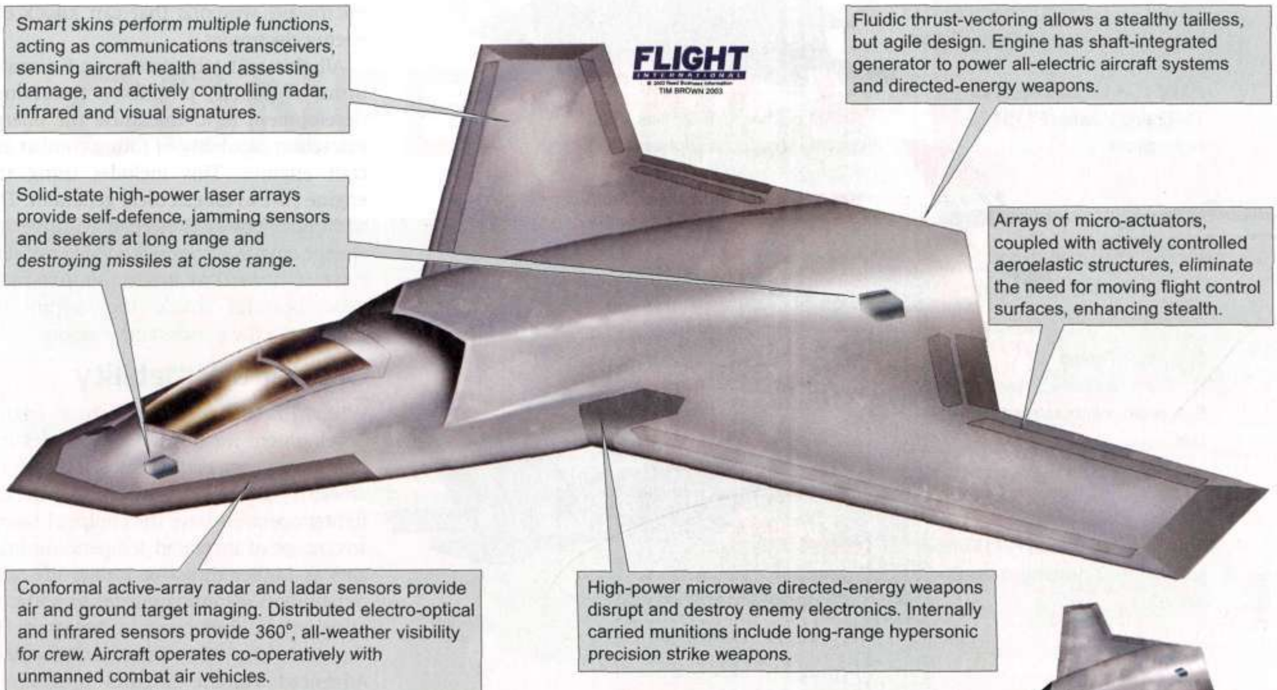

develop the US Air Force's planned long-range strike aircraft – which could be manned or unmanned. In Europe, meanwhile, industry attention is focused on production of the latest generation of fighters, the Dassault Rafale, Eurofighter Typhoon and Saab/BAE Systems Gripen. As a result, it sees UCAVs as adjuncts to manned aircraft, rather than replacements.

This time round, the fate of an entire industry does not rest on the outcome of the manned versus unmanned debate. Nor is the choice to be made as stark. Most of the raft of new technologies emerging from laboratories are applicable equally to manned and unmanned combat aircraft. The choice of how these technologies will be applied is likely to be made programme by programme, and country by country. And affordability is likely to be the driver.

Advances in sensor development should benefit both fighters and UCAVs. The new generation of active-array radars is the enabling technology for a range of new surveillance, reconnaissance and targeting capabilities. Active electronically scanned arrays generating "inertialess" beams enable essentially simultaneous operation in air-to-air and air-to-ground modes. The arrays, made up of hundreds of solid-state transmit/receive modules, promise unprecedented reliability. Performance degrades "gracefully" as modules fail, with manufacturers claiming the airframe will be retired before their radar needs repairing.

The days of a fuzzy blip on a cathode ray tube are long gone, and radar is now an imaging sensor. Today, synthetic-aperture radar (SAR) processing produces high-resolution ground maps in fighter cockpits. Development of foliage-penetration (Fopen) SAR able to locate targets under trees is under way. Next up is the demonstration of interferometric SAR (InSAR), intended to generate high-resolution digital terrain-elevation data in real time, while tracking moving targets, enabling GPS-guided weapons to be targeted with greater precision. Work is now beginning on active-array laser radars (ladars), promising higher-resolution imaging.

Future of **FLIGHT**

Imaging the future

Advanced sensors like Fopen and InSAR are likely to be applied first to UAVs that are able to provide persistent surveillance over the battlefield. But the images will be sent direct to the cockpit via datalink as fighters become part of the battlefield network. Ultimately, if they prove affordable, such imaging capabilities are expected to be incorporated into fighter radars, giving the crew the capability and flexibility to locate and identify unplanned targets.

Managing the blizzard of information available from on- and off-board sensors is the greatest challenge facing cockpit designers. Adding direct in-flight control of UAVs and UCAVs, their sensors and weapons, will only complicate the task. A clear future direction is provided by the JSF, with its distributed infrared sensors providing a 360° view around the aircraft, presented on the helmet-mounted display so that the pilot can look in any direction – even through the cockpit floor – and see navigation and targeting information. This is the first step towards a totally synthetic cockpit environment, produced by fusing sensor information with onboard databases, which will allow the crew to fly and fight regardless of visibility.

As sensor and battle management assume greater importance, flying the aircraft is likely to become less a task for the crew and more a function of automation. Here the work being done to enable autonomous UCAV operations is key. The same knowledge-based software tools that allow ground controllers to plan UCAV missions will help crews of manned aircraft replan missions in flight as new target information becomes available.

Digital fly-by-wire flight controls have transformed the capability of combat aircraft, enabling aerodynamically less-than-ideal stealth designs to be made both agile and safe. Work on tailless fighter designs, including flight tests of Boeing's manoeuvrable X-36 and stealthy Bird of Prey, paved the way for the UCAV.

The tailless X-45 is the first aircraft to use fluidic thrust-vectoring. This injects air at key locations within the nozzle to provide multi-axis thrust vectoring. A low-observable, conformal fluidic nozzle is light-