From custom built to off-the-shelf

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The MOD is showing great interest in commercial off-the-shelf (COTS) technologies, both for infrastructure such as DII and for technology platforms. It is likely to be key in future platform developments such as Network Enabled Capability and Future Carrier.

In the US, there has been a considerable development effort with COTS, some of which has contributed to the development of Network Centric Warfare concepts.

F-35 cockpit - network centric warfare concepts are driving COTS adoption

Twenty years ago, almost all technology was custom-built. From computer hardware to the electronics in guided missiles, everything was the result of custom design. Engineers worked within companies to produce proprietary solutions, often in conditions of complete secrecy. Even the hardware used for simple office functions like word processing and accounts was custom-built, as was the software that ran over them.

A decade ago that all began to change. The 1980s saw the development of Open Systems, which would help to standardise software development, and lead to ANSI and POSIX definitions. PCs arrived, a de facto standard for desktop computers, while the bigger computing world moved towards standardising on various flavours of Unix and RISC computing.

PCs are the ultimate COTS machines. Whichever manufacturer they come from, they're effectively interchangeable. Any PC of the same type will run exactly the same applications. That's because not only the software but even the hardware is highly standardised. A good proportion of PCs sold today in Europe are built by small businesses, often only one or two men, because the modern PC is as standardised as Meccano.

But it's the advent of cheaper memory and faster processors that is giving COTS the advantage in weapons platforms. Where once advanced functions demanded careful programming to exact the last ounce of performance from an embedded system, today memory and processors are so cheap that standardised hardware and software can be used for the most specialist embedded applications.

The reasons for the rise of COTS owes a lot to the failure of custom-built systems, according to Steve Jones, Consulting Principal for Defence at Hewlett-Packard UK: "Commercial off-the-shelf is attractive because of a long and undistinguished history of large-scale bespoke projects going horribly wrong for UK Government. They go over budget typically, and there are plenty of examples of this. They exceed timescales. Often, they don't deliver what was first

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promised. And this applies right across industry. There's been a very clear legacy from bespoke projects."

UK Future Carrier: cost pressures and future-proofing increasingly favour COTS adoption

In the US, the main driver for adoption of COTS has been the clear technology advantages it offers. "Access to the latest technology is really the biggest advantage of COTS", says Jeff Jussel, VP Marketing at defence technology developer Celoxica. "The branches of service here in the US have got together and are using COTS for their advantage. Rather than using it just as a cost reduction exercise, they put together programmes to take advantage of one the most interesting things that COTS brings, which is access to new types of technology. COTS gives you broader access to technology, and it gives you access to newer types of technology."

"In the early Eighties I worked on an army radio development programme", says Jussel. "One of our constant questions was: why does our radio weigh 100lbs and have to be packed in by a communications officer, when you can go buy a cellphone, which in the early Eighties might have looked like a brick, but was pretty small and portable? Well, you just don't get that disparity today because of COTS. The bigger the community you can draw from the better the technology will be, the more mature and developed it will be. If you limit yourself to just what's been done in a couple of defence companies, then obviously you're going to limit the technology you have access to, and everything is going to take longer. To me, COTS is all about keeping up with the pace of technology."

According to HP's Steve Jones, there are three potential groups of COTS users within UK defence: "There is the wider MOD which embraces all civil servants, and all its contractors and consultants. Most of these people work on restricted or unclassified networks, and standard systems work perfectly well for them. The next layer is specific functions with security classifications. An example would be mission support systems. Standard COTS equipment does provide sufficient robustness for these kind of tasks. It does also provide real benefits in terms of price. But along with this must go a fairly high degree of planning and control in the design of the systems to ensure security and authentication are maintained at the highest levels. So it becomes a fine point whether a COTS system, with all the management issues involved, is a more economical solution than a system built from the ground up, to order. It will probably differ from application to application."

Jones warns that COTS is not necessarily the panacea it appears: "Buyers need to ask themselves: does buying COTS introduce a compromise. It depends on whether you fit the budget to the task, or the task to the budget. But frequently with COTS, it will involve some kind of compromise. You could be spending more money than you need to, because you're taking a one size fits all approach, which to work must involve a large amount of redundant functionality, and hence a large processing and performance overhead. Or you're making a compromise with the way you're completing the task, because you're doing less to fit the functionality of a smaller COTS system you've opted for."

With embedded systems for battlespace deployment, one of the key issues is component availability. Opponents of COTS have seen the high obsolescence rate of commercial components as a major reason why COTS is unsuitable for the defence market. Custom-built systems are maintained over decades, but commercial components can be obsolete and impossible to source within just months.

"I think there are real issues with COTS-based systems in this

space", says Jones. "The typical life of a chipset is around six to eight months. It's commercial pressures that drive this short catalogue life for components, and it's a major factor in continually driving down the cost of commercial products. But it runs counter to the needs of the military, who absolutely demand assurance that the performance of the kit is within a specified set of parameters, but commercial pressures will continually stay ahead of the ability to respond. The danger is that you can end up with a continuous rolling evaluation of military equipment which is expensive, unproductive and difficult because of the exacting standards they must meet."

Eurofighter: modern weapons platforms are increasingly adopting COTS

Celoxica's Jussel believes that COTS helps keep embedded systems abreast of the latest technology: "Modularity of design helps protect against component obsolescence. We've been working with an army led project in the US where they've been trying to minimise obsolescence by making everything modular, by being able to substitute things in and out very quickly. In the US in particular, they're using COTS to reduce the vulnerability of systems. If I'm using a commercially off-the-shelf part, and I'm not depending on that brand being around and there are many sources for that, then I can switch easily to another supplier. If I architect my system properly, then I can also switch to the latest technology very easily. So overall, I am less vulnerable with COTS."

Bob Morris, VP of Marketing at COTS software developer LynuxWorks, says component obsolescence and sourcing problems are nothing new: it's been a problem for defence users for decades: "Grey market sourcing is a real issue. It's been an issue for at least 25 years, way before there was ever COTS. It's definitely an issue on the hardware side as vendors have moved from different bus structures, and different bridge chips, and they move pretty fast. Nowadays, we can mitigate that by using a COTS OS. Someone like us, when vendors change a bridge chip or change a processor, we just have to do a different board support package. So their applications will still fully function. We might have to develop new drivers to support a new board, but the applications remain intact. It's actually a worse problem if they use a proprietary OS, especially if it's a flat address model OS, because then they have to change their OS and they have to change the hardware. If they're using commercial boards, we make sure that the OS works with all the commercial boards. Using a COTS OS, it's much easier to switch a COTS board, and mitigate their costs."

Another issue for opponents of embedded COTS is the greater complexity of many COTS systems. "Can COTS increase complexity?", asks Celoxica's Jeff Jussel: "It can, if you don't plan properly for it up-front. I think that's one of the strengths of the US approach. Everything's been driven from one of the branches of the services or by several branches working together. They define up-front what the architecture is going to look like and then they define the modules."

"COTS shouldn't increase complexity", claims Jussel. "In fact, COTS FPGAs reduce design complexity, because you don't have to do the translation to another language. It also makes it easier to get from your algorithm directly to the actual implementation. So from that standpoint, it actually helps reduce complexity."

"COTS can entail greater complexity," admits LynuxWorks' Morris, "because you're trying to be all things to all men with a generalised platform rather than a dedicated

one. So defence contractors have to deal with this. There isn't a performance hit, but there is a hit in the size, particularly in extra money. And that implies a cost issue with COTS."

'What's the cost of 500Kb of RAM today?'

"If you look at a microkernal developed in a proprietary fashion, that might be 150Kb in memory. A wholly conformant POSIX real-time operating system like LynxOS would be around 500Kb, so that's about three times bigger in memory terms. But what's the cost of 500Kb of RAM today? It's really not much. So the argument is, in military parlance, overcome by events. RAMS are just so inexpensive."

"There's another argument against depending on a lot of RAM memory," continues Morris, "and that is you've more items for failure. And that's certainly true. That's why people add in more memory to allow redundancy. Modern memory also has millions of hours in mean time between failure, so it's becoming less and less of an issue. In fact, COTS can help eliminate memory failure as a vulnerability. The fact that real-time COTS OSs support MMU, if part of the memory goes bad, then the MMU will simply block that out and will recover the operation. A lot of internal, non-COTS OSs have a flat address space. That means that there's a set of memory that the system needs to access all the time. If anything goes wrong with the memory, the system freezes. This is the problem that the Mars Rover had. It suffered problems with its flash memory which took the whole system down with it. If you have an embedded system with MMU, then if you have problems with the memory, then the MMU will automatically deal with it and the application will never know there was a problem. So you have better reliability than microkernals with a flat address model, which is what most proprietary OSs are."

Lifetime management of systems is another area where many defence contractors point to problems with COTS sourced systems. But for Morris, lifetime management can be a real plus with COTS: "It's actually easier to do proper lifetime management, if the system is specified to be fully COTS. There can be real cost savings built-in, not only in capital costs, but in terms of lifetime costs. You're not dependent on the developments of a single supplier: you've got the whole industry keeping the technology up-to-date. And that industry pressure keeps the cost of refreshes down, because if it's properly open, then you can go to other suppliers. From the defence contractor's point of view, he's got to remain competitive in order to get the refresh business. So he can no longer charge the three, four, five times premium that he used to charge for a technology insertion."

But lifetime management is simpler with a 100% COTS solution. Systems that pick and mix COTS and custom solutions lose many of the benefits of COTS. "If you take COTS to its ultimate conclusion using all COTS components, that makes it much easier than using selected COTS components", says Morris. "If you go for a complete COTS board together with a COTS OS, all the COTS OS suppliers will support that board. That board will have everything you need. You can eliminate the parts of the board you don't need, and the COTS OS will take advantage of that by simply not loading the drivers, so you reduce overhead. As that board matures, the OS vendors keep pace with the latest boards. If I use a COTS board, but with custom components on it, then I'm introducing all sorts of problems. It's going to need all sorts of custom drivers, and the OS will have to be modified. And if I want to move to a new processor, then I won't get any of the economies of the marketplace, because I'll have to pay the OS vendor to produce a new customised OS for me, with updated drivers. From a life-cycle management perspective, you really want to go for a completely COTS solution to really achieve market value."

For HP's Steve Jones, defence ministries can no longer dictate the development of technology and keep abreast of technology developments: "A problem, particularly for the UK MOD, is that it's no longer a market in its own right. It's not sufficiently big to create a standard of its own, and achieve economies of scale from large manufacturers. So the question then is: should the UK MOD use what the US does? Yes, is the answer, because we already do that with defence equipment already. But there's a catch. There's a real danger of de-skilling your national resources. So you deplete your UK-based resources, which in defence can be a real issue. Sometime in the future, we'll see the development of a technology market focused around the group of five countries in the Technical Co-operation Programme. This will be big enough to generate an economically viable market for a dedicated off-the-shelf defence technology market. But we're far from it at the moment."