SAE INTERNATIONAL
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AEROSPACE ENGINEERING

Asian Programs

Pratt & Whitney's PW1217G Under Test for the MRJ

Camelina-Based Biofuel

Safety Avionics

Top Products

Radiation-hardened power converters

VPT Inc.'s radiation-hardened dc-dc power converters, point-of-load converters, and EMI filters are claimed to be the first power conversion products commercially available that are out-of-the-box compliant to the new Aerospace Technical Operating Report requirements for space power systems. The SVR series of space power products includes 24 new modules in seven product families, all based on space-proven heritage designs and available qualified to MIL-PRF-38534 Class K. Read more at ***www.sae.org/mags/aem/12231***.

Radiation-tolerant transceiver/transformer

Data Device Corp.'s radiation-tolerant SPACE-PHY is a +5V, dual MIL-STD-1553 transceiver/transformer. The unit is a completely integrated MIL-STD-1553 physical layer in a single package, including dual transceivers and transformers, creating a reliable MIL-STD-1553 space-level solution. The device has an extended -55 to +125°C temperature range for operating in the extreme environmental conditions encountered in mission-critical space applications. Read more at ***www.sae.org/mags/aem/12230***.

Pneumatic control of force and motion

Pneumatic control of force and motion with high accuracy and low friction is enabled by Airpot's Accurate Force Pneumatics packages. Literature from the company aids design engineers in selecting and specifying the components necessary to design accurate pneumatic force control systems using: clean, regulated air; proportional pressure control; and precise actuation at a lower cost than purchasing individual components. Read more at ***www.sae.org/mags/aem/12229***.

Rotary pulse generators

Omega's ZSD series of shaft servo mount, rotary pulse generators features high-precision accuracy, NPN open collector output, and quadrature outputs with indexing. The series is suited for applications requiring a miniature, high-precision, low-cost encoder. Construction is all-metal for trouble-free operation. Outputs are standard quadrature with index, available in 100 or 1000 pulses per shaft revolution. Read more at ***www.sae.org/mags/aem/12228***.

Excimer laser mirrors

Opto Diode's 16-element photodiode offers UV/EUV or electron detection. The AXUV16ELG features a 40-pin, dual in-line package and internal quantum efficiency of 100%. The device has a 2 X 5-mm active area and a sensitive area of 10 mm² per element. To enhance accuracy, the detector offers stable response after exposure to high-energy electrons or photons. Read more at ***www.sae.org/mags/aem/12197***.

Top Articles

Pratt & Whitney moves additive manufacturing into production

Pratt & Whitney is quickly ramping up its capabilities for additive manufacturing, using parts made with additive processes on an engine that is being tested on a new Bombardier jet. The engine manufacturer also christened a new laboratory that will focus on this rapidly emerging manufacturing technique. Read more at ***www.sae.org/mags/aem/12061***.

Pratt's PurePower PW1500G engine is set to go into production using parts made via additive manufacturing processes.

Fine-tuning vibro-acoustic countermeasures in a turboprop aircraft

Turboprop engines are gaining popularity for their fuel-consumption advantages, but they also generate substantial noise, so reducing cabin noise to ensure passenger comfort is an important engineering challenge. Read more at ***www.sae.org/mags/aem/12218***.

Solar Impulse readies next-gen aircraft for round-the-world sun-powered flight

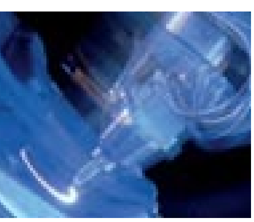
Capturing the Sun's energy during the day and storing it for later use at night are obviously critical engineering imperatives for the next-generation HB-SIB. Solar Impulse plans to use more solar cells to capture more energy and also use more efficient battery cells to store more energy. Read more at ***www.sae.org/mags/aem/12281***.

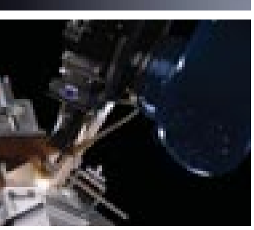
Aerospace to help ignite 3D printing boom

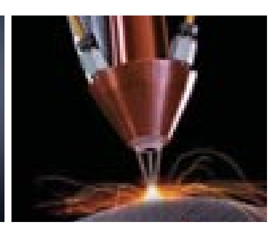
Touted as an enabling platform for applications ranging from personalized medicine to personal drones, 3D printing will grow to an $8.4 billion market in 2025 — up from $777 million in 2012, according to a recent report by Lux Research. Read more at ***www.sae.org/mags/aem/12048***.

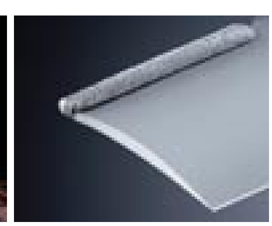
SAE G-19 Committee making progress on counterfeit parts standards

SAE International's G-19 Counterfeit Electronic Components Committee, chartered to address the different aspects of preventing, detecting, responding to, and counteracting the threat of counterfeit electronic components, provides a status report on the activities of the committee and its subcommittees. Read more at ***www.sae.org/mags/aem/12100***.









Webcasts

The following webcasts are available for free on-demand viewing at www.sae.org/webcasts:

- "The Re-emergence of Aerospace Metals" is the latest webcast in the Technical Editorial Webcast Series from the editors of SAE. In this webcast, industry experts discuss some of the latest technological breakthroughs and challenges facing engineers tasked with making thorough use of high-strength metals in various aircraft systems and structures while simultaneously reducing weight, improving fuel efficiency, and maintaining structural integrity. The speakers are Tony Morales, Global Marketing Director, Aerospace & Defense, Alcoa Global Rolled Products; Dr. Rob Sharman, Head of Metallics Technology, GKN Aerospace; and Sean Holt, Aerospace Application Manager, Sandvik Coromant. Sponsor: HBM-nCode.

GKN Aerospace discusses additive manufacturing technology and its benefits for creating complex metallic shapes in "The Re-emergence of Aerospace Metals" webcast.

- "Raising Engine Efficiency Through Boosting/Downsizing" is also part of the free Technical Editorial Webcast Series from the editors of SAE International. This webcast features experts from the supercharging, turbocharging, and engine-systems fields who present their companies' latest developments with an eye toward the future and answer questions from the audience. The speakers are Scott Makowski, Manager of Global Large I4 Programs at Ford; Grant Terry, Business Development Manager of the Supercharger Division at Eaton; and Frank Zwein, Global Director of Application Engineering, Valve Seats and Guides, at Federal-Mogul Powertrain. Sponsors: Eaton, Federal-Mogul, and Ticona.

- How do the improvements offered by modern transmission architectures weigh in against key customer acceptance criteria? SAE International has explored that question in a free webcast titled "How Does Choosing the Right Transmission Architecture Weigh Against Customer Acceptance?" The webcast examines the advantages of advanced transmissions and discusses the influence of innovative driveline technologies on improving fuel economy and ensuring customer satisfaction.

Editorial

Keeping an open mindset

For those readers who have had the pleasure, you know what I mean when I posit that when you read the title of any Government Accountability Office (GOA) report, you pretty much know what you may be in for over the next several hours, should you actually read it in its entirety.

A recent report titled "A Variety of Factors Influence Airport-Intercity Passenger Rail Connectivity" in fact provides a variety of factors that go into explaining how it is that there is essentially no airport-intercity passenger rail connectivity in the United States. (To be fair, and to save you from reading the entire report, the GAO cites that there are, in fact, two such instances of airport-intercity passenger rail connectivity at Newark Liberty International Airport and Bob Hope Burbank Airport.)

Another recent GAO report, "DOD Efforts to Adopt Open Systems for its Unmanned Aircraft Systems Have Progressed Slowly," does, in fact, provide proof that open system adoption progress has been slow. What was surprising was just how slow.

In its summary of the report, GAO starts with a stunning opener: "For fiscal year 2014, DOD requested over $11 billion to modify existing weapon systems — more than 10% of its total procurement budget."

The problem is, of course, that the DOD has a very long history of buying proprietary systems that are "costly to upgrade and limit opportunities for competition."

In contrast, an open system allows "system components to be added, removed, modified, replaced, or sustained by consumers or different manufacturers in addition to the manufacturer that developed the system."

Incorporating open systems early in development is also important. Neither the USAF nor the U.S. Army had at the start of any of their six combined UAS development programs (GAO focused on UAS programs from Class 2-5) any consideration for open systems, even though "as far back as 1994, the Under Secretary of Defense for Acquisition and Technology directed the use of an open systems approach in the acquisition of weapon system electronics."

The U.S. Navy, on the other hand, incorporated an open systems approach at the very beginning of three of its four UAS programs; Fire Scout started out proprietary. But when that program was being upgraded in 2004, the Navy took the opportunity to "secure the data rights to key system interfaces and introduced modularity into the air vehicle and payloads." Thus, payload data links are separate from flight control software and other systems. GAO cited that "program officials said they were able to integrate a new radar in only 18 months" when it previously would have taken three years.

For the Navy's STUAS (Small Tactical UAS) program that started in 2010, the Navy owns the right and specifications for the data links and payload interfaces, which program officials estimate will allow for all the integration and testing of "third-party designed payloads within a matter of days or months, as opposed to years." It estimates it will be able to use 32 different payloads developed by 24 different manufacturers.

According to the GAO, "policies and leadership support" are essential to the "DOD weapon acquisition community" to make a clean break from sourcing proprietary programs to embracing open system architectures. In particular, it recommends that the "USAF and Army implement their open system policies" and the "DOD track open systems implementation."

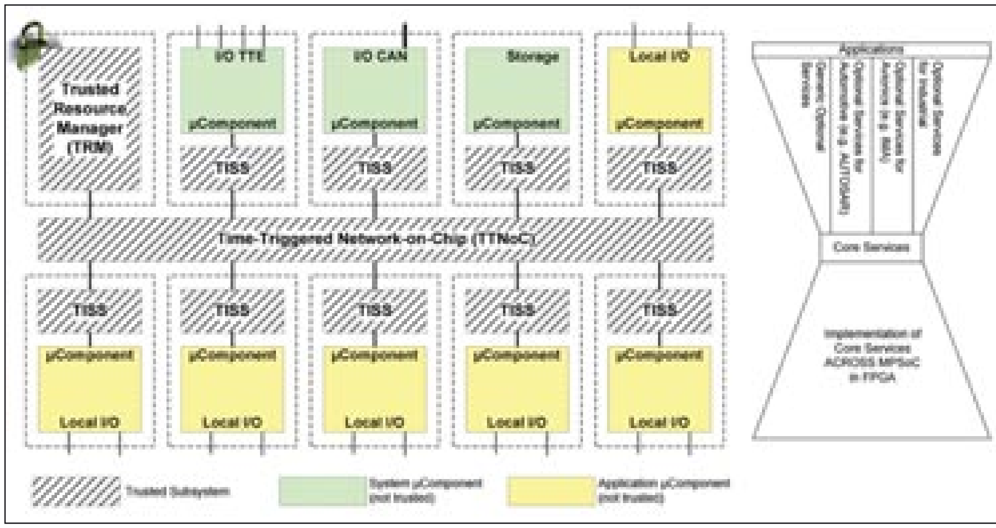
The really good news for the USAF and Army is neither has to start this task blindly. It would seem leaders from both services simply need to start an open dialogue with the Navy to see how it is done.

Jean L. Broge
Managing Editor

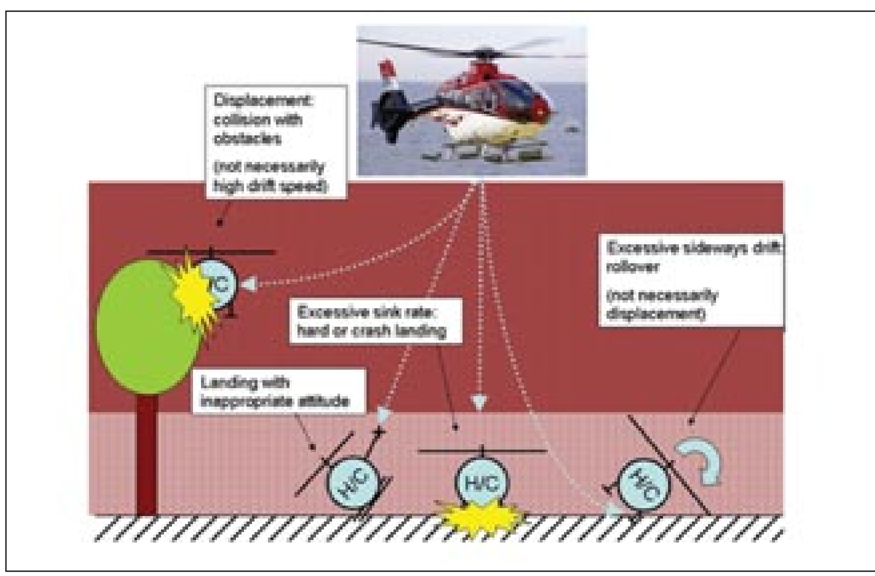
The DEVILA is in the Details of Software Integration for Safety Avionics

The decreasing relative cost of electronics and the pace of electronics development have significantly increased the need to adopt modern commercial off-the-shelf (COTS) computing architectures in avionics.

Increasing demand for energy efficiency and performance has led to the adoption of multicore processors, and especially multiprocessor system-on-chips (MPSoCs), in the avionics domain. The problem of leveraging COTS hardware in avionics, however, is complex. Guidelines on certification of COTS hardware originating from its high integration level confer to a certification memorandum from the European Aviation Safety Agency (EASA). Yet, MPSoCs potentially also introduce additional problems related to isolation of functionally disjoint functions.



ACROSS architecture with its time-triggered network on chip (TTNoC), left; ACROSS provides a waist line architecture with core services building the foundation, right.



Example of hazards at helicopter final approach, showing the different hazards that the system intends to help prevent by providing sensor-based information to the pilot.

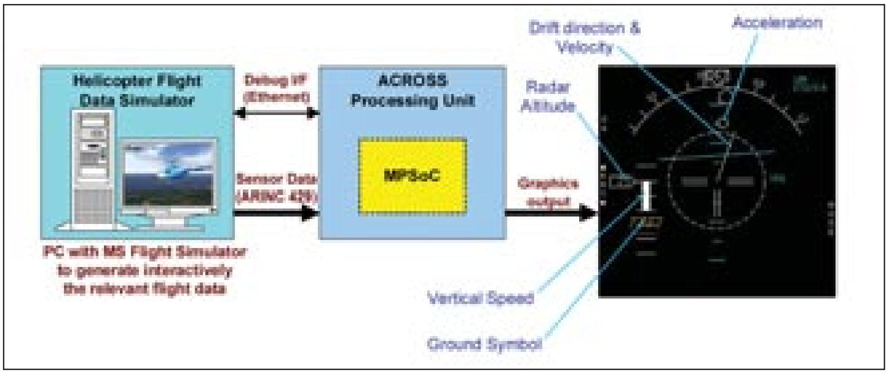
In the past, increased integration led to centralized avionics systems called integrated modular avionics (IMA). Advantages include lower purchasing cost, lower size and weight, reduced power needs, and lower maintenance costs.

In contrast to pre-IMA systems, IMA integrates functions of different criticality on the same set of resources. To keep safety aspects simple and thus feasible, unrelated functions should be segregated from each other and ideally run in separated environments. These concepts of time and space partitioning are defined, for example, in ARINC 653.

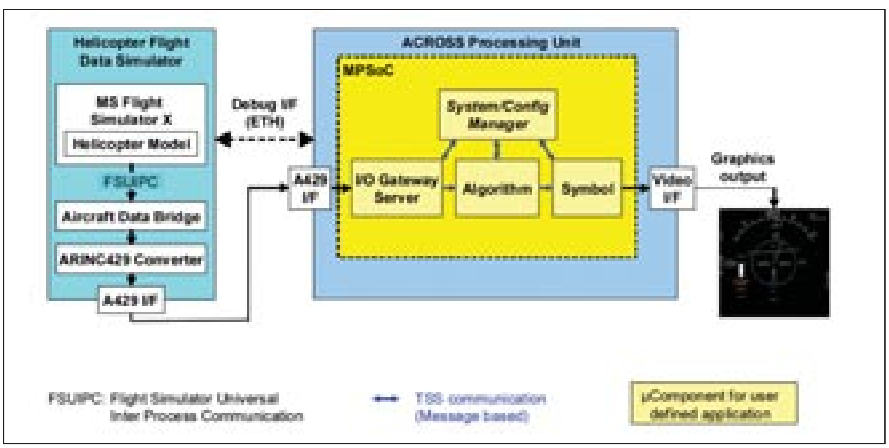
The partitioning concept comprises spatial and temporal separation. Spatial separation ensures that partitions are not able to access other partitions' memory spaces, whereas temporal separation guarantees that partitions do not influence each other's timing behavior. In general, partitioning ensures that applications have the same behavior on IMA systems as in separated platforms. Multicore processors introduce some challenges regarding temporal isolation, originating from physically shared resources such as network on chip (NoC), shared caches, and memory controllers.

According to the EASA, most existing MPSoCs are classified as "highly complex micro controllers." Most of the existing MPSoCs were not designed with a special focus on certification and fall into this category.

Engineers from EADS addressed multicore solutions in aerospace applications to evaluate a TTNoC (time-triggered NoC) solution in the context of a helicopter landing aid application. The main goal was to create a sample mapping to a prototype, integrating and leveraging fault tolerance approaches as well as domain-specific standards. This work was performed as part of a public research project called ACROSS (ARTEMIS Cross-Domain Architecture).



A Microsoft flight simulator provides realistic sensor data over an ARINC 429 communication interface. A display presents the resulting information computed in the MPSoC on a screen. This schematic also depicts the symbols presented to the pilot (vertical speed, drift direction, and velocity and acceleration).



Details on the ACROSS MPSoC in the demonstrator system context. For simplicity, µComponents for core system functions are not shown.

The referenced helicopter landing aid system is an implementation of a degraded vision landing aid (DEVILA), a system designed to support helicopter pilots when landing in a desert environment with limited visibility. Visibility is limited since the air downstream from the rotor causes sandstorm conditions, which are also known as "brownout."

To give the pilot an aid for orientation, a set of symbols is shown in the head-up display, which provides information such as a horizontal line or altitude. This increase of safety is especially needed when starting or landing the aircraft. In those critical phases, many accidents take place that can be avoided by providing the pilot a synthetic-vision aid based on information collected from the inertial navigation system and radar altimeter system.

The main goals of the research were to learn about the ACROSS MPSoC abilities, particularly in respect to the following:

- Meeting hard, real-time schedules (determinism)
- Integrating fault tolerance (different cores and partitions)
- Integrating different applications with different criticalities (IMA)
- Integration of domain-specific standards (e.g., ARINC)

A helicopter flight-data simulator was implemented using a COTS PC. The data from the various aircraft sensors were generated by a helicopter model inside the flight simulator. An aircraft data bridge extracted the information from the flight simulator via universal inter-process communication. It emulated the timing behavior of a real helicopter by assigning each parameter of the aircraft sensor data a specific timing behavior (i.e., a delay and an update rate). It then started encoding the information to ARINC 429 data format. The ARINC 429 converter realized the data transfer of the encoded data to the ACROSS processing unit. It thereby relied on an ARINC 429 interface card.

The landing aid system was implemented on MPSoC inside the ACROSS processing unit. The landing aid system's main functionality was split over four micro components (µComponents) of the MPSoC. The first µComponent (I/O gateway server) was responsible for filtering and forwarding input data from aircraft sensors. The second µComponent (algorithm) processed the received input data. The third µComponent (symbol) generated the synthetic vision for the pilot. And the fourth µComponent contained the system and the configuration management. It is responsible for health monitoring, system start-up handling, and compatibility checking.

Testing showed that the ACROSS MPSoC helped fulfill essential requirements needed in the aerospace environment. In particular, the segregation properties needed for integrating different criticality applications and a clear design structure helped in proving the design correctness of integrating applications.

Implementation of functional blocks of the MPSoC is relatively simple and provides a good basis for hardware assurance needed in aerospace. The current implementation on an FPGA has been proven sufficiently fast for the presented application. For more integrated approaches, however, more performance using higher-grade FPGAs and different cores may be needed. Additionally, a chip solution (or chip-like solution) would likely be needed for use in harsh aerospace environments with high single event effect rates.

This article is based on SAE International technical paper 2012-01-2117 by Michael Paulitsch, EADS Innovation Works; and Dietmar Geiger, Bernd Koppenhoefer, and Peter Ganal, EADS Cassidian.

Rolls-Royce says the T56 military turboprop (shown) and its 501D commercial version have been in production since 1954 and are expected to be in operation beyond 2020. They have accumulated more than 200 million flight hours. *Courtesy Rolls-Royce*

Camelina-Based Biofuel Shows Advantages in Turboprop

Researchers within the government of Canada see the need to improve the emissions performance of the Rolls-Royce T56 engine, which despite its age, remains a workhorse for its military aircraft fleet.

In the United States, more than 200 billion gallons of liquid fuel is produced each year in a ratio of about 7:2:1 for gasoline, diesel, and jet fuel, respectively. With international air traffic expected to increase in the long term, the cost of aviation fuel will continue to rise unless current production can be increased.

To address the global fuel challenges and economic sustainability, the International Air Transport Association (IATA) in June 2009 committed the airline industry to achieving a continuous improvement in fuel efficiency of 1.5% per year from 2009 to 2020, reaching carbon-neutral growth by 2020, and achieving a 50% absolute reduction in carbon emissions by 2050.

Aircraft engine design typically lasts several decades. Before all existing engines can be replaced by next-generation, fuel-efficient engines, the adoption of alternative fuels will be an important component in achieving IATA goals. Currently, one alternative is synthetic jet fuel, such as Fischer-Tropsch (FT) fuel. Typically, a feedstock such as natural gas, coal, or even biomass is partially oxidized in the presence of steam, oxygen, and a catalyst to produce synthesis gas (CO and H2). Then the FT reaction converts the synthesis gas into paraffinic hydrocarbons. The products then undergo cracking, fractionation, and isomerization to produce fuel with the desired physical properties.

Camelina Power

Another alternative is the hydroprocessed esters and fatty acid biojet fuel. A promising candidate feedstock for that type of fuel is camelina seed. Camelina is a member of the mustard family and a distant relative of canola. This non-food

Test setup at the Royal Canadian Air Force's 8 Wing Trenton, Ontario Air Base.

Exhaust sampling probe at the exhaust tailpipe.

crop is often grown as a rotational crop with wheat and other cereals when the land would normally be left fallow. The hydro-processing procedure for camelina seed oil involves conventional catalytic petroleum refining processes, such as hydro-treating, hydro-cracking, and hydro-isomerization processes. These processes typically produce normal paraffins and iso-paraffins.

Unlike the first-generation fatty acid methyl ester biodiesel used in the automotive industry, the second-generation hydro-processed jet fuel has physical properties closer to conventional jet fuel and is more suitable at high altitudes. A previous study on a turbojet engine operated on a 50% camelina-based hydro-processed esters fatty acid (C-HEFA) biojet fuel (C-HEFA) blended with conventional jet fuel showed that there were no significant differences in engine performance at a simulated atmospheric environment condition up to 37,000 feet. Similar to the FT fuel, hydro-processed biojet fuel typically contains a negligible amount of aromatic hydrocarbons.

The lack of aromatic hydrocarbons in hydro-processed renewable jet fuel creates challenges. Typically, the aromatic compounds that are present in traditional jet fuels diffuse into the nitrile rubber O-ring, causing the O-ring to swell and provide the necessary seal in the fuel system. Continued operation on the neat hydro-processed jet fuel leads to leaks in the aircraft fuel systems. For engine performance and safety reasons, alternative fuels are certified for usage only when blended with conventional jet fuel up to 50% by volume to ensure that a minimum of about 8% aromatic content is present in the blended fuel.

To date, many studies have been conducted regarding the engine performance and emissions characteristics of turbine engines running on synthetic aviation jet fuels, including the gas-to-liquid and coal-to-liquid FT fuels. But the effects of hydro-processed renewable jet fuel were not readily available from literature.

As a joint effort among several departments of the government of Canada, a study was conducted of the impacts of a renewable C-HEFA blend on the engine performance and emissions characteristics of a T56 turboprop engine. This engine from Rolls-Royce is of interest because it powers the legacy Lockheed Martin CC 130H Hercules military aircraft. A newer model, called the AC-130J, is powered by new engines and has started service in the Royal Canadian Air Force. But the CC 130H Hercules aircraft is still used extensively for transport and search-and-rescue missions due to its reliability and heavy lifting capacity, and it was determined that additional study on the impact of a C-HEFA blend on the T56 engine would be useful.

Test Setup

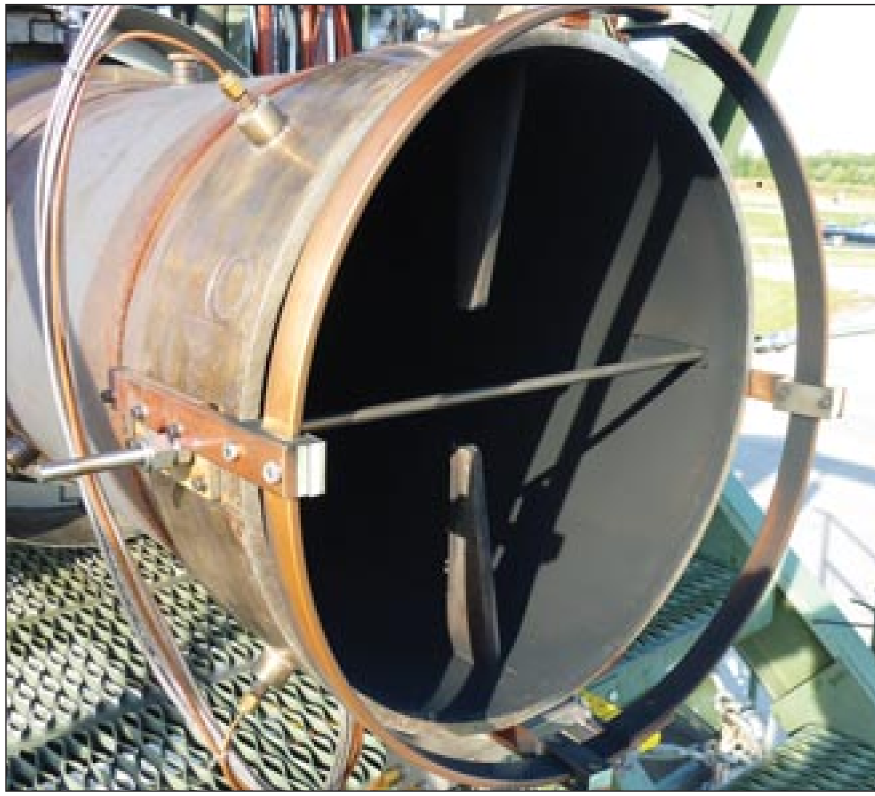
The test engine was a T56-A-15 turboprop engine that originally was installed on a CC-130H Hercules. It had been in service for 6123.4 hours since being overhauled, and 32,920.2 hours since new. For this testing, the engine was installed on an outdoor stand used for certifying T56 engines. The test stand is located at the 8 Wing Trenton, Ontario Air Base, Royal Canadian Air Force (RCAF). This test facility was used specifically to pass off T56 engines for the RCAF.

The two fuels that were tested were F-34 and the 50/50 F-34 and C-HEFA (F-34 is the NATO-equivalent version of JP 8 aviation jet fuel used in the U.S.). F-34 is the military equivalent version of Jet A-1 fuel with the additional military additives package, including the fuel system icing inhibitor, corrosion inhibitor/lubricity enhancer, and a static dissipater additive.

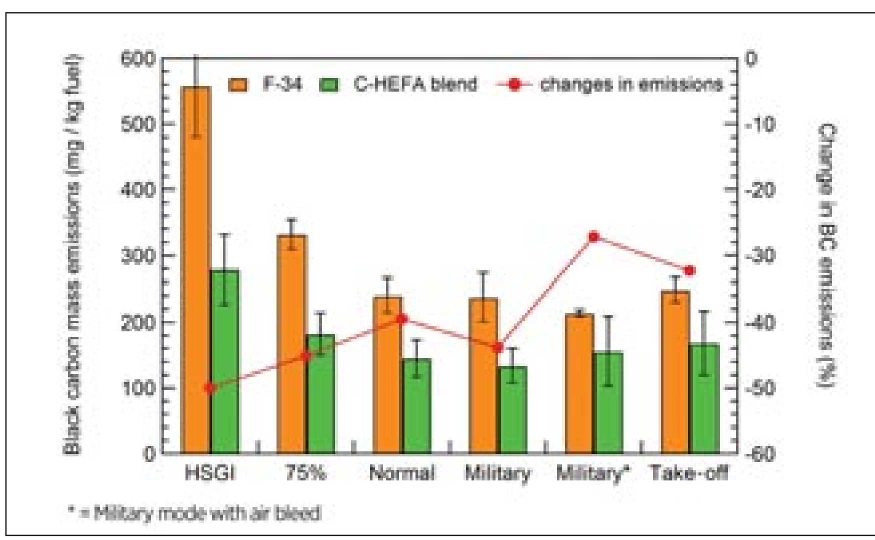
All emissions measurements were conducted during steady-state operations. The engine was first set at low-speed ground idle until the fuel and oil temperatures were completely warmed up before going through a series of steady-state conditions. At each steady state, the engine was maintained at the target engine speed for at least 4-5 minutes, allowing engine parameters to be stabilized. The engine then remained at each condition for at least 3-5 additional minutes for different measurements to be conducted. A complete test cycle included one idle mode called high-speed ground idle (HSGI) and five different non-idle engine modes (75%, Normal, Military, Military Mode With Air Bleed, and Take-off). These engine modes were characterized based on the turbine inlet temperature, engine speed, and power.

Emissions measurements were first made before the engine durability tests to establish a baseline reference. After that, the engine was subjected to a 20-hour durability test operated on the C-HEFA blend. This accelerated-aging durability test included a large number of test cycles with the objective of assessing engine degradation caused by operation on the C-HEFA blend. After the engine durability tests, emissions measurements were conducted again at the same engine modes.

Comparing the emissions results before and after the engine durability tests



Testing showed that the C-HEFA blend generated far fewer particles in all engine modes. There also was a general increase in mean particle diameter with increasing engine speed.



Black carbon mass emissions and change in emissions at various engine modes.

provided a realistic assessment of the gaseous and particle emissions over extensive operation of the engine. Comparing the emissions results between the pre- and post-engine durability tests showed some small differences. However, in all cases the trends were consistent.

For emissions measurements, the standard tailpipe was replaced by a straight tailpipe with the same cross-sectional area as the original standard tailpipe. Switching between the two tailpipes showed no significant difference on the engine performance, but the straight tailpipe provided a better condition for exhaust sampling. Exhaust samples were extracted using a multi-hole sampling probe that extended across the tailpipe with the aim of obtaining a representative average emissions sample.

Conclusions

Use of the C-HEFA blend showed significantly lower particle number and black carbon (BC) mass emissions. The majority of the emitted particles were in the range of 51 to 60 nm, with larger diameters at increased engine power. Particles emitted from the use of the C-HEFA blend were typically 2-4 nm smaller in diameter than the particles from conventional jet fuel. At HSGI, particle number emissions from the C-HEFA blend were 30% lower than from the conventional jet fuel. The smallest reduction in particle number by the C-HEFA blend was observed to be 16%. When using the C-HEFA blend, BC mass emissions at HSGI and takeoff were lower by 50% and 32%, respectively.

Additional measurements were also conducted and it was observed that a significant number of the emitted particles could be charged. Although the particle diameter cannot be accurately estimated in this case, results indicated that up to half of the emitted particles could potentially be charged. The use of the C-HEFA blend reduced the charged number particle emissions by the same extent.

Emissions data showed that the gaseous emissions from the conventional jet fuel and the C-HEFA blend were generally similar. Slightly lower CO_2 emissions from the C-HEFA blend were observed due to the lower carbon content in the fuel. CO emissions from the C-HEFA blend were also lower, but not by a significant amount. NOx and THC emissions from the two fuels were very similar.

This article is based on SAE technical paper 2013-01-2131 by Tak W. Chan and Vinh Pham of Environment Canada; Jennifer Chalmers, Craig Davison, and Wajid Chishty of the National Research Council Canada; and Pierre Poitras of National Defence Canada.

High Hopes or Just Dreaming?

A look at how Asia's aircraft manufacturers are trying to break into new markets to challenge the status quo.

By Richard Gardner, European Editor

So far only models and mock-up sections of the Comac C919 have emerged, but the program is fully backed by the Chinese government and has Western partners providing essential systems and the engines. (Richard Gardner)

For the past decade, the fastest growing aerospace sales have been in Asia, which has done much to boost Western aircraft makers at a difficult time in their own markets. This situation has led regional nations to look on enviously at the multi-billion-dollar rewards that can flow from successful advanced aircraft programs, and they have concluded that they should have more of this business for themselves.

The new Asian powerhouse at present is China, but South Korea and Japan are also anxious to expand their aerospace exports. The real challenge is how to get to a stage of manufacturing maturity that can attract market credibility.

Today's customers already have plenty of product choice and they know the suppliers they can rely on. By definition, any newcomer in this global market has little or no such history, and by the time an all-new program has been given an artificial momentum (aspirational rather than demand-led), probably aided by government subsidy, the competing Western suppliers have already moved on to improve their own offerings.

This is what faces the Asian aerospace start-ups, and both India and China are now showing evidence of over-heating their economies in the rush to hi-tech industrialization. As the Western economies falter, the market for new Asian products is also under increasing pressure, so there are no free rides on the journey toward transforming from a wannabe aerospace player to a serious global competitor.

China's Long March

Until comparatively recently, the People's Republic of China had no real domestic aerospace industry that was capable of developing and bringing forward indigenous aircraft designs and systems that were anywhere near Western products in quality, reliability, or performance.

Military programs were always shrouded in secrecy, but Chinese output was of little serious concern to Western military analysts who kept a close watch from spy satellites, and other means, on what was under test or entering military service. In broad terms, everything seemed years behind Western equivalent programs and relied very much on "cloning" existing Russian designs via reverse engineering.

When they did this to the highly capable Sukhoi Su-33 fighter, and put it into production (without any license-fee complications) to create the J-15, the Russians were not too happy. Even now, China is still largely dependent on Russia exporting supersonic aero-engines to power its home-grown military aircraft.

Engines currently remain a weak link in Chinese aspirations for a comprehensive aerospace self-sufficiency, but things are moving ahead rapidly. The country has invested enormously in educating new aerospace engineers as well as seeking as much knowledge as possible on modern Western engines and new technologies. This has enabled a great deal of hi-tech catch-up with the West over the last decade, and the capability gap is closing.

Western nations have shown little reluctance to sign up cooperative partnerships with Chinese companies to compete in this expanding market. This has

AVIC is basing its initial civil aircraft products closely on Western and Russian designs, as can be seen from these models of the proposed MA600 and MA700 regionals, which look very similar to the Franco-Italian ATR family. (Richard Gardner) brought a huge expansion in manufacturing capacity, and technical know-how, and new joint venture projects have been established by most of the big Western aerospace suppliers.

At first this covered components, but has gradually grown to include sub-assemblies and complete aircraft. These range from business jets and small transport aircraft, to major sections for Boeing and Airbus, and complete A320s off a Chinese final assembly line. As this experience has been absorbed, it was inevitable that China would wish to offer its own aircraft families for the commercial sector.


Japan is pinning its aerospace export breakthrough on its Mitsubishi MRJ jetliner, but it is up against tough competition from established regional supplier, Embraer.


South Korea is now making headway with its T-50 Golden Hawk, which comes in two versions for advanced training or as a light attack fighter. (Richard Gardner)


Helicopters, such as the new AC313, are part of China's aerospace expansion plan that builds on today's JV partnership experience with such Western companies as Eurocopter. (Richard Gardner)

Not content with local assembly of the A320 line, China has funded its main civil aerospace manufacturer, Commercial Aircraft Corporation of China (Comac), to launch its own similar size 150-180 seat twin jet, the C919, which is to be powered by the latest CFM Leap 1-C turbofans. This program aims to present a new-generation 737/A320 replacement design using fuel-efficient engines, modern cockpit and fly-by-wire controls, and the latest metal and composite airframe materials.

The C919 already has domestic orders for an impressive 380 aircraft, which might otherwise have been placed with Boeing and Airbus, but these market leaders see this as aimed mostly at meeting Chinese needs while having limited export potential.

Others, including some Western low-cost airlines who might well appreciate a third supplier option, are more positive about China's aviation plans for the future and are adopting a wait-and-see attitude before committing to firm orders. It remains to be seen whether the optimism is well founded, but Comac, with almost unlimited state financial support, has announced that it fully intends to build a whole family of airliners, including widebody 250-350 seat aircraft, to compete with Boeing and Airbus.

For the time being, China realizes that to stand a chance of giving its new products a wider customer appeal, it must use key systems and components from established Western suppliers, so international partnerships are essential.

Comac has signed a collaborative agreement with Bombardier to work together on both the C919 and the 130-seat Bombardier C Series. This covers flight test activities and areas of customer service including training, technical publications, and parts distribution. Comac has also signed deals with UTC Aerospace Systems for key systems on the C919 including cockpit and throttle controls and passenger door

Chinese military aircraft are also closely based on existing designs, such as this armed UAV (left), which could be mistaken for a General Atomics Reaper, or the latest two-seat advanced trainer (right), which bears a close resemblance to the Alenia M-346 and its close cousin, the Yak 130. (Richard Gardner)

systems, and there is a separate JV between UTC and China's Aviation Industry Corp. (AVIC) to develop and manufacture the aircraft's electrical power supply system. Comac has scaled back the composites content in the C919 to reduce program risk, but has a target of 16 JVs covering most areas of the structure and systems.

When Airbus made the decision in the 1990s to set up a Chinese-located A320 final assembly line, it answered its critics on the strategic implications of this by pointing out that its own advanced R&D efforts would continue toward a visionary path beyond whatever China might do based on A320 era technology. This is happening now with the emergence of the C919, while both Airbus and Boeing continue to develop even more advanced generations of their two most popular 150-seat products, as well as investing in more radical solutions for a 2030s in-service timescale.

As the sales backlog of thousands of Boeing and Airbus 150-seat airliners grows, the C919 may find a market niche among those airlines that do not want to wait for up to five years, or longer, to get their hands on new aircraft deliveries. Though the development timescale has slipped several times, the target for entry into service for the C919 is now late 2016.

In the meantime, China's technologically modest 100-seat Comac ARJ21 regional jet (an MD-95/B717 clone), which first flew in 2008, has still not achieved certification, let alone service entry. A shortage of engineers has been given as the reason why this program has taken so long, and the FAA has been helping in safety certification.

A similarly "cloned" ATR look-alike turboprop regional airliner is also being developed for China's growing internal airline network. So far, there appears to be little external customer interest, but while China establishes a more credible family of civil aerospace products, and increases its marketing efforts, it does not yet have global spares and engineering support with the critical mass to make an impact on major airlines.

China continues to reveal development examples of advanced military jet fighters, with visual stealth characteristics, but it is not known if the complex coatings and angular aerodynamics offer comparable degrees of radar reduction to that on such types as the F-35 and F-22. While China's latest military jets are looking more modern with features taken from current Western and Russian designs, the large-scale operational use of such aircraft appears to be well into the future.

Of more concern to Western analysts are large numbers of current-generation jets, such as the J-10 and J-15, armed with long-range stand-off missiles, which pose a potential threat to economic infrastructure and military targets in the region, including aircraft-carriers. China is negotiating with Russia on the supply of the latest Sukhoi Su-35 fighters, but the manufacturer is concerned that only a few may be bought and then cloned once again.

China's aerospace activities extend into space launchers and satellites and also helicopters, where it is involved in a growing number of joint ventures with major Western manufacturers, including Eurocopter.

Rising Sun's Rising Star

Japan's status as the leading Asian economic driver may have been overshadowed in recent times by China, but it has been the major regional aerospace manufacturer for decades, producing license-built U.S. aircraft, but also contributing major structural components in partnership with others on global programs. It has also produced its own military aircraft designs for the Japanese Forces, though the country's post-1945 constitutional laws prevent the export of military equipment, other than for use in humanitarian tasks.

Following the recent election of a more nationalist-inclined government in Japan, it is thought likely that policy may change, allowing the country's aerospace industry to become more competitive across a broader range of aviation products, military as well as civil. However, for the moment, the main national focus for aerospace expansion is arriving in the shape of the Mitsubishi MRJ, a regional jetliner offering 70-90 seats, with the possibility

China and Pakistan have cooperated on the FC-1 fighter, and a new trainer version is being introduced for export. (Richard Gardner)

of a 100-seat version following. This is the country's first medium-size civil program since the YS-11 turboprop airliner of the 1960s.

Mitsubishi has long been an important manufacturing partner on Boeing commercial airplanes, which has grown over the years from producing around 15% of the structure on the 767 to nearly 30% on the 787. The company's experience in producing large structural components from composite materials led it toward making its own regional jet design a largely composite aircraft. This, it was claimed, together with the use of the Pratt & Whitney PW1200G geared turbo fan (GTF) and advanced aerodynamics, would give customers the lightest and most efficient regional jet in the market.

That was back in 2007, and six years on the program has lost much momentum with several major changes in design and specification. Out are the all-composite fuselage and wings, to be replaced by an aluminum structure with composite fairings, spoilers, control surfaces, and tail units. The composite contribution is now down to around 12% of the total aircraft weight.

As Mitsubishi is the launch customer for the new GTF engine, it cannot avoid having to bear the introductory challenges of integrating an all-new engine on an all-new airframe. It undoubtedly underestimated the scale of the challenge, as the first flight was scheduled for 2011, but is now expected to take place before the end of 2013.

Many expect a further slippage, but launch customer All Nippon Airways is due to receive its first aircraft in 2015, so the flight test schedule, involving five flying aircraft and two ground test specimens, will have to go very smoothly to keep to the twice revised target certification date.

Other Regional Programs

South Korea has built up a large aircraft manufacturing capability for military aircraft. KAI has produced many U.S. fighters under license over the years, and with the help of Lockheed Martin, has developed a new supersonic trainer/light strike aircraft, the T/A-50 Golden Hawk. It is now being exported in Asia and also offered in competition with other advanced jet trainers for global orders, including a possible T-38 replacement program in the US. South Korea also offers a light trainer, the KT-1, for initial flying training.

Indonesia was expanding its aerospace manufacturing capabilities throughout the 1990s, but its ambitious dream of designing and building a series of indigenous regional transport aircraft came crashing to Earth when state supplier IPTN failed in the face of rapidly rising development costs and the collapse of the sponsoring government.

Today, the long-standing cooperative partnership with Spain's former CASA group, now part of Airbus Military, has been partly revived to restart joint production of small transports, including the CN-235. These will be used for internal transport in Indonesia, but will also be marketed for export to regional customers.

India, as a subcontinent beyond the scope of this feature, nevertheless has its fortunes closely liked to wider Asian developments. It has a very active aerospace industry and is producing indigenous military aircraft ranging from helicopters and transports to advanced fighters, built and assembled by Hindustan Aeronautics.

Fear of an expanding China and a hostile Pakistan on its borders motivates high defense spending in India supported by a very capable domestic R&D organization. Future expansion into civil programs is supported by government, with design work starting on an Indian 150-seat jetliner, though it is widely believed that if this progresses into eventual production it will struggle to compete in export markets.