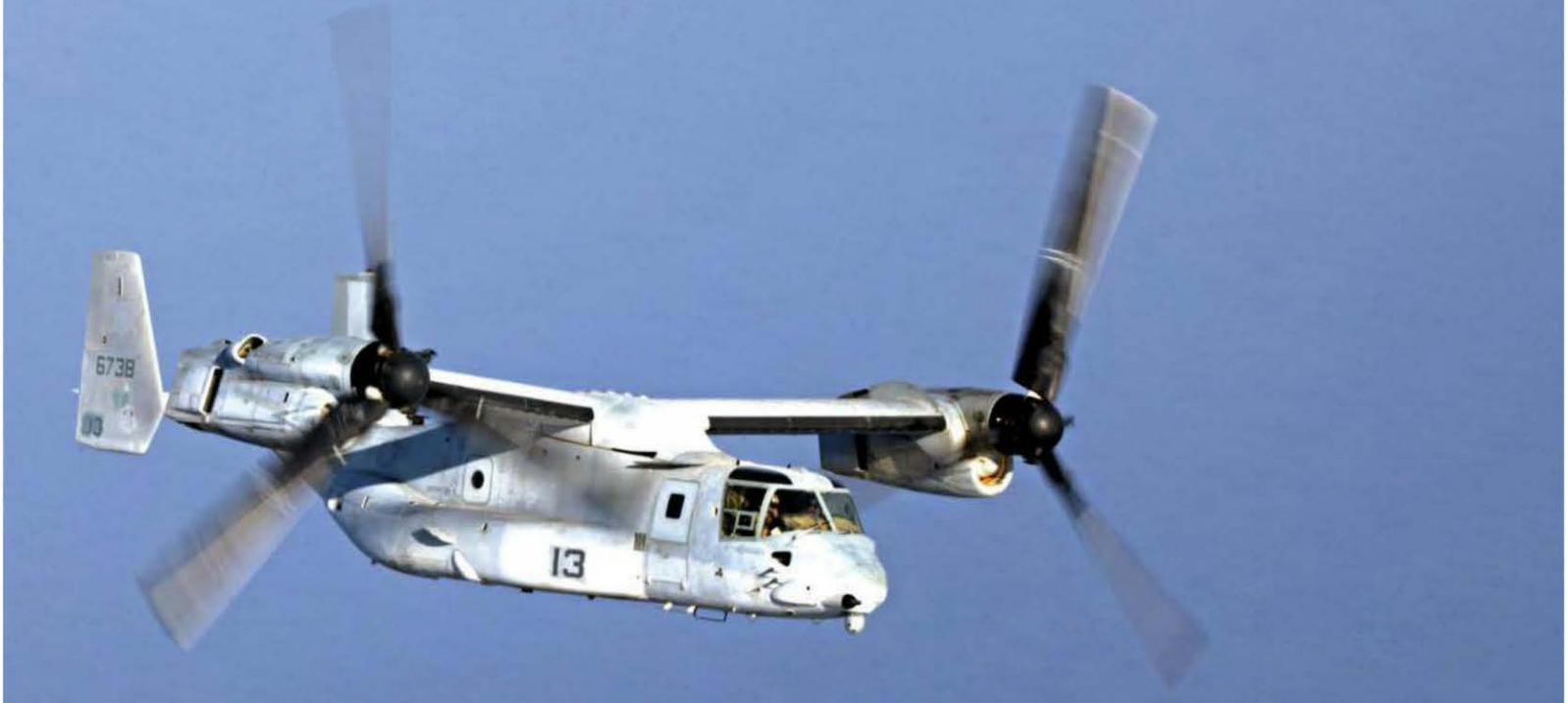


The More Affordable Tiltrotor

Manufacturing and sustainment changes make the V-22 Osprey cheaper to buy and fly.

By Frank Colucci

An MV-22B Osprey of Marine Medium Tiltrotor Squadron 261 (Reinforced), 24th Marine Expeditionary Unit, flies into position behind a KC-130 while conducting aerial refueling training operations. The Naval Air Systems Command continues to reduce the acquisition and operating costs of the fast, long-range tiltrotor. (US Marine Corps)

High acquisition and operating costs still make the V-22 an attractive target for defense budget cuts, but the Osprey contractors and the US government have already achieved significant savings and continue to attack tiltrotor costs. The first V-22 Multi-Year Procurement (MYP I) contract signed in March 2008 ordered 145 Marine MV-22 and 31 CV-22s aircraft from Bell Boeing for about $60 million apiece. (Osprey engines come from Rolls-Royce as Government Furnished Equipment.) V-22s are being delivered today around 2% under target price, and negotiations for MYP II will benefit from ongoing Cost Reduction Initiatives applied to the next 122 aircraft plus options. The Marine Corps meanwhile calculates MV-22 average cost per flight hour fell 21% in one year — from $11,648/hr in Fiscal 2010 to $9,123/hr in Fiscal 2011. At Boeing Philadelphia, V-22 production program manager Michael Rolecki explains, "Our objective is to get at least another 20% improvement in the cost per flight hour. With that kind of cost per flight hour, if you put the range and speed of the V-22 into the equation, the value proposition becomes a great one for the user."

By October 2012, Marine users had taken delivery of 161 of their 360 planned MV-22Bs. The Air Force Special Operations Command had meanwhile received 28 of the 53 CV-22Bs now programmed. The Bell Boeing team is under contract to convert remaining MV-22 Block A training aircraft to Block B operational configuration with cost-saving Reliability and Maintainability (R&M) enhancements. [The V-22 Program Manager, Colonel Gregory Masiello, USMC, was this year's recipient of the AHS Harry T. Jensen Award for "outstanding contribution to the improvement of vertical flight aircraft reliability, maintainability, and/or safety."]

Current production MV-22Bs conform to Block C standards with even more R&M and mission improvements. (See "Full Spectrum, Full Tilt," *Vertiflite*, Winter 2011.) New Air Force CV-22s and the 48 unfunded Navy MV-22s still in the program of record will likewise incorporate Block C features. While the Marines have no firm Block D plans, a second multi-year contract would carry Osprey deliveries through 2019, and follow-on contracts would stretch to 2021 just to fill US military requirements. Israel, Canada, and the United Arab Emirates have reportedly shown preliminary interest in V-22 Foreign Military Sales.

In August, the Bell Boeing team delivered a five-year, fixed-price incentive proposal the companies say offers the US Government double-digit percentage savings versus buying

aircraft year-by-year. With MYP II negotiations underway, the Naval Air Systems Command (NAVAIR) cannot discuss V-22 unit cost targets. However, the tiltrotor program office acknowledges stable multi-year contracts that enable prime contractors to lock-in supplier prices remain among the best tools to control acquisition costs. (Fiscal 2013 Department of Defense budget direction pushed 24 MV-22s out of MYP I and reportedly cost the Marine Corps an extra $6 million to $8 million per aircraft.) NAVAIR also acknowledges the acquisition cost of any aircraft is impacted by variables including inflation, labor rates, and the price of raw materials.

NAVAIR and the V-22 industry team have collaborated on 263 Cost Reduction Initiatives (CRIs) over the past seven years. Early on, each initiative began with an individual agreement between Bell Boeing and the government, funded through contract modifications. MYP I included CRI money from the start to let industry pursue promising process and tooling improvements, configuration changes, and supplier initiatives. CRIs remain joint efforts, but the V-22 program office notes at this stage of the program that industry has had more influence on manufacturing improvements, while NAVAIR has focused on sustainment and operational cost savings.

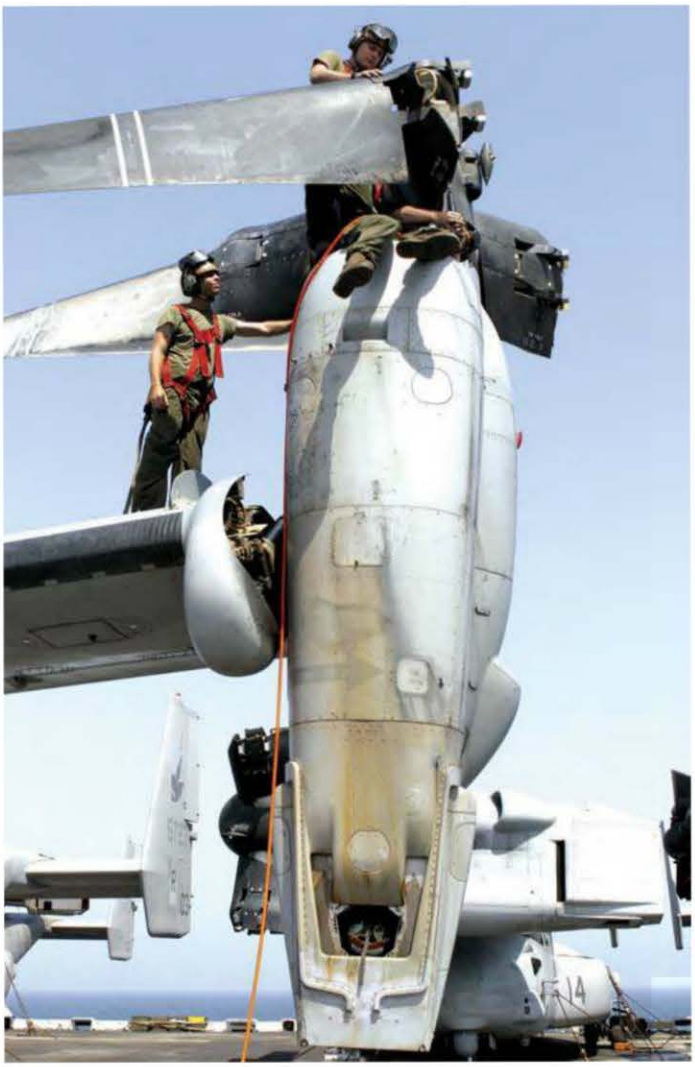
In the Factories

Bell Boeing V-22 work remains evenly split. Bell is responsible for the Osprey wing, proprotors, engine nacelles, drivetrain and fairings at Fort Worth, and final assembly and flight testing at Amarillo. Boeing in Philadelphia builds or integrates the fuselage, empennage and ramp, landing gear, electrical and hydraulic systems, and avionics. V-22 fabrication and integration routines are now mature. According to Mr. Rolecki at Boeing, "Within our production environment, we're working at about an 85% learning curve. Compared to [general] industry, that's world-class."

Bell refuses to discuss V-22 lean manufacturing initiatives, or engineering and process improvements. However, the government made investments in both tiltrotor makers to advance CRIs and secure Economic Order Quantities for their supply bases. According to Mr. Roleki, "Those enabled us to change our production environment, to combine some of the manufacturing jobs and build higher-value components . . . as well as redesign components for producibility." Boeing calculates the cumulative payoff has been an 8% cost reduction between MYP I production Lots 12 and 16 alone.

Changes have been made in the V-22 supply chain. In Philadelphia, Mr. Rolecki explains, "From a business standpoint, we've identified a lot of the low-value work, and we've pushed that low-value work out of our plant to other suppliers. Likewise, we've identified high-value work and brought that in-plant." Savings come from competitive labor rates and component re-engineering. "We'll run a competition and pick the highest-value supplier." An alternative source and a new design, for example, promise to cut the cost of the Osprey tail ramp 60%. Mr. Rolecki says, "We're taking a look at the actual structure of the ramp and ramp door, and we've done some redesign for producibility. And we've outsourced to a supplier who can produce the parts more cheaply."

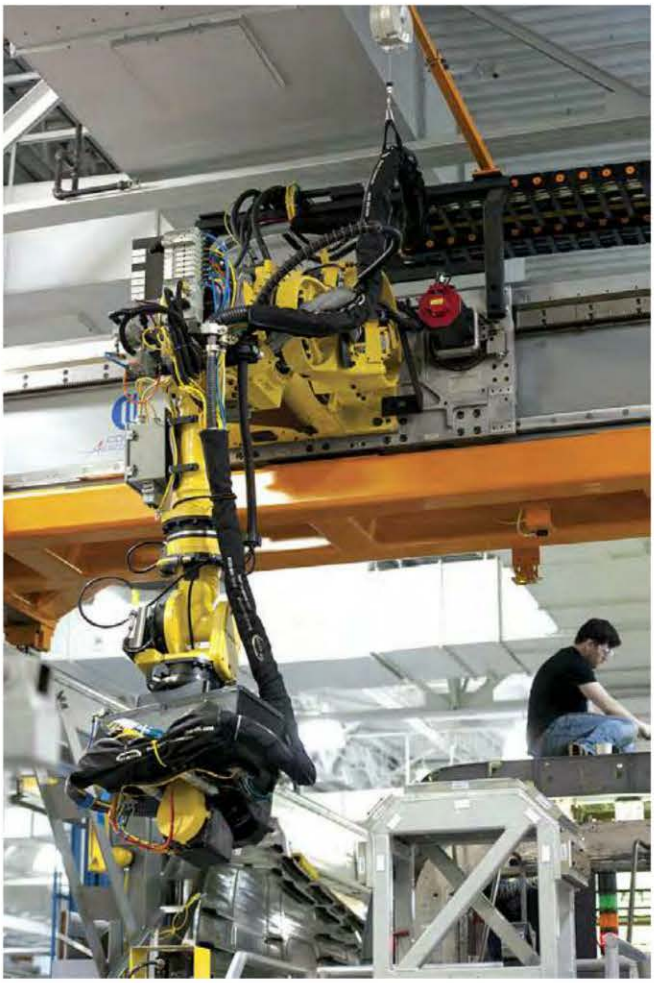
In-house process improvements meanwhile improve

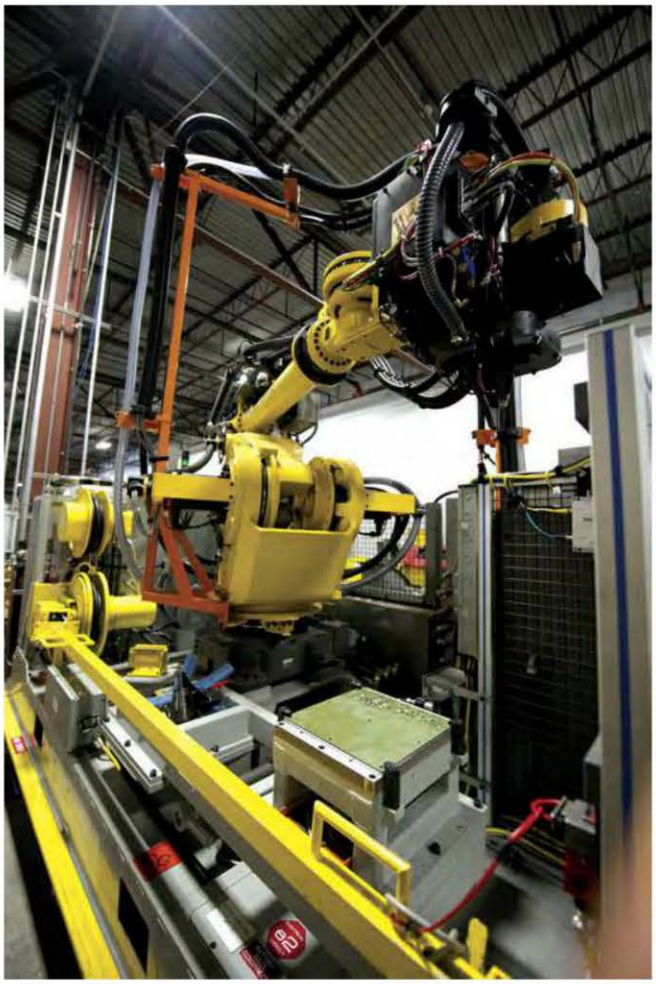


Marines of Medium Tiltrotor Squadron 261 (Reinforced), 24th Marine Expeditionary Unit, perform maintenance on an MV-22B Osprey on the flight deck of USS Iwo Jima. The Naval Air Systems Command and Bell Boeing continue work on maintenance procedures and component designs to improve tiltrotor readiness and cut operating cost per flight hour. (US Marine Corps)

efficiency and cut rework. Boeing Philadelphia, for example, automated the layup of V-22 composite side skins and drag angles. "We drew on technology out of our commercial company and other parts of Boeing to design very high-tech robotic devices in order to build those structural components in our composite shop." Since 2010, one fiber placement robot has cut part production costs at least 33% and reduced spares inventories 80% versus traditional industry machines. "Those have significantly benefited our quality analysis well as our cost to build those parts," notes Mr. Rolecki.

Hole-drilling operations are a common source of manufacturing defects across industry. Mr. Rolecki explains, "In our assembly factory, we installed robotics in a lot of our hole-drilling operations. . . . We've put automation in the factory to do our hole drilling more efficiently, and to improve the quality of our process." A robotic gantry brought on-line in April 2010 and a portable robotic drilling system implemented in September 2011 have cut drilling time and rework 50%.





Boeing Philadelphia has implemented robotic drilling on the V-22 production line to reduce manufacturing costs and improve quality. The illustrated gantry and portable drill systems have cut drilling time and rework in select operations 50%. (Boeing)

Simpler factory changes paid off with higher consistency and quality. Mylar templates gave way to hard tools that improved repeatability. Brush-on sealants were replaced by cap seals. "There's no guesswork. It's the same from job to job to job," says Mr. Rolecki. Boeing's cumulative production changes have reduced V-22 defects-per-aircraft 25%. "That's huge. From a customer-satisfaction standpoint, that's even bigger."

Boeing is also integrating cost-saving improvements into V-22 avionics. At the end of Production Lot 16, the company will replace the discrete V-22 mission computer, display processor, and digital map computer with a single Integrated Avionics Processor. The redundant avionics system trades five boxes for two yet provides room to grow. According to Mr. Rolecki, "This is going to provide an Open System Architecture for the airplane, more capacity for future functionality – whatever that might be – and 33% recurring cost savings for that system."

The Bell-engineered VSLED – Vibration Structural Life Engine Diagnostic – system is meanwhile trading four interface and memory boxes for four identical Mid-Wing Avionics Obsolescence computers. The switch promises a 20% savings in recurring costs, and a reduction in the V-22 avionics support footprint.

On the modernized Philadelphia production line, V-22 manufacturing engineers have also automated avionics testing. Where an operator once sat in the cockpit going through hours of functional tests, systems now perform about 90% of test routines hands-off. "From a value standpoint, you don't have a labor-intensive series of functional tests; everything is automated," says Mr. Rolecki.

V-22 engine maker Rolls-Royce acknowledges its AE1107 engine family benefits from low-cost manufacturing practices, high-speed machining, automation, and supply-chain re-design. A new Customer Delivery Center (CDC) in Indianapolis, for example, uses automated inspection and cleaning processes and has been designed to include AE1107 engines as they move from the assembly line for shipment. Though engineers in Indianapolis decline to share lean manufacturing specifics and their payoff for the tiltrotor program, Rolls-Royce defense senior vice president Tom Hartmann notes the AE1107C tiltrotor engine is part of the AE commercial turboshaft, turboprop and turbofan line. He says the commercial nature of the product line demands that Rolls-Royce keep its costs low in order to compete successfully in the marketplace. According to the manufacturer, the AE1107C turboshaft for the V-22 also has a defined roadmap

for product improvements and will demonstrate substantial growth capability next year.

In the Fleet

The NAVAIR V-22 Cost Per Flight Hour (CPFH) Reduction Team received the Department of Defense 2011 Packard Award for savings in the operational tiltrotor fleet. The Osprey program office launched the savings effort in 2009 and started by improving the fidelity of V-22 CPFH data based on actual component demand and pricing. The current model has the fidelity to reflect changes in individual component reliability, procurement and repair costs, and maintenance concepts.

NAVAIR subsequently established a multifunctional V-22 CPFH Reduction Team to identify and capitalize on opportunities in four key sustainment areas. An ongoing review of current fleet maintenance practices has so far generated 203 action items, such as using support equipment to provide aircraft ground power rather than starting the auxiliary power unit. Maintenance planning opportunities apply actual failure data to current component maintenance plans. Reclassifying more than 400 high-cost/high-failure consumable components to repairable status generated savings versus new components. NAVAIR also plans to expedite an organic repair capability to reduce the V-22 CPFH: Naval Supply Systems Command (NAVSUP) has already identified numerous V-22 components that could be contracted directly with the OEM in order to eliminate pass-through costs from Bell Boeing.

A V-22 In-Service Integrated Product Team was established in November 2009 in part to improve V-22 fleet readiness and reliability. Mike Rolecki at Boeing explains, "Starting about four years ago, after the first deployment to Iraq, Bell Boeing and the government formed a team to identify top reliability degraders in the airplane. In effect, what we have today is a world-class, closed-loop corrective action system." A Critical Item Logistic Review identified key readiness degraders as candidates for improvements. "We're driving those top degrader components into the Team to redesign for reliability with specific information on the failure modes."

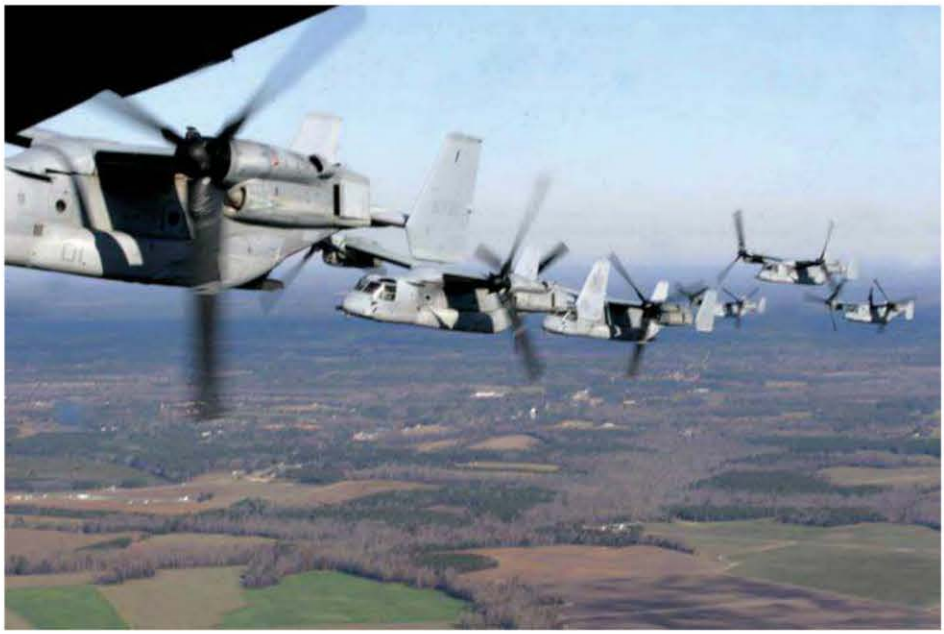
To date, about 40 components, including swashplate and flaperon actuators and constant and variable-frequency generators, have been redesigned and will be forward-fit on the production line and retrofit in the fleet. Mr. Rolecki adds, "We are taking a look today at how we would apply a SAFE [Structural Appraisal of Fatigue Effects] program to the V-22 and talking with our customer. That would be a huge benefit to maintainers." Damage-tracking SAFE methodology is being used to alleviate Osprey component life limitations by tracking individual fleet aircraft usage. Using SAFE, a V-22 Block A nose landing gear shock strut, for example, has a projected life nearly four times the original design landing limit.

NAVAIR calculates the cost reduction and reliability improvement initiatives collectively reduced the MV-22 CPFH 13% by the end of Fiscal 2011 and are expected to have achieved another 5% savings during Fiscal 2012. The CV-22 has followed a similar trend.

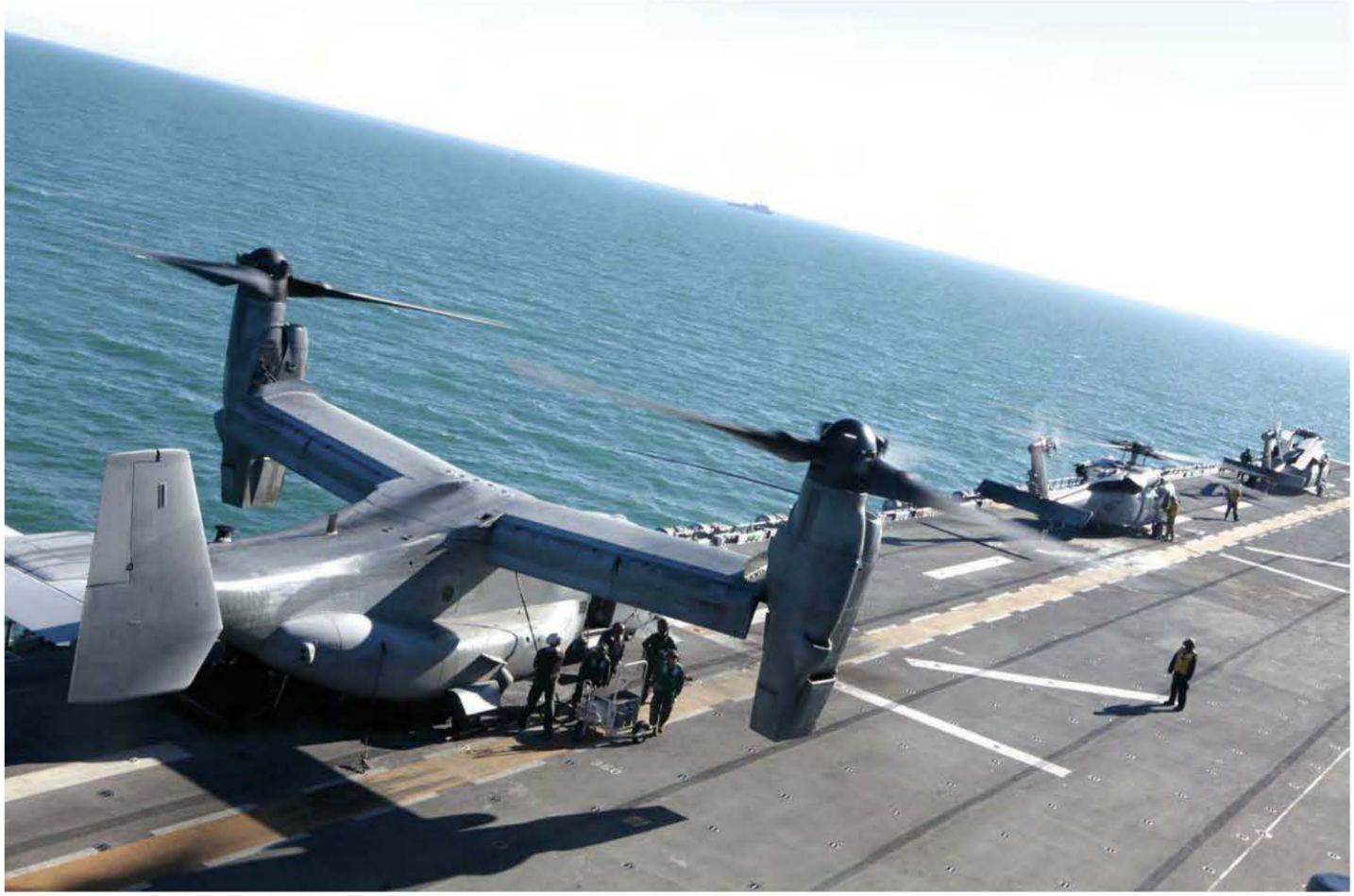
Component redesign and sustainability improvements also aim to achieve an 85% mission capable rate across the V-22 fleet. One of the biggest V-22 readiness degraders remains reduced time-on-wing for the AE1107C engine in desert environments. According to Rolls-Royce, engine improvements and maintenance changes have already increased time-on-wing by more than 100% and reduced overall V-22 operating costs. Continuing improvements include an inlet particle separator developed jointly by Rolls-Royce and Bell Boeing, plus an improved inlet barrier filter initiated by the airframers. Bell Boeing leased an MV-22B back from the government at the end of 2011 to work on nacelle improvements. Flight testing started in the summer of 2012 at Arlington, Texas and will continue in austere environments into 2013.

Within the V-22 engine itself, Rolls-Royce is working with NAVAIR to evaluate protective coatings. MDS Coating Technologies is working with the V-22 program office and the engine maker to introduce a BlackGold compressor coating to the fleet. Based on Marine CH-53 and CH-46 experience with earlier erosion coatings, the new erosion-corrosion protection coating is expected to at least double the life of the AE1107C compressor.

Sand and dust erosion also takes a toll on V-22 proprotors. A Hontek heat-conductive, erosion resistant polyurethane coating was sprayed on three CV-22 blades flying since 2009 at Kirtland Air Force Base, New Mexico. The



Marines from Marine Medium Tiltrotor Squadron 365 fly eight MV-22B Ospreys in an echelon right formation on their way back to Marine Corps Air Station New River prior to their deployment to Afghanistan. (US Marine Corps)



Marines and Sailors aboard the USS Wasp unload an MV-22B Osprey from Marine Medium Tiltrotor Squadron 266 as a Navy MH-60S Knighthawk idles nearby, during the Bold Alligator exercise in February 2012. The Navy remains in the V-22 Program of Record calling for 48 MV-22s, possibly for shipboard logistics missions. (US Marine Corps)

coating has performed extremely well in the sandy environments, and plans call for 16 more CV-22 blades to receive the Hontek coating applied by a money-saving robotic spray process developed by the Army for coating UH-60 blades. (See "Kaman's Collective Competencies," Vertiflite, March/April 2012.) The complex shape of the V-22 blades makes the proprotors especially attractive candidates for robotic coating.

The Navy Fleet Readiness Center East is meanwhile working on a Robotic Automated Coating Removal System (RACRS) that would eliminate labor-intensive sanding or impact blasting on rotor blades and other V-22 surfaces. Sanding the paint off a V-22 now takes 372 hours of costly labor and requires skilled workers to keep from damaging wire mesh lightning protection. FRC East at Marine Corps Air Station Cherry Point, North Carolina, has been designated the V-22 logistics and maintenance support depot, and laser-based robotic systems that can be adapted to the V-22 fuselage promise to cut costs and increase depot throughput.

In early 2012, the V-22 program launched the second-phase supply chain management portion of a four-phase Performance Based Logistics (PBL) program. Flexible enough to change with fleet requirements, PBL partners Bell Boeing with the government to better integrate Osprey production and sustainment. It packages spare parts, deployable technical support, rapid engineering support, and squadron training to keep MV-22s and CV-22s ready and affordable.

About the Author

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