

propeller. The brushless DC electric lift motor takes over powering the propeller after conversion to forward flight. "The rotors are deliberately out of balance," says NRL MAV principal investigator James Kellogg. "This thing shakes, but at this scale it is OK, and when you get it up to flight RPM it gets above the resonance of the rest of the vehicle, so it is not shaking itself to pieces. It is only something you could get away with on the micro-scale."

The NRL is developing a next-generation Samara that may not have a pusher propeller, although details are still to be determined, says Kellogg. "We are changing its configuration a little bit, which we hope will eliminate some of the problems." Assuming further development is successful, the NRL hopes the Samara will front up a whole family of "perch and stare" MAVs that could ultimately perform various roles for the US Navy and Marine Corps, ranging from carrying sensors for electronic, acoustical, magnetic, nuclear, chemical and motion detection to providing platforms for secure transmitters. Disguised as birds or even insects, Samaras could be sent out on covert surveillance missions, says the NRL.

Backpackable

Another emerging MAV is an unusual family of barrel-like UAVs being studied under a US Defense Advanced Research Projects Agency (DARPA) advanced concept technology demonstration. These MAVs are intended as backpackable battlefield reconnaissance tools and are miniature versions of larger relatives under development for possible use with the US Army's Future Combat Systems (FCS) and a wide range of other roles. All the designs rely on ducted propellers to provide thrust and manoeuvrability, including the capability of transitioning to forward flight – all without concerns over torque and at relatively low disc loading.

Again the concept of ducted propellers is not entirely new – the French company Nord (later part of Aerospatiale), for example, designed a VTOL aircraft powered by two large five-bladed ducted propellers dri-

ven by Allison T63-5A engines. The duct exit contained four control vanes in a diamond shape which controlled pitch (collectively) and yaw (differentially) in an attempt to expand the airflow for vertical lift and compress it for horizontal flight. Although it made a tethered hover flight in July 1968, the Nord 500 Cadet was cancelled, with no further tests taking place.

Today's ducted fan concepts include some that use the "ring-wing" lift of the fan duct to transition to horizontal flight, others that have wings to augment the lift from the duct, and distant descendants of the Nord 500 that support a fuselage or payload platform between paired ducted fans. All bring to bear advanced fly-by-wire stability augmentation and control systems and improved drive-train and gearbox technologies that make manned, remote and autonomous control feasible.

Virginia-based Allied Aerospace is in the forefront of ducted fan VTOL UAV development, having successfully demonstrated fully autonomous missions using its patented iSTAR (intelligence, surveillance, target acquisition and reconnaissance) vehicle. The lift-augmented ducted fan design recently undertook a series of trials at the Space and Naval Warfare Systems Center Robotics Testing Range in Point Loma, California, and at the Camp Pendleton Marine base in the same state. The 0.73m-diameter vehicle, which lands on its own landing support ring, needs no launch or recovery equipment and demonstrated completely autonomous flights that included hovering pauses, as well as "unattended ground sensor" missions in which it landed, shut its engine down, surveyed the area with a video camera, restarted its engine, took off and returned to base.

Honeywell, working with Allied Aerospace, is developing a family of iSTAR-related ducted-fan UAVs to meet the varied size requirements of an organic air vehicle for the FCS. In co-operation with DARPA, a related organic adverse-weather air vehicle programme is also under way to develop ducted-fan UAVs that can provide FCS direct and indirect weapons targeting in all



The Honeywell-backed Allied Aerospace iSTAR has completed initial flight tests (top), while Samara could be the first of a family of US Navy "perch and stare" UAVs

weather conditions.

Similar concepts are being explored by BAE Systems, as well as Virginia-based Aurora Flight Sciences, which is preparing to start flight tests of the GoldenEye-50, a smaller variant of the winged, ducted fan GoldenEye-100. Originally developed under DARPA's Clandestine UAV programme, the larger GoldenEye variant can carry payloads of up to 10kg (22lb), and has a gross take-off weight of up to 68kg. Unlike the alternative ducted fan designs, the GoldenEye concept includes torsionally disconnected wings that provide lift and enhanced stability in horizontal flight mode, without interfering in vertical flight operations.

Bond-themed

Perhaps the most extraordinary VTOL concepts on display at AUVSI – at least visually – were the Trek Aerospace ducted fan-powered Springtail EFV-4 and Dragonfly UMR-1. Although both are capable of being manned, the two vehicles are also being developed for autonomous operation as UAVs. Though every bit as James Bond-themed as the GoldenEye UAV, the dual ducted-fan designs are rooted in the dim

DARPA MORPHING AIRCRAFT CONCEPT

