Forum 72: Expecting Emerging Technologies

By Frank Colucci

Sikorsky's booth highlighted the Forum 72 theme of "Leveraging Emerging Technologies for Future Capabilities," as well as a mockup of the S-97 Raider and a cockpit simulator. (AHS photo by Chris Salata)

The 72nd Annual AHS International Forum & Technology Display — with its theme of "Leveraging Emerging Technologies for Future Capabilities" — was held this May in West Palm Beach, Florida. The event showcased technologies under development to maximize the performance, payoff and potential of vertical lift.

About 20 miles from the AHS Forum 72 venue, visitors to the Sikorsky Development Flight Center (DFC) glimpsed the current state of the art of rotorcraft technology and the possible shape of Future Vertical Lift (FVL). The DFC typically has 15 helicopters in test at a time, and the flight line and hangar hosted fly-by-wire CH-53K King Stallion and CH-148 Cyclone helicopters in test for the US Marine Corps and Royal Canadian Air Force, respectively. Returning from an acceptance test flight to the nearby Florida Assembly and Flight Operations (FAFO) center was a digitized S-70i Black Hawk for an international military customer. On the FAFO ramp sat the S-92 test aircraft used to develop hands-off oil rig approaches and other commercial advances. Inside the Sikorsky Innovations hangar were two industry-funded S-97 Raider coaxial rigid rotor compound helicopters built to sell the high-speed, agile-handing X2 technologies. Out of sight, the rapid prototyping team preparing the first Raider for its next flight was also assembling the bigger SB>1 Defiant Joint Multi-Role Technology Demonstrator (JMR TD) for the US Army. Though still a tenant on a United Technologies reservation, Sikorsky is now a Lockheed Martin company, and Florida telemetry rooms, propulsion system testbeds and other facilities showed Forum visitors the tip of a research, development, test and engineering iceberg; Sikorsky Vice President of Engineering & Technology

More than 100 Forum participants toured Sikorsky's Development Flight Center. The author is in the front row, second from the right — with his reporter's notebook. (Sikorsky photo)

The AHS Annual Forum is the world's largest gathering of vertical flight engineers, scientists, and leaders from industry, academia, and government organizations. (AHS photo by Chris Salata)

Mark Miller told a Forum audience, "From a selfish prospective, we gain access to a lot of technologies across the [Lockheed Martin] business units that are very important to us in the helicopter industry."

The pre-Forum tour set the tone for three days of AHS technical papers, special sessions and committee meetings attended by nearly 1,100 registrants. Unfortunately, the only actual helicopter at the Palm Beach County Convention Center was the third prototype, AW169, which dropped in during lunch while conducting local customer demonstration flights by the rebranded Leonardo Helicopters. The 10,000 lb (4.6 t) AW169 is at the light end of the company's helicopter family, which includes the stalwart 14,000 lb (6.4 t) AW139 and the recently-certificated 19,000 lb (8.6 t) AW189. Leonardo Helicopters Managing Director Daniele Romiti explained that the family concept, "allows us to meet the vast majority of our customers' requests with a standardized and therefore simpler, cost-effective solution. The family models share the same cockpit environment, the same architectural solution to aircraft flight management, as well as standardization in maintenance." As Leonardo injects all-weather capability, longer-duration run-dry transmissions, and other advances into helicopters, it continues development of the world's first commercial tiltrotor, the AW609. "The tiltrotor can couple range with speed," Romiti noted. "These are the elements of a new value proposition." A follow-on tiltrotor is part of Europe's Clean Sky 2 initiative, but the Leonardo chief executive added, "Any innovation we are proposing should deliver real value to the customer. . . . We are not investing in technology for the sake of playing with something more sophisticated."

Military customers are already investing in the transformational technology of FVL and mission systems to exploit Degraded Visual Environments (DVE), according to Forum keynote speaker and co-chair of the joint-service FVL executive steering group, Marine Major General H. Stacy Clardy, III. As commander of the first regimental combat team to use the MV-22 tiltrotor in Iraq, the veteran ground combat officer offered, "For vertical operations, we need to fly faster, further, higher and in wider variations of temperature and visibility against a more capable threat." He cited a supply convoy ambushed in Afghanistan and denied timely fire support by Apaches forced to break contact and refuel repeatedly to offset high density altitudes. Long distances and slow speeds cost an Army rear-area assault the element of surprise when combat power was forced to ride waves of Black Hawks and Chinooks.

"Our biggest limitation to full-spectrum operations is still our ability to operate efficiently and safely in a Degraded Visual Environment," said General Clardy. "In Iraq, we were often hampered by heavy dust storms. Insurgents used weather to attack US and coalition forces. We were limited by our inability to deploy vertical lift." The general said 20% of serious Army aviation mishaps in 2013 were due to DVE, but added, "This is not just a safety issue. It's about opportunity. We can certainly go faster and further, but the next generation of vertical lift must allow us to fight not only at night but in the weather in a contested environment and take advantage of it. We need to own it."

Just what form the next generation will take is still to be determined. Retired AHS Executive Director Rhett Flater explained in a Forum history session that what was founded in 1943 as "The American Helicopter Society" had its roots in a 1938 rotary-wing design meeting in Philadelphia and noted, "Up to then, it was believed the autogyro was the aircraft of the future. . . . After that, the helicopter was the aircraft of the future — it was more capable, more versatile."

Maj Gen Clardy, the co-chair of the FVL Executive Steering Group, told the Forum audience: "we need to fly faster, further, higher and in wider variations of temperature and visibility against a more capable threat." (AHS photo by Chris Salata)

Unusual Shapes, Scalable Sizes

All around the AHS Forum exhibit floor, models, graphics and videos showed new compound helicopter, advanced tiltrotor, and lift-fan concepts promising greater speed and range than today's helicopters. Next to a full-scale S-97 mockup, Sikorsky engineers coached guest pilots through a Raider flight simulation. Video at the Bell Helicopter booth showcased US Navy/Marine versions of the 30,000 lb (13.6 t) V-280 Valor tiltrotor being built for the Army-led JMR TD. By the time of the Forum, Bell Helicopter had mated the Valor wing and fuselage, fabricated proprotor blades, and assembled a V-280 Systems Integration Laboratory (SIL). The Sikorsky-Boeing team building a Defiant fuselage for proof testing meanwhile had its SB>1 SIL up and running. Both infantry squad-sized demonstrators are due to fly in 2017, and an FVL mission system architecture demonstration will develop processes, tools and standards for a truly Open System avionics suite. JMR/FVL Deputy Program Director Ned Chase told the Forum audience, "The bottom line is we want to know if this stuff works and if we can apply it to our next-generation aircraft."

Still a contender in the broader FVL initiative, AVX Aircraft showed the Forum a 1/10th scale wind tunnel model of its JMR-size Coaxial Compound Helicopter (CCH) and images of CCH and tiltrotor derivatives sized to bigger and smaller FVL Capability Sets. AVX is now developing control laws for a piloted simulation late this year or early next. Karem Aircraft, meanwhile, showed models of its Optimum Speed Tiltrotor (OSTR), sized for both the manned JMR TD and the unmanned VTOL X-Plane competition launched by the Defense Advanced Research Projects Agency (DARPA). In a Forum special session on transformative vertical lift, DARPA program manager Dr. Ashish Bagai explained the role of DARPA transitioning ambitious technology demonstrations to the US military and industry, stating, "You can't have transformative change unless you have transformative technologies." Karem X-Plane Program Manager Dr. Tom Berger noted that their TR36XP OSTR promised three times the speed and 18 times the range of the classic UH-1N helicopter with comparable disk loading. Karem has already built light, extra-stiff OSTR blades and will ground-test a JMR-size wing, including engine and drivetrain in 2019.

Forum 72 attendees had the opportunity to fly Sikorsky's S-97 Raider simulator. With the fly-by-wire control system, even non-rated engineers could experience the thrill of "flying." (AHS/Salata photo)

The Boeing technology display centered on the 12% Phantom Swift wind tunnel model built by the company's rapid prototyping Phantom Works for the DARPA X-Plane challenge. Though the 400 kt (740 km/h) ducted fan Unmanned Aerial Vehicle (UAV) failed to win a Phase II design contract, the effort left Boeing with a rich library of control laws, Computational Fluid Dynamics models and wind tunnel data. "It wasn't for nothing; we learned a lot," summarized Phantom Works Business Development Manager Adam Patrick. "A ducted fan is incredibly efficient. . . . Now, we have hours of tunnel testing to draw on."

In the throes of its Lockheed Martin assimilation, Sikorsky Aircraft chose not to pursue VTOL X-Plane Phase II, but the Forum panel presentation by Sikorsky Advanced Concepts Manager Mark Alber gave the AHS audience intriguing details of the Rotor-Blown Wing (RWB) designed in conjunction with the then-separate Lockheed Martin Skunk Works. The tail-sitting, twin-rotor VTOL vehicle bathes nearly 85% of its wing area in rotorwash. Without a hover downwash penalty and using elevons to supplement cyclic rotor control, the autonomous RWB avoids the historic cruise-to-hover conversion problems suffered by previous manned tail-sitters. "This is a tandem rotor helicopter with a wing instead of a fuselage," summarized Alber. "That autonomy knows how to fly that aircraft better than anyone with a joystick or control panel." The Sikorsky team wants to proceed with wind tunnel tests of the RWB concept: "We're still very interested in doing this," Alber concluded.

Winner of the VTOL X-Plane Phase II contract, Aurora Flight Sciences showed

Bell's display featured a model of their V-280 Valor for land-based FVL missions, as well as a video of their US Navy/Marine Corps concept. (AHS photo)

The AVX Aircraft booth at the AHS Forum displayed a 1/10th-scale wind tunnel model of its JMR-size Coaxial Compound Helicopter (CCH), their approach to FVL requirements. (AHS photo)

the Forum attendees a model of its LightningStrike demonstrator. Phase II will take the 12,000 lb (5.4 t) Electric Distributed Propulsion (EDP) concept through Critical Design Review, and with a Phase III go-ahead, LightningStrike is expected to fly in mid-2018. EDP let Aurora's designers put lifting power where they needed it: LightningStrike with a single AE1107 turboshaft driving three electrical generators uses no less than 24 variable-pitch ducted fans — and 74 fan, wing and canard effectors — to achieve vertical flight with a 40% useful load fraction and speeds greater than 300 kt (550 km/h). "We're designing and manufacturing concurrently," said LightningStrike program manager Carl Schaefer. "We re-use what we can and design-in what we must." A battery-powered 20% scale model flew in March to validate the CFD analysis, control laws and single-string avionics of the full-sized demonstrator. "This was not a stunt," noted Schaefer. "This is a real test asset."

Aeronautical engineer Alex Stoll from Joby Aviation provided an update on his company's work with variable-speed propeller EDP and explained, "You can have aircraft designs that were never possible, never practical before." He added, "The catch is . . . the batteries are extremely heavy compared to gas." Batteries account for 35% of the weight of the company's conceptual S4 four-seat vertical takeoff general aviation aircraft. Today's lithium ion battery technology may nevertheless be good enough to take the Leading Edge Asynchronous Propellers Technology (LEAPTech) design 150-200 nm (275-370 km) using 18 electric-motor fans on its wing. The SCEPTOR (Scalable Convergent Electric Propulsion Technology Operations Research) program will flight test an EDP wing, motors and propellers on a modified Tecnam P2006T general aviation aircraft within a year.

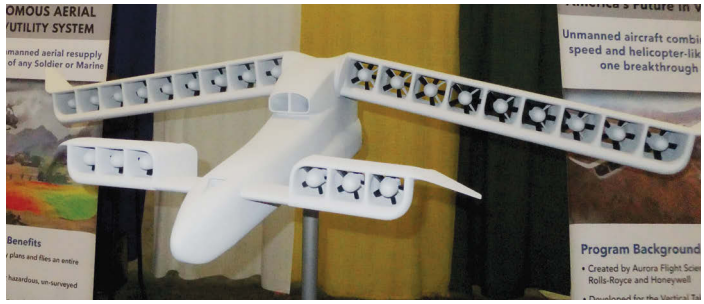
Piasecki Aircraft is, meanwhile, designing an optionally-manned Aerial Reconfigurable Embedded System (ARES) with Lockheed Martin for DARPA. The modular, autonomous transporter will use ducted fans and tilting wings to carry a range of loads up to 4,000 lb (1.8 t). "We didn't feel a mission-specific design was going to have a lot of possibilities," explained company President and CEO John Piasecki. Piasecki completed structural proof testing of the ARES last year and expects to complete an integrated propulsion testbed this summer.

Layne Merritt, chief engineer at the Army Aviation Development Directorate in Huntsville told the AHS audience of the international S&T managers' panel, "The capabilities that are being asked for by our users are beyond a single technology." The US Office of Naval Research, NASA, France's ONERA, and Germany's DLR all have rotorcraft modeling and simulation programs to help define next-generation aircraft. Bryan Finlay, principal engineer for rotorcraft analysis and engineering at the UK Defense Science and Technology Laboratory listed UK Ministry of Defense rotorcraft priorities topped by platform protection and DVE mitigation, and stretching through systems availability and cyber vulnerabilities. With no immediate plans for brand-new platforms, Dstl is pursuing systems enhancements in DVE sensors and cueing, integrated survivability equipment, and understanding aging helicopters. UK requirements for a next-generation medium-lift rotorcraft will probably seek a common Army/Navy solution, and Finlay noted, "If you want a new aircraft in 2035, 2015 was the time to start."

AHS Nikolsky Lecturer Tom Wood, chief technologist for Bell Helicopter Textron, gave the Forum historical insight into a half century of rotorcraft development and test, including application of active flow control test flown on the XV-15 tiltrotor, and extensive use of CFD to reduce drag and improve directional stability of its AW609 descendant. Wood observed, "Sometimes you think you know what the answer is, but you really don't know what the answer is. The only way to resolve that is go to flight." He concluded, "There are many new configurations being postulated. . . . Every new configuration will always provide new challenges for both test and analysis."

Mark Moore of NASA — and leaders from DARPA, Joby Aviation, Zee.Aero, Aurora Flight Sciences, Boeing, Karem Aircraft Sikorsky and Piasecki Aircraft — talked about the transformative potential of electric-powered and innovative approaches to vertical flight, with several companies currently building demonstrators. (AHS photo)

Reprising the role that Boeing's Phantom Swift small-scale demonstrator played last year, the actual wind tunnel model of this concept for DARPA's VTOL X-Plane was on display this year. (AHS photo by Chris Salata)



Aurora's hybrid-electric LightningStrike UAV was chosen for DARPA's VTOL X-Plane Phase II development. The Electric Distributed Propulsion concept uses a turboshaft engine to drive a generator to power 24 variable pitch electric fans. (Photo by the author)

Leaders in Change

The Forum's annual "Straight Talk from the Talk" industry panel enabled leaders from the major helicopter manufacturers to address both technology and trends in vertical flight. Airbus chief technical officer Jean-Brice Dumont noted, "New sensor technologies are improving the way we fly in the Degraded Visual Environment. . . . We see a combination of technologies that enhance safety and operational capability." Airbus was nevertheless stung by the loss of lives in an EC225 mishap off Norway, and Dumont acknowledged, "We realized by the accident we had at the end of April that the aircraft that we manufactured in our facility was born, was delivered to the customer, and then we know basically nothing about this aircraft [afterwards] . . . . With current technology, we could know a lot about all our friends' fleets in real-time. At least we could know what's happening with our aircraft, how they live, how they grow. That's paramount for us to improve our future aircraft."

Sikorsky Vice President Mark Miller noted that the S-92 has just passed one million fleet flight hours, and each of the 275 aircraft provides terabytes of data from its Integrated Mechanical Diagnostic

System/Health and Usage Monitoring System. Usage data is the cornerstone of Performance Based Logistics and has been used to calculate and extend component lives and to refine control laws. "If you think of the data and what it can do to bring higher degrees of reliability, safety and availability to the product, it's a very compelling area to be investing in," Miller said. Sikorsky has downlinked IMDS/HUMS data to ground stations via satellite (though the company would discuss neither the technology nor the business case for such in-flight reporting).

Dr. Cathy Kilmain from Bell Helicopter told the AHS audience the third Bell 525 fly-by-wire commercial helicopter is in flight test and discussed the payoff of Dassault Systèmes CATIA V6 design software for the clean-sheet helicopter. She said, "We have yielded on the back end a lot of benefits in manufacturing and cycle time. The digital thread between design and tooling to manufacturing has been realized on 525. We got a lot smarter on how to do that on the V-280." Bell deliberately mixes teams of new and experienced engineers on development programs to cultivate engineering talent. "My goal when I challenge my team is to open the aperture a little bit more. When you think about rotorcraft and vertical lift, think about missions. Think about what you want to do with that platform, and try very hard not to lock it into your current paradigms."

A follow-up discussion of engineering talent and the value of Science, Technology, Engineering and Mathematics (STEM) education led Kilmain to observe, "I think we have to do a better job explaining how exciting it is to be in rotorcraft. I think we are our own worst enemies in terms of public relations. It's exciting to be in rotorcraft. Everything we're doing here is exciting, and we need to get that message out."

Aerospace engineering in an industry known for lower salaries and frequent layoffs is still at a competitive disadvantage when competing for STEM talent. Mark Miller from Sikorsky offered, "This isn't a stodgy tin-bending thing. This is an exciting industry with lots of new products. . . . I think we can do a better job of advertising that and attracting new people."

Soldiers, Sailors and Marines

Old concepts of AirLand Battle have morphed into Unified Land Operations with joint-service players in a non-linear battlespace sharing common platforms and contributing unique capabilities. An FVL materiel development decision is expected the first quarter of 2017 and will launch an analysis of alternatives stretching through Fiscal 2017 and 2018. "It's going to be a family of systems, but we're not going to buy the family

James Drew, then at Flightglobal, moderated the panel of executives from the five major western helicopter manufacturers. (AHS photo)

Tom Wood of Bell Helicopter presented the 36th Annual Nikolsky Honorary Lecture, entitled "50 Years of Industry Perspective." (AHS photo by Chris Salata)

of systems all at once," explained Ross Guckert, US Army Acting Deputy Program Executive Officer (PEO) for Aviation.

The most immediate potential application of JMR Science and Technology will be the FVL medium-sized aircraft to replace today's Black Hawk helicopter. The UH-60, like all the current Department of Defense rotorcraft, nevertheless still has life and margin to grow, and Forum program managers' briefings provided insights into ongoing improvements in the current fleet.

Steven Kelley, utility helicopter technical division management chief, explained Army plans for modernized Black Hawks in just four configurations: UH/HH-60Ms and still-to-be digitized UH/HH-60Vs. Central to keeping the fleet viable with today's requirement for 6,000 ft/95°F (1,800 m/35°C) density altitudes is the Improved Turbine Engine Program (ITEP). Both General Electric and the ATEC partnership of Honeywell and Pratt & Whitney touted the advantages of their ITEP contenders on the Forum exhibit floor. The Army has yet to justify a new Black Hawk transmission, but it plans DVE and other avionics improvements sharing standards and tools of the Future Airborne Common Environment (FACE). "FACE is critical to our office and how we do our integration, something that's critical to maintain our capability and our aircraft," Kelley noted.

While the Sikorsky Black Hawk awaits incremental improvements, the Boeing CH-47F is approaching a decision on Block II Engineering and Manufacturing Development next spring. The next remanufacturing program for the Chinook will incorporate Advance Chinook Rotor Blades, lighter single-cell fuel sponsons, and dynamic and electrical improvements that will up gross weight to 54,000 lb (24.5 t), maximize commonality with the Special Operations MH-47G, and probably stretch the life of the tandem rotor helicopter beyond 100 years since first flight. Tom Neupert, technical chief for the cargo technology management division, told the AHS Forum, "What we are going to do in Block II is build a foundation for Block III. . . . We are laying groundwork for an FVL heavy." Current production of the CH-47F concludes in 2020, and Block II Low Rate Initial Production should begin in 2021.

The current production AH-64E attack helicopter is expected to remain in the US Army until at least 2048, and a fleet upgrade is expected between 2030 to 2040 period. Plans now focus on the 3,000 shp (2200 kW) ITEP engine, advanced but non-Fly-By-Wire flight controls, and a series of technology insertions likely installed at the unit level.

Across the Army fleet is a requirement for full operational capability in DVE. The service is pursuing an interim DVE/BORES (Brownout Rotorcraft Enhancement System) with a fixed, forward-looking sensor meant to see through sand and dust clouds on takeoff and landing. Starting in 2019 or 2020, about 300 cargo and utility helicopters will be equipped with the interim BORES, pending an all-round, all-environment, formation-tracking DVE system. The DVE-Mitigation (DVE-M) science and technology effort beginning this year will support an 18-month analysis of alternatives to identify definitive sensor, pilot cueing, and flight control technologies. "The real opportunity is for the full DVE solution," said Army aviation systems Program Manager Col. Matthew Hannah. "The intent is the full DVE capability is then integrated on the FVL and the other aircraft the Army has."

The Naval Air Systems Command has already made good on its plans to

Leonardo Helicopters flew the third prototype AW169 in through a hole in the storms to surprise Forum attendees. The lightest of a family of modern helicopters, it has a variable speed transmission and other innovations. (Photo by the author)

The AHS International booth — this year supported by the AHS South Florida Chapter — was again a popular destination for book signings and learning about member benefits and initiatives, such as Vertipedia and the Career Center. (AHS photo)

modernize most US Navy and Marine rotorcraft communities. Navy PEO(A) deputy program managers updated Forum attendees on the status of current production and addressed future systems enhancements.

The game-changing MV-22 tiltrotor is in the early stages of its third multi-year production run with 253 of 360 MV-22 tiltrotors in the Marine Corps and nearly all the planned CV-22s in Air Force Special Operations. The Navy has funded CMV-22s for the Carrier Onboard Delivery mission, and first COD deliveries should begin in 2020. With the Marine Corps CH-53K in test and Initial Operational Capability (IOC) expected in 2019, the Marines have begun a CH-53E reset effort. (MH-53E minesweepers are being sustained, but will be retired in favor of Organic Airborne Mine Countermeasures fielded on MH-60S Knighthawks and complementary capabilities on Littoral Combat Ships.) The VH-92 Replacement Presidential Helicopter is in test to achieve IOC in 2020 and Full Operational Capability in 2022. The Marine Corps UH-1 upgrade completes UH-1Y deliveries in 2018 and AH-1Z production for the USMC in 2022. With a largely brand-new fleet, the Marine Corps is looking at Army efforts in DVE mitigation, and wants improved digital interoperability across the fleet.

The Navy multi-mission naval helicopter program has completed production of the MH-60S and will deliver the last US MH-60R in 2018. The high-time MH-60S in the fleet has logged about 6,000 flight hours, and the first to use up its 10,000 hour airframe life will do so in late 2020. A dynamic component analysis is now underway, and a fatigue life analysis will be undertaken in 2017 for the MH-60S and 2019 for the MH-60R. The first MH-60R to pass the 10,000 hour milestone will probably do so around 2030. Aging helicopters point to a Service Life Extension Program starting in mid-2020 concurrent with an avionics refresh. Navy leadership have yet to decide on adopting an FVL derivative between 2030 and 2040 or pursuing another development path.

With a solid science and technology foundation, Future Vertical Lift opens a broad range of such possibilities for joint-service rotorcraft with transformational performance. A Milestone A decision to start technology development in 2021 would support Engineering and Manufacturing Development in Fiscal 2024 and Low Rate Initial Production in Fiscal 2029. However, Dr. William Lewis, director of the Army's Aviation Development Directorate, cautioned the AHS Forum presenters and their audience, "It's got to be affordable. It's going to take lots of money to replace all these aircraft."

For more photos, check out our gallery at **www.vtol.org/qr/forum-72** or scan this QR code!

About the Author

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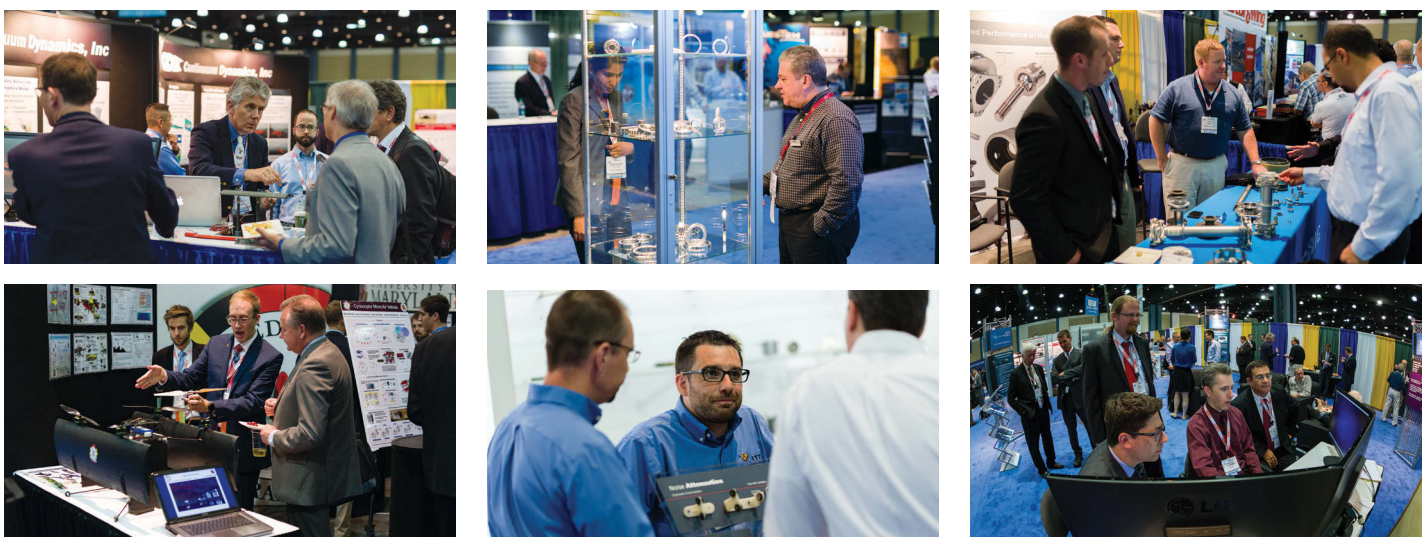

The AHS Forum includes the world's premier vertical flight technology display, where engineer-to-engineer inform, connect and inspire. (AHS photos by Chris Salata)