Britain catches the data bus

The exchange of data among the dozens of avionics systems carried on military aircraft has become almost unmanageable. But now the excessive weight and complexity and poor reliability of such installations can be overcome by using a “data bus” on which information is multiplexed, or modified by adding an identifying message to each piece of data. There are several such systems in production—on the F-15, F-16, F-18 and Mirage 2000—but now emphasis is being given to standardisation, which should reduce the cost of future applications.

Basic research has been carried out in Britain by a team headed by Dr Tony Callaway at RAE Farnborough. His department has performed case studies based on current British military aircraft, and co-ordinated its research with organisations such as the US Air Force Avionics Laboratory at Wright-Patterson AFB. American companies produced data buses as early as 1969, when the F-15 design was being refined. Now about 85 per cent of all data passed between equipment in the F-15 are carried on a digital bus. The joint Anglo-American development effort has been well supported by the avionics industry in both countries, and within the last few months standardisation procedures have been outlined in US specification MIL-1553B.

Each avionics system is linked to the data bus in such a way that it can inject or extract data, and all information is “tagged” with a digital message identifying its destination and source. The data-extraction equipment in each system listens out, only accepting information prefixed with its own name. It then converts the data into a form usable in its own equipment, and then passes it on to other systems. It is possible to try to pass too much data down a single bus, but one system has usually proved able to accept all but the most high-integrity data (with an extremely high repetition rate, that is) in aircraft with a dozen or more sizeable avionic units. Two data buses can be used in parallel, one down each side of the aircraft, as a safeguard against battle damage, and it is common to have independent systems dedicated to important tasks such as fly-by-wire control.

The Farnborough team would have liked to see digital data-bus techniques used on the Tornado and Nimrod MR.2. But the international nature of Tornado and the relatively large amount of analogue equipment remaining on Nimrod did not make either an easy application.

Though each data-bus-based system has to have its own interface, microprocessor technology permits this to be built cheaply and without using more than one circuit card in each piece of equipment. Guided by the Farnborough and Wright-Patterson teams, industry has recognised that standardisation is necessary if the full cost benefits are to be realised. Interface equipment costs should therefore be more than offset by the savings from having fewer wires to install.

Reducing the wire content makes it possible to add new systems to the data bus as the aircraft grows in complexity. It also lessens the electromagnetic compatibility problem, which now represent a major headache for many systems designers. Total savings will be limited, as power supplies will still have to be wired individually to systems, while the large amounts of instrumentation wiring, although a future target for multiplexing on a data bus, have not been integrated in the latest generations of aircraft. Total weight saving on a military aircraft could amount to 200-400lb (90-180kg).

Integrity is not impaired by using a data bus, although there is always the risk that a break will cause all bus-linked systems to fail. It is expected that for this reason any installation will have at least two parallel data buses, and triplexed or quadriplex installations are not ruled out for high-integrity data transmission.

A fibre-optic data bus is unlikely to prove worthwhile unless electronic technology turns towards electro-optics after the microprocessor era. Fibre-optics can be used within systems—as in the Boeing YC-14 autopilot—to ensure the integrity of internal data transmissions, and a blend of different techniques suited to individual requirements is almost certain to develop. The emergence of common standards for data transmission could have long-term repercussions in the avionics industry. If equipment can be fitted into any data bus with only a single circuit-board change, big cost savings can be expected as systems are standardised and production runs extended.

The engineers responsible for integrating the F-16 and F-18 avionics have a data bus on their test rigs and can add equipment “box by box” in a manner which is impossible with a complex inter-connection system. Initial system integration on the F-16 was demonstrated in a one-week test, a far cry from the months of trials and tribulations which are the norm for this kind of work.

Tornado does use a multiplex system to link its air-data computer and main computer, and Farnborough fully expects that any future military aircraft designed in Britain will benefit from experience with this application and from the RAeS’s own research. In the US the F-111 and B-52 retrofit proposals have specified digital data buses, and the Space Shuttle has benefited enormously from data-bus-inspired weight savings. Current British research and development projects likely to use data buses are the WG.34 and AST.403.

The simplicity of the data bus below can be compared with the complexity of the interconnections used on a typical conventional installation right. The main computer is 1, radar and electro-optic sensors are 2 and 3, navigation and barometric sensors (Doppler, INS, AHRS and air data) are on the bottom line, and on-board systems (weapon-aiming, HUD, electronic displays) are on the top line.