Collective Approach

European research shows benefit of public-private focus on greening rotorcraft

GRAHAM WARWICK/WASHINGTON

From diesel-powered helicopters with dramatically lower fuel consumption to composite airframes that can be recycled at the end of their lives, Europe's largest rotorcraft research program is moving from technology studies into hardware design.

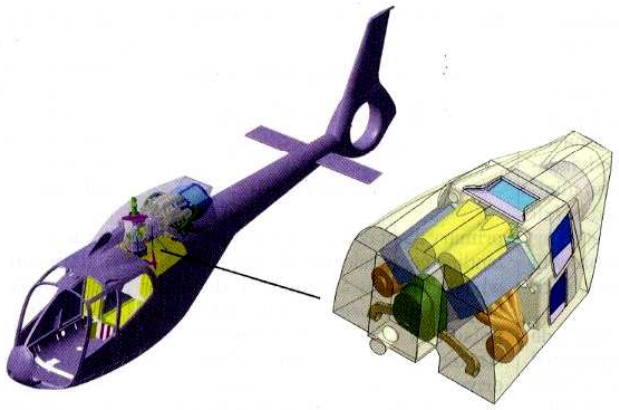
Part of the €1.6 billion ($2.1 billion) Clean Sky joint technology initiative, the Green Rotorcraft (GRC) program is advancing on a wide front to mature technologies for ground and flight demonstrations in 2014-16 that will enable European manufacturers to introduce cleaner and greener civil rotorcraft in 2020-25.

Funded 50-50 by government and industry, Clean Sky is focused on meeting the environmental objectives established for 2020 by the Advisory Council for Aeronautics Research in Europe. These include significantly reducing noise, emissions of carbon dioxide (CO_2) and nitrogen oxides (NO_x), and the environmental impact of manufacturing, maintaining and disposing of aircraft.

"The main objectives for the Green Rotorcraft program are to reduce CO_2 by 40% with a diesel engine and 26% with a turboshaft; NO_x by 53% for diesel and 65% for turboshaft; and noise footprint by 50%, or 10 EPNdb," says Sebastien Dubois, GRC project officer within the Clean Sky Joint Undertaking organization.

To meet those objectives, GRC is pursuing projects to increase rotor efficiency, reduce airframe drag, improve flight procedures, develop all-electric systems and demonstrate advanced turboshaft and diesel engines. The goal is to raise technology readiness levels from proof of concept (TRL 3) to prototype demonstration (TRL 6), "so that, at the end of Clean Sky, we have technologies ready for product development," he says.

"Europe now probably leads the world in green rotorcraft research, and has a well-coordinated and well-funded public-private partnership," says Michael Hirschberg, executive director of the Washington-based American Helicopter Society International. "Under Clean Sky, the Green Rotorcraft project includes €80 million each from both government and industry/academia. And despite the new austerity in Europe, the EU is continuing to show determined leadership to fund this work."



CLEAN SKY

Fuel-saving, emissions-reducing diesel powerpack will replace the turboshaft engine in the Eurocopter EC120 for ground demonstration.

Although NASA spends about the same on rotorcraft research—its Subsonic Rotary Wing (SRW) project is budgeted at around $28 million a year—it invests in different areas. "Green Rotorcraft has focused on fuel efficiency, emissions, noise and life-cycle impact at TRL 3-6. NASA SRW has no investment in life-cycle impact, integrated electrical systems or diesel engine technology," says Susan Gorton, principal investigator.

"SRW has investment similar to Green Rotorcraft in fuel efficiency, emissions and noise, but we have not focused on the TRL 3-6 range. Within the Fundamental Aeronautics program, we concentrate on the lower TRLs with some investment in selected areas that are higher TRL. We have no plans for an equivalent to the Eco-Design demonstrator." But Gorton points to areas NASA is pursuing that GRC is not, including cabin noise reduction, ice accretion and shedding, condition-based maintenance, drivetrain technologies and crashworthiness design.

Funded under the European Commission's 2007-13 research program, called Framework 7, Clean Sky got off to a slow start because of its complexity. Work began in 2008 and the program will now close in 2017, with all demonstrations to be completed by the end of 2016. "After a slow ramp-up phase, activity is now running at a steady pace," says Dubois. "We have completed most of the technology tradeoffs and are starting design and development of the selected technologies, to be completed by 2014."

With a budget of €155 million, Green Rotorcraft is one of six integrated technology demonstrators (ITD) within the Clean Sky program. Helicopter manufacturers AgustaWestland and Eurocopter are co-leads of the GRC-ITD and—along with suppliers Hispano-Suiza, Leibherr and Thales—are providing up to 50% of the industry contribution as founding members of the overall initiative.

Up to 25% is provided by associate members selected competitively at the outset of the program, with at least 25% of the overall budget for specific research topics coming from additional partners chosen through regular calls for proposals—the 11th of which was opened in January and will close in April.

"For the European helicopter industry, Clean Sky is a game-changing instrument in their research and technology road map, allowing them to study, design and test key technologies with the right horizon and level of funding," says Dubois. "Through Clean Sky, the main European stakeholders in the rotorcraft domain are teaming together. Through the calls for proposals, they can also team with new partners who might become suppliers on their next helicopter programs."

Across Clean Sky, €200 million has been set aside for the calls, with research

topics averaging €500,000 in value. Two-thirds of the topics have been launched and three calls a year are planned through 2013. By completion of the eighth round in mid-2011, more than 300 partners had been brought on board, 40% of them small and medium-size companies and more than 20% from academia.

"In GRC, more than 28 projects are running in parallel with the ITD activities," says Dubois. Project budgets range from €120,000 to €9.3 million, and durations from 12 to 66 months. The quality of bids has been good, but 15% of topics fail to attract viable proposals, he says, adding: "We are facing difficulties in appointing members in the field of composite materials."

Studies to confirm that the selected technologies offer the expected benefits are essentially complete, Dubois says, and GRC is moving into the design phase. Preliminary and critical design reviews are planned for 2012-13, with testing to begin in 2014.

Advanced rotor blades are expected to contribute to GRC goals by reducing power required by 8% in the hover and 3% in cruise, and noise by 6 db on approach. Active and passive designs will be tested. Passive rotor optimization using three-dimensional blade aerodynamics to maximize performance and minimize noise will be demonstrated at full scale on a whirl tower. Active twist using embedded piezoelectric actuators will be tested using a blade segment, with the goal of achieving TRL 4.

An active Gurney flap to increase blade lift and reduce rotor power will be tested at model scale in the wind tunnel in 2014 and at full scale on a whirl tower in 2015-16, aiming for TRL 5, says Dubois. The Gurney flap is a small, flat surface that deploys perpendicular to the trailing edge on the underside of the airfoil to increase lift, extending and retracting as the blade rotates from the retreating to the advancing side of the rotor.

GRC is targeting drag reductions of 10-15%, depending on rotorcraft configuration and weight class, for fuel-burn savings of 4-5%. Work includes optimizing the design of rotor hub caps and pylon fairings; delaying airflow separation on the blunt aft fuselage using passive and/or active flow-control devices; and reducing tail size through active control. A full-scale hub cap will be flight tested on an AW101 or EC145, aiming for TRL 6.

Passive and active vortex generators, as well as synthetic- and pulsed-jet flow control systems, are to be tested in the wind tunnel using blunt fuselage models, with the goal of achieving TRL 4 by 2013. A quarter-scale model of the active horizontal stabilizer will also be tunnel-tested, to validate full helicopter dynamic simulations. Work also includes computational fluid-dynamics optimization of helicopter and tiltrotor fuselages to reduce drag, and of engine inlets and exhausts to reduce noise and installation losses.

Research into all-electric systems that eliminate hydraulic fluid and bleed air, and reduce CO_2 emissions through improved efficiency and reduced weight, is part of a wider Clean Sky effort, and will use a ground-test rig shared with the Green Regional Aircraft program under the Eco-Design ITD. Located at Hispano-Suiza, Dubois says this "Copper Bird" rig will provide the 270-volt DC electric architecture within which specific rotorcraft systems can be tested dynamically through different flight profiles.

Systems to be demonstrated include electromechanical actuators (EMAs) for primary flight control, rotor braking and landing gear—electrically powering the wheels to allow taxiing with the rotor stopped to improve safety and reduce noise—as well as a brushless 28-volt starter-generator and electric tail-rotor drive. Two different flight-control EMAs will be tested, in a light helicopter on the ground and in the Copper Bird for medium/heavy rotorcraft. Prototype systems to recover waste heat from engine nozzles and store the energy will be tested in ground rigs.

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The most promising, and most challenging, project within GRC, Dubois believes, is the installation of a diesel engine in a light helicopter. While modern turbocharged and intercooled automotive diesels offer low fuel consumption and CO_2 emissions, current aviation-certified engines are too small and too heavy for helicopters. But they promise 30-40% fuel and emissions savings over turboshafts, if performance and power-to-weight can be increased.

Under the €9.3 million HIPE AE 440 project, Austro Engine and powertrain specialist TEOS are developing a 330-kw (440-shp), 250-kg (550-lb.) diesel powerpack for demonstration in Eurocopter's EC120 light helicopter. Challenges include weight, reliability and operability, as well as installation issues such as noise, vibration, cooling and drag. Ground tests are planned for 2014, but flight tests are not yet funded.

"For now, we will stop at the ground stage, and not fly within Clean Sky, as we do not have the additional funding. But I expect we will find a way to do it," Dubois says. Funds could be freed up, as some projects are likely to be shelved if the technologies will not reach a sufficient level of maturity by 2015. "Over the next year we will begin to identify those that will not mature in time," he says.

Separately, under Clean Sky's Sustainable and Green Engines program, Turbomeca is leading development of an advanced turboshaft for single-engine helicopters in the 3-ton class and twins in the 6-ton class. Engine testing is expected to begin in September.

Other research areas include work on optimized flight paths, which are expected to reduce fuel burn by 6% and noise by 5 EPNdb. GRC is also supporting the Eco-Design program with a thermoplastic-composite door and tailcone to demonstrate integrated design, simplified manufacture, ease of dismantling and recyclable materials. Eliminating hazardous materials and processes in the manufacture of gearbox housings and transmission components, while reducing energy and emissions, is another objective.

Results from all the GRC subprojects feed into Technology Evaluator, a simulation framework that enables the environmental benefits to be assessed in a full range of missions across worldwide fleets of light, medium and heavy helicopters and tiltrotors. Two fleets, one for 2000 and one for 2020 and beyond, are simulated to determine whether technologies are providing the expected benefits.

The Technology Evaluator is a network hosted at research agencies Onera in France, DLR in German and NLR in the Netherlands. "The assessment started last year with the light twin-engine helicopter model, which represents 15% of the overall fleet. Results will be available by April, but preliminary results are on track and we are pretty confident so far," says Dubois. "The assessment will continue with the light single-engine helicopter model . . . , and results should be available for 72% of the overall fleet by early 2013."