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AirMaintenance UPDATE

The Magazine for Aircraft Maintenance Professionals

A Refresh: the Primus Elite Avionics Suite

TRAS: Thrust Reverser Actuation Systems

Transport Canada Approved for R/T

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Bombardier Intern Program:

One Thousand Opportunities

Is there a bright young mind in your life, an aspiring student who could use some help as they pursue career or education opportunities? If so, give that person a heads-up about Bombardier's new internship program. The company announced in September that it will provide more than 1,000 paid internship positions in Canada for the 2019-2020 school year.

While Bombardier has provided paid internship positions in Canada for more than two decades, this is the first time the company has publicly committed to exceeding 1,000 internships for a single academic year. Bombardier expects to invest approximately $17 million (CAD) to fund its internship program, with the vast majority of this amount going toward intern salaries.

Bombardier internships are designed to provide students with practical, real-world experience that complements their academic training and better prepares them for careers in their chosen field. Each intern is partnered with a professional mentor and provided with additional enrichment and training opportunities, including networking sessions and direct interaction with senior executives.

For the upcoming year, Bombardier expects to recruit interns from 23 colleges and universities across Canada, and to provide approximately 600 intern positions in the coming academic year for students pursuing engineering or science degrees, including opportunities in mechanical, electrical, aeronautical, chemical, and industrial engineering, as well as computer science and artificial intelligence. Another 400 intern positions will be focused on other management functions, including finance, accounting, IT, human resources, public affairs and law.

"With hundreds of former interns accepting full-time positions at Bombardier over the past few years, our internship program serves as a valuable pipeline for talent to support our future growth," said Mike Nadolski, Vice President, Communications and Public Affairs, Bombardier Inc. "The program helps us identify and hire the brightest minds from the next generation as we drive innovation in the aviation and rail industries."

Interested students are invited to apply at www.bombardierinterships.com ■

Departments

Features

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Upcoming Events

CCAA labour market event will host workshops

The Canadian Council for Aviation & Aerospace is inviting industry members to participate in 'Convergence' in Ottawa on October 23-24. The CCAA calls Convergence "An opportunity to get together and drive development of the Canadian Aviation and Aerospace Workforce."

This labour market strategy event will feature workshops, speakers, and strategies with the Canadian War Museum serving as the host venue.

The workshops will be led by subject matter experts and include:

1. Increasing the participation of Indigenous Persons in the workplace
2. Increasing the participation of Women in the workplace
3. Increasing Work Integrated Learning / Co-op opportunities in industry
4. Addressing the pilot shortage in Canada
5. Education / Industry partnerships
6. Outreach networks and initiatives

Register at www.ccaaconvergence.com

Last year the CCAA produced its 2018 Labour Market Information (LMI) Report quantifying the workforce of the industry, as well as projected labour and skills shortages. The study projected a need to hire 55,000 new workers by 2025 to keep pace with projected industry growth and to replace workers who are retiring or leaving the workforce for other reasons. This represents one third of the existing workforce of 154,000 today.

The study also looked at the current and projected number of graduates. Only a quarter of the needed workers—about 14,000—will be domestic graduates. The LMI report confirmed the need for a National Labour Market Strategy to address these issues, according to the CCAA.

NBAA Business Aviation Convention & Exhibition
Oct. 22 - 24, 2019
Las Vegas, Nevada
www.nbaa.org

Florida International Air Show
November 1-3, 2019
Punta Gorda, Florida
www.floridaairshow.com

San Bernadino Fest
November 2-3, 2019
San Bernadino, California
www.sbdfest.com

HAC Convention & Helicopter Safety Forum
November 14-16, 2019
Vancouver, BC
www.h-a-c.ca

ATAC Conference and Tradeshow
November 18-20, 2019
Montreal, QC
www.atac.ca

25th Annual Manitoba Aviation Symposium
March 5-6, 2020
Winnipeg, Manitoba
www.camea.ca

Aerospace Tech Week
March 18-19, 2020
Toulouse, France
www.aerospacetechweek.com

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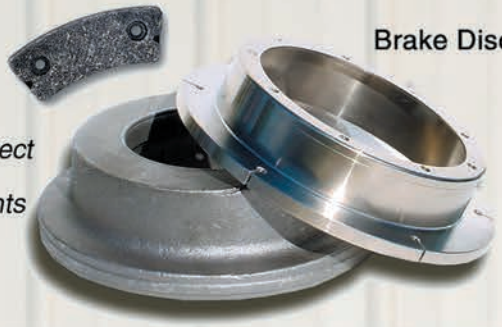

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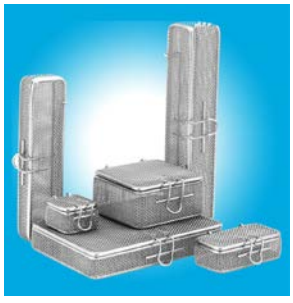
STCs & new products

Aircraft hoist offers wireless remote

Microcranes, Inc. now offers a wireless remote control option for the 2,000-pound rated, 21-foot hook height M1 Global Model pick-and-carry crane used indoors, outdoors and on rooftops. The Rigmaster wireless controller controls the crane from more than 50 feet away, utilizing an FM based signal at 915 MHz. The wireless control floats on water, and the transmitter and receiver have an operation temperature range of -4F to 122F. When compact, the M1 Model hydraulic portable hoist fits through doorways and inside elevators. The equipment is used in aircraft, aerospace, helicopter and facility maintenance.

For information visit www.smartrigcranes.com

Parts basket features micro mesh



WPI has introduced a series of micro fine mesh baskets for washing or sterilizing very small parts. The baskets are constructed with micro fine mesh with opening squares of 1.0 mm and wire diameter of 0.5mm. In addition to the micro fine Baskets, WPI also offers a series of fine mesh baskets and a series of perforated baskets. These baskets are manufactured with stainless steel that has been electrolyte polished. Each basket is provided with a lid with a wire-locking clip.

For information visit si.wpiinc.com

Daylighting system reduces energy demand

PrisMAX SL, a day lighting system from Varco Pruden Buildings, provides up to 70 percent light transmittance with 100 percent light diffusion allowing balanced lighting with no hotspots.

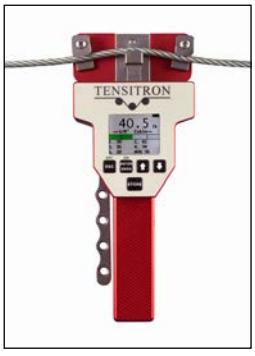
Recently improved, this skylight fixture reduces energy demand and features a self-curbing design to provide long-term, weather-tight performance with low maintenance.

For information visit www.vp.com

Welding helmet displays stereo image

SRI International's 3D-welding helmet acquires and synthesizes images as a stereo camera unit. These images are displayed inside the helmet as a stereo image. This helmet system runs on wearable hot-swappable batteries and therefore can be used indefinitely in environments that have no external power source. The helmet also includes display and recording functions of various real-time welding status parameters related to welding (temperature, voltage, current, etc.). The welder's eyes are completely protected from arcs because the weld is viewed indirectly through the screen in the helmet. **For information visit** www.sri.com

Cable tension tool features data storage



The ACX-1 from Tensitron verifies accurate cable tension and saves time and costs using advanced digital technology. This tension measurement tool features data storage, statistics and output. Used worldwide for military, commercial, and general aviation MRO, it measures aircraft cables with inch, metric, or CWT diameters with tension ranges from 0.50 to 1200 pounds.

For more information visit
www.info.tensitron.com

Kingpin-less casters can be customized

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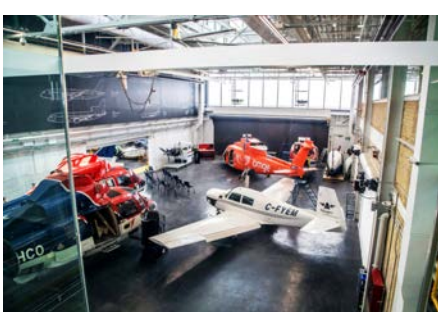
amu.editor@gmail.com

NEW AIRBUS H145 LANDS ON TOP OF THE ANDES

During the month of September, the latest version of the Airbus H145 set its skids down on Argentina's Aconcagua in the Andean Range, which at 22,840 feet is the highest mountain in the southern hemisphere. This is the first time a twin-engine helicopter has landed at this altitude, and Airbus says the high-elevation flight confirms the performance envelope of the rotorcraft.

SIKORSKY DONATION WILL BENEFIT 500 STUDENTS



Centennial College's School of Transportation recognized the donation of a decommissioned Sikorsky S-76A helicopter by Ontario's Ornge air ambulance service at an event at the college's Downsview Campus Centre for Aerospace and Aviation on September 25th. Some 500 students in Centennial's Aviation Technician and Aviation Technology programs will benefit from having the Sikorsky in the campus hangar where they will use it for component and landing-gear inspection, wire bundle installation and inspection, and avionic systems installation and troubleshooting.

The helicopter joins the college's expanded fleet of aircraft at the Centre for Aerospace and Aviation, the new home of Centennial's aerospace technology programs located at the former site of de Havilland of Canada. The $72-million campus repurposes the historic building with selective demolition and new construction to create 12,700 square metres of instruction space, including classrooms, labs and workshops, two aircraft hangars, a library and faculty offices.

CANADIAN TECHNOLOGY TRIALED AT SEA

Canadian engineering firm Gastops Ltd. gained recognition for its "ChipCHECK" equipment monitoring technology during a multi-national military training operation in September dubbed Exercise Talisman Sabre 2019. This event involved more than 34,000 personnel from 18 countries, including Canada, Australia, Japan, the United States, and New Zealand. During the exercise, ChipCHECK was trialed as a ship-based application providing maintenance staff the ability to accurately assess the health of an aircraft's propulsion system via debris analysis while the aircraft is operating. The technology uses digital image capture in combination with a Laser Induced Breakdown Spectroscopy system to automatically analyze wear debris. This analysis determines the alloy type and size for each individual particle in the sample.

PORTAL SAYS USED AIRCRAFT SALES ARE BOOMING

In its first seven months in operation, the new pre-owned aircraft search portal of the International Aircraft Dealers Association (IADA) has handled more than $1.6 billion dollars in aircraft sales, says its Texas-based operator. Since the launch of AircraftExchange.com in February IADA dealers have recorded sales of over 235 aircraft listed on the site.

"That's more than an aircraft a day seven days a week since beginning the site," said IADA Executive Director Wayne Starling. Currently the site lists more than 500 aircraft available for sale — almost 400 jets, over 70 turboprops, 20 piston aircraft, and 15 helicopters.

CITATION CERTIFICATION PAVES WAY FOR DELIVERIES

Textron Aviation Inc. announced in September that it has achieved Type Certification by the FAA for its super-midsize jet, the Cessna Citation Longitude, paving the way for customer deliveries. The experimental and demo fleet completed close to 6,000 hours of flight time. In addition to 11,000 test points during the certification process, the Longitude completed a 31,000-nautical mile world tour.

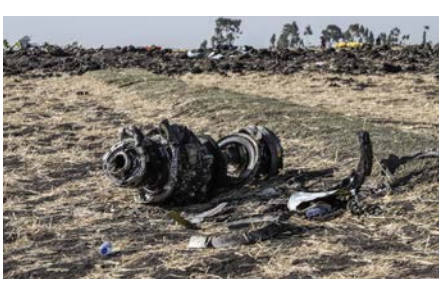
With seating for up to 12 passengers, including an optional crew jump seat, the Longitude features a stand-up, six-foot tall flat-floor cabin. A standard

double-club configuration delivers the most legroom in the super-midsize class: 11 percent more room than the nearest competitor. Fully berthable seats are designed and manufactured in-house. Cabin technology allows passengers to manage their environment and entertainment from any mobile device.

GLOBAL JETS AWARDED TC CERTIFICATION

Bombardier announced in September that its Global 5500 and 6500 business jets have been awarded Transport Canada Type Certification, paving the way for entry-into-service this year. Certification by the FAA and the European Aviation Safety Agency (EASA) are expected to follow shortly. Featuring purpose-built Rolls-Royce Pearl 15 engines with blade cooling and advanced engine health monitoring systems as well as Bombardier's Vision Flight Deck cockpit, the aircraft offers plush cabins with luxury seating. The manufacturer says these new aircraft will have highly favourable operating costs versus smaller competing aircraft with less range.

BOEING BEGINS FINANCIAL ASSISTANCE PROGRAM



The Boeing Financial Assistance Fund – designed to provide $50 million in immediate financial assistance to the families of victims of the Lion Air Flight 610 and Ethiopian Airlines Flight 302 accidents – has now begun operations. The fund represents the initial expenditure of a $100 million pledge by Boeing to address family and community needs of those affected by the tragedies. The additional $50 million in funds will support education and economic empowerment in impacted communities. Boeing is developing partnerships with local governments and non-profit organizations to address those varying needs.

In addition to this initial assistance package, Boeing has partnered with Global Impact to establish the One Boeing Support Fund, a separate charitable fund that gives Boeing employees and retirees a way to contribute voluntarily. To date, more than $780,000 has been raised to support affected communities. Boeing will match employee and retiree donations dollar-for-dollar. More information is available at BoeingFinancialAssistanceFund.com.

NEW PRODUCTS SHOWCASE TO DEBUT AT NBAA-BACE

Attendees at this year's National Business Aviation Association (NBAA) Business Aviation Convention & Exhibition (NBAA-BACE), set for October 22-24 in Las Vegas, will see a host of announcements in a first-of-its kind New Product Showcase, a comprehensive presentation of business aviation's newest and most distinct products.

The Showcase will feature 11 companies in business aviation, and every product to be presented is either new-to-market, or about to be launched, giving NBAA-BACE attendees insight into the future of the business aviation industry. Each of the exhibitors featured in the showcase will have just five minutes to present a video or PowerPoint. ■

An avionics refresh:

With the deadline for mandated avionics upgrades now looming, Honeywell makes the case here for its new Primus suite.

Opposite: Flight deck of Embraer Legacy. Above: For aircraft such as the Gulfstream IV, new insurance plans have been introduced by Honeywell for its Primus Elite avionics suite.

ideal for your aircraft

There are good reasons why the business and general aviation electronics aftermarket sector has experienced nine consecutive quarters of growth, according to the Aircraft Electronics Association's (AEA) first quarter 2019 report: mandates, obsolescence and a wealth of opportunities and options. "Mandates" is the key word here. For example, the FAA has imposed a January 1, 2020 deadline for Automatic Dependent Surveillance-Broadcast (ADS-B) compliance and there's speculation equipment and scheduling shortages may face tardy business owners who put off making the mandated upgrades.

That's why, if you're an owner or operator of a Bombardier Global Express or Learjet 40/45, Embraer Legacy 600, Falcon 900EX/C, Citation X, Citation 550/560 or Dornier 328 with the Honeywell Primus 1000/2000 cockpit or a Gulfstream G-IV/V with an SPZ-8400/8500 cockpit, a combination of factors makes an avionics refresh ideal for your aircraft right now.

One major consideration for cockpit avionics upgrades in the aforementioned aircraft is the upgrade trade-ins and savings on new insurance plans that have been introduced by Honeywell for its Primus Elite avionics suite, which is the modern replacement option for aging cathode ray tube cockpit configurations.

Above: Primus Elite Synthetic Vision System is available for Gulfstream GIV, GIV-SP and GV aircraft.

These new options include the following:

- Synthetic Vision is now standard with Primus Elite
- $35,000 trade-in credit for each individual CRT display
- Options to replace one LCD for CRT display at a time upon failure
- Free year of Maintenance Service Plan-Avionics

Adding Primus Elite to the Primus 1000/2000 configuration brings improved situational awareness, new electronic displays of Jeppesen charts and maps, XM graphical weather overlays and video inputs, all enabled and controlled through a cursor control device.

Joey Meier, chief pilot for NASCAR champion Brad Keselowski, said one of the noticeable differences he saw in upgrading his Lear 45 to Primus Elite last year was the amount of heat and weight that gets taken out of the cockpit and off the aircraft.

"On the standard CRTs of the Primus 1000 cockpit, when the avionics are powered up and turned on, it can generate a lot of heat in the cockpit because it's an old projector style screen. But now on the LCD, it's cool to the touch, you can leave them on indefinitely and there's little to no heat generated," said Meier.

Maximizing aftermarket value and Honeywell's 2019 primus incentives

With the Honeywell Primus Elite upgrade, it is now possible for owners of aging Bombardier Global Express business jets to have the same technology featured in the new $70 million Bombardier Global 7500 at a fraction of the cost. That's what a private owner of a Global Express experienced when he invested $5 million in what Honeywell described as the "largest single aircraft update in the business jet space," back in November 2018.

"Right now, aircraft owners and operators of those older Globals and other legacy jets can decide about buying a new one for a really high price or getting their old one retrofitted and modified," said Nils Janssen, managing director of ACC COLUMBIA Jet Service. "We upgraded a 15-year old Bombardier Global Express for $5 million, which is less than 10 percent of the money that the owner would have spent on a new Global jet.

"It could cost between $65 to 70 million for a brand new business jet like the Global 7500."

The Global Express upgrade included:

- Geo-referenced airport charts
- Graphical depiction of aircraft position during approach
- Enhanced Map on MFD with drop-down menus via a Cursor Control Device (CCD)
- Synthetic Vision

Honeywell's new basic Primus Elite upgrade package includes a free year of MSP Avionics protection from Honeywell, which is an approximate savings of $45,000 for the first year. Under the plan, any piece of Honeywell avionics that fails gets automatically replaced for free. There is also a new monetary value of up to $35,000 applied to the purchase of CRT displays provided by Honeywell for trade-ins of old CRT assemblies.

Airspace mandates take effect in 2020 in European and U.S. airspace, and having an upgraded cockpit such as Primus Elite that includes ADS-B compliant transponders, GPS position sourcing and wiring eliminates the challenge of complying with ADS-B and other upcoming mandates.

Over time, Honeywell has elevated its Primus Epic avionics embedded architecture, continually reducing weight and making it more software intensive. Among these upgrades include the use of processor cards installed in a cabinet rather than individual components for aircraft functions, such as the flight management system, central maintenance system and ACARS messaging.

Navigation-wise, the pilots of the Express upgraded by ACC Jet will also find satellite-based augmentation system-capable GPS, as well as the ability to fly LPV and RNP AR routes. They're also

Above: Having an upgraded cockpit such as Primus Elite that includes ADS-B compliant transponders, GPS position sourcing and wiring eliminates the challenge of complying with ADS-B and other upcoming mandates.

able to customize the Microsoft Windows-like interface of each individual cockpit display, including, for example, adding a small infrared camera view of the nose camera to the upper right-hand corner of the captain's left multi-function display view.

Since the ACC Jet upgrade also included the installation of Honeywell's JetWave modems for satellite-based internet connectivity, the Global Express operator can customize the way pilots use connected tablets and/or displays.

Another business jet with a lot of currently registered aircraft when considering aging CRT-based cockpits is Embraer's Legacy 600. Uniquely, the Brazilian manufacturer introduced a refreshed Primus avionics cockpit for the Legacy 650 model as a standard line-fit production configuration at a time when virtually no one could afford jets or aftermarket upgrades. This upgrade is now available to the in-service Legacy 600 as well.

That timing has left a lot of Legacy jets in-service with aging, obsolete avionics, according to Jose Costas, who

Above: For Citation 560 operators a combination of factors makes an avionics refresh ideal for your aircraft right now.

Above: Dassault Falcon 900EX flight deck.

spent 18 years as the vice president of sales for Embraer's European division prior to joining Duncan Aviation as their sales president for the same region in March 2019.

"The Primus Elite improvement for used aircraft didn't initially see much demand as a result of the high depreciation in aircraft prices in general as a result of the global financial crisis in 2008 and the high cost of investment in the new avionics upgrade," said Costas. "Notice that all new Legacy 650s delivered after 2009 had the new Primus Elite avionics from the factory. With the pre-owned market becoming more stable, the fleet for sale on the Legacy 600 right now, for instance, is less than seven percent, which is one of the lowest in terms of inventory as aircraft prices are stabilizing. The Legacy 600 is a workhorse designed to endure airline utilization profiles and low operating costs. To upgrade its avionics shall be the normal path for most Legacy 600 owners."

CRTs versus LCDs

Honeywell no longer supports aftermarket repairs for cathode ray tubes, which

leaves options scarce if finding replacement parts for existing CRTs. That has led to the introduction of the one-for-one CRT for LCD display swap. On average, the weight savings per cathode ray display replaced by a liquid crystal display is 7.5 pounds. LCDs also enjoy an average of 4,000 hours mean time before failure compared to 2,000 for CRTs, according to StandardAero. There is also a growth connector to add new applications to the displays that is included along with the standard CRT for LCD swap. On the Falcon 900, the Primus Elite upgrade includes a replacement of five CRT displays with five LCDs.

> Each LCD is installed with a new tray and an additional connector that can adapt the display to accept new applications and information such as a connection to data distorted across an ethernet data bus, according to Jerry Sanders, director of business development at StandardAero.

The Falcon 900 C and EX models, which entered into service in 1996 and 2000, each feature cockpit designs with five displays in the standard configuration. That means if all five displays are replaced, there is an automatic weight savings generated of 35 pounds.

Each LCD is installed with a new tray and an additional connector that can adapt the display to accept new applications and information such as a connection to data distorted across an ethernet data bus, according to Jerry Sanders, director of business development at StandardAero.

Sanders describes the Primus Elite upgrade package for the Falcon C/EX flight deck as a $700,000 investment for the full avionics suite upgrade. The upgrade does not require changes to existing CRT symbol generator software, the

Above: Falcon 900 DU875 Honeywell Synthetic Vision.

Above: The LCD is cool to the touch, you can leave them on indefinitely and there's little to no heat generated.

aircraft's existing primary flight display, multifunction display or EI-CAS symbology and format.

"Much like if you were to swap your CRT-based home television screen for an LCD television, you would not need to change the video game system, cable box or DVD player that generates imagery and video on those screens. We use that same premise when we remove a CRT screen and install an LCD, the existing symbol generators will generate the same symbology," said Sanders. "On the Falcon 900 C/EX, there is no aftermarket solution other than Honeywell for those displays. The company has done what they can to keep those displays, but if an operator comes to us and says we want to keep those CRTs for the long-haul, the only thing we can recommend is that the reality is there's nothing we can do to help maintain them."

StandardAero also has a special incentive program that provides trade-in credits of $35,000 per DU-870 display for in-service Falcon 900 aircraft. Across all five displays, that would equate to an immediate savings of $175,000 toward the full $700,000 cost required to add the full Primus Elite avionics package including the new LCD displays, upgraded flight management computer and new cursor control devices.

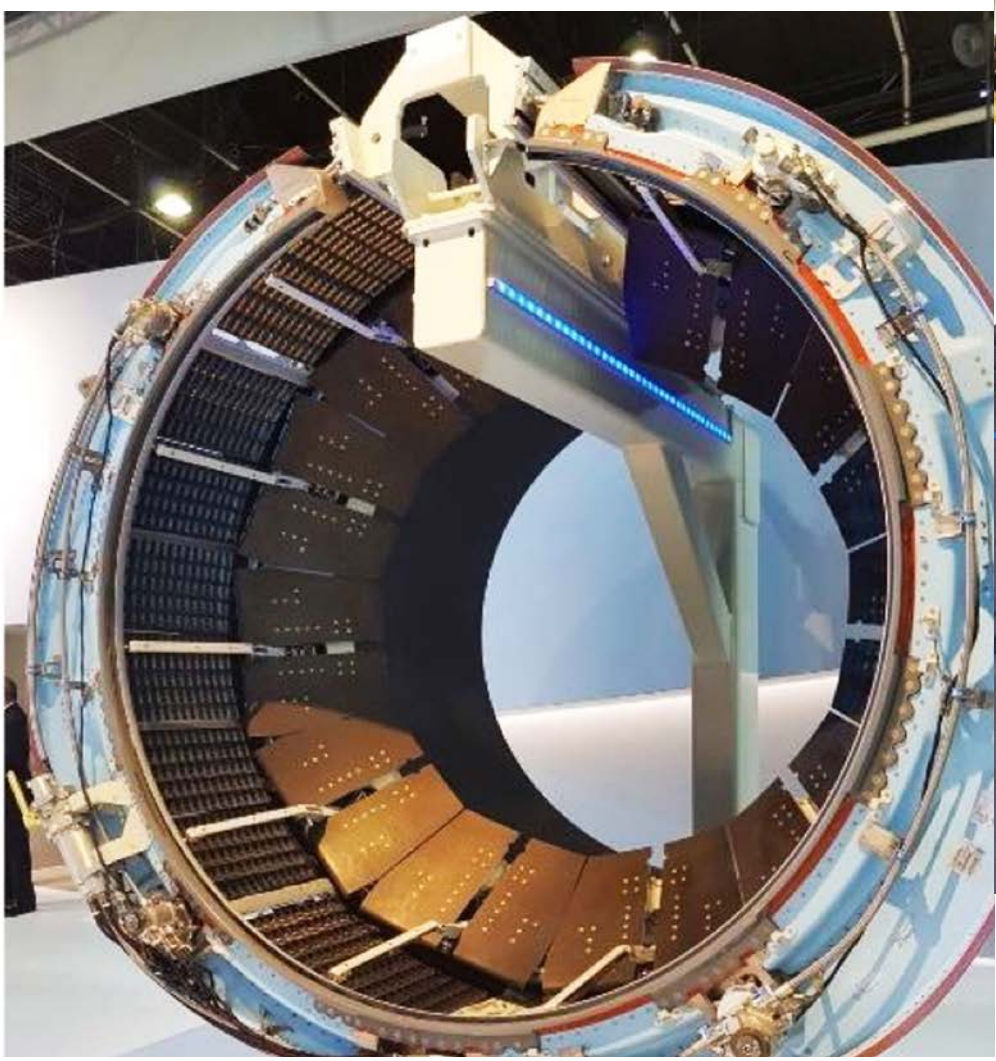
A new Falcon 900LX fresh out of the factory costs $44 million. In comparison, if a 900 C/EX operator were to use the CRT trade-in program savings, they could get an aircraft with avionics capabilities that are nearly identical in functionality to the flight deck technology featured on a new 900LX for $525,000 — or less than one percent of the cost of a new 900LX.

Out at Duncan Aviation's aircraft installation facility in Dallas, Texas, one of the aircraft models where they have been seeing great interest in avionics upgrades is the Embraer Legacy 600. Inside the cockpit of the Legacy 600, a total of up to nine CRT displays could be replaced, including old DU 870s (5), CD-810s (2) and RM-850s (2).

"Honeywell has pretty much quit supporting the CRTs," said Denis Kruse, a senior sales representative for Duncan Aviation. "Sooner or later you're going to have to deal with the obsolescence, especially if you try to re-sell it.

"Having the LCD displays and the avionics to meet the upcoming mandates already in there before 2020 is a better approach toward operating and maintaining that Legacy jet and establishing a better aftermarket value for its LCD-focused upgraded cockpit." ■

Above: Bombardier Global 6500 flight deck.



Redirecting engine thrust:

BY STEVE GRIMES

What key characteristics of flexible shafts should a TRAS engineering team consider?

Opposite: During thrust reversal, flexible shafts translate the aft cowl to the rear to reveal a matrix of openings through which the bypass air is redirected. When deployed, actuators redirect bypass air through a mid-engine matrix. Above: The CFM International LEAP-1C includes Nexcelle's O-Duct thrust reverser system.

TRAS & reverser actuation

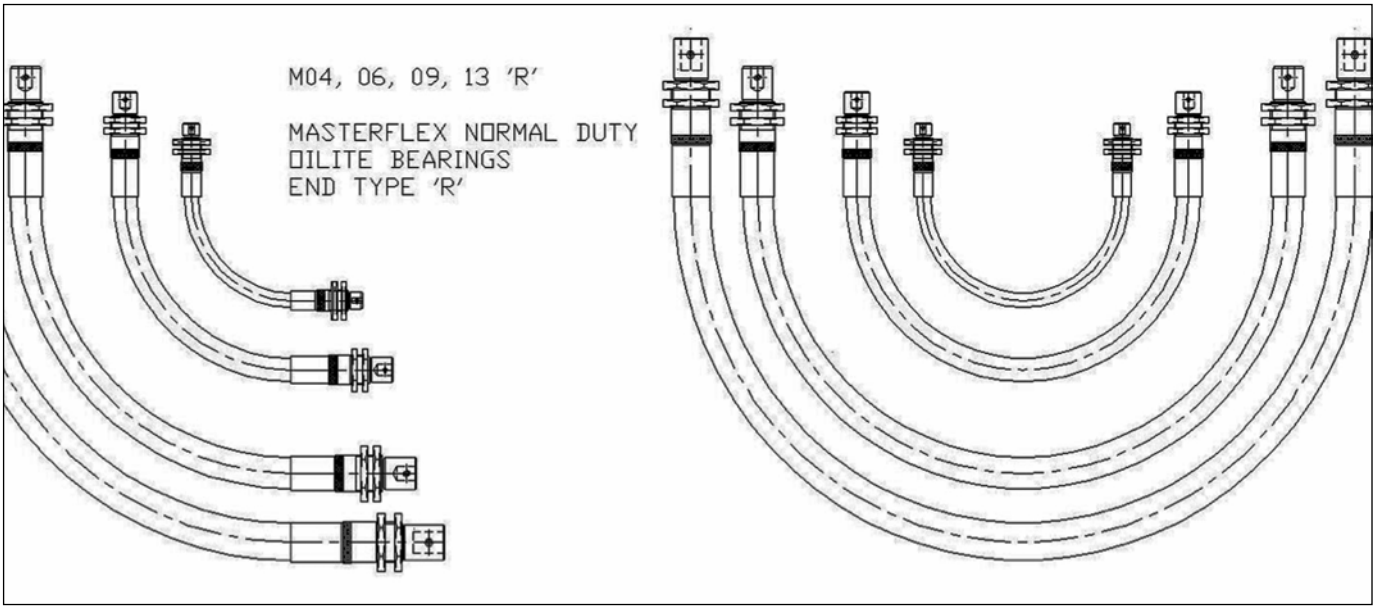
Thrust Reverser Actuation Systems redirect aircraft engine thrust immediately after landing to brake. On commercial jets, these systems provide critical safety and maneuverability to pilots.

Failure to deploy correctly during a landing could cause unsafe turning as an engine on one wing brakes while the other continues forward thrust. Even more dangerously, a poorly designed TRAS can rattle out of place during flight, effectively disabling an engine thousands of feet from the ground. Therefore, as is the case with most aerospace engineering, excellence in TRAS design is a necessity.

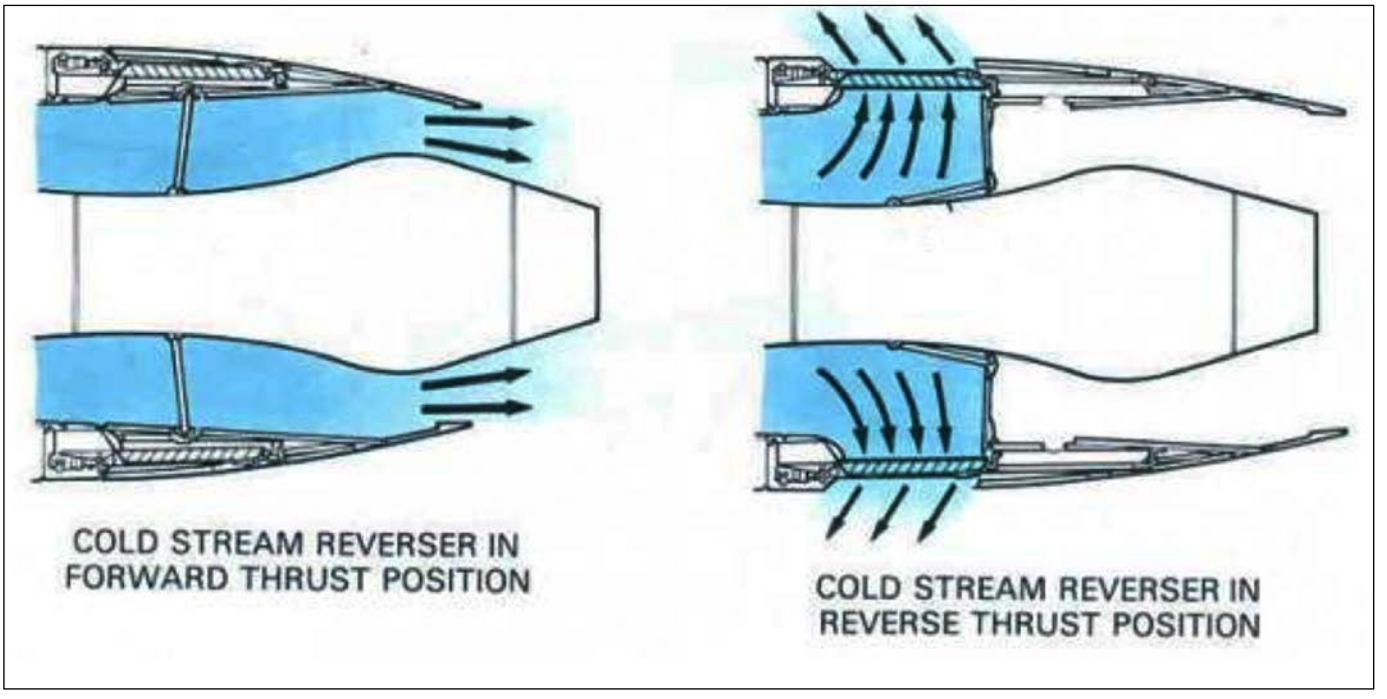
Understanding the characteristics of a key functional component — the flexible shaft — is vital to a configuring a successful TRAS. As an engineering team begins the initial design phase for a TRAS, it should consider what makes flexible shaft technology appropriate for aircraft engines, and what specifications best serve the application.

Flexible shafts in basic TRAS designs

Commercial aircraft fly on Larger Turbo Fan gas turbine engines, and Thrust Reverser Actuator Systems operate by



Above: By altering shaft radius, a flexible shaft's torque characteristics can be altered. Below: For commercial airplane engines, flexible shafts move actuators that change the direction of cold bypass air.



redirecting the cold "bypass" air. In order to achieve this redirection, a series of four to six actuators moves the rear of the aft cowl backward to expose a matrix of openings on the side of the turbine while simultaneously blocking the bypass airflow thus forcing the air through the mid-turbine exposure.

The actuators must move together in a synchronized fashion; a non-synchronized deployment can lead to the system jamming. This results in asymmetrical braking, affecting the pilot's ability to control the aircraft. Both principle system types address this consideration with flexible shafts, so the lifetime torsional deflection of flexible shafts is an important characteristic for the successful operation of any commercial TRAS. Engineers must control the deflection angle of these flexible shafts in order to ensure actuators deploy and stow fully. Managing this element of the TRAS design plays a critical role in avoiding inadvertent deployment during flight by correctly locking into the stow position.

In a hydraulic TRAS system, these flexible shafts are passive—their sole function is to ensure the actuators deploy and stow synchronously to prevent panels from jamming the system. In this design, the flexible shafts are contained within the hydraulic tubes that deploy the system, and so are lubricated by the hydraulic fluid. These systems generally support lower torsional loads.

Above: The TRAS, seen here stowed and deployed on a 747, blocks bypass air from exiting the engine to the rear during landing.

Alternatively, motor driven systems rely on flexible shafts both to ensure synchronization and to actually drive deployment. In this design, one or more electric motors generates torque, and flexible shafts are the only means of transmitting that torque from one actuator to the next. These systems offer higher torques than their hydraulic counterparts.

Engineers must also account for load cases when designing flexible shaft systems for success, as different load cases can impact the useful life of these parts in different numbers of operation cycles. Key load cases to factor into the design process include Normal Operating (stow / deploy), Rejected Take Off [RTO] (deploy), Limit Load (proof / acceptance test load), and Ultimate Load (failure / Ultimate Torsional Strength UTS).

Key flexible shaft characteristics for TRAS applications

Beyond the basic considerations of load, deflection endurance, and fatigue characteristics, a variety of

Above: Shafts can feature a variety of fitting types to minimize the chances of incorrect installation in a TRAS.

additional flexible shaft characteristics define the components' utility in TRASs. These can be organized into three categories: Performance, Assembly / Material, and Installation.

Correctly positioning actuators is a necessary function of flexible shafts in these systems. This positioning depends mechanically on the angular position between the ends of each shaft. Therefore, angular deflection / torsional stiffness, which is proportional to applied torque and flexible shaft length, asserts itself as a key performance characteristic.

Other important performance characteristics deal with stresses on the system. For example, TRASs must accommodate shock from a variety of sources, including "back driving" or static torque loads caused by system architecture or aerodynamic effect and "torque spikes" at the end of the stroke when the system hits its end stops when a system's inertia may be absorbed by the torsional elasticity of its flexible shafts. Depending on TRAS configuration, flexible shafts' ability to absorb shock loads can prove highly advantageous.

Likewise, change in angular deflection over time should be controlled, as wear over a number of cycles can be expected to add additional rotational angular detection. Lubrication can lessen this consequence of repeated use. However, engineers should consider another factor before specifying a lubricant: operating temperature.

Grease, for example, exhibits potential sticking effects at low temperatures—threatening to significantly increase the torque required to actuate the system and cause shafts to vibrate—although S.S. White engineers have developed mitigation techniques for such a scenario. Nevertheless, some vibration is unavoidable, including in flexible shafts' static position, and must be considered in the engineering process as well.

To best integrate flexible shafts into a cohesive and durable system, engineers must consider the long term and design with several material and assembly characteristics in mind.

Firstly, materials should be selected with the following in mind: electrical bonding path, in case of lightning strike; tribological (bearing) couples, with suitable materials for bearings designed to contact each other; galvanic couples, with materials that guard against long term corrosion; etc. Different materials offer a number of distinct benefits for certain applications and can affect how flexible shaft constructions operate within a TRAS. More fundamentally, any system using flexible shafts must competently fit those shafts into an overall assembly.

For this reason, engineers must give careful consideration to the radial clearance between the shaft and the casing. This clearance will limit the amplitude of the helix, and also the wavelength, of the flexible shafts. This is often influenced by the support clamp spacing, and by the bending stiffness of the casing due to the tendency of a flexible shaft to helix during operation.

Then, when determining the length of the flexible shafts in a design, engineers must factor in the likely routing

of the shaft compared to the routing of its casing. The centerline path of the installed shaft may be longer than the housing, meaning the shaft should be longer in turn. In some circumstances, a devise may be needed to retain the shaft in its casing to ensure its correct positioning.

Of course, the best designed system will fail if incorrectly or insecurely installed. If loose flanges are specified, for example, the engineering team may decide to develop a feature to retain them and prevent their falling from one end to another.

Installation can also be fool-proofed, by designing assemblies of differing lengths. When this is impossible, as in the many cases for which both shafts with dominant characteristic in clockwise and counterclockwise directions are required to be of identical length, creative engineers may select differing fitting types— square and hexagon cross section fittings, or fittings with alternate numbers of spline teeth—to prevent a detrimental incorrect installation.

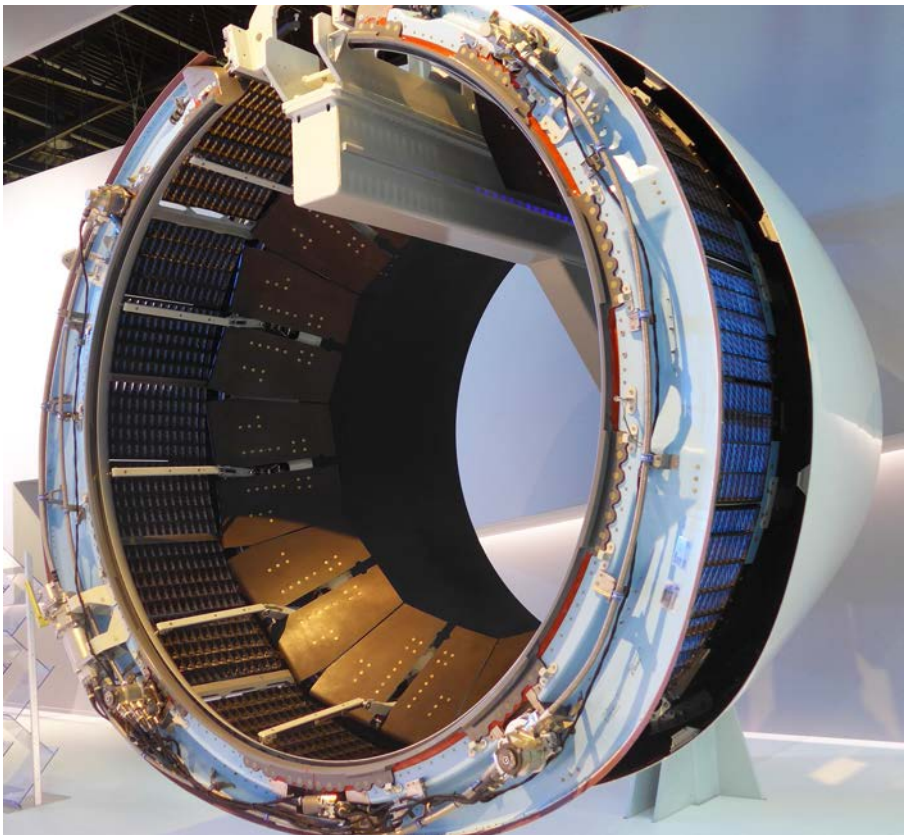
Another option to design for quality installation involves a trade-off. Assemblies can be "locked in" to aid installers, and prevent inner flexible shafts from separating from their casing, but this can inhibit maintenance and examination.

Flexible shaft experts provide TRAS engineering insight

Whether designing a hydraulic or motor driven system, TRAS engineering teams must consider an array of flexible shaft characteristics early in the design process. Engineers at S.S. White, a global leader in flexible shaft technology, provide valuable expertise on the intricacies of flexible shaft performance and assembly, and can help specify the ideal flexible shaft solution for a specific application the first time.

To ensure safe and efficient operation, engineers should consider torsional, wear, and assembly attributes among others—optimally, with insight from industry-leading application engineering professionals.

(Steve Grimes is Director, Sales & Marketing, S.S. White Technologies) ■



Above: A close-up view of the O-Duct thrust reverser provides a detailed view of the thrust reverser's architecture.

ATLANTIC

Atlantic AME Association

Details regarding the main levels of membership

Regular Membership

All voting members of the Association must currently hold an AME licence in any category, or a non-licensed aviation maintenance technician, technologist or individual meeting a recognized aviation trade standard (CGBS, Mil Standard, CAMC, SCA) or holding a position named in a MCM, MPM, ATO.

Student Membership

Student membership is available at a reduced rate and this specified membership can only be renewed over a six year period. Student members are non-voting members. Student members attaining AME licences may become full voting members by paying the difference between student membership fees and regular fees.

Corporate Membership

A corporate member is any corporation supporting the objectives of the association, and which is actively involved in the aviation industry in the Atlantic Region.

01. A representative of a Corporate member shall have the right to attend all meetings but no Corporate member shall be entitled to vote or hold office in the Association.

02. Membership is limited to AMEs, students and corporations in good standing with dues paid to date. Lapsed membership may be reinstated with the payment of annual dues.

03. The Association's President shall call executive meetings as are deemed necessary. Normal notice of meetings will be thirty days. Emergency meetings will be called as required.

04. Executive decisions can only be made with a quorum of 5 members of the executive, one of which must be the President or Vice-President.

05. An annual meeting of the general membership will be held to coincide with the Atlantic Region Aircraft Maintenance Conference.

06. All committee chairmen will report to the general membership at the annual general meeting.

07. An election of executive officers will be held annually at the general meeting. In the event that an elected committee chairman resigns, for whatever reason prior to the expiry of his term, the President shall appoint another elected director to fill this position for the remainder of the resignee's term.

08. The executive committee will be comprised of a maximum of eight (8) and a minimum of six (6) directors who will manage the affairs of the Association.

09. Half of the executive will be elected at each annual general meeting. All nominations must be accompanied by one signature of a member in good standing. Elections will follow the nominations. Nomination forms must have the nominee's signature of acceptance or the acceptance can be verified by phone call by the nominator.

10. If a serving member of the executive is nominated to another position of the executive, he shall tender his resignation upon accepting the nomination.

11. Elections will be by secret ballot.

12. Members serving on the executive should be prepared to offer their services for two years, and attend executive and other meetings as required.

13. The president will not be a voting member, with the exception of a tie breaking vote.

14. An agenda will be required for the general meeting for discussion and action on items proposed during the year, and will be mailed thirty days in advance.

15. Membership fees (regular, student and corporate) will be established on an annual basis by the members at the AGM.

16. Any amendments to the AME Association Objectives and By-laws will be approved by the general membership at the AGM.

www.atlanticame.ca

WESTERN

Western AME Association

Purpose and Objectives of this association are to:

1. Promote and protect the profession of AMEs.
2. Develop, maintain and improve representation and consultation with regulatory bodies that affect or may affect the profession of the Aircraft Maintenance Engineer.
3. Represent the objectives of the membership of the Association.
4. Promote and develop the knowledge, skill and proficiency of the profession of the Aircraft Maintenance Engineer through education, publication and research.
5. Cooperate and associate with groups, associations and organizations on matters of mutual interest.
6. Promote honorable practices among the membership and between persons in the aviation industry.

A separate committee, under the auspices of the association, runs an annual symposium/workshop. This workshop is a two-day event, which features speakers on a variety of related topics, as well as an industry tradeshow with over 50 booths from various companies, suppliers, manufacturers and other organizations. Attendance at this and our various other smaller workshops may be counted towards the recurrent training requirements required by Transport Canada.

www.wamea.com

AME Association of Ontario

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

45th Annual Conference and Workshop

The AME Association of Ontario held its 45th Annual Conference and Workshop, September 12-13. Over 500 attendees visited the 65 vendor booths and attended the 28 training sessions. Seven teams participated in the skills challenge. And the Aircraft Maintenance Association of Ontario had their Annual General Meeting.

Training sessions ranged from specific aircraft component subjects – Bell Helicopter 505 update, Airbus 220 program update, various engine sessions – to the proper completion of paperwork, SMS reporting, import and export documentation, SDR process and AD development to personnel and management, human factors training, managing risk and insurance, and engaging the next generation of professionals. The two days seemed to have no downtime as even the coffee breaks were filled with socializing and networking. The workshop was preceded with a Ministers Delegate training day for those AMEs with MD certifications.

The annual Association Awards were presented at the conference. Congratulations to John Longo, winner of the Claire Leavens Award for his outstanding contribution to the continued success of the association. The Gordon B. Rayner Award went to Wilson Boynton who was recognized as a Canadian whose career will always remain outstanding as an Aircraft Maintenance Engineer and a teacher.

Tom Hodges received the Aviall High Achievement Award, given to an Ontario AME or individual associated with the aircraft maintenance business who has consistently shown a positive attitude, a high level of professional skill in their particular work and leadership attributes, which serve as an inspiration to young people. We were very pleased to have Bert Vergeer and his family present as he was awarded his induction into the AME Hall of Fame.

— Submitted by Stephen Farnworth
For the Board of Directors

Pacific AME Association

What we do

The Pacific AME Association is a non-profit organization, run by a volunteer group of AMEs and non-AMEs. Directors are elected by member AMEs to the Board for a two-year term. The purpose of the association is to maintain and enhance the professionalism of the AME and the aircraft maintenance industry, and to promote the rights and privileges of the AME. The association works with and is consulted by Transport Canada in the formulation of regulations to promote the viewpoint of the AME. We are represented on committees and working groups involved with aircraft maintenance and licensing. We support community college aircraft maintenance programs throughout BC through annual monetary awards to their top students.

Two workshops are conducted annually: usually one in the Lower Mainland and one elsewhere based on demand and corporate requests. These workshops are run by volunteers and are single day events and feature speakers and interactive presentations on a variety of topics. Attendance at these can be counted towards the recurrent training requirements by Transport Canada. We publish periodic newsletters, which contain items of current interest to our members as well as commentaries and articles on maintenance procedures. We have monthly meetings and our Annual General meeting AGM usually in February.

www.pamea.ca

Central AME Association

About CAMEA

The Central Aircraft Maintenance Engineer Association is an organization dedicated to maintaining and enhancing the standards, rights and privileges of all AME members in the central region of Canada. Our chapter is one of six similar associations across Canada who collectively support 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.

Manitoba's Annual Aviation Symposium

We're looking forward to next year! Stay tuned for more information as we start planning the 25th Annual Aviation Symposium March 5-6, 2020.

www.camea.ca

Central Ohio PAMA

Welcome to COAGO 2019!

We want to thank our Central Ohio Aviators and Sponsors for their great support of this year's event. Proceeds raised $10,452 for the COPAMA Scholarship Fund.

This year's Central Ohio Aviation Golf Outing was held Friday, September 6th at the Willow Run Golf Course. The weather couldn't have been more perfect with a cool, clear morning and warm sunny skies for afternoon play.

This year's event entertained 116 golfers and made $10,452 with all proceeds going to the COPAMA Scholarship Fund. Its primary goal is providing help paying for certification testing of new AMTs.

www.copama.org

PAMA SoCal Chapter

PAMA supports Technician Education

Fourteen trade associations submitted joint comments to the part 147 supplemental notice of proposed rulemaking, delivering a powerful message of unity and support for technician education. The coalition echoed comments previously submitted by the Aviation Technician Education Council (ATEC), asking the agency to reconsider prescriptive terms, and pushing for an outcomes-based approach to regulatory oversight. The group reiterated the need for a simplified approach to dual enrollment programs and deference to Department of Education requirements for matters concerning the quality of education.

"Fixing 147 is an industry imperative," the letter said. "Handicapping our schools burdens both graduates and employers. Give us the flexible and dynamic rule needed to ensure we can educate the future workforce by the best means necessary."

In addition to PAMA and ATEC, the following organizations signed the letter:

- Accrediting Commission of Career Schools and Colleges
- Aeronautical Repair Station Association
- Aerospace Maintenance Council
- Aircraft Mechanics Fraternal Association
- Aircraft Owners & Pilots Association
- Airlines for America
- Cargo Airline Association
- International Air Transport Association
- National Air Carrier Association
- National Air Transportation Association
- National Business Aviation Association
- Regional Airline Association

Read the joint comments here:
www.regulations.gov/document?D=FAA-2015-3901-0132.

www.socalpama.org

PAMA Dallas – Fort Worth

About us

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

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

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

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

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

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

www.pamadfw.com

Under Pressure

Above: Humidity, atmospheric pressure and the amount of salt and dust an aircraft is exposed to determine which grease to use.

Greases are the unsung heroes that keep aircraft flying longer and cheaper.

Have you ever given much thought what the wheels of aircraft have to endure? Picture this: when a 380-tonne airplane — the weight of which is equivalent to a modest office building — touches down on a runway the entire load is transferred to the ground through the landing gear and wheels, no matter how gentle the landing is; a heavy landing places huge loads through the wheel bearings.

During takeoff an aircraft's wheels are thrust to accelerate from zero to 170 mph in under 50 seconds. Under these conditions, the bearings in the wheels need the best protection possible. Enter, grease.

We spoke with Vanessa Boag, General Manager at Shell Aviation Lubricants, to hear the evolution and integral role greases have on an aircraft's journey and the impact innovations have on performance and cost.

Can you provide a 101 on greases and how to pick the right one?

For me, greases are the unsung heroes of the aviation world. While fuel gets aircraft in the sky and oils keep the engines running smoothly, aircraft greases are responsible for keeping a huge number of an aircraft's parts operating efficiently during flight. Compared to other lubricants, greases are unique as they stay where they are put, act as a seal against dirt, dust and water, and enable key performance additives to be held in dispersion where they are needed.

A grease is a semi-solid product comprising of a base oil, thickener and additives. The base oil is responsible for delivering the required lubrication, whereas the thickener helps to determine a grease's consistency – whether it is stiff or soft.

The thickener acts like a sponge so that, when pressure or stress is applied, oil is released which then lubricates the mechanism and, when the stress is released, the thickener and oil return to a semi-solid state. Additives meanwhile can be incorporated to help further enhance performance such as anti oxidants, corrosion inhibitors, load carrying and extreme pressure additives.

When it comes to choosing the right grease, there are a number of considerations that must to be taken into account. This varies from environmental factors and the conditions the plane is operating in, for example, humidity, atmospheric pressure, as well as the amount of salt and dust an aircraft is exposed to.

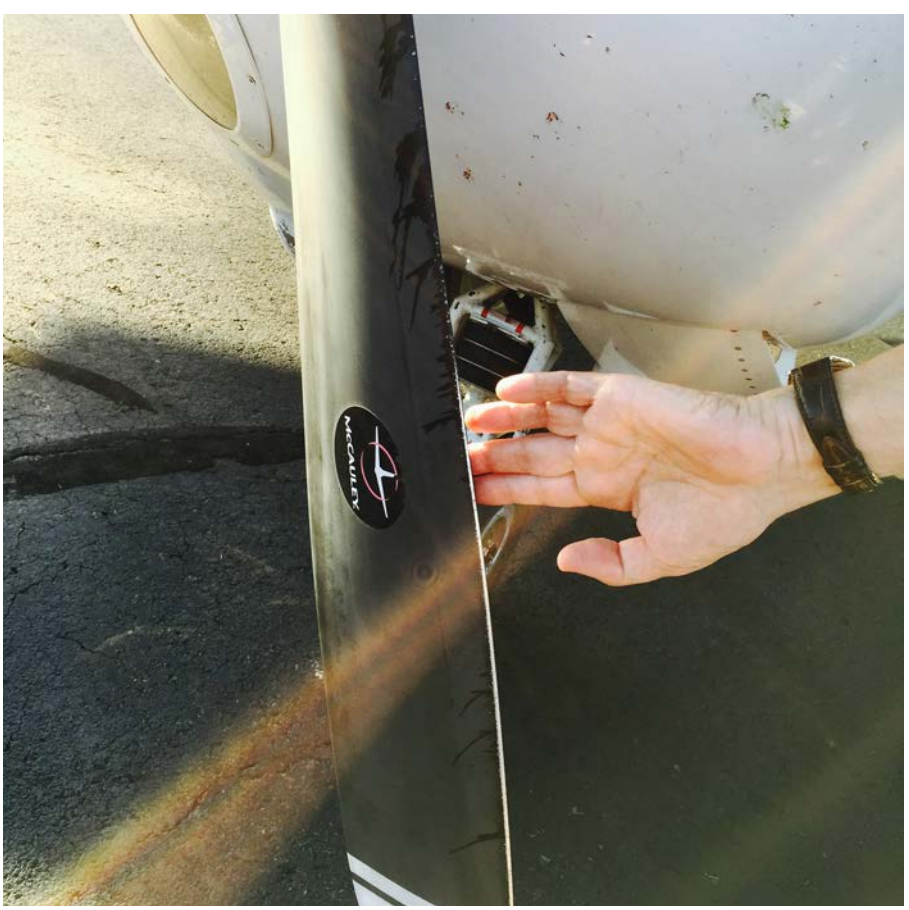
The type of component the grease is being applied to and the friction and wear requirements also need to be considered, along with the performance versus cost. Fundamentally, you're looking to understand what's the mechanical stability, base oil viscosity, corrosion protection and water washout — does the grease stay where you want it to stay, and it provide the best protection?

What does this mean for airlines?

The importance of greases cannot be overstated; they keep hundreds of parts of a commercial jet running smoothly.

Above: An AME applies grease to the rotor blade of a helicopter.

Above: A Boeing 737 has an incredible 359 grease application points, each of which requires the right grease. Below: Grease on the prop of this Mooney aircraft was cause for concern as the pilot wondered if grease was injected or not as part of the annual.



For example, a Boeing 737 has an incredible 359 grease application points, each of which requires the right grease to optimize the performance and extend the life of vital aircraft components. Put simply, if the thickener in the grease isn't right, this will increase both maintenance costs and the aircraft's downtime. This can be as a result of creating friction, allowing corrosion to develop or allowing dirt to get in between moving parts. The resulting increase in maintenance requirements can then have a negative impact on the aircraft's availability and cost of maintenance – and when you multiply this across an entire fleet, this can significantly impact the profitability of an airline.

We speak to airlines and MROs around the world, and they are all under pressure to keep costs low. So it's perhaps not surprising that some airlines and maintenance teams choose greases based on price, believing that this will help keep their costs down. What this doesn't take into account is the longer term – how often does the grease need to be reapplied? How resistant is the

Above: Compared to other lubricants, greases are unique as they stay where they are put, act as a seal against dirt, dust and water.

grease to corrosion after de-icing? How quickly does the grease soften or harden, or break down in service?

What's changing in how maintenance teams are applying greases?

As engine and airframe technologies continually advance, so too do aviation lubricants. Historically, aircraft maintenance operations carried several different greases for different lubrication points on the aircraft. The market is moving towards a reduced number of greases for aircraft lubrication and maintenance, with an increased use in more extensive multi-purpose greases. This has advantages from an operational standpoint, as it reduces the risk of product misapplication as well as the inventory required.

Increasingly we are seeing OEMs and airlines looking for solutions that help to minimize inventory requirements and costs, without sacrificing performance. As an example, this has been a particular focus for Boeing, which introduced specifications that called for a product that could deliver improved performance and could be used in the widest possible range of grease applications on the aircraft.

In response we developed AeroShell Grease 33, a multi-purpose airframe grease. Not only does this product achieve Boeing's standards, it is also best in class, outperforming other greases in key industry tests.

AeroShell Grease 33 sets the benchmark for airframe grease, including in mechanical stability, rust, water and wear resistance, and in use under extreme temperatures, ranging from -73C to up to 121C degrees.

Its high performance against a multitude of benchmarks highlights why Boeing introduced AeroShell Grease 33 to cut down the number of different greases being used on its aircraft. It is approved to specification MIL-PRF-23827C (Type 1) and by other aircraft manufacturers alongside Boeing, including Airbus, Comac, Embraer and others.

Above: Aviation tube kit.

How do you work with aircraft manufacturers?

We have partnered with OEMs and our aviation customers for over a century, jointly developing, testing and approving products for aviation that are used globally every day. In the 1960s we patented the Microgel thickener, and later our scientists developed a lithium complex soap thickener system for the aviation industry.

We continue to innovate alongside the OEMs and now see lithium complex thickeners being the standard grease for the aviation industry, helping to avoid concerns associated with grease thickener intermixing. Today, we are first choice with many OEMs.

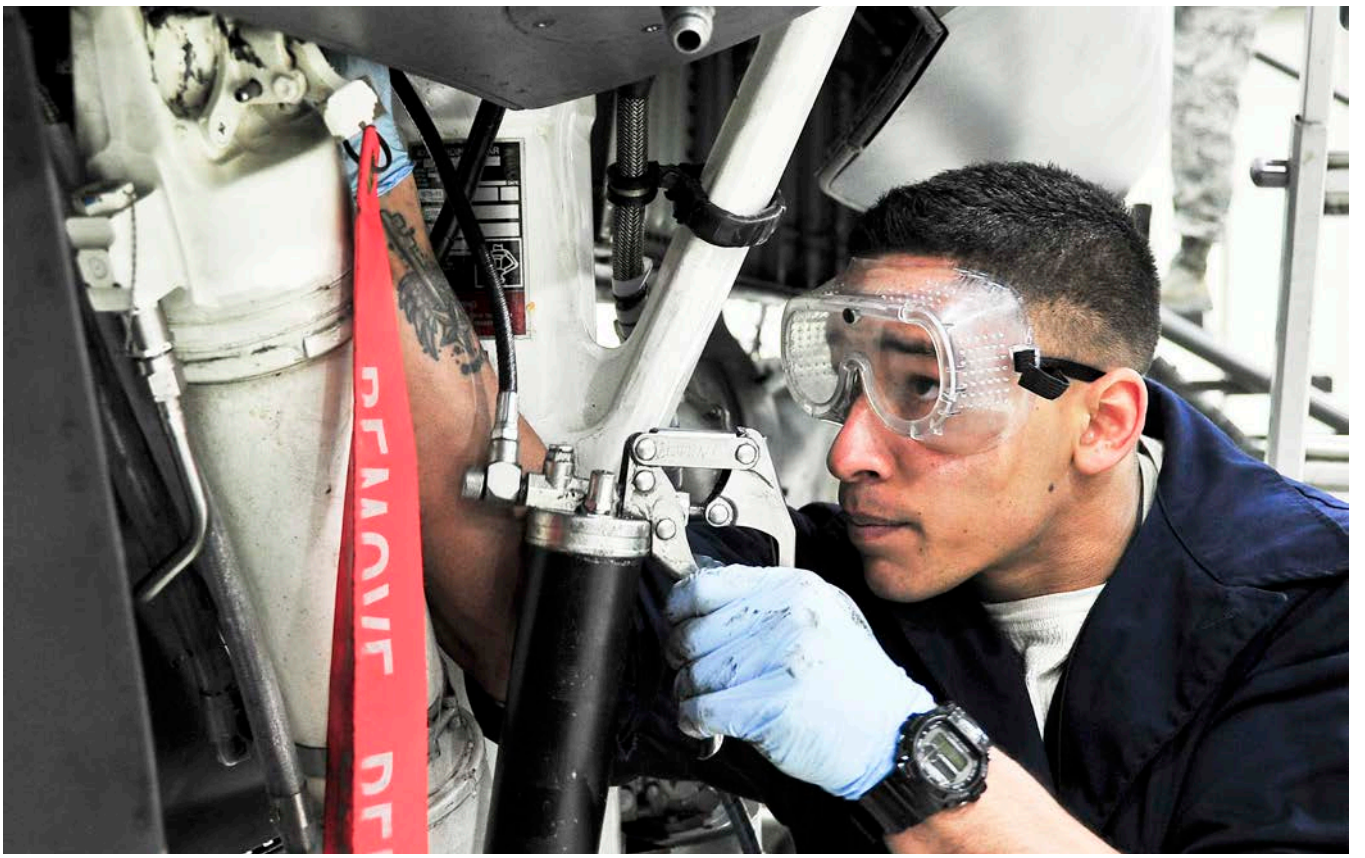
What's coming next?

From our perspective, multi-purpose greases deliver the best value for customers and will increasingly define the future of aviation greases. Based on a lithium-complex thickener system, the AeroShell Grease 33 is effective on virtually all components and now forms the basis for future developments within the AeroShell grease family. Shell can now offer a lithium complex grease for all key applications on the aircraft, ASG 33 for a general aircraft applications, ASG 64 for extreme pressure use and ASG 58 as the optimum wheel bearing grease.

More generally, one of the most exciting aspects of the aviation industry is that it is constantly evolving, with new technological advancements pushing the boundaries of what is possible in air travel.

So while OEMs continue to develop new technologies, innovations in greases and other lubricants must keep pace to ensure they continue to deliver the protection and performance required by the latest aircraft.

(To that end) the Shell Group spends an average of $1 billion in R&D every year and we are one of the few energy companies with a dedicated team of aviation scientists at a specialist aviation research facility, working on fuel quality, alternative fuels and lubricants. ■



Above: Aircraft greases are responsible for keeping a huge number of an aircraft's parts operating efficiently.

FLAME OUT!

Lack of clear policy and fuel supply oversight bring a tragic end to one helicopter survey mission.

On 05 September 2016, the Ridge Rotors Inc. Bell 206B Jet Ranger helicopter (registration C-GHHU, serial number 2196) was operating on a mountain pine beetle survey flight originating from Whitecourt Airport, Alberta (CYZU), during daylight hours, with the pilot and 2 surveyors on board. At 1520 Mountain Daylight Time, approximately 12 nautical miles southwest of Fox Creek Airport, Alberta (CED4), the engine lost all power while flying approximately 160 feet above ground level, and the helicopter lost altitude and collided with trees. The pilot was seriously injured. One surveyor received minor injuries and the other received fatal injuries. The helicopter was substantially damaged. There was no post-impact fire, and no dangerous goods were on board. The surviving surveyor exited the helicopter and called 911 on a personal cellphone. The pilot was evacuated by air ambulance. The 406-megahertz emergency locator transmitter activated and the signal was received by the Cospas-Sarsat search-and-rescue satellite system.

On the day of the accident, the pilot of C-GHHU arrived at the helipad at approximately 0700 and con-

ducted flight planning. During this time, the pilot installed the dual flight controls, to allow the surveyors to follow along on the controls. The survey area was located 44 nautical miles (nm) from CYZU, or 30 minutes' flying time.

At approximately 1222, after a delay of several hours due to poor weather, the pilot of C-GHHU initiated the engine-start sequence. The company engine-start checklist called for the caution circuit breaker to be reset after the engine stabilized at 60% to 62% N1.

It is likely that the circuit breaker was not reset at this time. Additionally, the checklist required that all circuit breakers be checked following the control and engine checks at 70% N1. It is likely that the caution circuit breaker was not reset at this time either.

At 1228, C-GHHU departed CYZU and transited to the survey area. The pilot was seated in the front right-hand seat, 1 surveyor was seated in the front left-hand seat, and the other surveyor was seated in the rear forward-facing seat. C-GHHU was equipped with dual flight controls.

During the transit flight, while the pilot-in-command controlled the helicopter, the pilot allowed the surveyor seated in the front left seat to follow the pilot on the controls. It is unknown how long this continued. There are no requirements in the rotorcraft flight manual (RFM), the Canadian Aviation Regulations (CARs), or the company operations manual requiring the removal of dual flight controls for non-training flights.

At 1300, C-GHHU arrived at the survey area and began to conduct the required survey flying. Another Ridge Rotors Bell 206B helicopter, C-GKMS, was also conducting survey operations within the same survey area. Both helicopters flew a north–south survey pattern. The survey was laid out in lines that ran north to south in a specific block of forest. The lines were 32 nm in length and spaced 800 m apart. The helicopter would fly a line at 120 to 180 feet above the treetops and at 60 mph, while each of the surveyors was tasked with observing an area of 400 m on either side of the helicopter.

At 1448, after 2 hours and 20 minutes of surveying, C-GHHU landed on a gravel bar by the Little Smoky River for a rest break. The engine power was brought down to flight idle, and the pilot remained at the controls.

The pilot and the surveyor in the front left-hand seat discussed the fuel remaining. The pilot indicated that 30 USG of fuel remained, which would allow for about 1 hour of flight, including reserve fuel. From the surveyor's perspective, the fuel quantity gauge appeared to indicate approximately 24 USG. The pilot decided to continue with the surveying operations before proceeding to the company fuel cache located at Fox Creek Airport, Alberta (CED4), approximately 12 nm northeast of the survey area.

After 20 minutes on the ground, the surveyors switched seats, and engine power was increased to 100% main-rotor rpm (NR). At 1508, C-GHHU departed the rest break area.

The pilot then began a northbound line, following a previously completed survey line. During this time, the pilot again allowed the surveyor seated in the front left seat to follow the pilot on the controls.

As the helicopter proceeded northbound, 1 of the surveyors identified the line as incorrect and indicated the need to reposition 1 line to the west. The pilot carried out a right turn and flew the helicopter approximately 4 nm south. The pilot then completed another right turn to roll out on the correct survey line. Moments later, at 1520, while flying at 58 mph in a descending left turn, approximately 160 feet above ground level (AGL), C-GHHU lost all engine power. This was immediately followed by a decay in NR and a descent.

The engine-out and rotor-low-rpm warning horns did not activate, and no warning lights illuminated on the annunciator panel.

Within 2 to 3 seconds, the aircraft descended and struck the trees. The heading at the time of impact was 246° magnetic. The helicopter came to rest suspended by the trees that it collided with, in a nose-high position, listing approximately 60° to the left and with its forward section approximately 7 feet above the ground; it did not strike the ground, but the aft portion settled to the ground.

General

The wreckage was located in a dense coniferous forest. The average height of the trees was 80 feet, and the average diameter was 12 inches. The trees adjacent to the site showed very little damage related to the helicopter's descent, although 2 trees had been topped. All of the helicopter's components were located and identified within a 50-foot radius of the aircraft. The helicopter's forward section and cockpit were destroyed. The cabin sustained substantial impact damage, particularly on the left side of the fuselage. The fuel cell was punctured during the impact sequence and was leaking. The main-rotor head was intact, with its 2 rotor blades still attached. Both main-rotor blades sustained minor damage consistent with low NR, indicating that no power was being produced at the time of impact.

The tail-rotor was intact. One blade was straight with no damage to its skin. The other blade had sustained impact damage and was bent in 2 locations.

The damage observed on both tail-rotor blades was consistent with low tail-rotor rpm, indicating that no power was being produced at the time of impact. Continuity among the engine, transmission, and tail-rotor assembly was verified. The investigation determined that there had been flight-control continuity before the accident. There were no visible ground scars.

Fuel system and engine component testing

During the TSB's post-accident examination of the helicopter, 10 USG of uncontaminated fuel consistent with type Jet A fuel were recovered from the damaged fuel cell. Following the occurrence, the fuel boost pumps and fuel quantity indicating systems were tested by the TSB. Both of these systems were found to be fully operational, with no abnormalities noted. The starter-generator and the voltage regulator were tested by

the TSB. Both of these systems were found to be operational, with no abnormalities noted that would have rendered the electrical system incapable of operating.

A post-accident examination of the engine found no mechanical issues that would have resulted in the deceleration. Fuel was found throughout the engine fuel system. All components tested met the required specifications, with no abnormalities noted.

The caution system warning-light panel was sent to the TSB Engineering Laboratory for light bulb filament analysis. It was concluded that the rotor-low-rpm warning lights and the fuel pump warning lights were probably not illuminated at the time of impact. It could not be conclusively determined whether the engine-out warning lights were illuminated.

The caution circuit breaker was substantially damaged during the impact sequence. The position and functionality of the circuit breaker could not be determined.

Analysis

The examination of the helicopter, as well as the data collected during the investigation, indicated that there were no mechanical issues that would have resulted in the engine flame-out and subsequent crash.

There was no indication that physiological factors, including fatigue, had played a role in the accident. Therefore, the analysis will focus on the operational and organizational factors that contributed to the accident.

The exact quantity of fuel on board C-GHHU at the time of the occurrence could not be determined, because the fuel cell was punctured during the impact sequence and there was a lack of detailed fuelling records maintained by Ridge Rotors Inc.

It is probable that C-GHHU departed Whitecourt Airport, Alberta (CYZU), with 86 U.S. gallons (USG) of fuel and, based on Rolls-Royce engine performance ratings burned 28 USG per hour. This would result in a fuel quantity of 12 to 21 USG at the time of the accident.

Ridge Rotors did not have a policy in place for helicopters to land with a specified minimum quantity of fuel to ensure appropriate safety margins to prevent the unporting of boost pumps.

It was common practice at Ridge Rotors to land with 10 USG of fuel. This amount of fuel is compliant with the minimum required by the Canadian Aviation Regulations (CARs); however, it is below the Bell Helicopter Textron Inc. recommended minimum fuel quantities for operation.

The rotorcraft flight manual (RFM) states that a pilot should land as soon as practical when the low fuel light illuminates (when there are 20 USG remaining). Although C-GHHU was not fitted with this system, the caution remained. Ridge Rotors did not consider this caution, as C-GHHU was not equipped with the low fuel light. The RFM also states that flight cannot be conducted with 10 USG of fuel or less when 1 boost pump is inoperative.

It is important for operators to understand the limitations of the Bell 206B helicopter fuel system and risks associated with flights conducted with less than 20 USG of fuel remaining. If operators do not follow the recommended minimum fuel quantities in the RFM, there is a risk that the helicopter will be operated at fuel levels that could be conducive to engine flame-out.

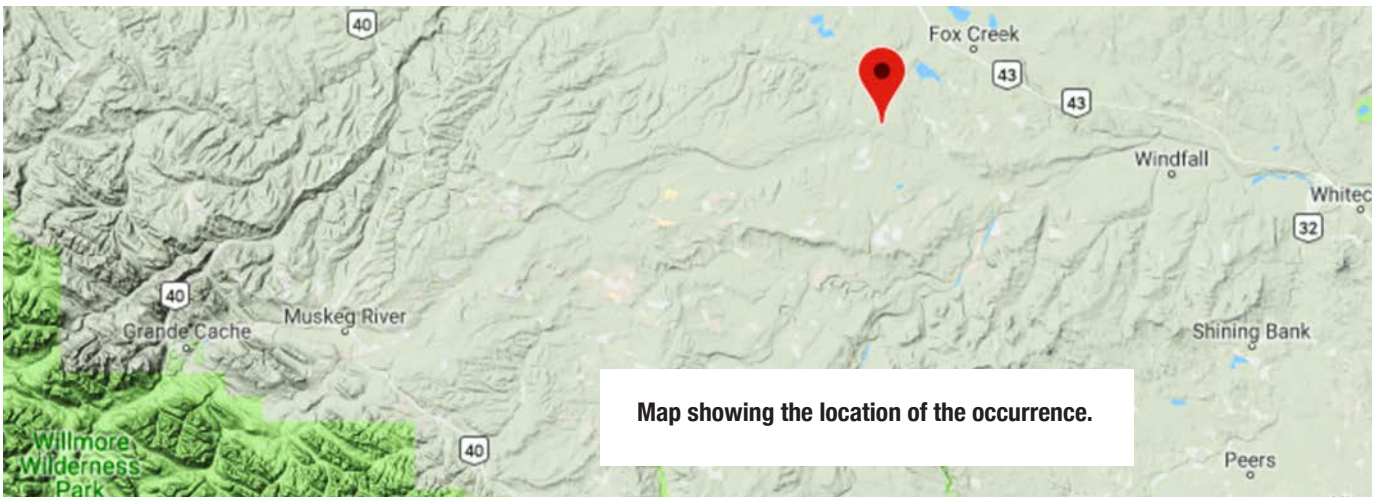
Ridge Rotors did not have a detailed method of recording the amount of fuel being loaded onto the helicopters. Often, more than 1 helicopter was being refuelled at the same time and only the total amount of fuel dispensed was being recorded as a single entry. Compounding this issue was the recording of several daily flight sectors in 1 entry in the aircraft journey log.

Due to the limitations of this practice, it was not possible to accurately determine the amount of fuel being consumed and the length of each flight. If operators do not maintain detailed refuelling and flight-time records, there is a risk that flights will be continued with low fuel states, increasing the risk of accidents.

Pilot decision making

When C-GHHU arrived at the rest break area, the fuel state was likely 21 to 29 USG. The helicopter spent 20 minutes on the ground, after which the fuel state at the time of departure was likely 18 to 26 USG.

The pilot continued the survey rather than flying directly to the fuel cache at Fox Creek Airport (CED4). It is likely that Ridge Rotors' practice of regularly operating with less than



Map showing the location of the occurrence.

20 USG of fuel influenced the pilot to continue the survey flight rather than proceed to the refuelling location.

Engine flame-out

The Bell 206B helicopter's fuel system can be susceptible to unporting when operating with less than 20 USG and acceleration forces are present. These forces can be due to turbulence or pilot flight control inputs. The greatest susceptibility occurs when 1 or both of the boost pumps are inoperative. The manufacturer states that, in these circumstances, 10 USG are unusable.

In this occurrence, it is likely that the acceleration forces in the turn that resulted in the interruption of fuel flow were brief, given that fuel was found throughout the engine fuel system in the post-accident examination.

While the helicopter was making a left turn, it is likely that acceleration forces caused 1 or both of the boost pumps to unport. The introduction of air into the combustion chamber interrupted fuel flow, resulting in an engine flame-out.

The engine relight system installed in C-GHHU was designed to activate when N2 decreased below 96%. When the engine flamed out, N2 would have decreased and conditions allowing the engine relight system to activate the igniter would have been met. The engine relight system in C-GHHU was not armed at the time of the accident. The system control switch was in the OFF position, so the engine igniter was not able to activate.

The engine relight system was off at the time of the occurrence, preventing the system from automatically attempting an engine relight following the engine flame-out.

Findings as to causes and contributing factors

1. Ridge Rotors Inc. did not have a policy in place for helicopters to land with a specified minimum quantity of fuel to ensure appropriate safety margins to prevent the unporting of boost pumps.

2. It is likely that Ridge Rotors' practice of operating with less than 20 U.S. gallons of fuel influenced the pilot to continue the survey flight rather than proceed to the refuelling location.

3. While the helicopter was making a left turn, it is likely that acceleration forces caused 1 or both of the boost pumps to unport. The introduction of air into the combustion chamber interrupted fuel flow, resulting in an engine flame-out.

4. The engine relight system was off at the time of the occurrence, preventing the system from automatically attempting an engine relight following the engine flame-out.

Findings as to risk

1. If operators do not observe the minimum fuel quantities recommended in the rotorcraft flight manual, there is a risk that the helicopter will be operated at fuel levels conducive to engine flame-out.

2. If operators do not maintain detailed refuelling and flight-time records, there is a risk that flights will be continued with low fuel states, increasing the risk of accidents.

3. If operators modify checklists without consulting the manufacturer, there is a risk that hazards will inadvertently be introduced into flight operations.

4. If helicopter operations are conducted outside of the safe area depicted on the height/velocity diagram, pilots risk not being able to complete emergency landings successfully.

5. If companies do not use thorough risk analysis processes, there is a risk that mitigation strategies for operational hazards will not be employed.

Ridge Rotors now requires the auto relight system to remain on during all phases of flight. This change has been incorporated into the company's standard operating procedures, and pilots have been trained accordingly.

(The preceding excerpts were from the official report concluding the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of the report on 13 September 2017.) ■

Aviation Services

Aviation Services

Aviation Services

Small, Medium, and Large

Airbus forecasts the need for over 39,000 new aircraft and 640,000 new technicians in the next 20 years.

During a press event in London, England in mid-September, Airbus presented a report saying the world's passenger and freighter aircraft fleet is set to more than double from today's nearly 23,000 to almost 48,000 by 2038 with traffic growing at 4.3 percent annually, also resulting in a need for 550,000 new pilots and 640,000 new technicians.

By 2038, of the forecast 47,680 fleet, 39,210 are new and 8,470 remain from today. By updating fleets with latest generation fuel-efficient aircraft such as the A220, A320neo Family, the A330neo and the A350, Airbus believes it will largely contribute to the progressive decarbonization of the air transport industry and the objective of carbon neutral growth from 2020 while connecting more people globally.

Reflecting today's evolving aircraft technology, Airbus says it has simplified its segmentation to consider capacity, range and mission type. For example, a short haul A321 is Small (S) while the long-haul A321LR or XLR can be categorized as Medium (M). While the core market for the A330 is classified as Medium (M), it is likely a number will continue to be operated by airlines in a way that sits within the Large (L) market segmentation along with the A350 XWB.

The new segmentation gives rise to a need for 39,210 new passenger and freighter aircraft — 29,720 Small (S), 5,370 Medium (M) and 4,120 Large (L) — according to Airbus' latest Global Market Forecast 2019-2038. Of these, 25,000 aircraft are for growth and 14,210 are to replace older models with newer ones offering superior efficiency.

Resilient to economic shocks, air traffic has more than doubled since 2000. It is increasingly playing a key role in connecting population centres, particularly in emerging markets where the propensity to travel is among the world's highest as cost or geography make alternatives impossible. Today, about a quarter of the world's urban population is responsible for more than a quarter of global GDP, and given both are growth drivers, Aviation Mega Cities (AMCs) will continue to power the global aviation network. Developments in superior fuel efficiency are further driving demand to replace existing less fuel-efficient aircraft.

"The four percent annual growth reflects the resilient nature of aviation, weathering short term economic shocks and geo-political disturbances. Economies thrive on air transportation. People and goods want to connect," said Christian Scherer, Airbus Chief Commercial Officer and Head of Airbus International. "Globally, commercial aviation stimulates GDP growth and supports 65 million livelihoods, demonstrating the immense benefits our business brings to all societies and global trade."

Airbus aircraft are market leaders in their segments. The Small (S) segment includes the A220 Family and all variants of the A320 Family. The core Airbus products in the Medium (M) segment are the A330 and A330neo Family, and can also include the smaller A321LR and XLR versions used on long-haul missions. The A330neo Family together with the larger A350 XWB Family, which also includes the Ultra Long Range (ULR) version, represents the largest segmentation Large (L). This segmentation will continue to be served by the A380 at the upper end. ■

Above: Airbus presented its Global Market Forecast 2019-2038, which projects an annual traffic growth of 4.3 percent, during a press event held in London, England

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