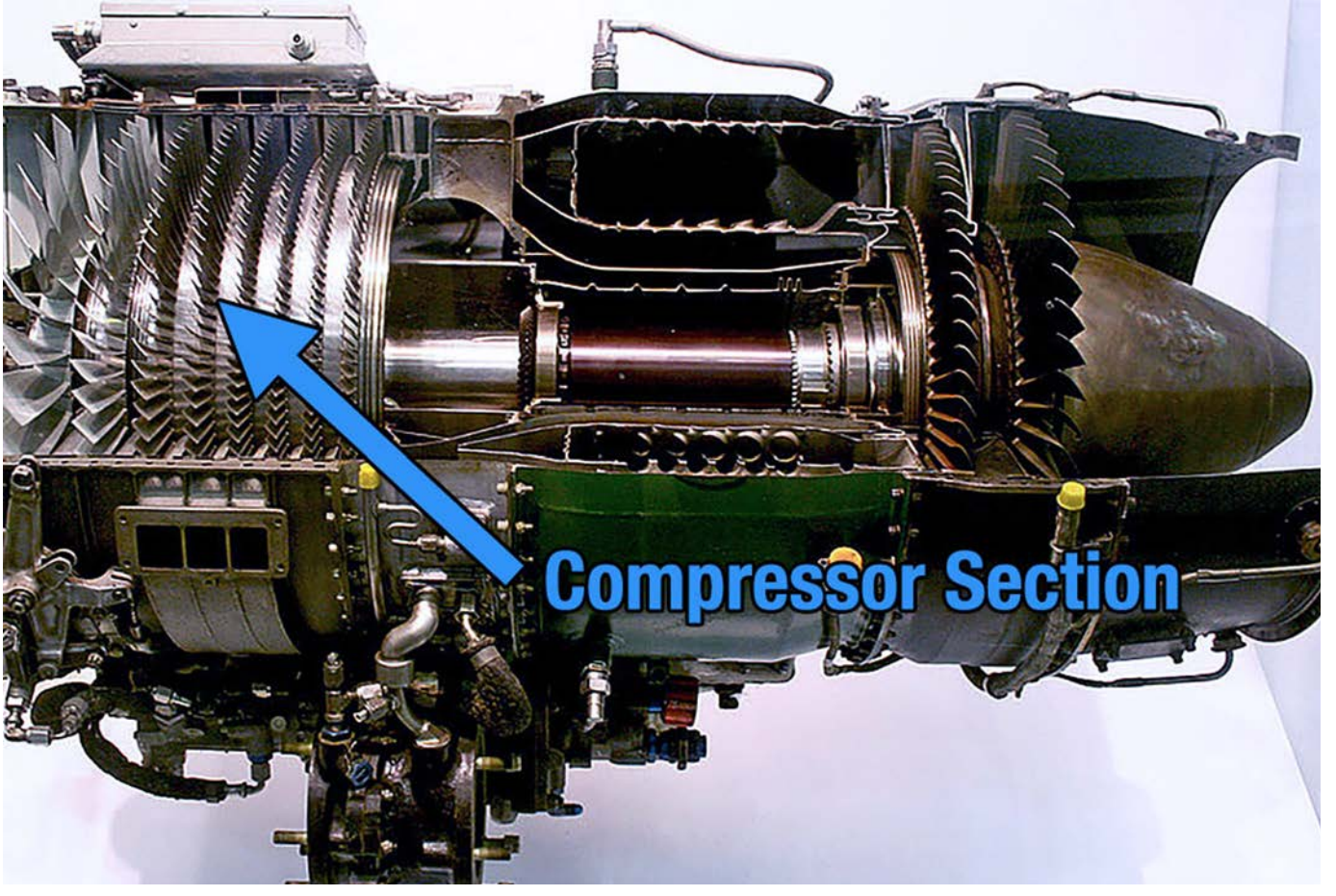
1) A single self-recovering surge
2) Multiple surges prior to self-recovery
3) Multiple surges requiring pilot action in order to recover
4) A non-recoverable surge

For complete, detailed procedures, flight crews must follow the appropriate checklists and emergency procedures detailed in their specific Airplane Flight Manual. In general, however, during a single self-recovering surge, the cockpit engine indications may fluctuate slightly and briefly.

The flight crew may not notice the fluctuation. (Some of the more recent engines may even have fuel-flow logic that helps the engine self-recover from a surge without crew intervention. The stall may go completely unnoticed, or it may be annunciated to the crew — for information only — via EICAS messages.)

Alternatively, the engine may surge two or three times before full self-recovery. When this happens, there is likely to be cockpit engine instrumentation shifts of sufficient magnitude and duration to be noticed by the flight crew. If the engine does not recover automatically from the surge, it may surge continually until the pilot takes action to stop the process. The desired pilot action is to retard the thrust lever until the engine recovers. The flight crew should then SLOWLY re-advance the thrust lever. Occasionally, an engine may surge only once but still not self-recover.


**Above: A C-17 with an engine compressor stall during reverse engine operations. Below: An engine's compressor section.**



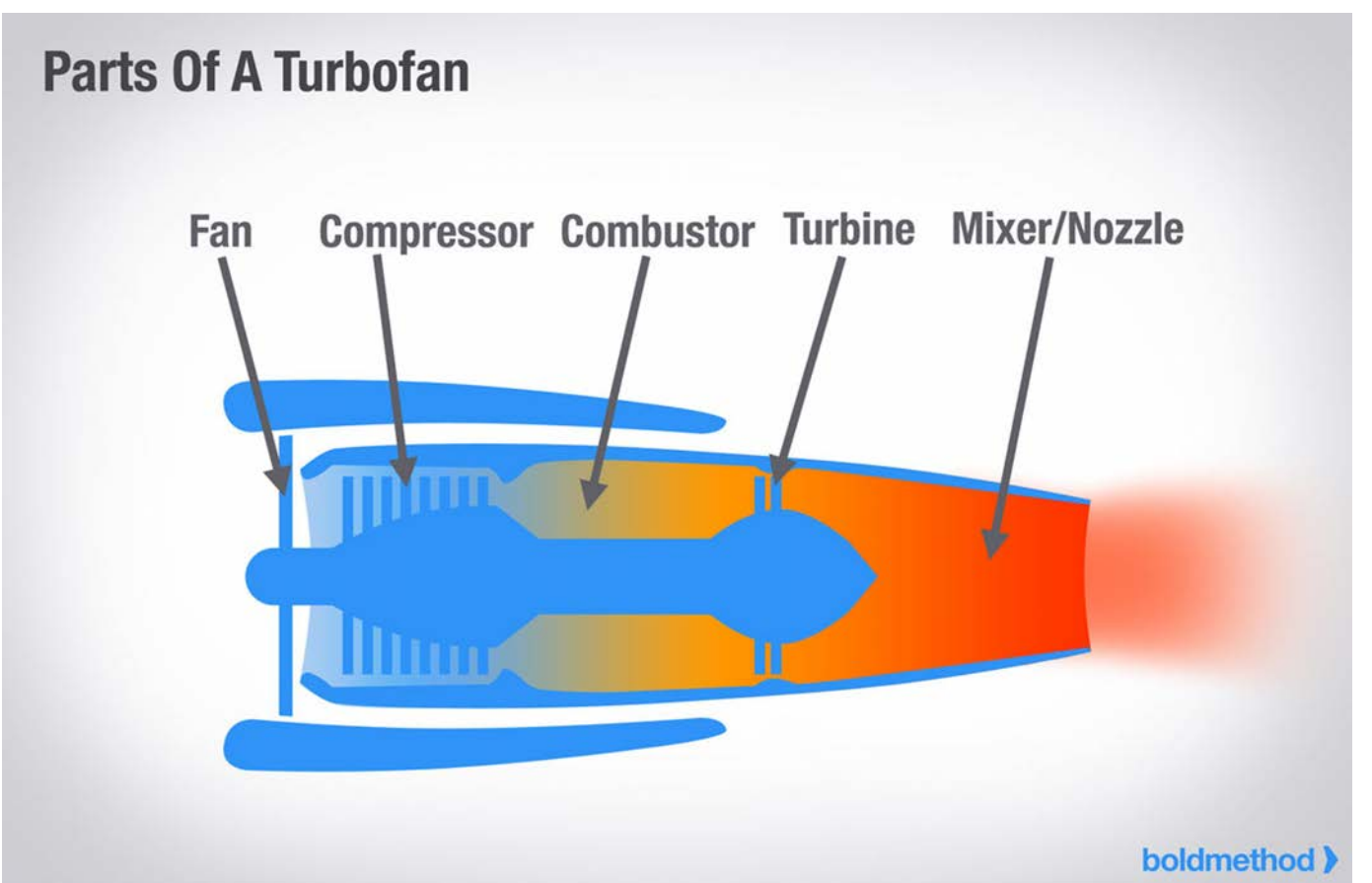
The cause for the compressor surge is often complex and may or may not result from severe engine damage. Rarely does a single compressor surge cause severe engine damage, but sustained surging will eventually over-heat the turbine, as too much fuel is being provided for the volume of air that is reaching the combustor. Compressor blades may also be damaged and fail due to repeated violent surges, resulting in the the engine's inability to run at any power setting.

Additional information is provided below regarding single recoverable surge, self-recoverable after multiple surges, surge requiring flight crew action, and non-recoverable surge.

### Single self-recoverable surge

The flight crew hears a very loud bang or double bang. The instruments will fluctuate quickly, but, unless someone was looking at the engine gauge at the time of the surge, the fluctuation might not be noticed. For example: During the surge event, Engine Pressure Ratio (EPR) can drop from takeoff (T/O) to





1.05 in 0.2 seconds. EPR can then vary from 1.1 to 1.05 at 0.2-second intervals two or three times. The low rotor speed (N1) can drop 16 percent in the first 0.2 seconds, then another 15 percent in the next 0.3 seconds. After recovery, EPR and N1 should return to pre-surge values along the normal acceleration schedule for the engine.

### Multiple surge followed by self-recovery

Depending on cause and conditions, the engine may surge multiple times, with each bang separated by a couple of seconds. Since each bang usually represents a surge event, the flight crew may detect the "single surge" for two seconds, then the engine will return to 98 percent of the pre-surge power for a few seconds.

This cycle may repeat two or three times. During surge and recovery, there will likely be some rise in EGT. EPR may fluctuate between 1.6 and 1.3, Exhaust Gas Temperature (EGT) may rise five degrees C/second, N1 may fluctuate between 103 and 95 percent, and fuel flow may drop 2 percent with no change in thrust lever position. After 10 seconds, the engine gauges should return to pre-surge values.

### Surge recoverable after flight crew action

When surges occur as described previously, but do not stop, flight crew action is required to stabilize the engine. The flight crew will notice the fluctuations described in "recoverable after two or three bangs," but the fluctuations and bangs will continue until the flight crew retards the thrust lever to idle. After the flight crew retards the thrust lever to idle, the engine parameters should decay to match thrust lever position. After the engine reaches idle, it may be re-accelerated back to power.

If, upon re-advancing to high power, the engine surges again, the engine may be left at idle or left at some intermediate power, or shutdown, according to the checklists applicable for the airplane. If the flight crew takes no action, the engine will continue to surge and may experience progressive secondary damage to the point where it fails completely.

### Non-recoverable surge

When a compressor surge is not recoverable, there will be a single bang and the engine will decelerate to zero power as if the fuel had been chopped. This type of compressor surge can accompany a severe engine damage malfunction. It can also occur without any engine damage at all.

EPR can drop at a rate of .34/sec and EGT rise at a rate of 15 degrees C/sec, continuing for eight seconds (peaking) after the thrust lever is pulled back to idle. N1 and N2 should decay at a rate consistent with shutting off the fuel, with fuel flow dropping to 25% of its pre-surge value in two seconds, tapering to 10 percent over the next six seconds.

*(More on this topic can be found here: www.faa.gov/aircraft/air_cert/design.../engine_prop/.../engine_malf_famil.doc)* ■

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# Bell carrying skiers bails on Blue River


**The failure of a compressor rotor bearing leads to engine power loss.**

The Bell 407 helicopter (registration C-GNVI, serial number 53847), operated by VIH Helicopters Ltd., was transporting five skiers and one guide to a drop-off site at about 6,000 feet above sea level, eight nautical miles southeast of Blue River, British Columbia. At 1035, Pacific Standard Time, as the helicopter neared the site, a bang and shudder occurred, immediately followed by the low rotor rpm and engine-out horns.

Moments later, the helicopter landed heavily and the pilot and the ski guide, respectively seated in the right and left front seats, sustained back injuries. The five skiers seated in the middle and rear seats were not injured. The helicopter was substantially damaged. The emergency locator transmitter activated automatically on impact and was manually shut off by the pilot once help arrived. There was no fire.

Immediately prior to the power loss, the helicopter was climbing at about 65 knots, about 200 feet above ground level (agl) over rising terrain. The intended landing site was about 100 feet vertically above and 700 feet laterally from the helicopter when a bang and shudder (later identified as a compressor stall) occurred.

The engine sound began to change about five seconds prior to the bang and shudder. The main rotor low rpm warning, which activates when the main rotor rpm falls below 95 percent, occurred one second after the bang and shudder. The engine-out warning that activates when the gas producer rpm falls below 55 percent, occurred four seconds later. The main rotor rpm decayed from 100 percent to 66 by the time the helicopter hit the snow-covered terrain.

The moment from the bang and shudder to impact was about six seconds. The helicopter remained upright but sustained structural damage consistent with low rotor rpm during a hard landing on uneven, snow-covered ground. There were no chip lights or abnormal instrument indications prior to the low rotor rpm warning. The weather at the time of the accident was suitable for VFR flight and the pilot was certified and qualified for the flight.

### Helicopter Examination

A portion of the inlet barrier filter located immediately forward of the engine's compressor inlet (normally the clean side of the filter) was bowed away from the engine and contaminated with debris, which is consistent with the momentary airflow reversal of a compressor stall. External inspection of the Rolls Royce M250-C47B engine did not show any obvious damage, but the compressor rotor (which includes the impeller) could not be rotated. The engine accessory gearbox chip detection system was tested and found functional. Data retrieved from the engine's electronic control unit (ECU) indicated that a Measured Gas Temperature (MGT) exceedence occurred almost coincidentally with an engine surge (compressor stall) and was followed immediately by a rapid decrease in engine torque, compressor and main rotor rpm. There was no indication that the helicopter was being operated outside of its approved limits.

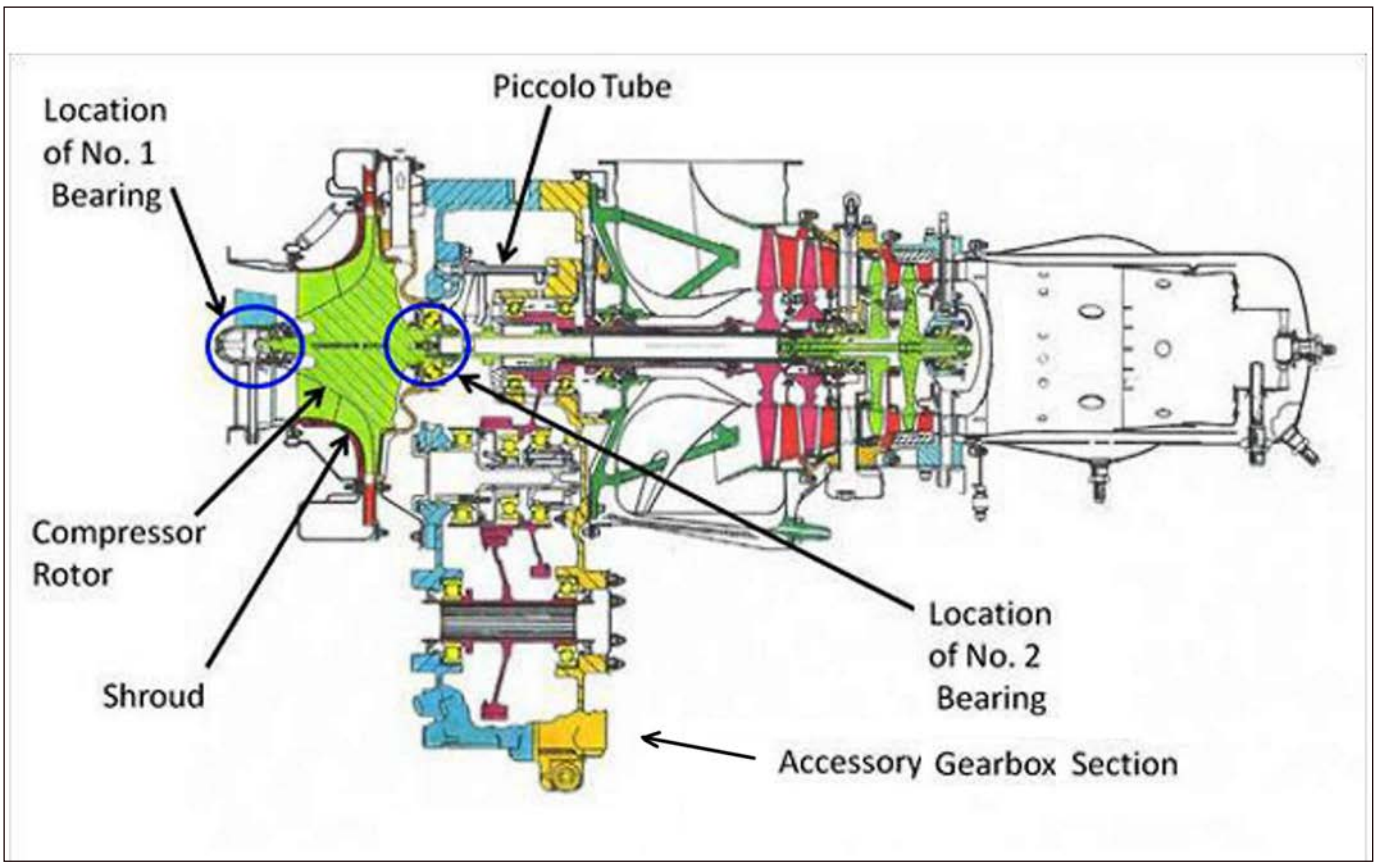
### Maintenance

Records indicate the helicopter was serviced and maintained in accordance with existing directives. At the time of the accident, the engine and airframe had accumulated approximately 1254 hours total time since new, and there were no outstanding maintenance issues with either. The last routine inspection was completed about eight hours prior to the accident.

The maintenance history of the engine was unremarkable with the exception that the power turbine section was replaced about 437 hours prior to the accident because the No. 5 bearing generated metal, which triggered a chip detection warning. The engine manufacturer indicated that the previous No. 5 bearing failure was unrelated to the power loss that occurred in this accident.

### Engine Examination

An examination of the engine (serial number CAE-848126) determined that the No. 2 bearing, (part number 23009670,




**Above: Engine architecture of the Bell 407.**

serial number MP001190), which supports the aft end of the compressor, had failed. The compressor impeller vanes and the compressor shroud exhibited severe rubbing damage. The oil slinger, located between the No. 2 bearing and the compressor rear support, was cut circumferentially into two pieces.

The No. 2 bearing support bore in the compressor rear support was not damaged, and the fit of the bearing in the bore was within limits. A substantial number of metal slivers and flakes were found on the magnetic portion of the upper and lower chip detectors in the accessory gearbox, and similar metallic debris were found loose inside the accessory gearbox.

The engine oil scavenge pump screen, the oil pressure pump filter, and the oil delivery (piccolo) tube were all free of contamination. No pre-accident defects were found with the lubrication system.

### Compressor Design

The accident engine, an M250 Series IV FADEC (full authority digital engine control) engine is a development of the M250 Series IV non-FADEC engine. The single stage centrifugal compressor impeller in the FADEC engines is slightly larger and heavier than the compressor used in the non-FADEC engines. The No. 2 bearing that failed in the accident engine is used in both the FADEC and non-FADEC Series IV engines as well as in some other M250 Series engine models and has been for the last 20 years.

The forward end of the compressor rotor is positioned radially by the No. 1 bearing, a small roller bearing supported inside a housing on a thin film of oil. This oil film damped installation allows a small amount of radial movement of the bearing within the housing to help reduce vibration.

The aft end of the rotor is supported by the No. 2 bearing, a large ball bearing designed to take combined radial and axial (thrust) loads as well as accommodate small amounts of angular misalignment. Angular misalignment in the No. 2 bearing can occur in part because slight radial movement is allowed in the No. 1 bearing. The angular misalignment in the No. 2 bearing results in moment loads.

The No. 2 bearing in the accident engine was manufactured for Rolls-Royce by Timken and is an on-condition item. It consists of a circumferentially split inner ring (also referred to as a race), 10 balls, a ball separator (cage) and an outer ring. Each component of the bearing is manufactured to a nominal dimension, which incorporates a specified allowance above or below that dimension.

The difference between the extreme allowable dimensions of any one part is referred to as the dimensional tolerance. The combination of tolerances of all the parts in the assembled bearing is referred to as the bearing tolerance stack-up.

### No. 2 Bearing Examination

The No. 2 bearing was taken to the TSB Laboratory for further inspection. Analysis determined that the bearing component

When the No. 2 bearing failed, the compressor rotor moved forward until it contacted the shroud, causing the surge (compressor stall), engine spool down, and power loss. Because the loss of power occurred when the helicopter was on final approach to the landing area, at low airspeed and low height above uneven ground, it resulted in a hard landing. The bearing failure was unusual in that it was very rapid . . .

alloys and hardness values were within the manufacturer's specified ranges; no pre-existing deficiencies were found with the No. 2 bearing materials. It was also determined that all of the metal particles found on the chip plugs and in the engine accessory gearbox matched the bearing and oil slinger material. There was no indication of a reduced oil flow to the No. 2 bearing.

The balls skidding damaged the outer ring raceway. It remained largely intact but was burnt and covered with coked oil, which precluded examination of surface wear damage. The lands of the outer ring were extensively worn and heat-affected. The ball cage (also referred to as the ball separator) was distorted and the ball pockets bulged forward. The rails to each side of one ball pocket were fractured with at least one of the fractures being primarily fatigue induced. The outside surface of the cage was worn along the rails from contact with the lands of the outer ring.

All 10 balls were similarly scored due to skidding. Each ball had melted material (solidified metal droplets) at the edges of the skid area. The raceways of the inner rings were burnt and covered with coked oil, precluding detailed examination of surface wear damage. Circumferential skidding marks were most severe on the aft inner ring raceway, and much of the material that formed the shoulder, that part of the raceway curvature nearest the land, was missing.

All of the No. 2 bearing components were thermally distressed. The greatest wear was found on the balls, the shoulder of the aft inner ring, and the lands of the outer ring where the cage contacted. The other engine components that were inspected, such as the No. 1, 6 and 7 bearings, were found to have been serviceable prior to the failure of the No. 2 bearing.

## Analysis

When the No. 2 bearing failed, the compressor rotor moved forward until it contacted the shroud, causing the surge (compressor stall), engine spool down, and power loss. Because the loss of power occurred when the helicopter was on final approach to the landing area, at low airspeed and low height above uneven ground, it resulted in a hard landing.

The investigation determined that the helicopter had been serviced and maintained in accordance with existing directives and was being operated within its approved limits. The chip detection system was found to have been functional and the bearing had been correctly installed and adequately lubricated. The parts that comprised the bearing were manufactured of the alloys and hardnesses specified by the manufacturer, and no pre-existing deficiencies in those parts were found. As a result, this analysis will focus on compressor and bearing design.

Because the compressor rotor acts like a gyroscope, it resists changes in orientation during yaw and/or pitch manoeuvres. As the bearing supporting the forward end of the compressor rotor (the No. 1 bearing) is oil film damped, it allows some radial movement of the compressor rotor. This subjects the No. 2 bearing to large radial loads due to the compressor moment loads in addition to the normal thrust loads. These high loads are usually momentary but they can cause damage if they are frequent or have increased duration, particularly in bearings with tolerance stack-ups that make them prone to large ball excursions.

The No. 2 bearing of this helicopter was manufactured with a tolerance stack-up that made it prone to large ball excursions at manoeuvre rates less than the design maneouvre envelope. The ball excursions led to rapid failure of the No. 2 bearing and subsequent engine failure.

The bearing failure was unusual in that it was very rapid, and it was not preceded by a chip detection warning. It also damaged the bearing components, in particular the cage and the aft inner race, in a way not typical of other, more common, bearing failures.

## Findings as to Causes and Contributing Factors

1. The tolerance stack-up of the No. 2 bearing made it prone to large ball excursions at maneuver rates less than the design maneuver envelope.
2. The ball excursions led to separator fatigue followed by rapid failure of the No. 2 bearing and subsequent engine failure.
3. The time of the engine power loss, at low airspeed and low height above the ground, contributed to the hard landing.

## Safety Action Taken

Transport Canada and the Federal Aviation Administration concluded that the probability of another similar No. 2 bearing failure was too low to warrant safety action beyond that recommended in a Rolls-Royce Commercial Engine Bulletin.

*(The above are excerpts from Transportation Safety Board's investigation report into this occurrence. The Board authorized the release of this report on October 12, 2011.)* ■

## Aviation Services

## Aviation Services

## Aviation Services

# The Little Window's Half-Century

**Originally designed as a safety measure, the Fenestron has evolved as critical rotorcraft technology that now celebrates 50 years of steady employment.**

This spring marked 50 years since the first Fenestron took to the skies on April 12, 1968 on the second prototype of the Gazelle. It has since become emblematic of Sud Aviation, Aerospatiale, Eurocopter and now Airbus helicopters with the H160 carrying this sound-reducing, safety-enhancing technology into the next generation of rotorcraft. Here, we look back on the history of this seminal rotorcraft technology.

The idea behind shrouding the tail rotor was initially developed to provide additional safeguards for workers on the ground but also to protect the tail rotor in forward flight and in complicated operational environments, such as working around high-voltage power lines. Sound reduction benefits followed after much research and optimisation from one generation of the Fenestron to the next.

Originally called the "Fenestrou," which is Provençal for "little window," the term evolved into the renowned Fenestron. It was first certified on the Gazelle in 1972 and then subsequently integrated into the first single-engine Dauphin prototype, whose first flight was in June 1972.

Trials were then conducted with a seven-tonne Puma in 1975, however with its 11 tail rotor blades it required too much power for the Fenestron to bring an operational advantage on this class of helicopters.

The second generation came at the end of the 1970s with an all-composite Fenestron, which increased the diameter of the new Dauphin's Fenestron by 20 percent. This improvement was motivated by the U.S. Coast Guards' requirement for a highly manoeuvrable aircraft for Search and Rescue operations. The U.S. Coast Guards aircraft are still in service today and have accumulated more than 1.5 million flight hours.

In the meantime, research continued to optimize the shape of the Fenestron, blade foils, and to improve sound reduction, especially during certain phases of flight. Between 1987 and 1991 it was successfully tested on an Ecureuil, the prototype of which is still on display at the entrance to Airbus Helicopters' headquarters in Marignane.

In 1994, the third generation was fitted onto the H135 and optimized sound levels by using an uneven setting of the blades. In 1999 the H130 performed its maiden flight with a Fenestron derived from this version. The H145 followed suit in 2010.

Fifty years later, the H160 possesses the latest and largest Fenestron to be built on an Airbus helicopter. The fact that it is canted to 12 degrees allows for improved performance with an additional payload and increased stability especially at low speed. With the H160 out to conquer the medium twin market, the Fenestron will be one of Airbus Helicopters' signatures in the skies for decades to come. ■

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