

# newelectronics

11 May 2021

INTELLIGENT EDGE SYSTEMS • OPEN SOURCE ARCHITECTURES • SPACE ELECTRONICS



## THE NEW FACE OF POLICING

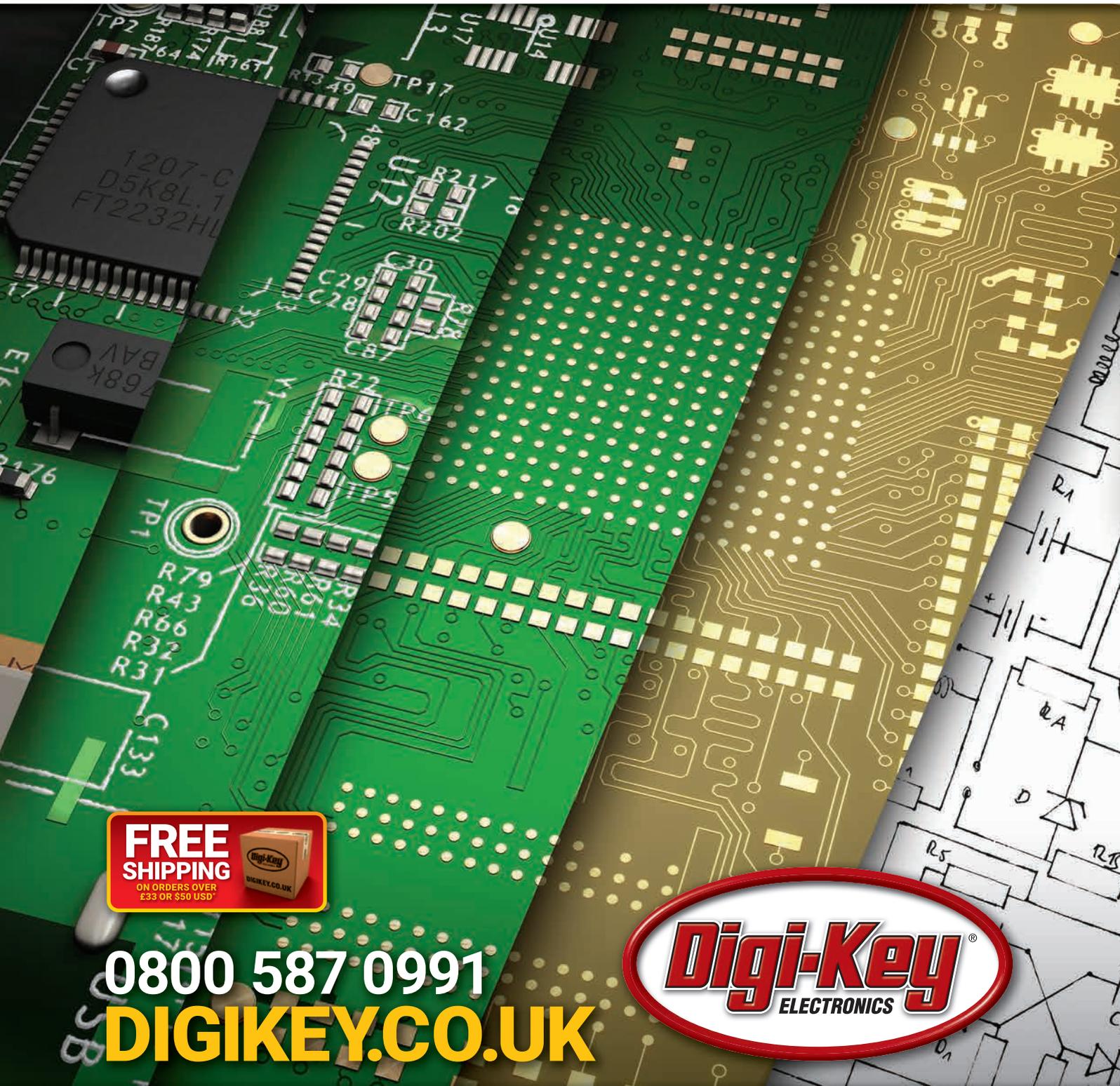
With resources and budgets stretched police services are turning to technology to help tackle crime

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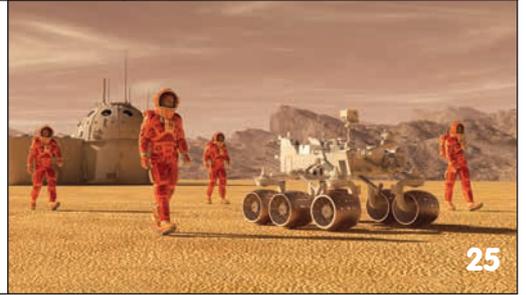
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# Robber barons of the C21

DESPITE RECORD SALES AMAZON DOESN'T HAVE TO PAY ANY CORPORATION TAX. ISN'T IT TIME WE LOOKED AT TAX REFORM?



**A**mazon generated record sales income of £38bn in Europe last year, while income in the UK soared by 51 per cent to reach almost £20bn – mind-blowing figures! At the same time Apple reported trading figures for the first three months of 2021 with another set of astonishing numbers. So much so, that it was able to announce a buy-back of shares worth \$90bn – that's equivalent to the value of BP, and that's spare cash!

Despite record revenues though, Amazon paid no tax. It reported a 'loss' and received €56m in tax credits that it can use to offset any future tax bills should it turn a profit.

Tax avoidance is not illegal but these figures do raise some interesting questions. Why should these companies, who use public services, infrastructure, and workforces paid for by taxpayers benefit when they don't pay enough into the common pot for the common good?

These companies are not being properly taxed and in the process are undercutting their competitors and those companies that not only talk about being responsible, but actually are.

President Biden has called for sweeping changes to the global tax system, which would include a minimum corporation tax rate that would look to stop companies like Apple and Amazon exploiting loopholes in the system.

It's a simple call for multinational companies to pay their fair share of taxes and to pay taxes to national governments based on the sales they generate in each country.

The likes of Amazon, Facebook, Google, Netflix, Apple and Microsoft have avoided paying \$100bn in tax over the past decade, according to research, and while taxing multinationals will not be easy creating a global minimum tax would make it possible to collect revenue from all these types of businesses. It would also stop a race to the bottom which has seen average corporate tax rates fall from around 40 per cent in 1980 to 24 per cent in 2020.

Some will argue that increased taxes will stymie investment – the UK has cut taxes but has a lamentable record when it comes to investment – and that tax avoidance is simply part of the system.

Fair enough, but governments are confronting global challenges and need money to tackle them, whether that's climate change, economic recovery or addressing Covid-19.

A minimum global tax will be complicated but, whatever the challenges, it is certainly worth trying to enact a global minimum tax on those companies that could be described as the 'robber barons' of the C21.

Neil Tyler, Editor ([neil.tyler@markallengroup.com](mailto:neil.tyler@markallengroup.com))

**“Why should these companies, who use public services, infrastructure, and workforces paid for by taxpayers benefit when they don't pay enough into the common pot for the common good?”**

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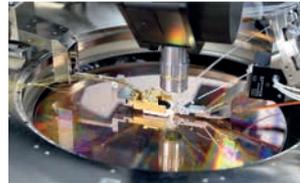
# PsiQuantum and GF to build full-scale quantum computer

COMPANIES ARE MANUFACTURING THE COMPONENTS NECESSARY FOR A COMMERCIALLY VIABLE QUANTUM COMPUTER. **NEIL TYLER** REPORTS

PsiQuantum, a specialist in quantum computing, and Globalfoundries (GF) have announced a major breakthrough in their partnership to build the world's first full-scale commercial quantum computer.

The two companies are now manufacturing the silicon photonic and electronic chips that will form the foundation of the Q1 system, the first system in PsiQuantum's roadmap to deliver a commercially viable quantum computer with one million qubits (the basic unit of quantum information).

According to PsiQuantum and GF they have been able to demonstrate the ability - a world first - to manufacture core quantum components, such as single-photon sources and single-photon detectors, with precision and in volume, using



the standard manufacturing processes available at GF's semiconductor fab. Proprietary production and manufacturing equipment have been installed in two of GF's 300mm fabs to produce thousands of Q1 silicon photonic chips and state-of-the-art electronic control chips.

Quantum computing is expected to deliver extraordinary advances across a variety of industries including pharmaceutical development, materials science, renewable energy, climate mitigation and sustainable agriculture.

GF's silicon photonics

manufacturing platform will enable PsiQuantum to develop quantum chips that can be measured and tested for long-term performance reliability.

This is critical to be able to execute quantum algorithms, which require millions or billions of gate operations and PsiQuantum is currently collaborating with researchers, scientists and developers to explore and test quantum use cases across a range of industries.

"This is a major achievement for both the quantum and semiconductor industries, demonstrating that it's possible to build the critical components of a quantum computer on a silicon chip, using the standard manufacturing processes of a semiconductor fab," said Pete Shadbolt, chief strategy officer and co-founder of PsiQuantum.

## Disruptive approach to Edge Data Centre infrastructures

**DataQube Global, a Cambridge-based start-up in the data centre space, is leading a new approach to edge computing and the seamless handling of high-volume data in readiness for 5G going mainstream.**

**The company, together with a consortium of Telcos and ISP providers, has developed DataQube, a self-contained solution, that will enable HPC performance at the edge of the network. A modular design it will be scalable according to different requirements.**

**5G, along with IoT and AI, will generate colossal amounts of data that will require real-time analysis as close to the source as possible for reliable**

**and safe operations.**

**Data centre infrastructures in their existing format are expected to struggle to achieve the required latency and uplink/downlink levels to make this possible.**

**DataQube will provide a full range of data centre services where companies need it, when they need it and in the configurations they require in any internal or external location.**

**Installations can range from a single unit to a fully operational collocation solution and be fully operational within six-month timeframe.**

**It comprises cutting-edge liquid cooling technology which offers the potential to reduce**

**energy consumption by as much as 40%, reducing O&M costs and helping businesses achieve their corporate responsibility of lowering CO2 emissions in line with the Paris Agreement to try and limit global warming.**

**"5G and automation are set to change the technology landscape. With easier access and faster interconnectivity businesses will become more agile and the adoption of smart applications will become more viable," said David Keegan, CEO of DataQube Global. "Our new offering will enable businesses to benefit from next generation technologies cost effectively and sustainably."**

# Integrated code development toolbox

GREEN HILLS SOFTWARE AND MATHWORKS CREATE INTEGRATED CODE DEVELOPMENT TOOLBOX. **NEIL TYLER** REPORTS

Green Hills Software is making available the MULTI Toolbox for Embedded Coder, enabling engineers to develop and deploy MathWorks' Simulink and MATLAB models on a wide range of embedded processors.

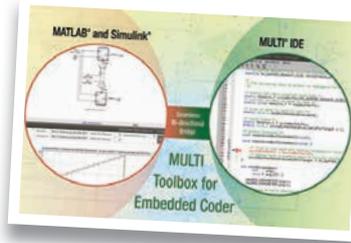
The integration will provide software engineers who develop algorithms in MATLAB and Simulink with a simple and safety-qualified way to develop, debug, optimise and deploy their programs across thousands of embedded processors supported by Green Hills.

The MULTI Toolbox connects Simulink and MATLAB on the desktop with the MULTI integrated development environment (IDE) that comprehends and controls embedded target processors. On the desktop, users develop

Simulink and MATLAB models and generate C/C++ source code. MULTI then compiles, connects and runs the optimised binaries on either the target processor, or on the MULTI IDE's built-in embedded core simulator.

MULTI then feeds back results to Simulink via Processor-In-the-Loop (PIL), enabling the user to visualise the results or to confirm programmatically that results from Simulink algorithms on the workstation match the actual results run on the embedded processor.

"Connecting Simulink to embedded simulators and debuggers is the next milestone in our customers' desire to move testing and verification from the field to the lab to the desktop,"



said Tom Erkinen, Product Manager, Embedded Code Generation at MathWorks. "Green Hills shares this vision and has worked closely with MathWorks to develop its MULTI Toolbox for Embedded Coder. As online collaboration continues to grow, the need for virtual testing and development environments will accelerate."

Once the program completes, users can run, debug and analyse the program at any point in its execution using MULTI and the TimeMachine debugger.

The MULTI Toolbox supports thousands of 32- and 64-bit embedded processors from leading processor manufacturers, including NXP, Renesas, Qualcomm, TI and Microchip.

## Development tools for Traveo II MCU family

IAR Systems has launched a complete set of development tools for the Traveo II family of microcontrollers (MCUs) from Infineon, which combined with AUTOSAR extends support to companies working with automotive body electronics applications.

IAR is also providing an online IAR Academy On Demand training course specifically aimed for developers who are new to embedded software development and want to get started with IAR Embedded Workbench and Traveo II MCUs.

The partnership between IAR Systems and Infineon enables scalable development across a wide range of Arm-based MCUs, including two generations of Traveo MCU devices, as well as Infineon FM MCUs and PSoC families.

The development toolchain IAR Embedded Workbench for Arm supports all available Traveo II devices, including CYT2BL, CYT2B6, CYT2B7, CYT2B9, CYT3BB, CYT4BB and CYT4BF and includes highly optimising build tools as well as advanced debugging capabilities.

With the code analysis tools C-STAT and C-RUN, developers will have complete code quality control.

For companies with requirements on functional safety, IAR Embedded Workbench for Arm is available in an edition certified by TÜV SÜD, while for those working with Continuous Integration workflows and automated build and test processes, the build tools from IAR Embedded Workbench are also available in a version supporting Linux-based frameworks.

## DALI Alliance specification supports DALI+

The DALI Alliance (DiiA) has announced the launch of DALI+, a new brand that denotes DALI over wireless and IP-based networks.

DALI+ builds on the DALI lighting-control features in wired (DALI-2 and D4i) options, and offers access to the same data from control gear, luminaires and sensors. DALI+ devices communicate using existing DALI commands, but these are carried over a wireless and/or IP-based medium rather than the dedicated pair of wires used by DALI-2 and D4i.

The DALI Alliance has published a new DiiA Specification, which supports DALI+ across different carriers and will lead to certification of interoperable DALI+ devices. The first certification program will be DALI+ with Thread, a low-



power, IP-based, wireless-mesh networking protocol.

In combination with a wireless carrier, DALI+ enables true wireless DALI, without any need to translate between protocols. Where access to DALI wired subnets or luminaires is required from the DALI+ wireless network, the new specification also supports bridges.

"Following the publication of our Wireless to DALI Gateway specifications last month, the introduction of DALI+ ushers in a new era of seamless, industry-standardised lighting control," said

Paul Drosihn, general manager of the DALI Alliance.

DALI+ enables lighting solutions that can scale to building-wide networks, or even across multiple buildings, by using new addressing features. The implementation of IP-based networks in commercial buildings allows IT systems and building automation services, including lighting control, to operate on a common platform, with features such as end-to-end security, unlimited scalability, and easy connectivity to other applications.

DALI+ networks connect sensors, controllers and luminaires in a data-rich environment and can deliver, for example, real-time monitoring of energy and power usage and access to diagnostics information for predictive luminaire maintenance.

# Oxbotica and Navtech unveil 'Terran360'

COMPANIES UNVEIL A 'WORLD-FIRST' RADAR BASED LOCALISATION SYSTEM CAPABLE OF CENTIMETRE PRECISION. **NEIL TYLER REPORTS**

Oxbotica and Navtech have combined to launch Terran360, said to be the world's first all-weather radar localisation solution for industrial autonomous vehicles, with the technology typically accurate to <10cm on any vehicle, in any environment.

The solution combines Navtech's patented FMCW radar sensor and Oxbotica's autonomy software platform, and is an entirely new offering to the off-road autonomy market. It utilises a single long-range, high-definition radar sensor to give a detailed 360 degree picture of a vehicle's surroundings, allowing it to work alongside conventional systems and be deployed in GPS-denied environments or in harsh conditions not suitable for LiDAR or vision while maintaining full pinpoint localisation at all times.

Navtech's high-resolution radar sensor is able to operate in very harsh conditions - such as in rain, fog, dust, or dirt as well as in complete darkness. The vibration resistant and IP67-certified sensor is designed to



be maintenance free, helping to reduce disruption to operations without compromising on precision, reliability, or safety.

Terran360's output can be fused with other sensor feeds or used as a standalone system, and is also able to provide independent and highly accurate vehicle motion. Terran360 operates on any vehicle, from slow moving to speeds of up to 120kph (75mph) and has been fully tested on different vehicle platforms and in dramatically different environments, including in mines, on urban roads, on railways and in marine settings.

Commenting Paul Newman, Founder & CTO at Oxbotica, said, "With the launch of Terran360, in collaboration with Navtech, we are bringing a game-changing localisation system to market that gives operators and manufacturers a new way to answer the crucial autonomy question of "Where am I?" – and one that is unimpeded by environment or place."

Phil Avery, Managing Director at Navtech Radar, added, "We are extremely proud to launch this outstanding product for commercial use, offering a radar localisation solution never seen before. Thanks to decades of experience in delivering radar solutions for safety and mission critical applications, and together with Oxbotica's world-leading autonomy software platform, Terran360 is trusted to answer the fundamental question for autonomous vehicles: "Where am I?", everywhere, every time."

## Agritech startup launches 'Tom'

Small Robot Company (SRC), a British agritech start-up for sustainable farming, has announced 'Tom', its first commercial robot.

The Tom monitoring robot is now entering service on UK farms and customers include the Lockerley Estate, where robots are a key part of its regenerative farming strategy, as well as the Waitrose & Partners and the National Trust.

SRC's first service using Tom will be per plant weeding, a world-first milestone. This is now in field trials, with Tom scanning first arable crops to detect weeds, and robot weeding prototype 'Dick' then being deployed to 'zap' individual weeds with electrical 'lightning strikes', using no chemicals. On-farm pilots of the service will commence this autumn.

With up to 95% of chemicals wasted in the current farming system, this new non-chemical weeding technology is seen as delivering more nature-friendly farming and is better for biodiversity. In future, Tom will also be used to gather data from multiple sources, such as sensors and microphones for birdsong and pollinators, to assess soil health and biodiversity.

Manufactured in Northumberland by Tharsus, Tom will be going into 5G trials in Dorset in the autumn in the £8 million 5G RuralDorset project.

"To prove the power of per plant farming we are focusing on answering the biggest problem that farmers face at the moment which is weeding," said Ben Scott-Robinson, CEO and co-founder, Small Robot Company, "We've now proved we can deliver per plant weeding: a world first. The focus for us now is being able to move forward to deliver this, repeatedly, and at scale. This will be game-changing."

Tom's scanning and measurement capabilities are also applicable to lots of wider players in the agriculture industry, offering highly accurate and repeatable measurement of crop data, with the opportunity for every field to become a trial plot. With trial plots yielding as much as 20 tonnes of wheat per hectare, versus the average of 8.4 tonnes on UK farms, there is considerable opportunity to improve performance.

SRC is currently conducting a pilot



with its Tom robot taking soil samples to assess soil health measurement. Robotic monitoring could provide accurate, repeatable carbon measurement at farm scale. According to the company this could be transformational in providing accurate carbon sequestration measurement to support the UK farming industry's transition to Net Zero by 2040.

Tom's highly accurate measurement capabilities are also seen as helping to enable farmers to access the new post-Brexit Environmental Land Management (ELMS) payments, due to be introduced in 2024. The new scheme creates a framework that links food production and the environment, and will replace subsidies with 'public money for public goods.'

# Self-testing in Embedded Systems

Unless available memory is totally exhausted, in an embedded design it is worthwhile considering the implementation of some self-testing capabilities.

Modern electronics tends to be amazingly reliable, but failures are still possible. In an embedded system there are broadly four categories of failure:

- CPU
- Peripheral
- Memory
- Software errors

If a CPU fails, it tends to be a hard failure. This does not offer any possibility for self-testing. Partial failure of a CPU is very unlikely. In a multicore system, it is good practice to assign one of the cores as “master” so that it can monitor system integrity.

Peripherals can fail in various ways, but many modes of failure are very device/application specific. If a device fails to respond to its address, the trap occurs; it is essential to include a trap handler to process this fault. Otherwise, communications devices commonly include a “loopback” mode that enables testing of transmission and reception and associated interrupts.

Memory failure is always a possibility. This failure may be transient – i.e., a single bit being flipped by a passing cosmic ray. It is generally not possible to detect such a fault and it may cause a software crash. It is, therefore, essential

```

set every bit of memory to 0
for each bit of memory
{
    verify that all bits are 0
    set the bit under test to 1
    verify that it is 1
    verify all other bits are 0
    set the bit under test to 0
}
    
```

Moving Ones Test

to accommodate crash recovery. A hard failure maybe a lack of address response or bits stuck at 0 or 1. A trap handler deals with the former, but the latter requires some specific testing. Comprehensive memory testing can only be done on device

start-up. A *Moving Ones* test is effective.

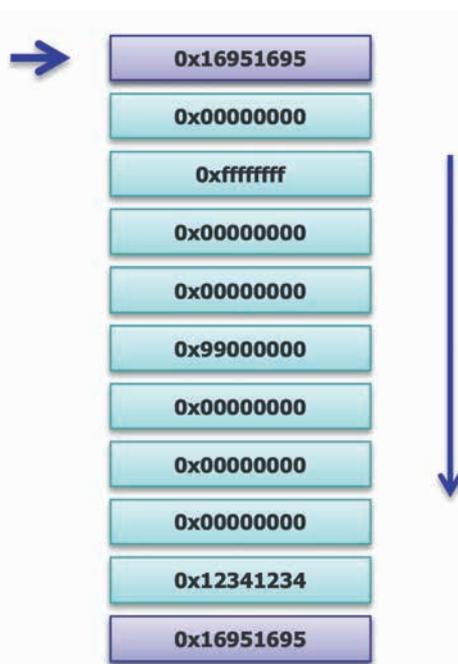
While the device is operating, pattern testing can be performed on individual bytes/words, which may highlight certain types of failure.

The most complex part of modern devices is software. Although software does not exactly wear out, its complexity can result in faults that are difficult to detect during development. Good, defensive coding techniques can help anticipate some problems. Broadly, there are two types of software error: data corruption and code looping.

Data corruption can be caused by pointer misuse, which is hard to detect or prevent,

but it can also be as a result overflow of a data structure, like an array or the stack. The insertion of “guard words” can assist with the detection of overflow before any damage is caused.

Code looping can be addressed by careful design – precautions like timeouts on waiting for devices – or some kind of watchdog facility (in hardware or software) that traps unresponsive code.



Stack Guard Words

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Colin Walls,  
Siemens Embedded

At a time when criminals are becoming more sophisticated how are the police using technology to respond? By **Neil Tyler**

**N**ew technologies are creating new pressures for modern-day police forces and, according to research published by Deloitte's in its 'Tech Trends' report, criminals are becoming increasingly sophisticated in their use of technology.

Some notable examples have been the use of artificial intelligence (AI) to replicate a target's voice, coupled with synthesized video of them speaking. Combined these were then used to impersonate a senior executive's voice, costing a UK-based energy company hundreds of thousands of pounds.

AI is also being deployed to hack consumer devices by using in-built sensors to snoop inside an individual's home, while speech recognition technology can exploit 'fragments' of conversations to glean details about personal lives, such as banking or medical details.

New domains of internet activity (darknets) and crypto currencies are also creating new crime challenges for the police, at a time when resources are stretched and budgets under pressure.

The Deloitte report warned that, "the accelerating pace of technological and social change places a new emphasis on the speed of reaction."

As a consequence the criminal justice system is itself embracing new forms of technology to react to new types of criminality, but also to be more proactive when it comes to traditional forms of crime.

To date, there have certainly been significant improvements in terms of both data capture and storage, with European research suggesting that at an average domestic crime scene at least eight connected devices, holding vast volumes of information, will be seized for examination.



# THE NEW FACE OF

Information that's gleaned from tracking and sensing technologies is also being used and now forms a critical starting point for most investigations.

Yet, according to experts from the criminal justice system, while this information can significantly increase the chances of securing a conviction there are real difficulties when it comes to handling, and then analysing, huge volumes of data as cases progress.

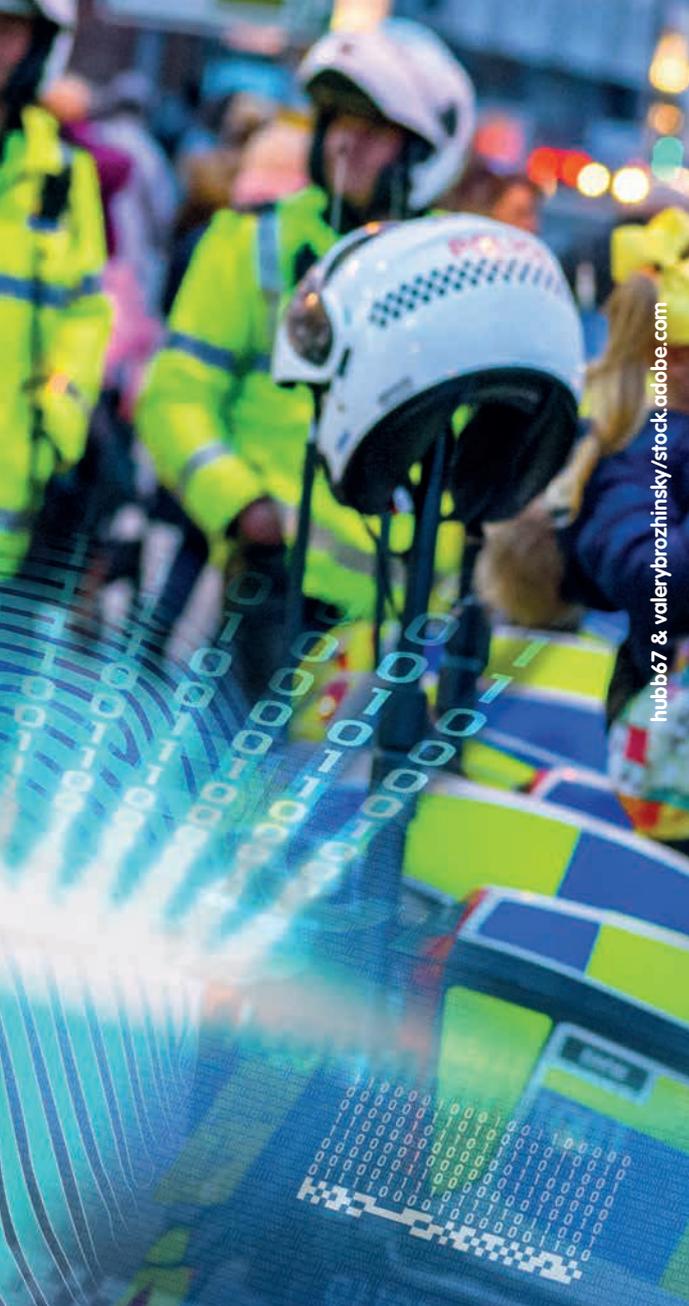
When it comes to surveillance and tracking, while they offer significant crime prevention and efficiency benefits, they also raise questions

around civil liberties and the legitimacy of the justice system.

And, on top of all this and adding even greater texture to the mix, Covid-19 has had a massive impact on the criminal justice system itself. Despite a rapid shift to remote court hearings and probation meetings, court backlogs have increased dramatically and while the courts have started to embrace technology, many justice professionals still need to adjust to new ways of operating.

## Engaging with technology

Whether it's drones, body-worn cameras or AI and facial recognition



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# POLICING

software police forces are turning to technology to enhance or improve their capabilities.

One area of interest is an old technique, biometrics, which police have been using since fingerprint technology was developed in the mid nineteenth century to identify people. Today, along with facial recognition and DNA, there are an array of new biometric (and behavioural) characteristics such as voice recognition, palmprints, wrist veins, iris recognition and gait analysis that are available to the police.

Biometric solutions are able to simplify and accelerate the

identification and processing of suspects. Most people in the UK don't tend to carry accurate identity documents, so many find themselves being processed in a station – that's not an efficient use of police time and is a financial and operational cost.

New biometric readers have been developed in response that use thin film technology. These much smaller devices mean that officers are able to use them in the field. Capturing prints is now easier, with the user being helped through the process, and automatic quality checks on the prints make for more accurate results.

When combined with mobile technology it is now possible to create a portable connected device which can be used anywhere and, by bringing together software and hardware with the operating systems of mobile phones, police forces and their technology partners are now developing their own apps to match their database checking processes.

These mobile readers are making it far easier to identify suspects but they also remove the need to 'drag' people into a station.

A European police force using these mobile biometric devices saw a six-fold increase in the number of individuals identified, with the number of persons of interest detained increasing significantly. Not only that, it was able to save \$600,000 in the first year of the reader's use.

Interestingly, the deployment of this technology saw officers noting that trust and respect between them and the communities they engaged with actually improved. People seemed comfortable with this quick and easy way to prove their identity.

In many cases, on seeing the mobile biometric device people proactively admitted to their real identity. They didn't protest their innocence or employ a false identity.

Their acceptance of the technology was based on trust and it's that issue of trust that is at the heart of effective policing.

It's also viewed as essential when it comes to the deployment of technology, especially when it comes to something like facial recognition software which has raised a number of serious issues.

By using algorithms to scan an image of a suspect loaded onto a video surveillance network it should be possible to scan streets and recognise a suspect. That's the theory, but too often the technology has mistakenly identified the wrong person.

So while advanced forms of facial recognition do offer the potential to track wanted criminals, the risk of making mistakes is high and there are worries over how the technology is being deployed.

However, with so much valuable data being generated, collected and analysed the police are now turning to AI to support technologies like facial recognition and biometrics.

AI is also being used for crime mapping or to simply crunch data to better pinpoint high-crime areas, which means that the police can deploy additional resources more effectively.

One area of particular interest is 'predictive policing', which uses deep learning algorithms to analyse data from a vast array of sources and categories to predict when and where crimes are likely to occur, and in some cases to actually predict the identities of those about to carry out the crime.

While this technology is meant to enable officers to be in the right place at the right time it does raise questions about accountability and how the technology is deployed.

Proponents of predictive policing argue that it provides a cost effective solution and can avoid the bias that is often associated with human-generated crime analysis – but critics warn that it can easily replicate those biased patterns of policing and end up simply targeting minority groups of marginalised communities.

## Technology convergence

According to VNC Automotive, a

transport and connectivity software specialist, vehicle and mobile phone platform technologies are converging in the form of new systems.

“We’re already seeing a focus on app-based solutions, but there is now a shift towards exploring technology including remote control functionality, the relaying of remote surveillance footage to a car’s dashboard and even augmented reality,” explained Philip Handschin, Technical Consultant at VNC Automotive. “However, all this functionality needs to remain intuitive and easily integrated with the large format touch screens that are becoming commonplace in today’s vehicles.”

While VNC Automotive has long experience in programming entertainment, navigation and comfort control systems, that knowledge is now being deployed to the benefit of law enforcement agencies.

According to Handschin, “We can tap into the systems that OEMs build into cars, utilising large format touch screens and the existing hardware for communication and connectivity, but we can also add new functionality that empowers police and first responders to allow them to work more effectively and make better-informed decisions.”

The roll-out of smart platforms and apps with the connectivity services that are being built into cars as standard, will allow an officer’s phone to sync with a vehicle but now VNC Automotive’s IVI connectivity software makes it possible to automatically lock a vehicle or activate remote functions like sirens, cameras and PA systems.

Enhanced dashcam capabilities are seen as being particularly useful for surveillance and information gathering, as well as for gathering evidence or for accountability purposes. In the future it’s likely that we will see this technology integrated with wearable tech, covering the likes of biometrics, personal security and incident management.

### Wearable technology

Police officers have to operate in very



challenging situations and a number of high-profile incidents, particularly last year, drew intense public and media scrutiny on the actions of individual officers.

Police services are issuing body-worn cameras that not only provide street-level views of police at work but which also enhance the ability to monitor the activities of police officers themselves, especially in difficult or contested situations.

Cameras are now less cumbersome and more durable and many are being designed to better integrate with in-car systems to provide synchronized recordings of an event from multiple points of view.

Higher resolution, clearer audio and wider fields of vision and heightened resistance to environmental conditions are all extending the capabilities of wearable technology.

In the US smart holsters have been designed to activate a body camera whenever an officer draws a firearm, while other cameras are able to issue an alert when an officer is injured. Body-worn police cameras equipped with facial recognition capabilities are now also in development.

The use of wearable cameras and other technology means that the role of the police vehicle is itself changing and they are now becoming ‘intelligence gathering hubs’ in which first-hand data is passed back to a central command centre allowing the coordination of teams and other services.

In future, it will also be possible to transmit video and other live data to provide even more granular levels of surveillance and the emergence of drones and advanced robotics is now making it possible to obtain video and data from units capable of operating in extreme or dangerous environments.

Drones, or UAVs, can provide enhanced aerial vantage points for crime scene work, search and rescue efforts, accident reconstruction, and crowd monitoring. More sophisticated models are now using thermal imaging or 3D mapping software to offer GPS-enhanced precision to the areas being monitored.

UAVs can also be equipped with zoom cameras, making them valuable for delivering actionable, real-time intelligence when it comes to assessing and handling high-risk situations.

The police are certainly faced with a technological revolution that includes the likes of augmented reality, mobile surveillance and remote device control – the range and scope of developments is astonishing.

In the US, Ford is currently developing self-driving police cars that will be equipped with AI and the ability to transmit information to officers, while in China, robots have been developed to patrol banks, airports and schools. In Dubai a touchscreen-equipped robot officer is on duty in tourist ‘hotspots’.

While all these advances in police technology should be welcomed, they do raise serious issues around civil liberties and while there are efforts to draw up new policies and procedures it’s crucial that public confidence is maintained and that the individual’s rights are upheld.



## MANHATTAN SKYLINE

4inch square High Brightness TFTs with MIPI interface.

WF40ETWAA6MNN0 is a 4 inch Square IPS TFT-LCD display module; made of resolution 480 x 480 pixels. WF40E module supports MIPI DSI Serial interface (2 lanes), it is featured with IPS panel which has the advantage of wider viewing angle of Left:80 / Right:80 / Up:80 / Down:80 degree (typical), contrast ratio 800:1 (typical value), brightness 500 nits (typical value), glare surface panel, aspect ratio 1:1.

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WF40ESWAA6MNN0 module has integrated driver IC ST7701S on module, the interface supply voltage range from 2.5V to 3.6V, typical value 2.8V. WF40E module can be operating at temperatures from -30 to +80 ; its storage temperatures range from -30 to +80 .

These panels are ideal for home and building automation having the same form factor as a light switch.

CTP and RTP touch versions under development.

<https://www.mansky.co.uk/products/display/tft/mipi-interface-tfts/>



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# END GAME

How are IoT technologies keeping vaccines safe, in storage and transit, and in the process bringing the current pandemic to an end? Benjamin Brown, Client Success Manager at Sigfox, talks to New Electronics



**W**ith billions of lives depending on COVID-19 immunisation, today's global vaccine rollout efforts are faster than any other in history. However, this urgency has left very little time for the pharmaceutical supply chain to adapt.

According to medical experts dealing with the crisis there are a number of key operational levels and choices that need to be made to ensure a successful roll-out.

Critically these include clear information about supply and inventory; appointment scheduling and registration systems to reduce the variability of demand; ensuring prioritisation, in order to avoid wasting vaccines; and the introduction of linear distribution models, which provide greater accountability and better information flow. Keeping the vaccines in storage and successfully delivering them, in good condition, are also critical to the successful roll-out of vaccine programmes.

"Like many other vaccines, COVID-19 doses must be stored in a freezer or refrigerator to be effective, so supply chain players are required to take the necessary measures to respect the cold chain and ensure that storage conditions are maintained at the right temperature," explains Benjamin Brown, Client Success Manager at Sigfox.

Cold chain monitoring is not a novelty and has existed for decades but, with the unprecedented scale of this pandemic and the urgency of the distribution of the COVID-19 vaccines, the healthcare industry has become one of the main applications for cold-chain monitoring solutions to avoid temperature excursion.

"A temperature excursion occurs when a pharmaceutical product is exposed to temperatures outside the specified range for storage and transport, resulting in considerable product loss. This happens when cold chain storage and transport is mismanaged, and can result in high financial losses," says Brown.

While cold chain monitoring has been addressed by telecommunications technology providers for many years, these have been with limitations that were commercially or operationally blocking in given scenarios (namely cost of and skills required for installation and operations), including vaccine distribution.

"IoT technologies address these limitations and, providers are supporting the delivery of vaccines globally," suggests Brown.

Before 2020, losses due to temperature excursion were estimated at \$35 billion, in the medical field alone. That figure is expected to rise significantly in 2021 thanks to the specific temperature requirements of

the COVID-19 vaccine and the additional costs that have to be invested in temperature monitoring.

"With billions of vaccine doses needed, any loss due to transport or logistics issues will have negative social and health impacts because of resulting delays to vaccination programs. Vaccine losses will also affect health departments, hospitals and pharmacies as they will need to find additional resources to manage the disposal of unusable doses as well as the procurement, inventory management and reporting of new vaccine stock," explains Brown.

For pharmaceutical distributors, the challenge will be far greater. "Thermostatic packaging and monitoring solutions to avoid temperature excursion are not provided by some vaccine manufacturers and so will have to be managed internally.

"The healthcare industry can rely on communication technologies to provide vaccine status updates from the manufacturing plant to citizens across the world. In terms of newer technologies, sensors relying on IoT networks can be fitted to packages or pallets to collect data throughout the supply chain and provide visibility. In some cases, they are already used to identify weak links in the supply chain – such as revealing a recurring location where temperature excursions occur," says Brown.

On the other hand, however, solutions that only monitor trucks not the packages themselves, only enable temperature checks when the truck is loaded or unloaded. If there is a temperature excursion during transportation, it is impossible to know when it happened or what portion of the cargo was affected. Additionally, solutions that only monitor trucks are generally based on technologies which are often costly and unaffordable for developing countries.

"IoT sensors using a 4G network to collect and send data can be easily retrofitted directly onto packaging to monitor temperature status from the moment the vaccines leave the factory until they reach their destination. For pharmaceutical distributors or thermostatic packaging manufacturers, this is an opportunity to offer value-added services and quality assurance to health departments, medical unions or hospitals," says Brown.

## The benefits for developing countries

The secure distribution of vaccines is complex in developed countries, but it is an even bigger challenge for developing countries; especially in sub-Saharan Africa, South America and Asia, where temperature excursion can happen a lot faster.



“According to Toby Peters, a professor of cold economy at the University of Birmingham, ‘the problem is particularly acute in the global south, where many rural villages don’t even have a working vaccine fridge.’ Additionally, technologies normally used for tracking and monitoring temperatures, like Wi-Fi and Bluetooth, are still expensive for developing countries. Unfortunately, there may also not be local individuals who have the right skill sets to independently deploy and maintain such solutions,” Brown points out.

“IoT solutions that have been designed as plug and play can help clear the cost hurdles and skills gaps because there is a very limited need to invest in training or additional resources to implement the solution compared to its technology counterparts,” Brown adds.

“OG network IoT solutions can be used to better monitor stocks in developed, and all other, countries so that a smoother redistribution of any surplus vaccines can be undertaken, which can only support the global distribution of vaccines – bringing the world one step closer to the end of this pandemic.”

### Conclusion

Unfettered global access to vaccines has become one of the most important topics for governments and global institutions, and is an essential condition to end the global COVID-19 pandemic.

By employing IoT solutions, the healthcare and pharmaceutical industry can ensure better visibility of the supply chain to support the integrity of transported vaccine stock, as well as contribute to the global distribution of vaccines – bringing the world one step closer to the end of this pandemic.

**“The healthcare industry can rely on communication technologies to provide vaccine status updates from the manufacturing plant to citizens across the world”**

# OLD AND NEW WORLD CHALLENGES

What are the hurdles facing developers in their race to deploy intelligent edge systems? By **Matt Jones**

The next frontier of digital transformation will be at the intelligent edge. Use cases such as autonomous vehicles, drone management, energy networks and advanced factory robotics will all demand the intelligent handling of massive amounts of data for smart decision making at the edge of the network as well as in devices, right where it is needed most. Over the next 12-18 months, 5G adoption will pick up speed, achieving far greater proliferation across North America, Europe and parts of Asia. 5G will be heavily dependent on edge computing to meet the low latency requirements of the next generation of use cases.

These significant developments will put greater emphasis on the need for distributed cloud infrastructure, with edge solutions and cloud deployment accelerating across enterprise environments. Coupled with a global transition to 5G, distributed cloud will emerge as the preferred infrastructure model, driven by increased demand for flexibility, reduced latency and support of a remote workforce.

However, the development and deployment of intelligent edge systems comes with its own set of old and new world challenges.

## The old vs the new

We are in the midst of an age of disruption. Emerging technology trends, constantly evolving



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customer demands, new industry dynamics, and business models are setting a precedent for what is expected of developers, both new and old, in years to come. Everything is expected to be autonomous with critical data processed in real time. Cloud-native trends driven by AI, 5G, and intelligent systems at the edge, are leading a surge in demand for developers with new skill sets.

Meanwhile, legacy code continues to run in embedded systems for those mission critical sectors – industrial, aerospace & defence, transportation, utilities – as it will take time to further modernise those systems with greater intelligence and automation. Layered on top of this, is a shift in the developer workforce from boomer, to millennial, and beyond.

As the current generation of developers, who understand legacy code running in older languages, start to retire, we face a situation where colleges and universities have not focused on training the next generation of developers to work with these legacy codebases. This will present a significant hurdle for enterprises looking to engineer greater flexibility into the

fabric of their business and meet with new demands.

Enterprises will need to act quickly and invest in the appropriate training and tools to support this workforce transition. While this may seem like uncharted waters during challenging times, actually what it truly creates is an opportunity to realign the future of intelligent systems at the edge around the newer cloud-native skills and thinking that recent graduates employ.

## Training the winners

This new world driven by intelligent edge systems requires a range of new skills, thinking, and knowledge. Knowing where the data is coming from primarily, whether edge or cloud, will shape the way teams should be organised and what expertise is most critical.

A deep understanding of mission critical intelligent systems including AI & ML, real-time analytics, security and network reliability are all fundamental to realising an edge computing system or an embedded system for edge computing.

With enormous quantities of data to process and analyse in real time in an edge environment, developers must leverage automation, AI and



new use cases and applications at the network edge. Security must always remain front of mind as the attack surface grows along with a more distributed environment, securing the DevSecOps environment and providing the tools to ensure that the output is as secure as possible. DevSecOps will ensure customers receive the products they demand in the fastest time possible, therefore it is critical developers work harmoniously with the rest of the business to fully understand customer and industry challenges. However, this is all theoretically unachievable if the skills gap is not addressed.

**“In an increasingly software defined world, developing high quality software is a top priority”**

DevOps for software developments are an inroad into edge computing systems. It demands the usage of modern software development tools, techniques and programming languages. Developers are expected to familiarize themselves with modern tools without impacting customers’ productivity and efficiencies, regardless of the learning curve they’re faced with.

Cybersecurity must also be at the forefront of the development and operations of these systems. With edge computing comes connected smart devices with different levels of connectivity and deployment scenarios. This increased attack surface requires an integrated secure development process, as well as security rich features in the products that provide defence during deployment and thereafter, once in autonomous operation. The final challenge customers face is handling data at scale, they require that information to be converted into actionable insight and failure to do so comes at the risk of security and safety of enterprise personnel.

The shift to the edge is occurring rapidly, spurred on by a greater impetus around distributed infrastructure and a desire to realise the potential of the intelligent edge. The advent of 5G brings promise closer to reality for edge computing environments, and enterprise intelligent systems demand security, safety and reliability. Legacy code and current developer skillsets are not enough to achieve this. Developers will need a deep understanding of the new technologies that enable the automation and orchestration of a new generation of use cases at the network edge. 5G and the edge will propel enterprises into a fully digital, AI driven future. Developers with crucial new skillsets, adopting a DevSecOps approach, will be the driving force that puts enterprises into pole position as edge leaders.

**Crossing the finish line**

As edge computing systems continue to become more ubiquitous, developers don’t only need to up-skill, they must also be mindful of broader customer challenges. In an increasingly software defined world, developing high quality software is a top priority. Edge computing systems today pack many features that are all differentiated through the software. The expectation is that more features are delivered in less time and at lower cost without compromising the quality of the software. The need for continuous deployment means the entire process needs to be more automated and reliable.

Software culture and best practices are rapidly evolving. The practices of adopting Agile and

ML capabilities to better understand and use the data at hand. This will see developers understand not only the error, or the occurrence of a fault, but the detail of what happened in the run up to the fault – vastly reducing the chances of incurring that fault again.

Engaging with real time analytics will see developers empowered to anticipate, identify and resolve faults or errors as or even before they happen.

Development teams will need to understand a breadth of coding languages, and be well versed in data science, before reaching this promised land of AI and ML infused systems. Equally the teams will need to develop understanding for application deployment, maintenance and security from cloud to edge. Adaptability will also be key for developers, enabling them to update and reprogram systems and software in newer more flexible environments. Modern developers should be encouraged to design with ambiguity in a modular way, for systems to be more adaptable, deriving benefits and value from real time insights.

DevSecOps will continue to play an instrumental role in the development of systems that breed a wealth of



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# POWER TO THE

From the dawn of the semiconductor until the late 1980s it was commonplace for software to be completely open source. When you purchased a device, not only did you have the best Bakelite clad hardware, but also complete access to the code that made it run, allowing you to fine tune the product to its intended purpose.

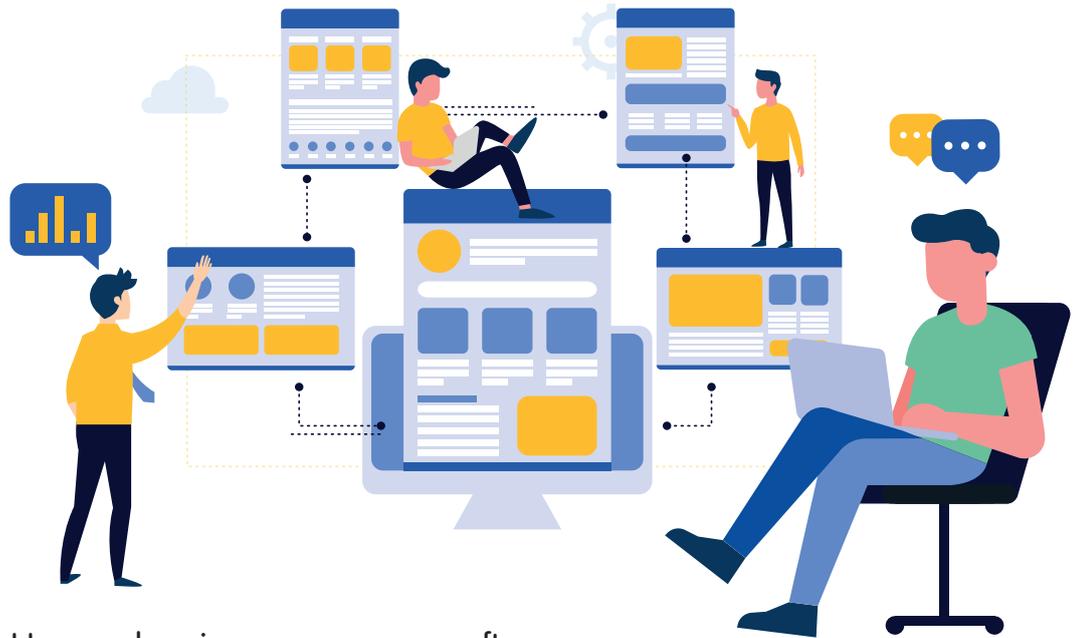
As computers became smaller and found their way into more walks of life, software became big business. As the value of the industry exploded so too did the rise of a curtain of code secrecy. Much of the source code that many designers and engineers were used to seeing found itself behind costly paywalls or held onto by device manufacturers.

Since then, open source has seen a resurgence, with Linux's creation in 1991 as an open-source operating system to the founding of the Khronos Group, creating open standards for graphics APIs, and most recently with the RISC-V open access CPU architecture. This open availability of coding has grown alongside the ever-changing and ever-expanding digitization of our lives.

But how does open-source software factor into the existing business model of many IP vendors and semiconductor OEMs and will we see open source growing in its prominence as an offered service?

## Many hands make light work

Semiconductors are becoming vital to more and more industries. For example, as display technology becomes more affordable than mechanical dials and interfaces, industries are witnessing a meteoric growth in demand for semiconductor technology. This ever increasing



How embracing open-source software architecture can provide the best of both worlds for customers.

By **Ploutarchos Galatsopoulos**

diversification of semiconductor technology into smaller and more niche applications poses a problem for many semiconductor OEMs that open source can help to solve.

With thousands of unique industry customers, 1-to-1 technical and service support is almost impossible to provide in a timely and cost-effective manner, so many of these smaller industry segments are turning to open source software to take the lead themselves and develop highly specialised systems and interfaces. This in turn frees up OEMs to go about what they do best improving their semiconductor products for the next generation.

Another area that has seen a blossoming of open-source work is Artificial Intelligence (AI). AI, sitting on the cutting edge of computer

science and semiconductor technology is changing all the time. With growing understanding and breakthroughs being made every day, open-source programming is the only way to keep pace. Paddlepaddle, Kitisieg and many other AI languages are developed in consortium to keep up with the ability of Neural Network Accelerators to crunch data and to keep on the edge of evolving science.

For a proprietary system to be developed in this area would mean a lengthy product development cycle, so that come launch these solutions would already lag behind.

Most importantly, open-source architectures can be invaluable to entire semiconductor segments for one simple reason – competition.

# PEOPLE

One of the best examples of open technology generating healthy competition is the Khronos Group and their work in creating open-standards for graphics extensions to be used across the Graphics Processing Unit (GPU) sector.

Imagination has been an active member of the Khronos Group for almost 20 years and in that time alongside other OEMs and IP vendors, has collaborated in the development of many of the extensions in use today such as OpenCL and Vulkan raytracing.

With IP vendors and OEMs all conforming to and supporting a set of open-source standards, they can focus on innovating in their hardware, and keep their focus on providing the “secret sauce” for their customers. It is great for semiconductor customers too, because having a range of options that can support standard operating instructions, gives choice, and keeps manufacturers from being able to dominate the market and force up prices.

Open-technology looks like a vision of a perfect software Utopia, and for some that is the case, but like all things, there is no one size fits all solution.

## Putting the control in quality control

For the myriad niche industries embracing a digital future, a heavily open-source workflow is the way to go. But what of the established semiconductor consumers, should they look to open-source as their shining saviour?

The automotive sector is a huge consumer of semiconductors and with increasing pressure to

electrify, will only eat up more of the semiconductor market share. Many of the future and current applications of automotive silicon are in safety critical systems. An increasing demand for ISO26262 compliance and the need for ASIL certified systems is creating a requirement for the entire supply chain of silicon products to be traceable and accountable.

The recent certification of Imagination and the B-Series GPU is an example of where an IP vendor’s processes as well as their products need to be verified. With open-source software, by-design it is developed in widely spread-out networks where many people and organisations have access and editing rights making the process of accountability a lengthy one.

Alongside the need of many customers for accountability there is also a need for clearly defined Service Level Agreements (SLAs) and timely product support. Looking back to our automotive example, if a fault is identified in the software or hardware once a vehicle is on the road or in production, a robust support network provided by OEMs and IP vendors is essential.

We have seen recently how a chip shortage can cause long delays, and an issue in software at any point could do the same.

## The ecosystem spectrum

We have looked at the two ends of the software ecosystem spectrum, from fully open-source to the completely proprietary, but most customers would benefit from a solution somewhere in the middle. IP vendors and OEMs need to open their eyes to this future.



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The best open-source code in the world still requires bespoke APIs to allow it to correctly interface with hardware, which is still seldom open-source in many industries. This puts the onus on IP vendors to become experts in the field of open-source development and lead the charge on emerging frameworks.

By being involved in consortiums and development groups, IP vendors and OEMs can ensure they have day one compatibility and can approach customers with a well-tested and supported ecosystem with open source and open standards at its foundation.

Customers in this new hybrid model will benefit from the value added by a forward-thinking IP and OEM partner saving them development time and money. It also provides the added safety net and assurance that SLAs can provide. They now have a product that can take full advantage of the rapid innovation of open-sourced software architectures but have the peace of mind that these changes will be fully supported and rapidly integrated into the semiconductor products of the future.

## Only a Sith deals in absolutes

Semiconductors are making their way into everything. In the ever-expanding patch work of industries using semiconductors, IP vendors and OEMs need to offer everything they can to support their customers.

Open source can’t be regarded as a speed bump in monetising products and needs to become a fully integrated piece of IP vendor and OEM offerings. Those offering proprietary solutions and leaning completely into supporting and developing their products around an open source framework set themselves up as the ideal partners across the spectrum and will reap the benefits both in terms of business acquisition and most importantly customer satisfaction.

# The sun will come out tomorrow

**Steven Shackell** compares the performance of IGBT and SiC MOSFET PIMs when it comes to solar inverters

According to the International Energy Agency, solar power (PV) installations are on track to reach an installed capacity of 3,300 TWh by 2030, a yearly growth rate of 15% from 2019 levels, representing an increasing proportion of energy supply.

Installations will be a mix of micro, mini and utility-scale, but in all cases similar PV technology is used, with cells connected in series for high, usable voltages and in parallel for higher power. A trend is to increase voltages with strings of panels for the advantage of proportionally lower current, producing less power loss in connections and cabling. Typical nominal panel installation voltages are around 500 V to 1000 V but 1500 V is predicted to become more common in the future.

Rather than using a single central inverter, each string will often have its own relatively low power inverter for scalability, economy and fault tolerance. Within the equipment, the PV voltage is typically boosted to a regulated DC value suitable for input to a DC-AC conversion stage and a Maximum Power Point Tracking (MPPT) controller optimises the load on the panel for best energy utilisation.

The boost DC-DC converter and inverter are high efficiency switching circuits and the semiconductors employed can be of various technologies.

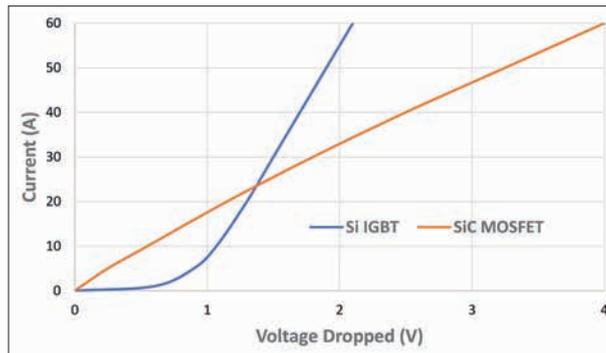


Figure 1: IGBT and SiC MOSFET PIM voltage drop compared at 125°C

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## PV power conversion options

Insulated Gate Bipolar Transistors (IGBTs) have dominated high power DC-DC and AC-DC conversion in the past, but new wide band-gap (WBG) semiconductors such as silicon carbide (SiC) MOSFETs are now available. Both are available as individual devices in common packages such as TO-247 but also as Power Integrated Modules (PIMs). A PIM integrates several switches, sometimes with diodes and even drivers and protection circuitry, in an industry standard housing. This can provide complete power stages for converter and inverter functions in a single package.

IGBTs and SiC MOSFETs differ markedly in several respects; IGBTs are restricted to low frequencies because of their dynamic losses but drop a nominally constant saturation voltage when conducting, leading to power loss simply proportional to current. SiC MOSFETs in contrast can switch at hundreds of kHz with low dynamic loss but exhibit a nominally constant resistance when conducting, leading to power loss proportional to current squared, clearly an increasing disadvantage as power throughput increases. Figure 1 shows the voltage dropped, proportional to conduction

loss, of a 50 A-rated IGBT PIM and a 38 A SiC PIM with the crossover point for best efficiency at about 25 A, under otherwise similar conditions. The plots are for a junction temperature of 125°C which is typical for the application.

Dynamic losses are frequency-dependent and if the IGBTs and SiC MOSFETs are compared at around 20 A to 30 A switching at the same low frequency, say 16 kHz, conduction losses are similar but dynamic losses are very different.

Figure 2 shows two sources of switching loss, turn-on and turn-off energy  $E_{on}$  and  $E_{off}$  respectively. Again, there is a crossover point but  $E_{on}$  is similar, with both device types at around one quarter of the conduction losses, a little worse for IGBTs but anyway not a large absolute value.  $E_{off}$  is much higher with IGBTs however due to 'tail' current – minority carriers that have to be swept out of the device N-drift region on turn-off, which are present with rising collector voltage, producing transient power dissipation.

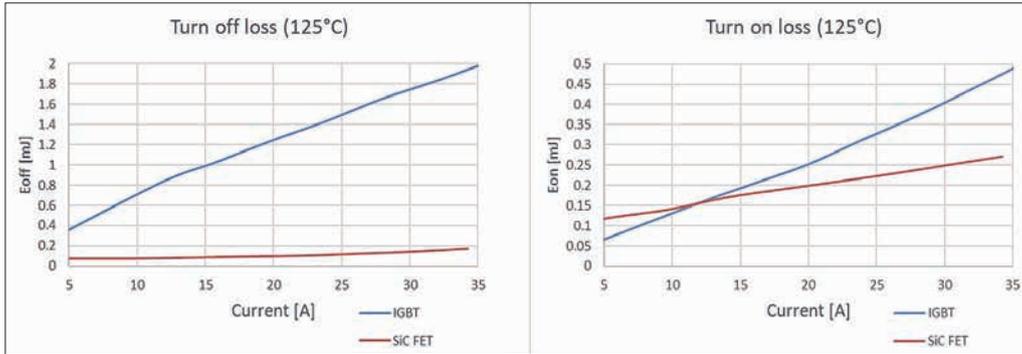
Table 1 summarises the differences in a practical PV boost converter with an input of 500 V, 25 A and an output of 800 V DC, running a 16 kHz and 95°C case temperature. There is a clear overall power saving with SiC with a total loss around a third of the IGBT circuit and a lower junction temperature for higher reliability.

## SiC MOSFETs score at higher frequencies

Apart from energy savings, the benefit of better efficiency with SiC can be taken as reduced size and costs of heatsinking, a lower rise in temperature for the same heatsinking or, alternatively, higher power throughput for the same heatsinking and temperature rise.

Table 1: Breakdown of losses in example boost converter at 16 kHz

	PIM-IGBT	PIM-SiC
Conduction loss	13.33 W	12.17 W
Switching frequency	16 kHz	16 kHz
Turn on loss $E_{on}$	3.8 W	3.17 W
Turn off loss $E_{off}$	34.66 W	3.06 W
Total loss	51.79 W	18.39 W
$T_j$ ( $T_c = 95^\circ\text{C}$ )	137.9 °C	109.9 °C



These are all valuable gains, but it is worth investigating what happens if the high frequency capability of SiC is exploited. Comparing SiC MOSFETs at 40 kHz with IGBTs at 16 kHz, the figures in Table 2 are obtained.

The SiC devices now have a higher junction temperature, but as WBG devices, they are anyway rated for typically 25°C higher operation than silicon. The SiC MOSFET results still show a significant efficiency gain over IGBTs, a little over half the losses, with all the benefits mentioned to a large degree. However, the increase in frequency also allows a reduction in the boost inductor value and size by around a factor of three with consequential cost, size and weight savings. Additionally, EMI filtering at the fundamental frequency and low harmonics can be smaller with further savings. SiC MOSFETs do have very fast edge rates though so high frequency filtering must be considered carefully to meet emissions standards.

Losses are not the only differences between IGBTs and SiC MOSFETs - a body diode is present in MOSFETs but not in IGBTs. This can be useful in conversion stages that require reverse or 'third quadrant' conduction in the switch. The SiC MOSFET body diode can be utilized for this although its forward voltage drop is relatively high. When using IGBTs this way, an extra parallel diode must be added.

A balance can therefore be found where system benefits from the use of SiC at a higher frequency

	PIM-IGBT	PIM-SiC
Conduction loss	13.33 W	13.6 W
Switching frequency	16 kHz	40 kHz
Turn on loss Eon	3.8 W	7.22 W
Turn off loss Eoff	34.66 W	8.34 W
Total loss	51.79 W	29.16 W
Tj	137.9 °C (Tc = 95°C)	133.6 °C (Tc = 110°C)

are substantial, far outweighing the difference in PIM unit cost between the technologies. As SiC MOSFET on-resistance decreases with release of new generations of devices, the benefit cross over point increases to higher power levels in ever wider applications.

**SiC needs careful design**

The gate drive for IGBTs and SiC MOSFETs may seem nominally similar but the on-drive for the SiC device is more critical for lowest conduction losses and must be as close as practical to the absolute maximum of typically 25 V. For this reason, 20 V is often used, giving some safety margin. Both device types are nominally off with 0 V gate drive, but both are often driven negative by a few volts. This gives smaller Eoff, less gate-source ringing on turn-off and helps prevent 'phantom turn-on' which can result from spikes from any source or emitter inductance common to the gate drive loop.

Any device 'Miller' capacitance can also tend to spuriously turn devices on with high drain or collector voltage edge rates (dV/dt). Again, the negative gate drive helps to avoid problems. (See Figure 3)

Table 2: Losses compared – IGBTs at 16 kHz and SiC MOSFETs at 40 kHz

Figure 2 (top): Dynamic losses of example IGBTs and SiC MOSFETs compared at 16 kHz

SiC MOSFETs have much higher dV/dt and di/dt than IGBTs and in practical circuits, high frequency layout techniques with careful decoupling must be used to avoid unreliable operation and excessive EMI. Drivers must be close to the SiC MOSFET PIM and any available 'Kelvin' connection to the MOSFET source should be used as the driver return, to avoid common inductance.

Accurate measurement of SiC MOSFET PIM dynamic performance can be difficult due to the fast edge rates, so typically equipment should have 300 MHz bandwidth and high frequency measurement techniques used. Voltage probes should be connected with a minimum ground loop and current monitored with high performance sensors such as Rogowski coils.

Making the switch away from IGBTs to SiC MOSFETs is a net system benefit at increasing power levels, with PIMs providing an easy solution. Those familiar with using IGBTs, however, should be aware that a simple swap-out will not give good results – gate drive arrangements, layout and EMI filtering need to be re-evaluated for optimum performance.

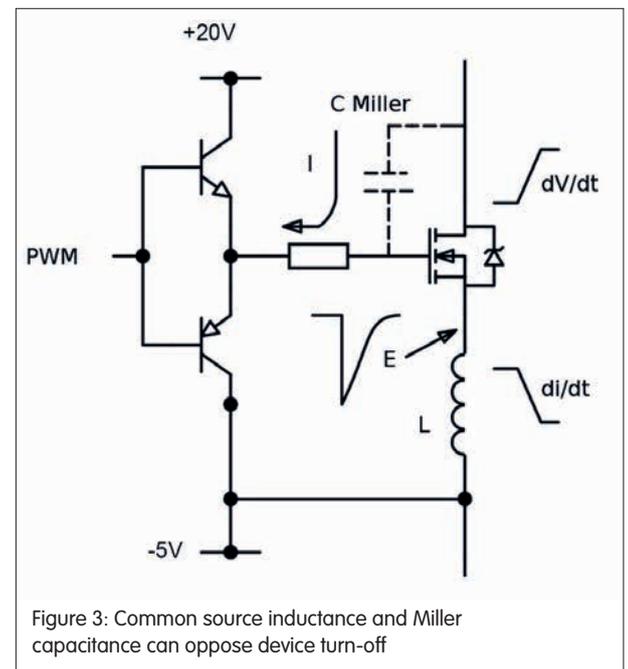


Figure 3: Common source inductance and Miller capacitance can oppose device turn-off

**F**rom radiation hardened SoCs to the growing use of flying plastic encapsulated modules, recent developments have made doing business in space more achievable for a broadening base of companies.

Not that long ago the space market consisted primarily of major defence contractors and national governments, but today it is being disrupted by a growing list of commercial companies. For many this represents a 'paradigm shift' which is helping to open up new developments in space products that will have a dramatic impact on both spacecraft size and performance in the future.

Across the sector commercial companies are reporting huge investments in space technology at the same time that the cost of space launches has dropped to its lowest level in history, as companies develop new approaches to launch vehicles.

Investments of up to \$1 billion are going toward deploying constellations of low Earth orbit (LEO) satellites to connect people in remote corners of the globe, while other approaches are looking to increase internet connectivity and include high altitude unmanned aerial vehicles (UAVs).

With a growing number of deep space initiatives including planetary exploration, orbiter missions and space research there's a growing requirement for innovative spacecraft system technology capable of providing connectivity and processing capabilities.

"Spacecraft and satellites are expanding in complexity to provide commercial and military operators with robust new communication and data capabilities, greater reliability and faster speeds, while the operators continuously seek to reduce cost, size and weight," said Bob Vampola, associate VP of Microchip's aerospace and defence business unit. "In this environment, lowering system development costs while enabling greater capabilities and space system integration are ever more critical."

# A 'NEW ERA' IN SPACE PRODUCTS

Radiation tolerant commercial products are having a growing impact on the burgeoning space market, as New Electronics discovers

## Arm opens up new perspective

In a move designed to respond to these pressures Microchip has recently announced the qualification of its SAMRH71 Arm-based microprocessor (MPU) and the availability of the SAMRH707 MCU, both of which implement Arm Cortex-M7 SoC radiation-hardened technology.

Both the SAMRH71 and SAMRH707 have been developed with the support of the European Space Agency (ESA) and Centre National D'Etudes Spatiales (CNES), the French space agency, to further research and support initiatives.

"The introduction of Arm technologies for space applications opens up new perspectives by enabling the use of the same ecosystem that's already well-established in the consumer and industrial sectors," said David Dangla, VLSI Components Expert at CNES. "The SAMRH71 is the first Arm Cortex M7-based rad-hard microprocessor available and offers developers the simplicity of a single-core processor and the performance of an advanced architecture without having to implement heavy mitigation techniques as is required for non-space components."

Using a standard Arm Cortex-M7 architecture and the same peripherals as automotive and industrial

processors, the SAMRH71 and SAMRH707 are able to reduce system development costs by leveraging standard software and hardware tools from the consumer devices.

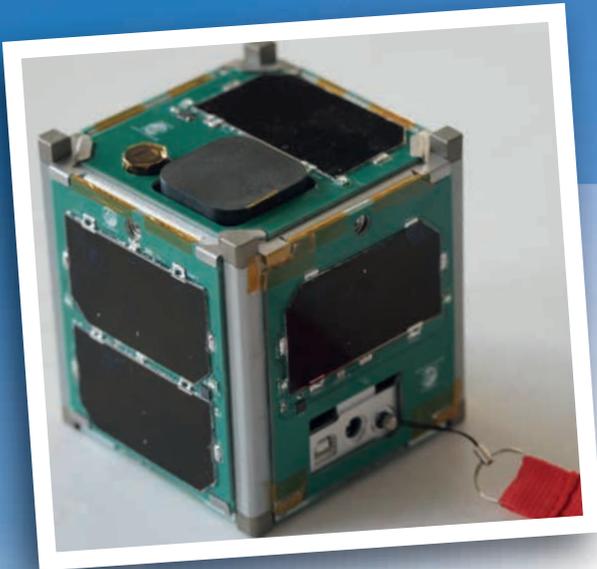
The SAMRH71 is a radiation-hardened variant of Microchip's COTS automotive SoC technology, and provides a combination of space connectivity interfaces along with high-performance architecture with more than 200 Dhrystone MIPS (DMIPS).

Designed for high-level radiation performance, extreme temperatures and high reliability, the device's Arm Cortex-M7 core is coupled with high-bandwidth communication interfaces such as SpaceWire, MIL-STD-1553, CAN FD and Ethernet with IEEE 1588 Generalized Precision Time Protocol (gPTP) capabilities.

The new SAMRH707 device provides analogue functions on top of a >100 DMIPS processor unit with Digital Signal Processing (DSP) capabilities, combined with space connectivity interfaces in a small footprint designed for high-level radiation performance, extreme temperatures and high reliability.

The SAMRH707 enables a high level of integration embedding Static Random Access Memory (SRAM) and flash memory, high-bandwidth communication interfaces including





SpaceWire, MIL-STD-1553 and CAN FD, along with analogue functions such as a 12-bit ADC and DAC.

Another company with a long history in space is Analog Devices which has been delivering products that are both reliable and resilient to the damaging effects of radiation in space.

“Our heritage line of space products is well known in the industry to be hardened to over 100 krad, making these products suitable for the harshest orbits,” said Tyler Fure a specialist in semiconductor design, who is currently developing military and space products at Analog Devices.

While developing new ICs for the commercial market is challenging, transitioning these ICs to space qualified products is complex and time-consuming.

“The vast majority of new ICs are built on BiCMOS processes that give us the capability to combine the best of bipolar and CMOS process technology,” explained Fure.

“From a radiation tolerance perspective, however, these BiCMOS devices require us to characterize and mitigate effects of both total ionizing dose (TID) as well as single event effects (SEEs). This extends the development time for new products at a time when we need to release new products more rapidly.”

Above: An example of a miniaturized satellite platform using PEMs

### Packaging innovation

Another factor driving new product development is packaging since many new products are being designed with unique packaging that enhances the performance of the commercial IC.

“In some cases, transitioning a commercial product to space becomes impractical when its performance is tied directly to the existing non-hermetic package,” said Gabino Alonso, the marketing manager for the Power by Linear Group at Analog Devices.

According to Alonso, this might include issues related to additional parasitic effects that require complete new hermetic package development, costly redevelopment of post package trim, or procurement of new highly complex test systems and handlers.

“Luckily, there are other forces at work that will allow us to develop more advanced products more rapidly. The first is that the total dose radiation requirements of LEO, for example, are lower than traditional orbits, so a product that can meet 30 krad to 50 krad tolerance is acceptable. The second is a ground swell of support for the use of flying plastic encapsulated modules (PEMs) in space, an idea that until recently had been met with outright disdain from EEE parts managers and engineers.

“It will not be easy, but if done properly and accepted by the space community, these developments will open the door to dramatic improvements in performance, as well as reductions in size, weight, and power (SWaP) for the spacecraft,” according to Alonso.

Producing space qualified PEMs with the highest quality and reliability is crucial and the major space agencies have long had specifications for the post-processing of PEMs to qualify them for space use.

“Yet, the space community has long resisted the use of PEMs due to inherent risks and uncertainties in the process, including lot traceability, validity of radiation test results, test program correlation, and lack of

manufacturer warranty and support,” said Alonso. “It is costly and time consuming to do the testing and carries the risk of a lot failure leaving the designer to start the process over with a different part, add shielding, or include other mitigation techniques that add cost and weight.”

If manufacturers can offer a space qualified PEMs product, those risks are not only greatly reduced but it will also open up the possibility to dramatically improve the build schedule as well, if the product being offered is in stock.

Analog Devices has introduced a new line of commercial space products and is now offering three distinct flows that are targeted at differing requirements from customers depending on the quantity of satellites they will be looking to operate.

According to Fure, the lowest flow is intended for pure commercial space customers looking to fly high volume in space, offering special support for radiation requirements. The medium level flow is an optimised flow offering additional radiation test, screening, and lot qualification.

“These flows will likely satisfy the vast majority of commercial space customers,” Fure suggested.

The high level flow combines improved quality and reliability screening and qualification with radiation characterization and assurance. The combined flow will include radiation characterization both for TID and SEE as well as lot qualification for TID.

The work required when it comes to delivering commercial components for space is extensive and can be costly, but the benefits in performance, and reductions in size, weight, and power compared to existing space qualified products, together with the quality and radiation assurance, more than justify the cost and will enable future spacecraft to deliver higher performance at a lower total cost than ever before.



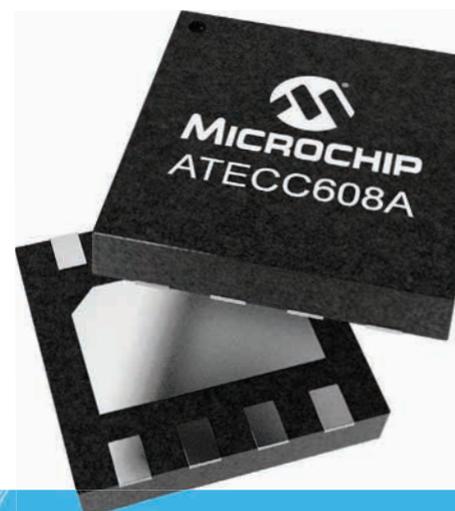
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# Engineering the next giant leap for mankind

**H**ailed as one of man's greatest achievements, the first moon landing catalysed efforts to venture further into space. However, if we are to travel further we will need to better understand and overcome the biological challenges of long term space travel.

The BAMMsat project aims to enable biological research that will uncover these threats and better understand the effects spaceflights can have on astronauts as they travel beyond the International Space Station to deep space destinations such as the moon and Mars.

The next major milestone is a manned mission to Mars, which NASA estimates will be achievable in the 2030s. Space exploration pushes the boundaries of science and technology, as well as the limits of the human body, so before we are able to send astronauts further into space, we need to expand our knowledge of the resulting long term effects of microgravity and high radiation on the human body – how will the body react to long duration space flight and what physical programmes and standards need to be put in place?

According to Nasa the risks associated with extended periods of

New Electronics looks at how the BAMMsat project is aiding biological research and helping us realise our ambitions of deep space travel

space travel can be grouped using the acronym – RIDGE – short for Space Radiation; Isolation and Confinement; Distance from Earth; Gravity fields and Hostile/Closed Environments.

So the number one priority, when it comes to deep space, is keeping astronauts alive and healthy. Data will be critical to this, however, current space medicine and biology is profoundly limited and testing is prohibitively expensive.

The objective of the BAMMsat-on-BEXUS project is to improve technology for biological research in space, with an ultimate aim of supporting human spaceflight. The technology is being developed by a team of academics and students from Cranfield University and the University of Exeter.

## Science in small spaces

The project team is developing a miniaturised lab system that is compatible with 3U CubeSats, a sub-type of miniaturised satellites designed for space research, consisting of three units stacked



**“Researching the effects of microgravity and radiation in on-ground facilities has technical constraints that can add complexity to data interpretation.”**

Aqeel Shamsul

together. The compact system is said to hold many advantages over other techniques used to research the influence of space conditions on living systems.

“Researching the effects of microgravity and radiation in on-ground facilities has technical constraints that can add complexity to data interpretation,” explained Aqeel Shamsul, a PhD student at Cranfield University and head of the project. “However, in-flight experiments come with their own challenges, often entailing expensive launch missions.

“These factors are limiting research into the effects of environmental space factors on biological systems, therefore impeding progress in deep space travel. We’re combatting this by designing a cheaper way to conduct biological research in space, with a system that can facilitate experiments within remarkably small dimensions.”

CubeSat’s are built to a standard dimension and that standardisation means that a lot of the technologies and interfaces for a CubeSat can also be standardised.

The lab system that's been developed includes a disk with multiple chambers along its edge that contain isolated biological samples. A motorised system turns the disk to position different chambers opposite microfluidic inlet and outlet openings, which can channel small amounts of fluids without human intervention.

The device can then supply food or extract waste from the samples using a fluidic pump.

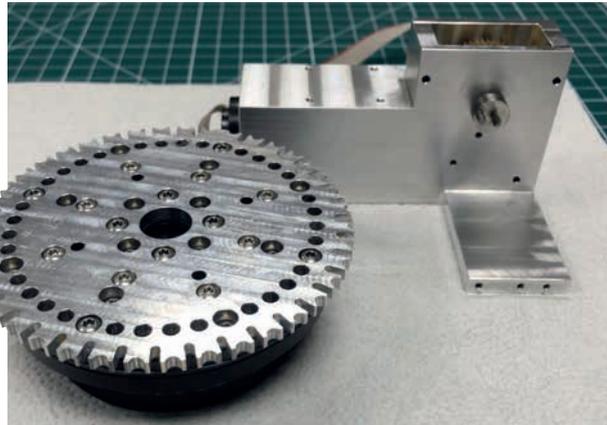
The disk can also be turned to orientate a chamber in front of a microscope, which can send an image of the sample back to researchers on Earth. In addition, the rotating disk allows the samples to be aligned with a visible spectrometer. This technology can measure the amount of light absorbed, reflected or transmitted from the sample to reveal certain biochemical characteristics, such as protein quantification.

Compared to other equivalent systems that have one block containing one sample, the multi-chambered disk system allows numerous experiments with different samples to occur simultaneously. Biological samples can include microorganisms such as *Escherichia coli* (*E. coli*) and *Caenorhabditis elegans* (*C. elegans*).

*C. elegans* in particular is a valuable study organism for researching the effect long term space travel will have on the human body. This is because both humans and *C. elegans* are eukaryotic organisms, and share many genes and molecular pathways.

These factors, along with the fact that the genome of *C. elegans* has been completely sequenced, allow them to be used as a model organism in experiments that research human disease progression. At only a millimetre long, and with minimal survival requirements, they can be relatively easily transported into space with minimal human intervention.

"As well as using a small organism,



light weighting other components of the system was important to ensure the satellite could be viably and economically launched into space," added Shamsul. "One area where this had to be considered in detail was the motor system used to turn the disk containing sample chambers."

To deliver the high torque required to turn the disk, the project needed a motor system capable of delivering the necessary power but also one that remained compact. To achieve this EMS, a UK supplier of Faulhaber motors was brought into the project.

According to Shamsul, "We originally considered a stepper motor for the BAMMsat system, but EMS showed us that a brushed DC motor would better fit our torque and space requirements."

EMS conducted thorough calculations to find a system that would deliver maximum performance in the given space envelope. After careful consideration, a 22mm diameter brushed motor from the Faulhaber SR series was selected. The motor was paired with an encoder to deliver fine speed control, as well as a planetary gearhead to maximise torque and being small and light weight, the motor system ensured minimal weight and bulk was added to the CubeSat.

### To infinity and beyond

The BAMMsat system is planned to be launched into the stratosphere in October 2021. With the help of the Swedish National Space Agency,

Above: The rotating disc forms part of the motor driven sample chambers

German Aerospace Centre (DLR), European Space Agency and their partners, the prototype will be flown using a high-altitude balloon.

This will allow the BAMMsat team to test aspects of the system, such as the control system and payload hardware, in a spaceflight-representative environment.

The ultimate aim of the stratosphere mission is to increase the system's Technology Readiness Level (TRL). Developed by NASA, the TRL scale measures the maturity of a particular technology on a scale of one to nine, with one meaning it's at basic research level, and nine indicating it's been flight proven through successful mission operations.

Once the BAMMsat system has been validated for future missions, it could go on to conduct biological research in low Earth orbit (LOE) and deep space, including trips to the International Space Station (ISS).

"The BAMMsat project is a result of impressive collaboration between a number of engineering sectors, incorporating aerospace, biological and mechanical expertise," said Dave Walsh, sales manager at EMS. "University projects are at the forefront of this type of technology, and the potential of this system to enable safe long term space travel is sensational."

The project is intended to look at microgravity and radiation from high-energy particles and their impact on Earth's biology whether that's human biology, food or bacteria and for many it's biology that is the biggest challenge when it comes to deep space travel and the prospect of settlements on planets like Mars.

But while the BAMMsat project will help fill the knowledge gap when it comes to long term human duration in space, it will also be able to benefit those of us who are left back on earth. A better understanding of how a virus or bacteria behaves in space could lead to better vaccines, while a better understanding of the ageing process could benefit all of us.

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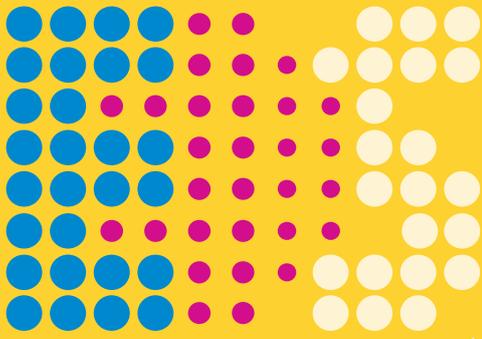
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