Eurofighter Typhoon – Staying Ahead

Business Need

- To insert a new generation of processor technology to deliver improved performance and a clearer path for future upgrades.

Solution

- Designing and producing a reduced form factor version of Radstone's commercial PowerPC4A rugged single board computer.
- Sourcing and designing-in new components to meet low power consumption specifications.
- Innovative mechanical engineering to meet high levels of vibration.
- Reducing software development time via the Board Support Package.

Business Benefits

- Improved performance.
- Reduced cost of ownership.
- Strategy for countering component obsolescence.

Agile and stealthy, the twin-engine Eurofighter Typhoon is the world's most advanced multi-role combat aircraft, capable of operating from hastily prepared bases and small runways around the globe.

The aircraft's ability to deliver air dominance beyond visual range and in close combat - and high sortie rates in all weathers - is made possible by the unprecedented use of integrated flight control and avionics systems supporting the pilot.

RADSTONE TECHNOLOGY

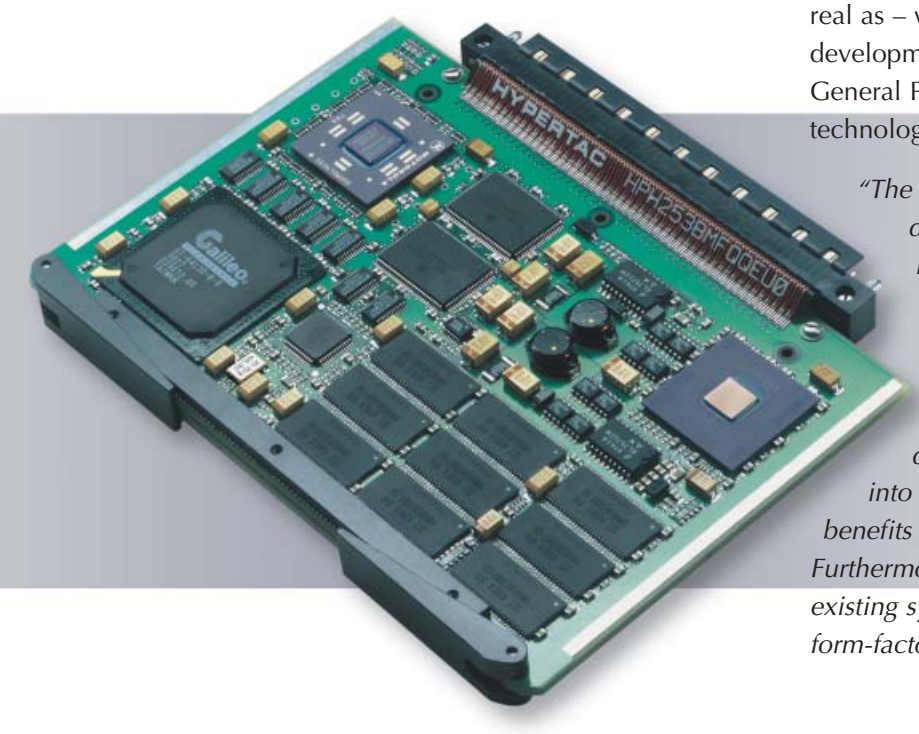
Why settle for less

Staying Ahead

To deliver unrivalled agility, power and multi-role capabilities – is at the heart of the designers' vision. But such is the unremitting pace of change in the world of commercial silicon that, still within its development phase, the Eurofighter program faced a major challenge. There was the need to insert a new generation of technology into one of the aircraft's key sub-systems – the Defensive Aids Sub-System (DASS) – that provides state-of-the-art, all round prioritized assessment and fully automated responses to single or multiple threats.

To help it meet that challenge BAE Systems, the prime contractor for the DASS, turned to Radstone Technology. Its response has been to develop a customized form-factor version of its PowerPC4A rugged single-board computer, combining cutting-edge design and production technologies with over 40 years of experience serving the defense industry. Five Radstone boards now lie at the heart of each Eurofighter DASS.

"Radstone understood our requirements very well," explains Richard Edwards, the Engineering Project Manager for the DASS at BAE Systems. *"They listened to us and didn't respond by asking us to make changes to our existing system; they worked with us to meet our exact requirements. Their people have a deep understanding of how to utilize commercial components in demanding environments and working with them we have been able to integrate leading-edge silicon into the program within a very demanding timescale."*



World-Leading Performance and Value

It is not just performance that sets the Eurofighter Typhoon apart from its rivals. From the start of the program, a strong emphasis has been placed on reducing cost of ownership in addition to delivering outstanding performance and flight safety.

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With the increased focus on smart procurement has come renewed interest in how to best take advantage of the economic and performance advantages of COTS (Commercial Off the Shelf) technology without compromising long-term system integrity.

For the DASS design team at BAE Systems in Stanmore, England, finding the answer to that question became very real as – with the system entering the final stages of its development phase – they decided to replace the original General Purpose Processor, based on Motorola 68020 technology, with a PowerPC-based solution.

"The original specification was written about a decade before," recalls Edwards. *"Technology had moved forward greatly since then, so in 1999 we decided to look towards inserting a new generation of silicon that promised better performance and a clearer path for future growth. Our design brief was clear, but demanding. We wanted to drop PowerPC boards into the current processor space and realize the benefits of increased performance from day one. Furthermore, because the new boards were going into an existing system, things like power, weight, interfaces and form-factor were not open for debate."*

With flight trials due to start in 2002, speed was of the essence. The initial development contract, won by Radstone following a stringent international tender, called for extremely aggressive timescales. Radstone delivered the first board to BAE Systems in just six months – on Christmas Eve 1999 – having completed several significant developments including:

- sourcing and designing-in new components to meet low power consumption specifications
- reducing the size of its commercial 6U processor boards by two-thirds to meet BAE Systems' exacting form-factor requirements, enhanced functionality and the resulting high component density
- mechanical engineering to ensure that the boards are able to withstand high levels of vibration
- reducing application software development time by migrating elements of BAE Systems' existing periphery software architecture on to a variant of Radstone's standard Board Support Package thereby providing a software emulation layer.

Stringent Power Requirements

The need to work within the DASS power envelope posed an immediate question for Radstone engineers because only 11 Watt were available as opposed to the 17.5 Watt typically drawn from Radstone's commercial boards.

Techniques to reduce power consumption such as removing Level 2 cache were not an option, so Radstone decided to source alternative components, balancing slightly less performance against much-reduced power requirements. The Tundra Universe VME controller was replaced by an IBM Alma controller, while the Motorola PMC 106 Northbridge was switched with the Galileo Terrano. Despite this, the new Radstone design offered BAE Systems a ten-fold increase in processor performance.

Reduced Form Factor – With Increased Functionality

One of Radstone's first tasks was to develop a board that matched the original 7 x 4 inch form factor – and the pin-outs – of the original design instead of the industry standard 9 x 6 inches. BAE Systems also required additional functionality over Radstone's standard PowerPC4A.

"We had a lot of development work and software invested in the DASS' legacy SDLC (Serial DataLink Controller) interface," explains Edwards. *"It was based on the 85230 Zylog interface chip, and we were keen to be able to port as much of our software as possible to the new chipset."*

Radstone's solution was to dedicate an engineer for six months to design and blow a new Field Programmable Gate Array (FPGA) that integrated the DASS' communications circuits to the Northbridge, including some additional functionality requested by BAE Systems.

Recognizing the importance of this part of the design, Radstone produced a trial board with the core FPGA mounted on a PMC module which sat on a standard processor card, so that BAE Systems could continue with software authoring in parallel with the development of the main processor design. More functionality was added later.

Richard Campbell, BAE Systems' Senior Software Engineer on the Eurofighter program, explains the significance of the module: *"Both we and Radstone recognized that this was one of the critical areas of the development. The module was a very good way of de-risking that part of the design, enabling us to work on the SDLC algorithms and porting software to VxWorks before we received the main card. Our ability to start testing was very significant because the SDLC code is very timing dependant and the use of faster processors required very thorough testing."*

Radstone recognized from the start of the program that the reduced form-factor and increased functionality also inevitably led to the need for very high component density on the board. One facet of the solution was the decision to use then innovative sequential build technology, which enabled placement of BGA components on both sides of the board irrespective of position. Radstone pushed its PCB (Printed Circuit Board) manufacturing partners to the limit with it's mechanical and electronic design engineers (equipped with state-of-the-art CAD (Computer Aided Design) tools such as Mentor Expedition PCB Design and Signal Integrity Analysis) designing complex networks of micro-vias with completely different patterns on each side of the board.

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Withstanding an Extremely Hostile Environment

Radstone designs rugged systems; it does not ruggedize commercial systems for a hostile environment. Its solutions can be found in the nose cones of torpedoes and orbiting the earth in the NASA International Space Station. Even so, with the Eurofighter DASS the company faced one of its most hostile environments yet.

"The environmental requirements set by the Eurofighter program were unusually severe – we have seen nothing quite like it before or since," admits Edwards. The reason is simple – the cards 'live' in the avionics bay of the Eurofighter, close to its guns and the vibration those guns create.

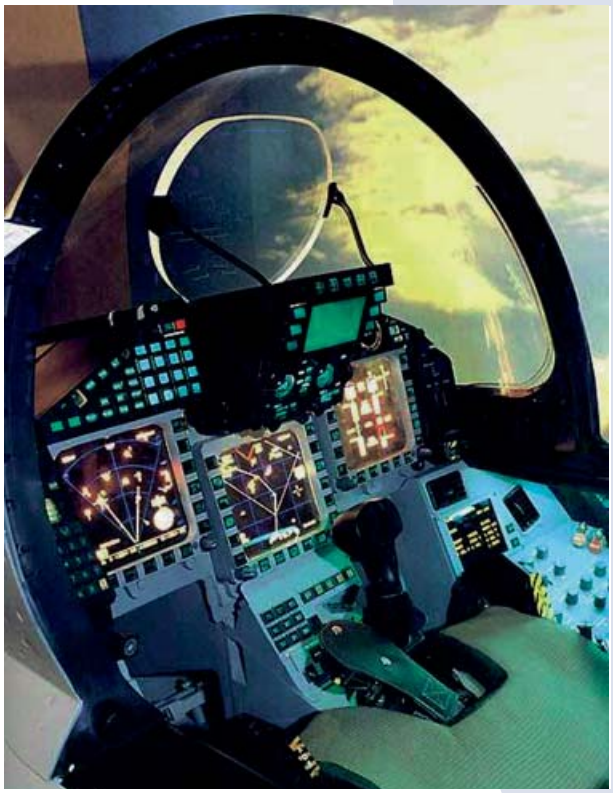
Hostile environments are, however, well understood by Radstone and are countered using a range of techniques.

The original DASS PCBs used a specialist manufacturing technique for which there was a price premium. In contrast, Radstone's commercial rugged PCBs are built to the company's design, with two thick copper cores, in addition to the signal layers, that act as both mechanical stiffeners and an integral part of the heat management system. Radstone's commercial board not only proved up to the environment, it also resulted in reduced board costs. One challenge facing Radstone, however, was that the physical space limitations of the DASS enclosure meant the company was not able to utilize its normal technique of using a stiffening bar to reduce vibration-induced flex across the PCB. Besides which, BAE Systems need access to a high-speed bus on one side of the card used for software testing.

It's said that necessity is the mother of invention, but the elegance of Radstone's solution belies its fresh thinking – a stiffening bar was actually soldered onto one side of the card, leaving free access to the high-speed bus on the other side.

Edwards also remembers being impressed by Radstone's approach to component placement and thermal management – both key to ensuring ruggedness.

A detailed component placement review by Radstone early in the design process, identified where best to sit components on the board in order to best match their characteristics to the stress across a PCB while keeping electrical connections as short as possible.



"Radstone's thermal management expertise was also impressive," recalls Edwards. *"They know their stuff backwards, using thermal imaging techniques that we hadn't previously seen."* Flomerics' Flotherm, an advanced computational fluid dynamics package, is used for 3D airflow simulations, while a variety of other systems provide comprehensive mechanical modeling capabilities. Thermal management even extended to the Radstone PCB being manufactured to match as closely as possible the thermal co-efficient of expansion of the components placed on it.

Software Support Critical

Software is typically the single largest investment made to any defense sub-system and the Eurofighter DASS was no exception. Hardware exists only to run the software and any changes to that environment have the potential to send costs skywards while performance stalls.

"Radstone's approach to the software environment is very good," explains Campbell. *"They aim to insulate the operating system and user's application software from the low-level hardware, and the fact that they have maintained the same form, fit and function across several generations of PowerPC products is impressive."*

In moving to a PowerPC solution, BAE Systems decided on VxWorks as the operating system and asked Radstone to write the Board Support Package (BSP) to facilitate porting the application to the new card. The new components on the board meant that Radstone software engineers exerted some two-man years writing the new BSP. *"It went smoothly,"* recalls Campbell. *"The BSP was fully tested using Wind River's BSP porting kit and we were provided with the full set of results. Because of the considerable time pressure of the project, Radstone provided us with early releases of the BSP so that we could keep working, with minor changes we requested being incorporated onto the final contracted cards."*

Radstone also provided BAE Systems with example source code for Built-In-Test. "Radstone's contribution to software development has been very good," says Campbell in summary. "They did the job well and met the timescales we needed."

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Whole Program Life COTS™ Working for the Long Term

While component obsolescence is the curse of COTS, Radstone has developed a holistic approach – Whole Program Life COTS – that addresses the issue at all stages of the program lifecycle. With cards now in production, the company's Product Lifecycle Management team closely monitors the program, including pro-actively auditing all key components every three months to ensure the earliest possible notification of parts being made obsolete. Already this has resulted in last-time buys of Alma chips which are now held by Radstone in its bonded and environmentally controlled facility, on behalf of BAE Systems.

"This was our first venture into COTS," admits Edwards, *"and we have noticed that Radstone take component obsolescence very seriously. In the past we have used military components which have a longer life, but for Radstone – working in the rugged COTS arena – it is almost a daily occurrence and one that they really understand and take steps to manage."*

Looking to the future, BAE Systems is already preparing to start discussions on the boards for Tranche 2 of the Eurofighter program, which will need to be available for integration in 2005. *"Component obsolescence is obviously an issue and will feature in our discussions with Radstone,"* says Edwards. Processing power will also be on the agenda. "The way that the Radstone BSP and VxWorks perform should give us future-proofing over a couple of generations of silicon at least," explains Campbell.

In the quest to ensure that the Eurofighter delivers on its *'Staying Ahead'* promise, BAE Systems looks to Radstone to help keep the DASS at the leading edge. *"Radstone is an extremely competent designer and manufacturer. Our relationship with the company and its people has developed during the program and I'd like to think that we have in Radstone a partner for the long term. We trust them,"* observes Edwards.

DASS – Performance Critical Pilot Support

The Eurofighter Typhoon cockpit is internationally recognized as the best of its generation with clear, easily interpreted displays automatically tailored for each specific phase of the mission. The information from a full suite of sensors is integrated through sensor fusion, and the cockpit provides the pilot with all the information needed in the right format in the right place at the right time.

In addition, Direct Voice Input (DVI) is used to control many aspects of the cockpit displays and assists the pilot in remaining head-out for longer than ever, enhancing the operational edge. This edge is sharpened even more with a world-leading DASS that offers unprecedented levels of protection and operational flexibility in response to known and unknown threats to the aircraft.

The DASS is fully integrated into the aircraft design and does not need to use any weapon stations. The state-of-the-art system provides front and rear Missile Approach Warners (MAW), decoy systems, chaff and flare dispensers, and laser warning. Stealth technologies have been incorporated in to the design features, minimizing the aircraft's radar signature.

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