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Composites key to Grumman forward-swept-wing
Bethpage—Grumman has received a
$71 million Defence Advanced Re-
search Projects Agency contract to
build the X-29A forward-swept-wing
(FSW) technology demonstrator. The
aircraft is expected to fly in October-December 1983. The contract keeps open the option for a second demonstrator, providing funds for certain long-lead-time items.
The X-29A is a 16,0001b aircraft powered by a single General Electric F404 turbofan of around 16,0001b thrust. General performance is ex-pected to be similar to that of the F-16. To reduce costs, an F-5 forward fuselage, supplied by the US Air Force, will be married to the new rear fuselage, wing, tail, and canard. FSW is expected to provide a num-ber of benefits, including improved low-speed handling and an overall in-crease in aerodynamic efficiency. The former is achieved by reversing usual swept-wing behaviour at the stall— with FSW the root stalls first, leaving the wingtips and ailerons in clear air, maintaining controllability.
Improved aerodynamic efficiency is a combination of better wing-body shaping, the aft location of the wing root improving area ruling, and the optimisation of wing/canard pressure distribution, including interference be-tween canard and wing, to bring it closer to the ideal elliptical spanwise loading for lowest lift-induced drag. The problem with FSW has always been to build a wing strong enough to withstand the divergent aero-elastic twisting force from the wing-tips, yet light enough to be feasible. Previous forwardnswept-wing applica-tions, all subsonic, have used metal structures considerably heavier than the equivalent aft-swept wing.
The X-29A wing has a carbonfibre composite wing torsion box and carry-

FLIGHT International, 2 January 1982

through structure. The secret of re-sisting the divergent twisting force is in the layup of carbonfibre laminates in the wingbox. Laminates are orientated 0° (spanwise), 45°, and 90°. Overall proportions are: 20 per cent 0°, 60 per cent 45°, and 20 per cent 90°. To control twisting, outboard 0° laminates are rotated forwards by 9°, and, because of the increasing bending load towards the tips, there is a slightly higher proportion of 0° laminates outboard.

Tunnel tests

Windtunnel tests show that the wing leading-edge re-entrant, where forward sweep changes to aft sweep, has the biggest static load. This is caused by the centre of pressure mov-ing forward relative to the rest of the wing, putting a disproportionate load on the front spar. This area is beefed up, with 156 laminates in the region around the V-corner beam. Wing weight is around 1,6001b, or

some 10 per cent of the X-29A's take-off weight. Wing-section is an aft-loaded, supercritical aerofoil, with discrete variable camber. Strakes ex-tending aft from the wing-root trailing-edge terminate in flaps, which give a clean stall break, and which help unstick the nosewheel.
The X-29A is highly unstable and has a Honeywell triplex digital fly-by-wire flight control system. The basic wing/body combination has neutral longitudinal static stability. Addition of the all-moving canard shifts the overall centre of pressure forward of the centre of gravity by 35-40 per cent of the mean aerodynamic chord (area/span).
The combination of neutrally stable wing/body and destabilising canard provides the lowest "tail-off" control power requirements. A 35-40 per cent statically unstable tailed aircraft, equivalent to the X-29A, would be 60-70 per cent unstable tail-off. Brute force actuators would be required to balance the aircraft.

There are no plans to carry stores/ pylons on the first aircraft, although the wing will be stressed for pylons. The second aircraft, if it is built, may incorporate additional technology, in-cluding a two-dimensional exhaust nozzle, radar absorbing materials, and light-level matching "active" camouflage.
Initial shake-down flight-tests will
be carried out by Grumman before the demonstrator is transferred to

Nasa Dry den, Edwards AFB, Cali-fornia, for the majority of tests. Grumman expects the aircraft to be spin-resistant because of its low-speed controllability. The company is look-ing forward to the first flight: "It should be interesting, but, we hope, not too interesting."