



Major advances in propulsion will be vital to future supersonic aircraft developments

mance, against which data on pressures, temperatures and speeds will be compared.

A key target for new engines will be the use of smart structures, materials and sensors combined with advanced control algorithms to mimic the responsiveness of a living organism. Active compressor stabilisation, for example, could control post-stall behaviour in the event of a sudden throttle change. Using smart algorithms, response settings and actuation, the operating point can be moved to the stall line and back. With this ability, designers will drive stage loading up significantly.

This should be good news all round. Because the trade between pressure ratio and stability margin will be simplified, actively controlled compressors will be easier to develop. Fewer design iterations will cut development costs, and reducing the compressor stages will trim manufacture and maintenance costs. Elimination of stall and surges will lead to the development of maintenance-free compressors. Similar "intelligent engine" concepts include active blade vibration control and active combustor control.

Engine versatility may also embrace variable-cycle systems, which could be the next major innovation to the jet engine. Variable-cycle engines tune bypass and pressure ratio to the unique mission requirements, while all propulsion systems are designed for the critical point in the mission. This could be take-off power, take-off noise, acceleration or cruise. The concept could provide more efficient operation than the current fixed cycles.

Along with versatility and intelligence, a third focus area is durability. A major part of the drive for affordability will be pre-

venting component failure, increasing engine life and reliability, and making them easier to repair. To make this possible, engines of the future will move towards high-speed, high-temperature, oil-free turbomachinery using technology such as foil bearings and tribological coatings.

NASA is also examining the potential advantages of an oil-free rotor system as part of Glenn Research Center's aerospace propulsion and power programme. The aeropropulsion programme offers a blueprint for NASA's vision for the 21st century and, in common with many engine makers and global study groups, sees a gradual shift from today's reliance on chemical combustion energy, through a phase of hybrid systems to a largely electrochemically-based aerospace world.

The first steps toward these greener engines involve the experimental development of fuel cell-powered unmanned air vehicles and general aviation aircraft. Fuel cells are electrochemical devices that convert hydrogen directly into electricity and heat without combustion, making them more than twice as efficient as an internal

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