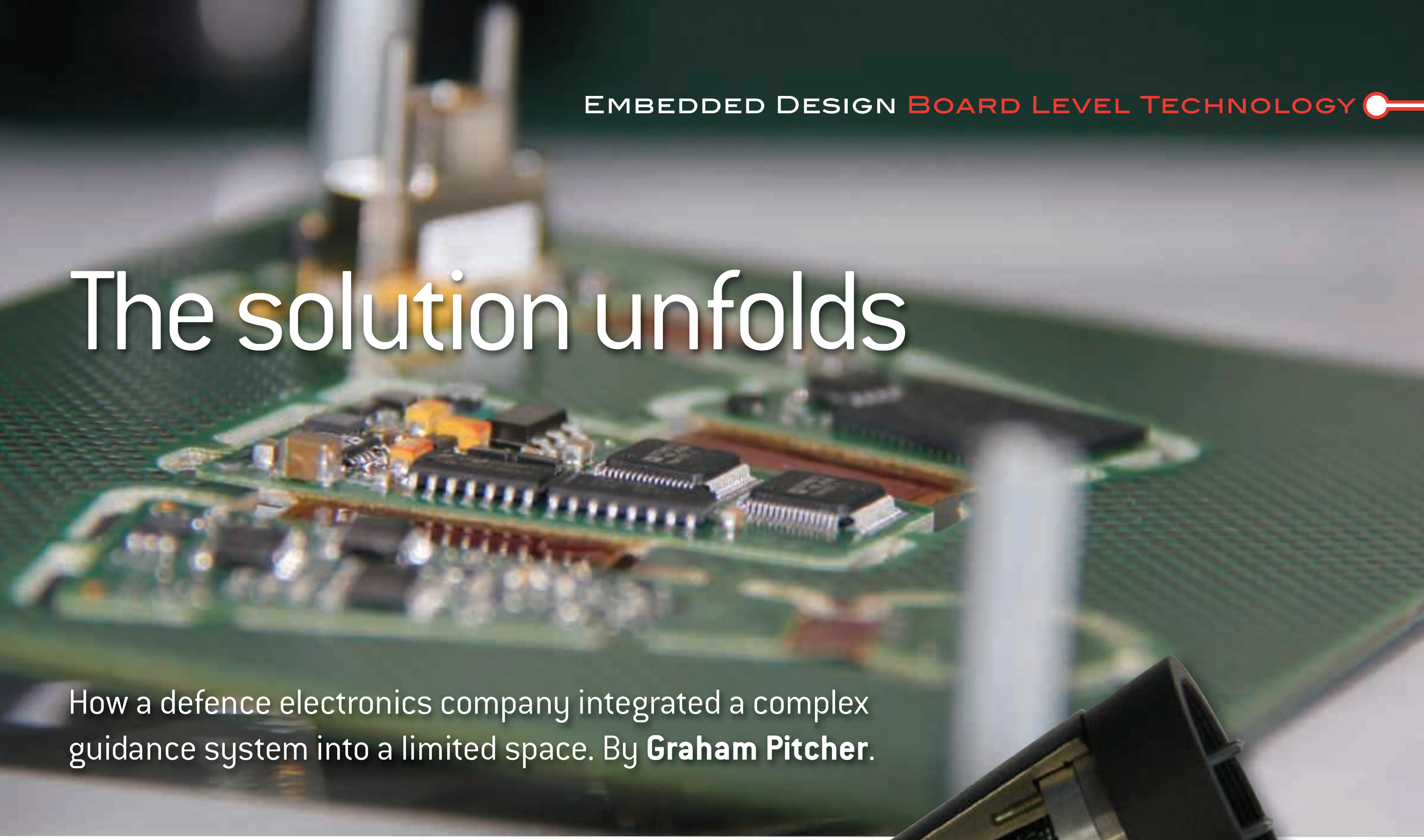


The solution unfolds

How a defence electronics company integrated a complex guidance system into a limited space. By **Graham Pitcher**.

Military applications present complex electronic design challenges as manufacturers look to take advantage of the latest technologies. The challenges increase when existing designs need to be revised for use in new systems.

Selex Galileo faced this problem when it looked to repackage a proven design into a new form factor. Its solution is a flexi-rigid board which can be accommodated in very small spaces within guided munitions. Such was the scale of the achievement that the project was named the best overall design in Mentor Graphics' 2012 Technology Leadership Awards. John Daly, head of capabilities with Selex Galileo, said: "It was a bit of a surprise, but we are extremely pleased."

Daly said the company has been using Mentor Graphics' tools for more than 10 years. "We've been using Expedition for the last couple of years and this is now used for all new projects at the Basildon site."

The board needs to resist thermal stress, high vibration and extreme shock. Robustness and reliability were major design criteria, requiring stringent placement and routing of components. Not only did the new design need to fit a predetermined conical space, it also had to be easy to manufacture and to meet an aggressive cost target.

The design integrates requirements from a number of existing semi active laser applications. These systems guide munitions towards a static or moving target identified by a laser. Daly said: "It's a well proven technology, but some weapons use old electronic designs. We've shrunk that into one of the smallest semi active lasers."

Using a flexi rigid pcb design allowed Selex Galileo to integrate electronics and optics in a limited volume

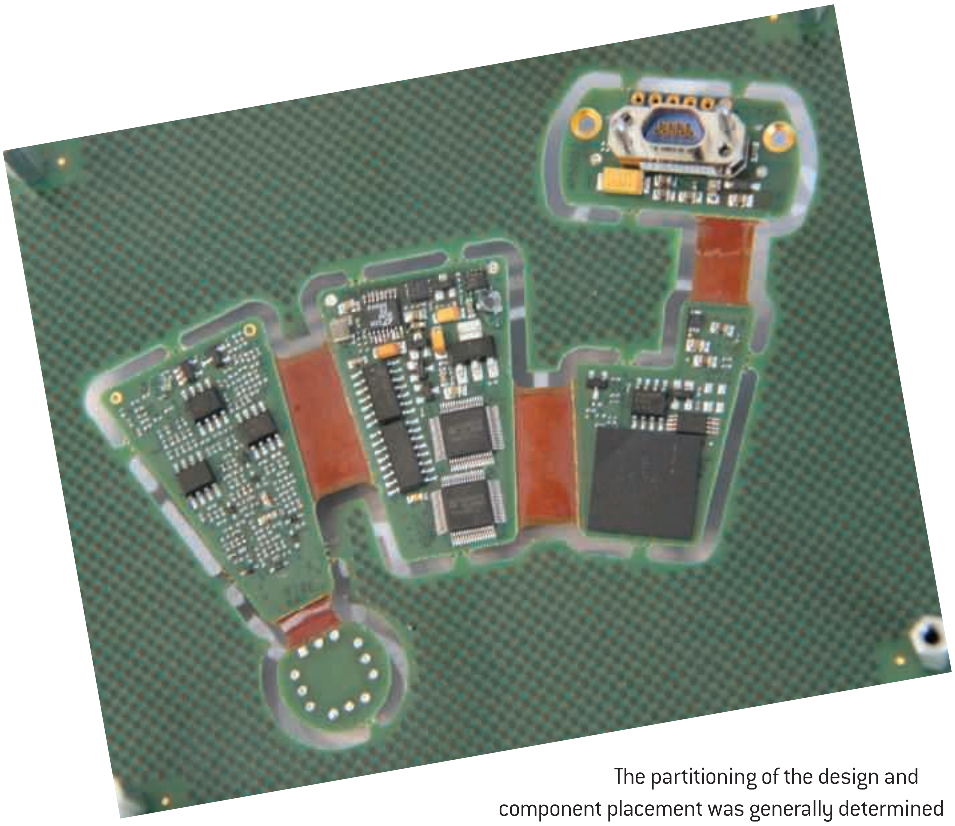
In the new format, the boards form a cone within a metal framework, which also integrates the optics. Redesigning the board has been a Selex Galileo initiative. Daly said: "We looked at customer requirements and knew there would be the need for this move." The project started some 18 months ago. Daly noted: "We took on board a number of requirements and pulled them together. Some needed very small solutions, which we thought would not be feasible. But, after discussion, we challenged the pcb, mechanical and optical engineering teams to come up with a solution and they came back with the concept."

The available volume meant it would not be possible to use connectors; the only viable solution was flexi rigid construction. There are five rigid pcb sections, with a 12 layer stackup and an overall thickness of 1.7mm. There are four flexi layers, with four rigid layers either side. Because of the design constraints, only through vias are used.

One of the flexi limbs has three layers dedicated to power and one to signal tracking, while another features two layers for signals and two layers for power.

Daly said a number of design options were considered. "We had one solution with three boards, another with four. But we wanted to find one design that would support all the different interfaces we needed, as well as the power requirements."

Selex also realised the space available for the new design meant its existing design rules would not be suitable. This required the teams to work closely with their chosen board manufacturer to develop a strategy that would



allow them to place and route the design.

The most complex elements in the redesigned system are two a/d converters housed in 0.4mm pitch lqfps. This pin pitch, said Selex, coupled with a small board which doesn't use high density interconnect, meant breaking these devices out for routing was extremely difficult without the use of microvias.

Because only through hole technology was available, the solution was to use an aspect ratio of 8.5:1 – very large for a flexi-rigid design – to reduce the pad size. The connections also had to escape from the pins, so the track widths and clearances in those areas also needed to be reduced. As these changes could have a large effect on yield, it was agreed to minimise the number of design rule adjustments made throughout the layout.

Daly noted: "The a/d converters featured a 0.4mm pin pitch and that's something we wouldn't normally specify. That made the design phase pretty difficult and, because we decided to use through vias, rather than microvias, the design process became more complex."

The elements of the design allow the boards to fold around each other within a conical space. "Our challenge was to think in 3d," said Daly, "not in the normal orthogonal manner. The boards had to be connected at different angles so they formed a cone."

The partitioning of the design and component placement was generally determined by the interconnects and by the flow of the signals through the circuit. In order to fit all the components in the design, some had to be placed at an angle. Although the board is double-sided, the major components are placed so they face inwards when the design is assembled. This limits the use of the secondary side.

Daly: "Because we decided to use through vias, rather than microvias, the design process became more complex."

With the design folding into a given space, there was the possibility of collisions between components. Following an initial phase, where electronic and mechanical designers worked together to avoid clearance problems, the layout was exported to Pro/Engineer. At this point, it was found there was insufficient clearance between an 11mm high component and the digital board alongside it. To overcome this, the mechanical team defined a new outline for the digital, including a cutout, and exported it to the pcb design tool.

Selex said the use of 3d checking enabled the design team to optimise the use of available space by allowing component bodies to overhang board edges if necessary, knowing this would not impact other parts of the design.

Rule areas were used to define where large aspect ratio vias could be placed, as well as where reduced track and gap was needed. The team also had to use an alternative rule set in other locations to complete the routing. Each rule relaxation was discussed with the fabricator to determine the risk factors and Valor NPI was used to ensure none of these areas were missed.

All angle routing

When developed into a flat shape, all rigid sections but one lie at an angle. Although modern tools can handle this, the layout designer had to rotate the components and then route with 'all angle routing on'. Meanwhile, the mechanical team created two board outlines: one, a fully developed view with the boards at the correct angles for final product fabrication; the second with all rigid sections positioned in the orthogonal plane.

The second outline was used to generate the design, which meant all components and traces would be placed and routed orthogonally, speeding the design process.

Once complete, the layout engineers used 'Copy Move Circuit' to select and copy the rigid section components and traces from the orthogonal representation to the fully developed design using known origin or snap locations.

While most applications for the new design are for semi active laser guidance, one specific use is as the fire sensor on front of round of ammunition. "This will typically have to withstand 20,000g," Daly said. "It has brought some interesting systems engineering issues," he concluded.