HOW AI IS CHANGING THE FACE OF DEFENCE

As investment accelerates how are militaries around the world using AI and machine learning?
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The changing nature of defence

Next month sees DSEI, one of the world’s biggest defence and security shows, returning to the UK. Held at the ExCel arena in London’s docklands on the 10-13 September it looks to connect governments, national armed forces, industry leaders and the defence supply chain.

It takes place during a period of profound change with a growing number of countries investing in AI and machine learning and developing programmes to support advanced weapons systems.

The US, China, Russia, France and the UK are investing billions in these technologies, and the commercial opportunities for the likes of Oracle, IBM, Google and SAP are huge.

The scope of AI and machine learning and their application by the military is far broader than simply ‘killer robots’ or autonomous weapons, yet the military application of these technologies is critical and there is certainly a big push towards the development of technologies that will better protect servicemen and place machines, rather than personnel, in the front line.

While AI weapons are a stark reality, many of the deployments involve uses of the tech in automated diagnostics, defensive cybersecurity and hardware maintenance assistance.

AI and machine learning are opening up new opportunities for the military too and playing an increasingly important role in new forms of warfare – such as psychological in the form of fake news and the spread of miss-information.

The use of AI brings serious ethical concerns and calls for civilian over-sight of AI research. There are also calls for more open research and dialogue between nations due to fears that unregulated AI could ultimately lead to an international arms race.

The US has suggested that there needs to be a thoughtful and more human centric approach to the use if AI in the military, and that’s an approach that should be welcomed.

Yet discussion around the use of AI is complicated. Is it ethical not to use AI if you could save lives or shorten a conflict and if, as a country, you face an enemy with AI capabilities shouldn’t you be looking to match those capabilities?

The very nature of warfare is changing and will only accelerate as this technology becomes ever more pervasive.

Neil Tyler, Editor (neil.tyler@markallengroup.com)

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Rust programming language application for IoT device

ENGINEERING CONSULTANCY ANNOUNCES WORLD FIRST FOR RUST PROGRAMMING LANGUAGE APPLICATION. NEIL TYLER REPORTS

The product design and engineering consultancy, 42 Technology, has announced the world’s first Rust programming language application for a single-chip Internet of Things (IoT) device.

According to 42 Technology, this software could help accelerate the development of more robust and secure low cost, low powered cellular IoT products and systems, and play a crucial role in unlocking significant new markets for smart industrial and consumer products such as real-time asset tracking and monitoring, utility metering and smart city technology.

Rust is described as a high performance alternative to systems programming languages such as C and C++, which avoids the memory safety issues that tends to affect those languages and can be used without the complexity and overhead of Java.

42 Technology’s application demo is based around the Nordic Semiconductor nRF9160 System in Package (SiP) device, which features a full multimode LTE-M/NB-IoT modem to connect to the mobile network, assisted GPS and an ARM Cortex-M33 processor. The ARMv8-M architecture’s TrustZone security features allow applications and associated services to operate securely, protected from hacking, misuse and corruption.

High-density 3D stack test chip

GLOBALFOUNDRIES has taped-out an Arm-based 3D high-density test chip suitable for computing applications such as AI/ML and high-end consumer mobile and wireless solutions.

The chip was fabricated using GF’s 12nm Leading-Performance (L2LP) FinFET process and features Arm’s mesh interconnect technology in 3D that allows data to take a more direct path to other cores, minimising latency while increasing data transfer rates.

The chip demonstrates the progress that Arm and GF are making in researching and developing differentiated solutions that enable improvements in device density and performance for high-performance computing.

“Arm’s interconnect technology in 3D enables the semiconductor industry to augment Moore’s Law to address a greater diversity of computing applications,” said Eric Hennenhofer, vice president, Arm Research.

“GF’s expertise in fabrication and advanced packaging capabilities, combined with Arm technology, gives our mutual partners additional differentiation to venture into new paradigms for next generation, high-performance computing.”

Scientists create the world’s thinnest gold

Scientists at the University of Leeds have created a new form of gold with a thickness of just 0.47 nanometres. The material is regarded as 2D because it comprises of only two layers of atoms sitting on top of one another. All atoms are surface atoms - there are no ‘bulk’ atoms hidden beneath the surface.

The material could have wide-scale applications and be the basis of future electrical components.

Laboratory tests show that the ultra-thin gold is 10 times more efficient as a catalytic substrate than the currently used gold nanoparticles, which are 3D materials with the majority of atoms residing in the bulk rather than at the surface.

Synthesising the gold nanosheet takes place in an aqueous solution with chloroauric acid, an inorganic substance that contains gold. It is reduced to its metallic form in the presence of a ‘confinement agent’ - a chemical that encourages the gold to form as a sheet.

Professor Stephen Evans, head of the Leeds’ Molecular and Nanoscale Research Group, said: “Gold is a highly effective catalyst. Because the nanosheets are so thin, just about every gold atom plays a part in the catalysis.”
Intel and HPE to boost workload acceleration

Intel has announced that it is working with Hewlett Packard Enterprise (HPE) to provide increased workload acceleration capacity for the HPE ProLiant DL380 Gen10 server.

The move looks to address computing intensive markets, like streaming analytics, media transcoding, financial technology, and network security. The new high-performance Intel FPGA Programmable Acceleration Card (Intel FPGA PAC) D5005 is the second card in the Intel PAC Portfolio and is now shipping in the HPE ProLiant DL3809 Gen10 server.

Applications like streaming analytics, artificial intelligence (including speech to text), and media transcoding require large amounts of computational capability to meet increasing demands. Data centre customers use hardware accelerators for specific workloads and by diverting such tasks to tailored hardware accelerators it’s possible to offload suitable workloads and free up a server’s CPU cycles for higher-value workloads. By offloading appropriate workloads data centre operators can reduce total cost of ownership.

The Intel FPGA PAC D5005, offers more logic, memory and networking capability than previous PACs. The D5005 is now qualified in the HPE ProLiant DL380 Gen10 server, offering customers a higher performance PAC option in addition to the already shipping Intel PAC with Intel Arria 10 GX FPGA.

HPE is the first server OEM to announce pre-qualification of the Intel FPGA PAC D5005 accelerator card for use with its servers, specifically the HPE ProLiant DL380 Gen10 server. Other server vendors are also qualifying the Intel FPGA PAC D5005 accelerator card.

Soft wearable health monitor

A SOFT WEARABLE HEALTH MONITOR THAT USES STRETCHABLE ELECTRONICS HAS BEEN DEVELOPED BY SCIENTISTS. NEIL TYLER REPORTS

Scientists from the Georgia Institute of Technology have developed a wireless, wearable monitor built with stretchable electronics which could allow comfortable, long-term health monitoring without concern for skin injury or allergic reactions caused by conventional adhesive sensors with conductive gels.

The monitor can broadcast electrocardiogram (ECG), heart rate, respiratory rate and motion activity data as much as 15 meters to a portable recording device such as a smartphone or tablet computer. The electronics are mounted on a stretchable substrate and connected to gold, skin-like electrodes through printed connectors that can stretch with the medical film in which they are embedded.

“This health monitor has a key advantage for young children who are always moving, since the soft conformal device can accommodate that activity with a gentle integration onto the skin,” said Woon-Hong Yeo, an assistant professor in the George W. Woodruff School of Mechanical Engineering and Wallace H. Coulter Department of Biomedical Engineering at the Georgia Institute of Technology.

Because the device conforms to the skin, it avoids signal issues that can be created by the motion of the typical metal-gel electrodes across the skin and can obtain accurate signals from a person who is walking, running or climbing stairs.

The monitor uses three gold electrodes embedded in the film that also contains the electronic processing equipment. The entire health monitor is just three inches in diameter, and a more advanced version under development will be half that size. The wireless monitor is now powered by a small rechargeable battery, but future versions may replace the battery with an external radio-frequency charging system.

Two versions of the monitor have been developed. One is based on medical tape and designed for short-term use in a hospital or other care facility, while the other uses a soft elastomer medical film approved for use in wound care. The latter can remain on the skin longer.

Fabrication of the monitor’s circuitry uses thin-film, mesh-like patterns of copper that can flex with the soft substrate. The chips are the only part that’s not flexible, but they are mounted on the strain-isolated soft substrate instead of a traditional plastic circuit board.

As next steps, Yeo plans to reduce the size of the device and add features to measure other health-related parameters such as temperature, blood oxygen and blood pressure. A major milestone would be a clinical trial to evaluate performance against conventional health monitors.

Semiconductor IP development

Agile Analog, a Cambridge-based analogue IP company, has successfully been awarded funding from Innovate UK, the UK’s innovation agency, to accelerate their new product development.

The project, totalling around £1m, will be 45% funded by Innovate UK and will extend Agile Analog’s leading edge, AI-driven technology to address much higher complexity analogue IP, and result in a large expansion of products available to Agile Analog’s customers.

Analogue IP, or analogue circuits, are needed on microchips as they provide the connection between the real world and the digital world. Agile Analog has developed a technology to automate the design and delivery of these circuits.

Agile Analog says that its design technology is programmatic, systematic and repeatable leading to IP that is more verifiable, more robust and more reliable. The availability of high-quality analogue IP enables the company’s customers to integrate more functionality on chip.

The two-year project will focus on enhancing the company’s technology to develop new categories of IP that will complement its existing range of products. These components can then in turn be further integrated to provide even more complex analogue systems.
Xilinx unveils adaptable accelerator card

XILINX HAS EXPANDED ITS ALVEO DATA CENTRE ACCELERATOR CARD PORTFOLIO WITH THE LAUNCH OF THE ALVEO U50. NEIL TYLER REPORTS

The Alveo U50 card from Xilinx is the first low profile adaptable accelerator with PCIe Gen 4 support and has been designed to ‘supercharge’ a broad range of critical compute, network and storage workloads, all on one reconfigurable platform, according to the company.

The card provides customers with a programmable low profile and low-power accelerator platform built for scale-out architectures and domain-specific acceleration of any server deployment, on-premise, in the cloud and at the edge.

“Ever-growing demands on the data centre are pushing existing infrastructure to its limit, driving the need for adaptable solutions that can optimise performance across a broad range of workloads and extend the lifecycle of existing infrastructure, ultimately reducing TCO,” said Saidel Raje, executive vice president and general manager, Data Center Group, at Xilinx.

The Alveo U50 is able to deliver between 10-20x improvements in throughput, latency and power efficiency. For accelerated networking and storage workloads, it has been designed to help developers identify and eliminate latency and data movement bottlenecks by moving compute closer to the data.

Powered by Xilinx’s UltraScale+ architecture, the U50 is the first in the Alveo portfolio to be packaged in a half-height, half-length form factor and low 75W power envelope. It features high-bandwidth memory (HBM2), 100 gigabit per second (100 Gbps) networking connectivity, and support for the PCIe Gen 4 and CCIX interconnects.

By fitting into standard PCIe server slots and using one-third the power, it helps to significantly expand the scope in which adaptable acceleration can be deployed to unlock throughput and latency improvements for demanding compute, network and storage workloads. The 8GB of HBM2 delivers over 400 Gbps data transfer speeds and the QSFP ports provide up to 100 Gbps network connectivity.

The high-speed networking I/O also supports advanced applications like NVMe-oF solutions (NVM Express over Fabrics), disaggregated computational storage and specialised financial services applications.

Fixing UK 5G blackspots

Ranplan Wireless is collaborating with the University of Warwick on a project funded by Innovate UK’s Geospatial Commission to identify wireless blackspots to support the rollout of 5G and help improve coverage.

The COCKPIT-5G project will use crowd blackspot intelligence sourcing and social media techniques along with sophisticated real-time natural language processing to curate consumer data and build up an accurate connectivity map of the UK.

The rollout of 5G in the UK will see new cell sites address the problems of service blackspots and meet the demand for new services to support autonomous vehicles, AI and the growing digital economy.

The COCKPIT-5G project leverages the latest and best cutting-edge advances in social media viral campaigns and natural language machine learning to automatically build a database of blackspots and their geospatial and contextual information by understanding the consumer experience in real-time.

“The aim of the project is to use customer-centric data to improve network deployment efficiency and increase user satisfaction,” said Jie Zhang, Chief Scientific Officer at Ranplan. “The vision is for 5G wireless networks to self-regulate as this is the future of managing complex ‘on demand’ connectivity in dense environments. By being able to identify coverage blackspots means that operators can also more precisely determine where to place additional small cells to ensure quality of service and save on CAPEX.”

CEVA and Immervision in strategic partnership

CEVA, a licensor of wireless connectivity and smart sensing technologies, has entered into a strategic partnership agreement with Immervision, a Canadian company that develops and licenses wide-angle lenses and image processing technologies. Its patented image enhancement algorithms and software technologies deliver significant improvements in image quality and remove the inherent distortions associated with the use of wide-angle cameras.

Under the partnership agreement, CEVA has made a $10 million technology investment to secure exclusive licensing rights to Immervision’s advanced portfolio of wide-angle image processing technology and software.

This includes real-time adaptive de-warping, stitching, image colour and contrast enhancement, and electronic image stabilisation. CEVA will also license the company’s Data-in-Picture proprietary technology, which integrates within each video frame fused sensory data. This adds contextual information to each frame that enables better image quality, video stabilisation and accurate machine vision in AI applications.

The companies will also collaborate in licensing full end-to-end solutions comprised of Immervision’s patented wide-angle Panomorph optical lens design and the complementary image enhancement software.

Commenting Gideon Wertheizer, CEO of CEVA, said: “This strategic partnership and technology investment provides CEVA with a significant market advantage for the fast growing wide-angle camera market, particularly in smartphones, surveillance, ADAS and robotics.”
There is little doubt that many electronics businesses continue to be uncertain over the notion of IP and what it means to protect it. Busy innovators can obviously be forgiven for focusing their efforts on tangible developments to bring to market. But failing to protect the ‘crown jewels’ in any organisation can leave the door wide open for competitors to grab a free ride on the back of all your hard work.

The electronics industry is, by and large, dominated by a volume market, where innovation largely occurs incrementally and there is a number of big players with innovation departments and budgets to match. That means a smaller enterprise looking to carve out its own space in the market must keep innovating to stand out.

In our experience, a smaller player with strong IP can present a serious challenge to the big boys. IP disputes between the larger players very often get resolved through negotiation, but smaller firms that can robustly defend their commercial activities can also enjoy considerable success.

Some people argue that IP protection can curtail collaboration in new technologies such as autonomous driving. In that industry, though, the real barrier arguably is the lack of infrastructure to fully promote innovations. Electric vehicle companies such as Toyota and Tesla have released some of their patent portfolios for royalty-free use (with conditions). There is debate as to their motivation for doing this; but the business rationale is likely to be that they wish to encourage growth of the marketplace as this probably will lead to dividends for them in the end.

While robust IP protection requires funding, it should really be seen as an investment as opposed to a mere cost. It needn’t always come at a high price either. There are many resources available to smaller firms from the UK Intellectual Property Office (UKIPO), that will very often give guidance and support to SMEs for free. What’s more, electronics businesses won’t always need to seek the highest level of protection through a traditional patent. Different levels of IP protection are available to suit different requirements and indeed budgets, meaning businesses can tailor a regime of protection accordingly.

For example in contrast to a patent, which lasts 20 years, a ‘petty patent’ is a shorter-term and often cost-effective way of protecting invention. Petty patents are available in more than 50 countries including France, Germany, the US, Japan and China.

Such protection is not currently available in the UK however. The current regime for patenting in the electronics industry is well established in this country, with little change on the horizon likely even though it can be hard to obtain full patent protection for some algorithm-based inventions.

At a time when global AI patent activity is significantly increasing, often using known AI building blocks applied to new areas, further innovation could be unlocked in the UK if this shorter-term option for fast-moving and shorter lifespan developments was available.

Ultimately, some hands-on innovators may be reluctant to work with professional advisers, especially when budgets are tight. In our experience, however, those who truly grasp the extent of their IP and take appropriate steps to safeguard it from competitors stand best placed to reap the innovation rewards over the long term.

Saiful Khan is a partner and electronics industry specialist at IP law firm, Potter Clarkson.

**The case for robust IP protection**

**TAKING THE APPROPRIATE STEPS TO SAFEGUARD YOUR RETURN ON INVESTMENT IN R&D WILL ALWAYS BE WORTH IT, ACCORDING TO SAIFUL KHAN**

"Failing to protect the ‘crown jewels’ can lead to competitors grabbing a free ride."  Saiful Khan

Looking at the image, it seems to be a page from a magazine or a report dedicated to IP protection, discussing the importance of robust protection and the various options available for smaller innovators. The text emphasizes the need for businesses to invest in their IP to prevent competitors from benefiting from their work. It also highlights the benefits of using different types of IP protection, such as petty patents, and mentions the availability of resources and guidance for small and medium-sized enterprises (SMEs) from the UK Intellectual Property Office (UKIPO).

The cartoon at the top of the page humorously illustrates a scenario where innovation and experimentation are mentioned, suggesting that while there may be challenges, there is also a spirit of experimentation and creativity. The text at the bottom of the page credits Saiful Khan as a partner and electronics industry specialist at Potter Clarkson, emphasizing his expertise in the field of IP law and his insights on the importance of protecting innovations.
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The US, China, Russia and the UK are among a growing number of countries that are turning to artificial intelligence (AI) and machine learning as they look to develop a new generation of advanced weapons systems.

The Pentagon, in the US, has made a commitment to spend $2 billion over the next five years through the Defense Advanced Research Projects Agency (DARPA). Its OFFSET programme, for example, is looking to develop drone swarms comprising of up to 250 unmanned aircraft systems (UASs) and/or unmanned ground systems (UGSs) for deployment across a number of diverse and complex environments.

In China, there are a growing number of collaborations between defence and academic institutions in the development of AI and machine learning and Tsinghua University has launched the Military-Civil Fusion National Defense Peak Technologies Laboratory to create “a platform for the pursuit of dual-use applications of emerging technologies, particularly artificial intelligence.”

Russia has gone one step further and is creating a new city named Era, which is devoted entirely to military innovation.

Currently under construction, the main goal of the research and development planned for the technopolis is, “the creation of military artificial intelligence systems and supporting technologies,” according to the Kremlin.

“What we are seeing is a renaissance in interest in AI and machine learning (ML),” says Dr Andrew Rogoyski, Innovation Director at Roke Manor, a contract research and development business owned by Chemring.

“The initial surge in AI came in the 1940s and 50s and then again in the 1980s. Today, in what can be described as a ‘third renaissance’ we have the computing power and enough data to deliver on the promises made for the technology in the past. It’s a really exciting time in terms of what is possible.”

According to Dr Rogoyski, “When we talk about AI we tend to mean machine learning. You have to remember that AI is a vast subject and includes areas such as natural language processing, robotics, machine vision and data analytics.

“While the media tends to focus on ‘killer robotics’ the use of ML in the military space takes in areas as diverse as logistics, surveillance targeting and reconnaissance. Healthcare is one of the biggest costs for the military as it needs to keep service personnel fit and ready for deployment. ML can be used to optimise and tailor individual training schedules. As such, the application and use of AI and ML is extremely broad.”

The UK’s Ministry of Defence (MoD), sees autonomy and evolving human/machine interfaces as enabling the military to carry out its functions with much greater precision and efficiency.

A 2018 Ministry of Defence report said that the MoD would be pursuing modernisation in areas like, “artificial, machine-learning, man-machine teaming, and automation to deliver the disruptive effects we need in this regard.”
The MoD has various programmes related to AI and autonomy, including the Autonomy programme, which is looking at algorithm development, artificial intelligence, machine learning, as well as "developing underpinning technologies to enable next generation autonomous military systems." Its research arm, the Defence Science and Technology Laboratory (Dstl), unveiled an AI Lab last year.

"The MoD is focused on a variety of AI techniques such as machine vision and robotics across a number of different use cases," explains Dr Rogoyski. "These range from threat intelligence to data science, and the ministry is now having to operate in much the same way as it would if it was in the commercial world. That means it needs to be able to deploy these technologies fast enough to match deployments in the commercial space. Keeping up is a real challenge, you are looking at getting technology into operational use without taking 5-10 years to procure it and go through the long drawn out cycles of the past.

"Ultimately, it will mean changing procurement strategies."

In terms of weaponry, one of the best-known examples of autonomous technology currently under development is the Taranis armed drone, the "most technically advanced demonstration aircraft ever built in the UK," according to the MoD.

"Whether it’s drones or autonomous vehicles, there’s a big push to develop technologies that protect servicemen," explains Dr Rogoyski. "Whether that’s drones or route clearance vehicles, the aim is to move servicemen away from the front line and to allow technology to take their place."

The Royal Air Force and Royal Navy are ten per cent short of their annual recruitment targets, while the Army is more than 30 per cent short, so the MoD also sees automation as a possible solution to this manpower shortage.

"Another area of interest, and which is becoming increasingly important, is where ML is being used in psychological operations," explains Dr Rogoyski. "It may not have anything to do with ‘killer robots’ or drones but these types of operations, via social media or through the use of fake news, are transforming the way we can influence the political will behind the use of military force."

According to Dr Rogoyski, psychological management is just one of a number of new ‘fronts’ that need to be addressed.

"Another is the security of a nation’s critical and increasingly connected infrastructure and the role of AI in protecting it. How can we project military power overseas when our entire infrastructure could be at risk from a cyber-attack, not just from other nation states but from non-government organisations?"

The MoD has a cross-government organisation called the Defense and Security Accelerator (DASA), that looks to find and then fund exploitable innovation to support UK defence and security quickly and effectively.

"Advances in AI and automation offer real opportunities but will require a fundamental shift in how they are viewed and treated. Instead of being seen as something confined solely to research labs, the MoD has been urged to adopt a much nimbler and more ambitious approach in terms of how they are used to transform defence programmes, using experimentation to try, fail, learn and succeed, while at the same time developing procurement processes that allow for a more agile adoption."

Below: Envitia is using artificial intelligence to seek autonomous submersibles with hunting for underwater mines for the UK’s Royal Navy

The history of military innovation shows that operational advantage is secured more by understanding how best to use new technology than developing the technology itself.

"A key issue with both AI and ML that will ensure their successful adoption is that they need to be explainable and come with a level of assurance," says Dr Rogoyski. "Both are fundamental and are not solely confined to the military.

"If you supply a black box system and the user has no idea how or why it makes a decision, how can they trust it if, and when, it makes a mistake? Trust in weapons systems is critical, but then would you put your trust in a robotic surgeon or a banking system that made arbitrary decisions about your savings?

"AI needs disciplined thinking and the systems will need to operate in the way you expect, under specific circumstances. If they make a mistake you want to be able to understand why, so there’s an important link with post analysis and how a system has made a particular decision."

In fact, by gathering and analysing multiple limited implementations it could provide the MoD with a clearer sense of direction and an ability to rapidly exploit AI developments in the commercial sector, leading the way for further military development.

Military use of AI

"Roke Manor is involved with a number of projects using AI," says Dr Rogoyski. "We have developed STARTLE, for example, for users operating in a cluttered marine/air situation. Its situational awareness software continuously monitors and evaluates potential threats using a combination of AI techniques.

"It operates by rapidly detecting and assessing potential threats, augmenting the human operator providing enhanced situational awareness in a very complex environment."
Another project involves Envitia, a UK geospatial and data company who, along with its partner BAE Systems Applied Intelligence, is using artificial intelligence to task autonomous submersibles with hunting underwater mines for the Royal Navy.

Mine-hunting is currently carried out by a fleet of mine-hunter ships using sonar. These new AI-enabled submersibles will be much quicker in being able to scan an object, identify the threat, and make decisions about what to do with it.

The Royal Navy’s Route Survey & Tasking Analysis (RSTA) project looks to adopt autonomous vehicles, open architectures and AI, with the intention of delivering an unmanned capability for routine mine countermeasure tasks in UK waters by the year 2022.

Commenting the outgoing First Sea Lord, Admiral Sir Philip Jones, said: “AI is set to play a key role in the future of the service. As modern warfare becomes ever faster, and ever more data-driven, our greatest asset will be the ability to cut through the deluge of information to think and act decisively.”

Envitia is working with BAE Systems Applied Intelligence to deliver RSTA, one of the first applications to be built on the Royal Navy developed NELSON data platform that is used to deliver coherent access to data generated by the Royal Navy at sea and ashore.

In addition, Envitia is utilising its maritime geospatial toolkit to deliver geospatial services into the application, ensuring RSTA has accurate and up-to-date maritime data for each mission.

As part of the Mine Countermeasures and Hydrographic Capability (MHC) programme, RSTA will intelligently task a fleet of autonomous vehicles, utilising machine learning, to analyse mission conditions and improve the success rate of all its missions over time.

Ethical dimension

The question of AI ethics has become an increasingly important one. The EU and other countries have been engaging for some time with the issue of AI ethics and the importance of civilian oversight of AI research, and have been encouraging more open research and dialogue between nations due to fears that unregulated AI could ultimately lead to an international arms race.

The worries around AI are varied,” according to Nick Colosimo, Chief Technologist, BAE Systems. “One is the ease of weaponisation of commercial off-the-shelf technology, another is the growth in small vehicles, no bigger than a human hand, which could prove difficult to detect and counter. The growth in machine speeds is another issue - how will human intervention be managed with the development of ever faster machine speed warfare?”

According to Adam Saulwick, Senior Research Scientist, the Australian Government, “We are faced with a data deluge; information comes from natural engagement, human machine interaction etc. and we are faced with a plethora of problems when it comes to AI. How do we use that data ethically? Can we trust it? If the Western democracies look to use data correctly can we be sure that their opponents will do so too?”

According to Dr Rogoyski, “AI and ethics is a difficult area. But it is crucial that we continue to research both the benefits and pitfalls of widespread AI application and implementation.

“In terms of norms of behaviour momentum is building. Earlier this year the US published an AI strategy document in which they talked about the need for a thoughtful and human centric approach to AI – which I think is both a sensible and pragmatic approach.”

Dr Rogoyski makes the point that when it comes to ethics, “Is it ethical not to use AI if you can save lives and shorten conflict? Is it ethical that if you are faced with a country or organisation with AI capabilities that you don’t seek to match that capability? There is a duty as a military planner/strategist to keep up with your adversaries.”

At the end of the day, who decides what is ‘ethical’?

“We know that both Russia and China see AI as a key element of both their industrial and military strategies and it is striking the scale of the investment they are making,” notes Dr Rogoyski.

With the level of investment set to accelerate in both AI and machine learning over the coming years we are entering a critical period in determining how militaries around the world will use AI – whatever happens, the nature of warfare is changing and that will only accelerate as the technology becomes ever more pervasive.
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It’s true to say that when a new technology appears on the market it is often accompanied by its ‘opposite’ – the bad versions that are used for various, invariably, criminal activities – and this has been true of the drone market, both here in the UK and around the world.

The drone that caused chaos at Gatwick airport is a case in point. It showed up how unprepared one of the UK’s leading airports was to the threat drones can pose.

“It was, however, a one in a thousand incident,” according to Richard Gill, the CEO of Drone Defence Services, a UK company which provides security against the actions of unmanned aerial vehicles or drones.

“You have to remember that this incident was carried out by someone very determined and with a very good working knowledge of drone and counter-drone technologies.

“Security or operational managers at facilities like Gatwick have a lot to contend with and only have a limited budget with which to operate. With the events at Gatwick it’s now possible to work out the costs of such an intrusion – Easyjet’s own impact assessment put the cost of the disruption at over £50m – so it’s now a lot easier to understand the risks and obtain a budget to counter this type of threat.”

According to Gill, Gatwick changed everything in terms of the drone defence sector.

“Post Gatwick, we are going through a profound period of change,” explains Gill. “We are looking for seed round funding and are working to bring all that outsourced expertise into the business. Now is the time to do that as the market evolves.”

Despite the events at Gatwick, Gill warns against ‘demonising’ drones and says that while people will abuse this technology, there is a positive argument that needs to be made about their uses.

“I believe that drone technology will change the way we view, interact with and move around the world,” he says. “It’s a transformative technology and I believe that UAVs will have a massive, and positive, impact on the way people live.”

While Gill is a great proponent of drone technology and the benefits it can bring, he has built a company which provides security against the actions of drones. Established in 2016, Drone Defence Services is the UK’s first drone focused security consultancy and it offers a range of different technologies, techniques, and procedures to help individuals and organisations to protect themselves from unwanted drone intrusions.
For example, its SkyFence system has been deployed at Guernsey Prison to stop drones flying drugs to inmates and it has devised a portable system, the Dynops E1000MP, which is being used to protect VIPs.

“With any new technology there’s a dark side, so drones are being used to smuggle contraband into prisons, disrupt airports and planes, and invade people’s privacy. Drone Defence was established to counter that threat,” Gill explains.

Gill set the company up after leaving the army, where he’d served as an officer in the Royal Logistic Corps.

“It was while I was in Afghanistan that I first saw the extensive use of drones by coalition forces. They were being used to collect information that was then streamed around the battlefield. At the same times there was a fast growing, emerging commercial market for drones. When I left the army I decided I wanted to get involved.”

Gill did an MBA at Northampton University, as part of a scheme made available to armed forces personnel, and used his time to conduct research into the commercial opportunities that drones afforded. It was during discussions with clients that he realised there was a demand for counter drone technology.

“These early client meetings usually turned to a discussion about the negatives around drones, so I formed a company to prevent their malicious use,” he explains.

Among the devices and technology that have been developed is a net gun and a portable backpack jammer. Gill explains that the company is focused on disrupting the radio communications between an operator and device.

“The radio link is the critical component when it comes to defending against drones,” he
From airports to prisons, a growing number of facilities need protection from illegal drone activity.

Drone Defence Solutions has created a handheld counter drone device.

Drone Defence categorises various levels of security. So, from facilities that need permanent protection, such as airports and prisons, where signal and disruption techniques can be employed to block radio links, to events that don’t need protection all the time, such as sporting events, the company has developed different methods and technologies to counter rogue devices.

“While there is legislation that prevents some drone usage we want to be able to use a proportional response to drones being used incorrectly. Our approach can be defined as track it, identify it and then act. If we find that a drone is acting in a hostile manner we can then, legitimately, jam its signal, turn it around and get it to fly home.

“That’s fine if the drone is being flown in line of sight; if it is being flown in an autonomous manner then that’s a different level of problem. We would pass details on to the authorities and it would be their decision as to whether they would look to bring it down.”

Recently launched by the company, AeroSnare has been designed to allow organisations, such as police forces, to upgrade their own drone fleet and turn them into drone defence interceptors.

“A number of police forces are testing AeroSnare,” says Gill. “It works by being attached to a friendly drone and the aim is for the security drone operator to fly the friendly drone over the offending drone. A Kevlar trailing line is then used to snare the offending drone’s propellers causing it to stall and lose lift. As the drone stalls, it pulls a parachute out of the AeroSnare and then descends gently to the ground.”

According to Gill, “The application is simple and we can upgrade commercial drones with the ability to intercept and safely interdict illegally flown drones.”

Another product is SkyFence, which is deployed around a perimeter fence and uses low power directional antenna technology to jam the radio signal between the operator and drone.

“The various ‘boxes’ are located around a base, usually every 40m around the perimeter, and are intended to do the bare minimum to stop a drone entering an area illegally.”

When it comes to regulating the market Gill is opposed to what he sees as something that could stymie innovation.

“In truth, those operators getting up to serious mischief won’t be the ones affected by legislation. Rather it will be the hobbyist and the casual user. We need an environment that encourages innovation and commercial experimentation,” Gill believes.

A report from PwC has estimated that by 2030, there will be more than 76,000 drones in operation across UK skies.

“The more drones that we see, the more that entrepreneurs will deliver new ways of making money out of them,” says Gill, who thinks that the next couple of years will be critical in the development of the drone market and argues that it is vital that the industry, or broader drone community, have one consolidated and positive voice.

“We need a lobbying group to promote the interests of this burgeoning industry, but that will be a challenge,” he concedes.

Gill believes that drone technology is set to become more capable and attitudes towards the use of drones will evolve, with people becoming more accepting of it.

“The potential for drone technology is massive but I do think there is a natural pace in terms of development. As the market evolves I think people will start to wake up to its ‘good’ potential and to the opportunities it can afford them.”
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Overcoming some of the hurdles associated with the development of unmanned aerial vehicles. By Abhishek Kapoor

Unmanned flying vehicles that can be programmed to perform various tasks are a huge technological leap toward, however, the limits to our material science, propulsion, power and battery, sensor, and software technology capabilities continue to restrict the use of drones to very specific industries and applications.

Traditionally, only large military forces were able to justify the cost to develop and use drones for intelligence, reconnaissance and surveillance missions in environments that are too dangerous for humans to operate.

However, low cost drones have been gaining in popularity and as the industry makes strides in component technology and computing software so commercial applications are now growing.

The drone market is expected to be worth over $21 billion by 2022, with over 80 per cent of that focused on military applications. Commercial drones are expected to account for about $2.5 billion by 2021.

There is a wide range of use cases in the commercial and industrial drone market, but it is a market that is heavily regulated.

In addition to regulatory hurdles, the drone market is becoming increasingly competitive, with 400 companies worldwide involved in some form of drone-related development.

To enable their widespread use, commercial and consumer drones must be equipped with navigational sensors that help them autonomously operate in a safe and reliable way and which use RF and microwave technology. However, most commercial companies in this space are start-ups with limited expertise in RF and microwave design.

The lack of RF expertise and readily available radar solutions creates a vicious cycle for the industry. The UAV market’s inability to offer reliable sensors that enable fully autonomous operation, in turn, prevents government agencies from relaxing regulations that currently restrict autonomous drone operation.

UAV manufacturers have an opportunity to influence regulatory policies governing drone operation, however, by embracing the RF, microwave, and mmWave technology that will enable the safe navigation of drones using proven sensor technology. One example is the deployment of 24 GHz radar, which potentially is one of the most basic and versatile solutions for demonstrating multiple use cases for safe navigation, given that it already is classified as the globally recognised industrial, scientific, and medical (ISM) band.

A 24 GHz ISM band radar can be used anywhere in the world, without regulation, for functions such as automatic collision avoidance systems and radio altimeters. The same radar band also can be used to detect and track multiple different objects and measure how high a drone is flying above the ground - two of the most basic features of safe drone operation.

One should note that there seems to be a common misconception that 77 GHz radar can be used in place of 24 GHz ISM radar. Based on the regulations today, the 77 GHz band is dedicated only for automotive vehicles and does not include UAV/UAS.

By proving that their solutions are technically capable, manufacturers will be able to influence existing regulations, but to do this they will need to take three steps:

1. Develop a basic understanding of radar and its various modes;
2. Understand the components of the RF signal chain required for a complete radar solution; and
3. Adopt radar solutions that provide a complete hardware setup and the software algorithms that will allow them to get to market faster.

When compared to optical/vision or ultrasonic sensors, radar sensors have the ability to accurately detect and measure objects over a much longer range and wider field of view in very difficult environment conditions that include dust, smoke, snow, fog, or poor lighting.

A typical RF/microwave radar can be used in various modes, depending on what needs to be detected and measured.
SECTOR FOCUS    DRONES

tracked. In frequency modulated continuous wave (FMCW) mode, the radar measures the distance of stationary targets. By modulating the frequency wave (FMCW ramps or chirp), the radar can measure the response of the reflected wave to derive range, velocity, and angular resolution of the target object. Figure 1 below, shows the FMCW ramps for radar transmit, and a set of important radar equations are used to define the radar sensor design information.

- Range resolution is dependent on transmitter carrier sweep bandwidth; the higher the transmitter sweep bandwidth, the higher the range velocity of the radar sensor.
- Velocity resolution depends on dwell time and carrier frequency; the higher the carrier frequency or dwell time, the better the velocity resolution.
- Angular resolution depends on carrier frequency; the higher the carrier frequency, the better the angular resolution.

FMCW radars are able to provide a continuous, inherent averaging of the measured target reflection information. This provides a wide, 3D field of view by measuring object speed, angle, and distance from as little as a few cms away to several hundred meters from the sensor to the target.

In range-doppler mode, the range and speed of the target can be analysed. This mode is one of the most powerful, because it processes multiple transmit ramps or chirps simultaneously by evaluating a two-dimensional Fourier transform.

The processed data is displayed in a map that allows for a separation of targets with different velocities, even if they are located at the same distance from the sensor - useful for distinguishing multiple targets moving at high speed and in different directions.

Digital Beamforming mode

In digital beamforming (DBF) mode, the receive signals from the four receive channels are used to estimate the angle of the target. The display shows spatial distribution of targets in the xy plane. In DBF mode, the system is configured in the same manner as FMCW mode but with different processing of the IF down-converted signals.

After calculating the range, the angle information of the target is calculated by evaluating the phase differences between the four receive channels. In DBF mode, a radar front-end system calibration is required to eliminate unwanted deterministic phase variations between the receive channels.

24 GHz radar is widely used in commercial and industrial applications due to its high accuracy, low power requirements, and small form factor. These characteristics also make 24 GHz radar a good fit for most commercial and consumer UAV manufacturers that are looking to reduce payload and power requirements.

In Figure 2, see page 22, you can see a complete multichannel radar signal chain from Analog Devices.

When building a radar sensor every dB improvement in receiver sensitivity affects the detection range. Most solutions primarily focus on cost reduction and thereby trade off phase noise performance and limit the number of channels. This degrades the overall receiver signal-to-noise (SNR) ratio, which limits the detection of smaller objects or targets while in the presence of larger objects.

In practical radar applications, busy or cluttered target scenarios exist, which can cumulatively increase system phase noise and desensitize the radar receiver.

Higher system noise masks or hides small targets and prevents object detection, which potentially can cause a sensor safety issue. Most single-channel, single-chip, low cost solutions are unable to provide the needed performance to make this distinction.

By using Analog Devices’ 24 GHz multichannel platform, UAV manufacturers are able to use FMCW radar to detect range and velocity of objects up to 200 m away with a resolution of approximately 60 cm, achieve a field of view of approximately 120° in azimuth and 15° in elevation based on the antenna array design and, by combining antennas as used in digital beam, the radar can use DBF to calculate angular information for a wider field of view.

Simplifying radar design

In order to simplify 24 GHz radar design for designers and non-RF experts, Analog Devices is able to...
provide a complete 24 GHz radar application development kit.

The Demorad, which includes all necessary hardware (including antenna design) and software on a full reference design, is a novel microwave radar evaluation platform solution with out-of-the-box software examples. It enables rapid product prototyping and is aimed at R&D interests in investigating radar and developing radar sensor products that can measure real-time information.

The system hardware solution includes RF antennas and a full RF-to-baseband signal chain, including DSP, and quickly connects to a laptop/PC with easy to use graphical user interface (GUI) software and radar algorithm software.

Using this kit, a user can plug into a computer with loaded software and enable 2D/3D radar FFTs, CFAR, and classification algorithms to prototype the full radar and introduce a new drone with functional radar to market sooner.

Demorad comes with a complete GUI and DSP radar support function libraries and the radar system signal chain in demorad includes basic software algorithms to allow designers to get started with no coding. Using these built-in software algorithms, engineers can quickly start to use the radar to detect and classify targets from a host PC.

Developers can also edit the existing software code to specifically detect and classify objects for their applications.

With or without RF design experience, Demorad makes it possible to quickly develop applications for the safe navigation of UAVs.

Summary
The UAV/UAS market is growing fast and offers tremendous potential for many new commercial applications. But to make this vision a reality, UAV manufacturers need to lead the industry by embracing RF, microwave, and mmWave sensors to demonstrate that UAVs can be safely operated autonomously.

In addition, the landscape of sensor technologies is rapidly changing, and newer technologies such as LiDAR (light detection and ranging), ToF (time-of-flight), and ultrasonic are on the rise as well. UAV manufacturers should continue to stay aware of these newer solutions to be able to use the latest technologies for their drones.

As they evaluate these technologies, radar performance, and versatility should be among their key criteria, and factor more than just the cost of the hardware.

Figure 2: A complete multichannel radar signal chain

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**Figure 2: A complete multichannel radar signal chain**

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UAVs are being deployed in conflict areas and in terrain that would exclude more conventional military vehicles. The increased intelligence and mobility place demands on embedded computing. By Alex Brinkley

In ancient China, tethered kites were deployed to gain an aerial advantage over the enemy. Later, armies used hot air balloons for aerial attack and information gathering and, shortly after the Wright brothers’ first flight in 1903, aeroplanes were used in small and large scale battles, before the First World War.

Today, aeroplanes are joined in the skies by unmanned aerial vehicles (UAVs), or drones. Although UAVs are used in industrial and commercial applications, a military UAV is defined as 20kg or more. They are also classified according to altitude range, with high altitude, long endurance (HALE) and medium altitude, long endurance (MALE) versions. There are also unmanned combat aerial vehicles (UCAVs).

Military UAVs are the largest segment of the UAV market, ahead of industrial, agricultural and commercial uses. They are used for intelligence, surveillance and reconnaissance (ISR) or equipped to carry missiles in combat operations which are deemed too dangerous if a human pilot should be shot down, lost or captured. UAVs can be remotely operated, semi- or full-autonomously, using either passive or active sensors, such as light detection and ranging (Lidar) cameras and an on-board embedded computer for the computer vision and path planning algorithms.

**The principles of SWaP**

The amount of data and computing, as well as the need for agility, places a burden on UAV design and adds another dimension to the size, weight and power (SWaP) principle.

Minimising size, weight and optimising power has been a long-held tenet of mil/high-rel design. Today, mission times have also been extended, further fuelling the need for optimal density in constrained or limited areas.

In addition to the need to minimise component count and reduce wiring, processors for processing vision imaging and data transmission to and from multiple sensors must be power-efficient, secure and reliable.

**Mil-spec modules**

One response to the SWaP criteria has been from Acromag, which has developed mezzanine modules that boost I/O density. Its AcroPack I/O modules are for use with the company’s AcroPack carrier cards for CompactPCI Serial, Mini-ITX Com Express Type 10, PCIe, XMC or VPX-based systems. They enable developers to route I/O through a carrier card without any loose cabling, using a 100-pin connector that is positioned face-down on the module. The AcroPack modules measure 30 x 70mm and can up to four can be plugged into a single carrier card.

The latest additions to the range include the APS13, an isolated RS232 communications module based on the PCI Express mini card (mPCIe) standard and the APc7043, a ¾ length PCIe carrier card for smaller computers and servers (pictured).

The APS13 has four RS232 serial ports, each isolated to 250V from digital circuitry and from the three other ports to protect equipment and signal integrity in electrically noisy environments. For data processing, each port has 256-byte FIFO buffers on the transmit and receive lines to minimise CPU operation.

SWaP restrictions can mean a full length module cannot be used. In response, the company has introduced the APc7043 (pictured). This 10 inches long module carrier card, based on mPCIe, has expansion slots for up to four I/O modules to install analogue or digital I/O, serial comms, FPGA, Mil-Std-1553 or CAN bus for example. Two slots have sockets for optional, isolated power supplies to support isolated I/O modules.

"We use the same technology as commercial applications, but we make sure they are rugged enough to operate in extreme conditions.”

Lorne Graves
All modules run on Linux, Windows or VxWorks OS.

Another company, Abaco, believes the SWaP maxim is no longer sufficient for high-rel design. It has introduced SWaP-C3, adding cost, cooling and compliance to the embedded board design checklist.

As defence budgets have dwindled, cost is now considered to be as much an evaluation point as the conventional size, weight and power.

Lorne Graves, chief technology officer, Abaco Systems explains: “In most cases, there is a cost associated with [mil-aero] design. Companies are not building 10s or 100s of thousands . . . to build 200, 500, there is a cost,” he says. The company’s solution is to use a group of products to accelerate commercial off the shelf (COTS) development. Evaluations need to take into account the lifetime cost of ownership. If a product is easy to upgrade to meet new levels of functionality, this lowers the lifetime.

**Cooling design**

Processor manufacturers are working hard to optimise power efficiency, but still, high performance embedded computing (HPEC) systems generate heat which can jeopardise performance.

Abaco’s HPEC SBC347D SBC, for example, uses the Intel Xeon D multi-core processor in a low power SoC and operates at its full core speed at temperatures up to 75°C. The predictable performance meets mission-critical scenarios that require real time determinism and its 20 PCIe lanes can be used with the company’s general purpose graphics processing unit (GPGPU) modules.

The use of traditional cooling techniques such as fins, fans and heat sinks, add to both weight and size. To counter this, Abaco uses integrated heat pipes in heat assemblies to improve the thermal design power (TDP). “Cooling is more than just adding heat sinks,” says Graves. He advocates efficient cooling via design techniques, for example removing heat more efficiently through the heat plates, to the assembly and then out to the platform. As a result, a system can run at the same frequency but lower operating temperatures and without having to reduce the processor performance at high temperatures.

“Cooling is most impactful on the performance of video for a UAV,” reveals Graves. Vision systems also rely on edge computing which typically demands the highest, most SWaP-critical design. These systems also need computing power at the edge for a faster response and for more communication at the edge for faster reaction times to avoid collisions. “The reaction time for collision avoidance in ground-based autonomous vehicles moving at 30mph has to be scaled up for applications operating at 200mph,” observes Graves. The differences in performance for mil-aero embedded computing, for example operating at altitude and for a period of 10 years or more, accounts for the third C, compliance. “Abaco uses the same technology as commercial applications, but we make sure they are rugged enough for operation in extremes of temperature, conditions and altitude,” explains Graves.

The life cycle of a vehicle is around 10 to 40 years, he says. He cites the B52 platform which has been in service since Vietnam and which is still being upgraded for new equipment. “Compare this with 10 to 15 years in the commercial arena,” says Graves. “In 2008, the iPhone was introduced, today we have the iPhone X (10).”

The asymmetric progress of mil-aerospace and commerce highlights the issue of compliance. The mil-aero market is now demanding the same type of processing power as we have in cell phones, desktops servers and cloud computing, says Graves. They are also, however, tasked with additional parameters, namely operating at altitudes, temperatures and reliability levels far beyond anything in a phone or server. Abaco uses the same technology as its commercial applications, says Graves, but makes sure embedded boards are rugged for use at altitude, saltwater and explosive resistant and operate in high temperatures.

“We are trying to move at the same pace as commercial products; ruggedising existing products and looking to new ones,” concludes Graves.
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Do the unique features of DRAM memory modules outweigh the benefits of down-board DRAMs? **Arthur Sainio** compares

A common practice when designing embedded computing systems for aerospace and defence applications is to use down-board DRAMs which are extremely reliable, have very efficient thermal ratings and the fastest electrical characteristics. This makes sense because these types of systems have some of the most stringent performance, qualification and reliability requirements in the electronics industry e.g. the severe shock and vibration testing required for aerospace and defence applications authorised by NEBS (Network Equipment-Building System).

While placing down-board DRAMs is beneficial, an increasing number of design engineers are now using DRAM modules. Although there are many benefits to using down-board DRAM, the comprehensive features of DRAM modules provide significant advantages from scalability and system density to thermal management, environmental protection, testing and cost.

**Scalability**

Common system designs can be leveraged to support different levels of performance for different defence applications by using low, or high, density modules with slow or fast speeds. Defence systems using DRAM modules can be designed for future upgrades without the need for a total redesign, a critical requirement of down-board DRAM systems. DDR4 module densities continue to increase and now range from 4GB to 256GB. DRAM speed grades have also made step migrations from DDR4-2133 to DDR4-3200. Many industry-standard server and storage motherboards are designed for DRAM module and CPU steppings which can be upgraded to offer the next level of performance by swapping out the old memory and old CPU with the latest versions. This methodology can be used in the Industrial Internet of Things (IIoT) and defence segments.

**Routing and signal integrity**

Using modules instead of down-board DRAMs also simplifies system design as there is less routing complication on the main board due to back-to-back DRAM placements on the module. In addition, VTT termination can be completed on the module. All the passives including the thermal sensor are on the module which can help decrease the layer count on the main board. The required timing parameters are completed which can reduce schematic and layout errors. Modules can also help to eliminate the use of blind and buried VIAs in the DRAM section due to the aspect ratio problem with VIA size. Overall, it is easier to replicate, and reuse modules as opposed to down-board DRAMs.

**Design Flexibility**

The Joint Electron Device Engineering Council (JEDEC) Solid State Technology Association, an independent semiconductor
Engineering trade organisation, reported that the number of standard memory modules available in the market have more than doubled since the launch of DDR2. This means system designers are more likely to find an ‘exact fit’ memory module specifically designed for defence applications.

Modules are available in a variety of bus widths, form factors, densities and speeds. Module connector varieties have also increased with options ranging from 22.5° angled connectors to ultralow profile connectors with very low seating planes.

A key concern for design engineers in the defence industry is the ability to withstand mechanical shock and vibration. Aircraft and ground vehicles are equipped with highly precise recording, tracking and telecommunications equipment that need reliable high-density memory. Small form factor memory modules provide an optional solution for these densely configured systems. DDR4 Mini-DIMM connectors have been specifically designed with a level of ruggedisation to endure rough handling, tough physical environments and transportation. They have features such as positive module pre-alignment vibration damping end support and dual centre solder nail support inserted from top of housing. Mini-DIMMs were developed with extra power and ground pins compared to SO-DIMMs for more robust and reliable operation as well as long-term reliability. Underfill can be applied under the DRAMs on a module after it has been built to help safeguard the module and mitigate vibration issues. An underfill material, such as Loctite 3593, is injected under all Ball Grid Array (BGA) devices on the module (DRAMS and register etc.).

Environmental hazards
Sensitive electronic equipment can be regularly exposed to a variety of environmental hazards ranging from moisture and sea salt to sulphur dioxide. Modules exposed to these conditions can be conformally coated. The coating application process (plasma etching) protects the modules from shortages or leakages of critical components caused by moisture, fungus, dust, salt-spray and other contaminants. This step involves applying a spray coating to each module. The coating material consists of a 25-75µm thick polymer film that conforms to the circuit board topology. Critical contact areas of the module, such as the gold contact fingers, are masked prior to the coating. This protective technique, when used in conjunction with underfill, helps to reduce the need to send a technician onsite to replace memory modules, which can be costly both in terms of hardware replacements and service disruption.

Memory failures in the field are a major area of concern and without stringent system testing prior to release, products are at risk of potential DRAM failure. Systems with down-board DRAM need to incorporate some level of stress testing in order to weed out any weak bits that may have potential to fail in the field. If failures do occur the down-board DRAM must be removed and replaced. In the case of modules both electrical and system testing is completed at the module level prior to application, greatly reducing the potential of field failures. While it may seem like a straightforward decision to use down-board DRAM as opposed to modules due to the added costs of the connector and PCB for the module, there are several critical factors to consider. Modules provide benefits that include system scalability, design simplification, environmental protection and quality that are not as easy to quantify but can significantly impact an application’s success. For example, an unplanned event to redesign a defence system to accommodate a different DRAM package type or a larger density DRAM can have significant cost implications, particularly in use cases where long system qualification cycles are combined with a long product service life.

Bringing it all together
Embedded computing systems designed for defence applications must be able to handle environments where electrical, mechanical and/or human-related hazards are a common occurrence. Design engineers need to ensure the memory within these applications can handle unexpected bumps in the road and continue to perform at optimal levels. DRAM modules offer greater design flexibility and scalability along with ease of routing and improved signal integrity. Despite the added costs of a connector and PCB, modules increase system density and support thermal management by making the most efficient use of board space. The ease of completing critical stress tests to DRAM module-based systems and the ability to add extra protection against environmental hazards offer long-term performance and cost-saving benefits. In addition, DRAM modules can be made more reliable and ruggedised to withstand mechanical shock and vibration, achieving the same performance levels associated with down-board DRAM chips.

Author details:
Arthur Sainio is Director of Product Marketing, SMART Modular Technologies

Below: IoT motherboards that use modules and can be exposed to harsh operating environments

Above: Examples of a VLP DIMM, a DDR4 SO-DIMM and a VLP Mini-DIMM SO-DIMM
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If you want to send a high-data rate signal more than a few centimetres optical is the smartest choice. At least that is the case if you look at the big picture. Optical wins every time in a straight shootout of energy per bit and bit density.

But things change when you look at the additional cost and complications of converting between the optical and electrical domains. Once those factor into the equation, it’s no surprise why so much data gets forced through serialisers onto electrical traces using an increasingly exotic blend of materials and signal processing.

One indication of how the economics of optical communication affect system design can be seen in the world of data-centre computing. A major trend in this area is to distribute computing across entire rows of server racks. For this, they need to use optical for its long-distance capabilities. But the optical signals do not yet go straight into the switch chips and SoCs on the blades themselves.

“The data-centre customers that we are dealing with, they are still doing optical-electrical conversion on the front panel. They want to take advantage of the optical-module infrastructure that exists,” says Matt Burns, technical marketing manager at connector maker Samtec.

Typically, data-centre operators use pluggable small form-factor (SFP) optical modules based designed to common standards to handle electro-optical conversion. With a wide range of suppliers, the standard modules tend to lead to lower purchase prices and the confidence that the format will be supported for many years.

But pulling in the other direction is the viability of the connection to the board behind that front panel. With earlier generations of serial data link and technologies such as 1Gbit/s Ethernet, it was entirely feasible to route electrical signals through the PCB. But thanks to the advanced transceivers that chipmakers have added to FPGAs and SoCs to support protocols such as PCI Express and 10Gbit/s and 100Gbit/s Ethernet, attempts to use the PCB to link switch chips and SoCs for those signals have run in trouble over signal integrity.

At the Optical Fiber Communication Conference in the spring, Benny Mikkelsen, founder and CTO of Acacia Communications, described a second problem faced by data-centre owners such as Facebook: the amount of front-panel space they need to provide enough optical connections to their compute boards.

Some have had to go to 2U or wider panels simply to provide the area needed for the multiple SFP connectors, even though many have move to quad-density (QSFP) versions. “We can keep putting optics on the front or go to onboard optics or co-packaged optics,” Mikkelsen says.

Tech in its infancy

Today, the technology to bring optical communication to chip packages is still in its infancy, though there are numerous projects underway including an industry-wide research programme: the Integrated Photonic Systems Roadmapping group organised by the International Electronics Manufacturing Initiative (iNEMI). Companies such as Acacia, which is soon to be acquired by Cisco, aims to use 3D stacking based on chiplets to build its next generation of transceivers.

Tom Marrapode, director of advanced technology development in Molex’s optical solutions group, points to power savings of around 30 per cent with fibre to the chip:

Servers slowly open the door to light

The boundary between electrical and optical is shifting in high-end systems, as Chris Edwards explains
“The real bang for the buck comes with co-packaged optics. But there are definitely some big technical challenges to solve in in-package or co-packaged optics. The timing on that is maybe around 2025.”

Chips in the 50Gbit/s switch environment could need hundreds of fibre connections. This leads to a mismatch between the way fibre is made today and what will be needed to bring connections down to the package.

Marrapode says it will probably need a combination of wavelength division multiplexing to connect multiple channels over single fibres on top of small-diameter fibres.

“Silicon photonics pitches can be pretty tight: they don’t match today’s fibre. And you will want to move your lasers to a remote position: you can’t have them next to a hot switch-chip package,” he explains.

And the connectors will have to make it relatively easy to assemble in a factory though they will not have to be user-_connectable as is the case with SFP-type modules.

The question is what happens before the middle of the next decade. The answer depends on the industry.

Burns says customers in sectors beyond cloud computing, such as high-end medical and military and aerospace are exploiting mid-board optics. Marrapode notes telecom switch designs have employed the strategy for many years in order to get high-density connections to switch ICs.

The midboard approach uses a connector with built-in electro-optical converters that plugs into a socket placed as close as possible to a serdes transceiver. A flyover fibre from the connector then takes the signal to an optical backplane or pluggable fibre connectors in the front panel. Burns says a common application is to extend protocols such as PCI Express over much longer distances. “We are agnostic in terms of protocols,” Burns notes.

Marrapode says speed is rarely enough on its own to force a move to midboard optics. Instead, the decision is driven largely by the realisation that copper connections will not provide the scalability the system demands. “It’s the point when people say ‘I need optics to get around this whole system’, ” he says.

Burns says the military and medical customers have fewer concerns about the multi-sourcing that data-centre customers demand. “They don’t have to be compliant with other vendors.”

For data-centre systems, customers are more willing to stretch the use of front-panel pluggable connectors until they need to move to a replacement for those widely sourced modules.

Marrapode points out that bringing optics to the package will create complications for systems designers.

Ideally, they would want to be able to support a mixture of electrical and optical links to cater for a range of distances, from a few metres to kilometre-level runs. This is straightforward with front-panel pluggable converters, not so with copackaged optics. Vendors may have to provide a selection of boards that provide different combinations.

The arrival of double-density versions of the QSFP connector that co-package multiple transceivers has slowed the growth of the mid-board metalwork for the time being. That has been helped by the availability of high-grade flyover cables based on copper twinax wiring and similar approaches. These cables make it possible to take protocols such as 56Gbit/s PAM4 over a distance from an SoC or switch chip to a board’s front panel in situations where routing it through FR4 on a PCB would degrade the signal too much. Products such as Samtec’s Firefly are in the same way as midboard optical connectors but with an electrical connection to conventional front-panel SFP modules.

Marrapode says there is an additional advantage of twinax flyover cables is that they provide greater flexibility for front-panel design: the cages are no longer constrained by the need to connect to a PCB-based connector.

“The twinax flyover is looking really attractive: the performance is good and will probably be the stepping stone to when the photonics go into the switch chip,” he says, adding slightly ruefully: “It’s another push-out for optics. Every speed bump goes through this. It seems there is always something to supplant optics.”

However, the transition may finally be forced on designers when serial links move to 112Gbit/s and the 50Gbit/s switch chip looms, Marrapode adds. There may be no way to stave off direct photonic connection any further. Within five years, the connectors could well be designed for chiplets instead of PCBs and front panels.
Join the UK’s leading design engineers and tomorrow’s rising stars as we unveil the winners of the 2019 British Engineering Excellence Awards

Where
The Landmark London

When
11th October 2019, 11.30am

What
Drinks reception followed by a 3-course lunch

Host
Dr Lucy Rogers, science author, inventor, and a judge on the BBC2 show Robot Wars.

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THE NEW THERMAL

How are the size, performance and reliability advantages driving the adoption of specialist RF transistors in industrial heating applications? Yves Francois explains

Radio frequency (RF) and microwave power transistors are essential components in high-power communications equipment such as cellular base transmitter stations and TV broadcasting equipment.

By contrast, solid-state RF components are rarely found in today’s factories or process plants. This is about to change, however, with the introduction of a new generation of high-voltage, high-power RF transistors operating at frequencies ideal for certain industrial processes and operations. Drying, curing, welding and bonding processes all derive huge benefits from the application of RF rather than thermal energy for targeted heating operations.

The recent introduction of a broad set of evaluation and development tools for RF energy components smooths the path from development tools for RF energy techniques provides numerous benefits to the operators of industrial drying, curing and bonding processes.

Heating time is typically between two and 20 times faster, as the heat is generated internally. While reduced exposure time to high external sources of heat results in less deterioration of the treated material. For example, in food processing, heating through RF energy preserves more of the nutritional content of food than oven heating.

In drying applications, the use of RF energy can reduce the risk of surface cracking.

Since RF energy does not heat the ambient air, the heat transfer system is also simpler. This can enable process operators to replace a batch process with a continuous process as well as to reduce floor space.

Furthermore, the power of the RF energy applied to a material and the duration of the application of power may both be precisely controlled.

Using information from moisture and temperature sensors, the system can stop applying RF power immediately when the target moisture level or temperature is reached.

These benefits result in reduced energy consumption, operating costs, maintenance requirements and downtime. For example, to dry cotton from 55% moisture to 9% with RF heating requires 57% less energy than fresh air drying, and 23% less energy than pressure air drying.

Welding of plastics is another application which benefits hugely from conversion to RF energy. Conventional plastic welding requires a hot die applied to two plastic sheets until the temperature throughout the material is high enough for them to fuse together. They must then be held together under pressure until the die cools. This means that the highest temperature is applied to the faces of the material, and the die must be heated and cooled each time a weld is made.

By contrast, dielectric heating allows the weld to be made with cold dies the temperature of which rises only a little during the weld and falls rapidly after bonding. As the die is cool, the hottest spot is at the interface between the two sheets – where it is needed – reducing energy cost and greatly accelerating the process.

A growing market

The cost-saving and operational benefits of using RF energy put

<table>
<thead>
<tr>
<th>Material</th>
<th>Loss factor</th>
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</thead>
<tbody>
<tr>
<td>Water</td>
<td>12</td>
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<td>Field Corn</td>
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<tr>
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<tr>
<td>Silica, glass</td>
<td>0.002</td>
</tr>
<tr>
<td>Teflon</td>
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Figure 1: Dielectric loss factor of various common materials. The higher the factor, the easier it is to heat with RF energy.
this technology in pole position to replace thermal ovens and other thermal energy equipment. In fact, microwave energy is already used in industrial processes, such as drying or sterilising food.

Weight and size reduction are one of the important benefits of using solid-state transistors to generate RF or microwave energy – but they’re not the only advantages. A transistor offers much greater control over both power output and frequency. A low-end magnetron is either fully on or off, and even a high-end magnetron can only control power output at above 60% of full power. By contrast, an RF/microwave transistor offers full control of output power over a range from <1% to 100% of full power.

A solid-state RF or microwave generator also offers a certain amount of frequency agility. Figure 2 shows the effect of tuning the frequency of a transistor rated at a nominal 2.45GHz. In a material sample of mixed composition, different components of the material might have a different dielectric loss factor and generate heat at different frequencies. Dynamic frequency sweeping across a transistor’s frequency range redistributes hot and cold spots for even heating across the sample. Such dynamic, in-process frequency sweeping is not possible with a magnetron.

The generation of RF energy by solid-state components also produces equipment that is easier to install and operate in a factory. It provides a rapid response to changes in power requirement, and starts up instantly, with no delay for warming up or cooling.

A transistor system uses reliable, compact, and efficient switch-mode power supplies operating from a low-voltage supply. For a power output of 800W, a magnetron requires a 4kV supply, whereas a microwave transistor runs from a safer 50V supply.

In addition, the solid-state technology requires no complicated electro-mechanical controls and sequencing. It’s also insensitive to vibration. This also contributes to the transistor’s high reliability; the lifetime of a high-end 915MHz magnetron is between 2,000 and 6,000 hours, or up to eight months of continuous operation. When a magnetron needs to be replaced or serviced, a factory operator can expect downtime of between several hours and several days.

By contrast, a transistor’s rated lifetime is 100 years, and it suffers no performance degradation over time. Even if a fault occurs, a hot-swap architecture allows a failed transistor to be quickly replaced with minimal downtime.

Finally, the transistor-based system will be smaller and lighter than the equivalent magnetron-based design: at 915MHz, transistor-based RF generator can be half the size and weight of a magnetron system (see Figure 3).

The number of existing drying, curing and bonding applications to which RF energy could be applied is vast. But the ready availability of small, high-power RF transistors opens up many new applications for which a bulky, heavy magnetron is unsuitable. An example is handheld surgical equipment for skin ablation, but many others are sure to emerge as the advantages of solid-state RF energy equipment drive the replacement of magnetron technology in factories and process plants worldwide.
Helping ensure astronaut safety

Smiths Interconnect products perform well during NASA's successful Orion test flight

London, UK – In the week that the world celebrates the 50th anniversary of Apollo 11 taking man to the moon, Smiths Interconnect have their own space-related achievement to celebrate. Smiths Interconnect’s high-speed, high-performance connectors and harnesses were part of NASA’s successful Orion test flight to conduct a full-system test of the Launch Abort System (LAS). The test proved that Orion could pull away safely in the event of an emergency during launch.

The Orion LAS, with a mock-up Orion capsule, launched on a modified Peacekeeper missile from Cape Canaveral Air Force Station in Florida to an altitude of about 6 miles. Travelling at nearly 1,000 miles per hour, the LAS pulled the crew module away from its booster and oriented it for splashdown in the Atlantic Ocean.

The Smiths Interconnect connectors are at the backbone of the data and control network on Orion and must withstand the extreme levels of mechanical shock and vibration produced by the LAS. Test data from 850 sensors was sent in real-time to ground sites, as well as recorded by 32 on-board data recorders. The success of this test flight is a major achievement for our product.

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Mouser Electronics Now Stocking Broad Portfolio of Xilinx Products

Two Industry Leaders Sign Global Distribution Agreement to Benefit Engineering Design

Mouser Electronics, Inc. today announces a new global distribution agreement with Xilinx, Inc., the leader in adaptive and intelligent computing, to stock one of the industrys broadest portfolios of Xilinx products, including digital downconverters and development tools and IP. Xilinx is the inventor of the FPGA, programmable system on chip (PSoC™), and the adaptive compute acceleration platform (ACAP), designed to deliver the most dynamic processor technology in the industry and enable the adaptable, intelligent and connected world of the future. To learn more, visit www.mouser.com/xilinx.

“Xilinx is an industry leader and proven innovator in new technologies. We are very excited to expand our product portfolio for our customers by now offering a broad stock of Xilinx products and technologies,” said Glenn Smith, Mouser President and CEO. “We look forward to assisting Xilinx expand its global customer base and revenue with our focus on e-commerce and new product introductions for design engineers.” With Mouser’s exceptional customer service for engineers, world-class logistics, and responsive customer base, we are very excited to add them to our global distribution channel,” said Mark Waddington, Senior Vice President of Global Sales at Xilinx. “We expect this to be the beginning of a long and successful relationship.”

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Nexperia honoured with Bosch Global Supplier Award

Winners are ‘the cream of the crop’ sharing competitive objectives and achieving outstanding levels of excellence

Nexperia, the expert in discrete and MOSFET components and analog & logic ICs, today announced that it has received a Bosch Global Supplier Award in the category of Purchasing of direct materials – Mobility Solutions. Nexperia was one of only 13 companies from Bosch’s 42,000 strong supplier base to be honoured with such an award for its outstanding performance and impact in 2017-2018.

Bosch has presented these awards every two years since 1987, to reward outstanding performance in the manufacture and supply of products or services, notably in terms of quality, costs, innovation, and logistics. The year’s award ceremony carried the theme: Transforming together. Staying Ahead. and was held in Blackbusch, Germany. For Bosch, suppliers are more than just deliver components; they are also partners in development and innovation that help the company stay competitive. Bosch relies on partners who share the company’s long-term competitive objectives and who are willing to collaborate closely with the company.

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PicoCoreMX6SX

Compact ARM SOM with High Performance and Real-Time on 35 x 40mm

The new family member of the new and compact PicoCore product family, by Lattice Semiconductor, is based on the successful NXP i.MX 6 SoC ARM® application processor (AP).

The NXP applications processor (Dual Core with heterogeneous processor architecture) comes with ARMP® Cortex™-A9 core and ARMP® Cortex™-M4 core. NXP combines its heterogeneous concept with Linux on the ARMP® Cortex™-A9 core and FreeRTOS on the ARMP® Cortex™-M4 core. Both cores (ARMP® Cortex™-A9 and -M4) are connected to the internal bus fabric and have the possibility to access all peripherals.

The advantages of the core are real-time processing and the immediate availability of all the interfaces after power-on.

PicoCore-MX6SX is offered with SC NAND Flash or eMMC. EEPROM can also be found on the module. Two 80-pins plug connectors (3.54mm board-to-board) enable a large number of interfaces: SD Card slot, 2x Ethernet, 2x USB, CAN, SPI, UART, Audio (Line In/Out/Mic/Headphone) and many more.

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Lattice Semiconductor Delivers Flexible Connectivity for Industrial Vision Applications with New CrossLink Reference Design

New SoC/ISD to MPI C2-2 Image Sensor Bridge reference design helps machine vision and robotics applications leverage advanced application processors

Lattice Semiconductor Corporation (NASDAQ: LSCC), the low power programmable logic leader, today announced the availability of the latest in a series of reference designs featuring the Lattice CrossLink™ FPGA for video bridging applications. The SoC/ISD to MPI C2-2 Image Sensor Bridge reference design provides industrial device customers with a flexible, easy to implement solution for connecting advanced application processors (APs) with many of the image sensors currently in use today in machine vision applications for industrial environments.

Many industrial machine vision applications use image sensors with SoC/ISD interfaces, which is incompatible with the MPI C2-2 Video Interface Protocol that is used on today’s APs. However, many industrial device OEMs want to implement these APs in existing machine vision capable products. The Lattice SoC/ISD to MPI C2-2 Image Sensor Bridge reference design lets customers quickly and easily create a bridging solution so an AP with a MPI C2-2 interface can connect with a SoC/ISD image sensor.

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New connector series launched by Nicomatic

New low profile, modular EN165-compliant rectangular V/I connector series launched by Nicomatic

Nicomatic, the leading manufacturer of high-performance interconnection solutions, is launching Optimus, in EN165-compliant, modular, rectangular (C) connector series. This low profile interconnect solution is user-configurable and is applicable either to provide an equipment interface connection for a harness or as a robust rack panel. Solution.

Conforming to specifications set out in EN165, Optimus connectors are highly versatile. Modular construction enables designers to specify the layout they need. Connectors can be configured with size 22 signal contacts rated at 5A or size 8 power contacts rated for 60A. 30T PCB mount versions are also available. Devices are waterproof and offer EMI protection.

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Power Integrations Releases InnoSwitch3 AC-DC Converter ICs

Power Integrations Reasses GaN Nitride-Based InnoSwitch3 AC-DC Converter ICs

Advanced GaN technology yields significant increase in power and efficiency. Power Integrations (NASDAQ: POW)’, the leader in high-voltage integrated circuits for energy-efficient power conversion, today announces the release of its InnoSwitch™3 family of off-line DC-DC converters. The new ICs feature up to 95% efficiency across the full load range and up to 100 W in enclosed bottom-ported power supplies offering 50% to 75% footprint reduction compared to existing solutions on the market. The ground-breaking stage increase in performance is achieved using a novel, internally-developed high-speed GaN switch technology.

Quasi-resonant InnoSwitch3-OP, InnoSwitch3-OP and InnoSwitch3-Pro ICs combine primary, secondary and feedback circuits in a single air-core mounted package. In the newly released family members, GaN switches replace the traditional silicon high-voltage transition on the primary side of the IC, reducing conduction losses when current is flowing, and considerably reducing switching losses during operation. This results in substantially less wasted energy and therefore increased efficiency and power delivery from the space-saving 1090 x 1240 package.

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