SYNAPS Broadband Software Defined Radio. Photo courtesy of Thales

Digitising the battlefield with software defined radios

As more and more data is relayed between the command centre and the battlefield over radio frequency, defence forces are increasingly seeking affordable solutions that minimise costs while maximising capabilities. Software defined radios (SDRs) are the perfect solution, providing the flexibility of in-situ programming, while increasing data relays through a single handheld device. The market for SDRs within the military is well-established, and exemplified by the growing number of new contracts, as well as the influx of new devices, each boasting enhanced statistics such as size and weight reductions, and increased power.

The battlefield is a changing place. New technologies are enabling defence forces to send and receive more information, faster, accelerating response times and actions. Today, more than ever before, defence forces are undergoing a technology overhaul to ensure that soldiers are equipped with the best possible equipment. Size, weight and power (SWaP) factors play a major role in the effectiveness of a soldier, since large, heavy items hinder progress in the field, while higher power devices are required to provide increased operability.

Software defined radios (SDR) are a big part of this trend. Ideal for military applications, many of the traditional components in a radio such as amplifiers, detectors and modulators/demodulators, are replaced by software within a single handheld device that perform the same task. That software can be rapidly configured in the field to suit the changing environment and protocols, providing much-need flexibility.

SDRs have been in play for some time now, but their use is growing practically daily. Research and Markets' '*Software Defined Radio Market by Applications (Defense, Commercial, Homeland Security), Component (Software, Transmitter, Receiver), End User (Military, Transportation), Type (JTRS, Cognitive/Intelligent Radio, TETRA) – Global Forecast to 2021*' estimates that the SDR market will grow from US$16.24 billion in 2016 to US$29.12 billion by 2021, with a CAGR of 12.39 percent. The defence sector largely dominates the SDR market as global defence forces invest heavily in new technologies, modernising their forces with equipment that delivers unparalleled performance with reduced development costs.

The major growth drivers are the need to replace legacy equipment with advanced communications systems, network interoperability, device compatibility with future standards, reduced cost of products and services, and universal connectivity. G7 nations are the main driving forces in the market, with demand for SDRs stemming from the military, public safety and commercial sectors. During 2016-2021, the BRICS countries are expected to provide the highest growth rate for SDR investment.

New SDRs designed for the military space

As the digitisation of the battlefield continues to increase in pace, more and more companies are expanding into the field of SDR production, each launching products to meet a specific need. Those companies already present in the market continue to enhance their offerings with new designs featuring increased capabilities, reduced size and weight, or increased power.

In May 2016, Barrett Communications announced the Barrett 4050 HF SDR, its latest high frequency (HF) SDR product. The new SDR comes with a unique user-friendly touch screen interface and multiple languages as standard, enabling it to be marketed to a broad range of users, including law enforcement, peacekeeping, security organisations, humanitarian and non-governmental organisations (NGOs), in addition to commercial businesses.

"The level of user accessibility at a local and remote level is

a highly significant technological advance in the HF radio communications market. This can all be achieved whilst still providing secure communications via encryption, or frequency hopping options," said Greg O'Neill, Managing Director of Barrett Communications.

The Barrett 4050 HF SDR comes with a choice of modems, including MIL-STD-188-100A/B options. The SDR is remote control enabled over iOS, Android and Windows devices, and transmits at up to 150W. IP connectivity for straight-forward integration with existing networks and on-board WiFi, and 2G and 3G Automatic Link Establishment (ALE), come as standard. Advanced frequency hopping is available as an optional add-on, with rates of 5 or 25 hopes per second using an eight-digit hopping encryption key and a user-selectable hopping bandwidth suitable for a variety of antenna types.

June 2016 saw Thales unveil a new broadband tactical SDR family designed to support battlespace digitisation and C4I systems. In addition to hierarchical communications, SYNAPS provides a unique collaborative combat capability based on real-time horizontal communications between all the units on the ground. Building on the CONTACT system, the largest SDR programme in Europe, SYNAPS is designed for international markets and meets the requirements of land, air and naval forces.

SYNAPS is built around SDR/SCA technologies compliant with the latest NATO and international coalition standards, most notably the European Secure Software Defined Radio (ESSOR) high-data-rate standard, developed by the armed forces of six European nations (Finland, France, Italy, Poland, Spain and Sweden). ESSOR is also a candidate for the NATO specification and standard. In addition, SYNAPS radios are reprogrammable and ready to accommodate new standards in the future.

Thales' new SDR devices provide voice, messaging, video, chat and Blue Force Tracking simultaneously and with differentiated quality of service, with the most critical data transfers being accorded priority status. They also offer excellent range performance and protection against jamming on the battlefield, while optimising use of the frequency spectrum for the same amount of useful data throughput. SYNAPS provides the optimum combination of data rates, security and connectivity and adapt automatically as operational deployments are reconfigured during a mission. The SDR family is suitable for forces of any size and was designed for all types of users, platform types and branches within the armed forces, as well as joint, combined arms and allied operations.

"The launch of SYNAPS heralds a revolution in military radiocommunications, comparable to the transition from 3G to 4G. With unparalleled performance, particularly in terms of operational range and protection, SYNAPS will become the central nervous system of military deployments and enhance command capabilities in collaborative combat operations," said Marc Darmon, Executive Vice President of Secure Communication and Information Systems at Thales.

Barrett 4050 HF SDR

Meanwhile, in September 2016, Codan Radio Communications expanded its Sentry product family with the addition of the Sentry-H High Frequency (HF) SDR Radio. Based on the company's proven Envoy HF SDR platform, the Sentry-H provides an advanced high power radio solution with rugged and secure voice and data communications. The new SDR is equipped with second-generation digital voice, frequency hopping, embedded GPS, 3G ALE and IP/USB connectivity. Custom-built for mobile and base configuration, the Sentry-H eliminates the need for an external amplifier, and features a Smart handset and a simplified intuitive menu system with multiple language options.

"At Codan we've addressed the most important issues for our customers — reliability, affordability, and ease-of-use. For government and militaries with tactical requirements, the Sentry-H is the smart and cost-effective choice," said Paul Sangster, Codan's VP of Business Development and Marketing.

US Army launches Handheld, Manpack and Small Form Fit programme

With so many SDRs available on the market, all boasting to be market-leading products incomparable with competing devices, it can be challenging for defence forces to decide which to pick. One solution is to procure a small number from a variety of suppliers for rigorous testing, with the promise of a large contract to the leading device manufacturer.

In February 2016, the US Army awarded contracts to Rockwell Collins, General Dynamics and Harris Corporation to manufacture battlefield radios for soldiers. The US Army plans to reduce the current weight of its handheld and manpack radios, the AN/PRC-155 SDR, from 19lb to 16lb, while supporting eight hour missions. Ultimately, the army aims to reduce the weight to 14lb by 2025.

Each company was to provide 30 radios to the US Army for testing to ensure the products met requirements as part of its Handheld, Manpack and Small Form Fit (HMS) programme. If the initial 30 radios were found to meet requirements, the Army would then buy 60 from each manufacturer for the customer test phase. The programme would ultimately see the US Army invest some US$12.7 billion for 60,000 radios in ten years.

In May 2016, General Dynamics Mission Systems became the first of the three companies to deliver the required 30 radios to the US Army for testing. General Dynamics' contribution was based on the proven AN/PRC-155 two-channel networking radios it had delivered to the US Army as part of a previous low-rate initial production order. They are the only fielded two-channel radios to successfully communicate using the mobile user objective system (MUOS) network during a demonstration at a joint Navy-Army operational test in November 2015.

"The General Dynamics radios incorporate the secure, network communications capabilities of the AN/PRC-155 along with technology and functionality improvements suggested by soldiers who have used the PRC-155 in combat," said Paul Parent, Vice President of Radio Products for General Dynamics Mission Systems. "By leveraging a proven radio design, the General Dynamics digital radio is the most capable and cost-effective next-generation tactical radio for the Army."

Harris Corporation pledged to provide 30 of its Harris AN/PRC-158 multi-channel radios for the programme. The Harris AN/PRC-158 radio features a two-channel architecture and integrated cross-banding. It includes SRW, SINCGARS and MUOS waveforms, in addition to maintaining backward interoperability with legacy waveforms.

"The HMS Manpack award is a major step forward for the US Army's tactical radio modernization program, and brings essential battlefield networking and communications capabilities to the warfighter," said Brendan O'Connell, President of Tactical Communications at Harris Communication Systems. "The award also allows Harris to now compete at all echelons of the Army tactical communications architecture — from dismounted handheld radios through vehicular-based radio platforms."

In December 2016, Rockwell Collins successfully completed qualification testing for the 30 AN/PRC-162 two-channel radios it supplied for the US Army's HMS programme. Based on Rockwell Collins' TruNet networked solution, AN/PRC-162 hosts narrowband and wideband waveforms, point-to-point data and MUOS in a SDR architecture.

"The AN/PRC-162 benefits directly from this technology baseline as well as our proven experience integrating networked communications across the battlefield," said Troy Brunk, Rockwell Collins' Communication and Navigations Solutions Vice President and General Manager. "Our TruNet product line represents a complete turnkey system solution utilising both air and ground assets and using many common assemblies, parts, and manufacturing processes between them."

New SDR innovations from the commercial sector

Many of the greatest innovations and new ideas come from small start-up companies in the private sector, where new technologies develop into major game-changers throughout a number of industries. This is as true for the SDR sector as anywhere else.

One noteworthy example comes from Lime Microsystems, which, in May 2016, launched a crowd-funding campaign for US$500,000 to bring its Lime SDR platform into full-scale production. LimeSDR is a low-cost application-enabled SDR platform that can be programmed to support 'virtually any type of wireless standard – including Wi-Fi, ZigBee and Bluetooth through to cellular standard such as UMTS, LTE and GSM, and to the emerging IoT communication protocols such as LoRa.' Potential applications identified by the company include Radar, radio astronomy and IoT gateways.

The 100x60mm LimeSDR board uses the Lime Microsystems LMS7002M field programmable RF transceiver to provide continuous coverage over the 100kHz to 3.8GHz range with a 120MHz RF bandwidth. The transceiver contains two transmit and two receive chains for provisioning a 2x2 multiple in multiple out (MIMO) capability. Complementing the wireless transceiver is an Intel/Altera Cyclone IV field programmable gate array (FPGA) that allows high bandwidth DSP tasks to be carried out in hardware. Interfacing to the host application is via USB 3.0 using a Cypress USB 3.0 microcontroller. Transmit output, up to 6.5dBm continuous wave, is through four U.FL connectors, providing two outputs per transceiver chain. Six U.FL connectors, three per receiver chain, are used for receiver antennas.

"With LimeSDR, our aim is to bring the same level of programmability we have in the digital domain into RF and, as a result, we believe the next generation of wireless networks could bring real innovation into this field," said Ebrahim Bushehri, CEO of Lime Microsystems.

Lime Microsystems has built a range of open source support tools and resources, including a host drive architecture that supports SoapySDR and UHDTM APIs. SoapySDR is a vendor and platform-neutral SDR support library used to provide a C++ API with C wrapper and Python bindings. Radio application development is made possible by support from the Pothos dataflow programming software suite and the GNU Radio open source signal processing toolkit. With these open source support tools and resources, young engineers can gain expertise in working with SDR systems, providing a much-needed education boost to the next generation, who may play a significant role in military and defence system design. They are also able to use today's technology and open source resources to solve challenges in other fields in a cost-efficient way.

Others innovators, like start-up company Bastille, are using SDR technology in inventive new ways that could one day be adapted for military applications. Bastille has designed SDR sensors to protect enterprises from network security threats. The patented technology, Bastille Enterprise, pairs SDR sensors with machine learning to identify abnormal events on the wireless network, be it WiFi, Bluetooth, cellular, or an Internet of Things (IoT) protocol. According to CEO Chris Risley, the technology can identify threats and attacks, in addition to unapproved wireless devices such as a keyboard or camera.

Bastille Enterprise uses three types of technology to scan the spectrum from 60MHz to 6GHz. Collaborative bandit sensing scans the spectrum for emitters and threats using a Bandit prediction algorithm and machine learning, Bayesian device fingerprinting detects and identifies devices in the enterprise's airspace, and Distributed Tomographic Localization provides position information of all emitters in a corporate airspace.

As Bastille Enterprise is based on SDR, adjustments and upgrades can be made without replacing radios or chip sets. "We can deploy these sensors, and if a new protocol comes out, we just push a new software update," said Bob Baxley, Chief Engineer at Bastille.

The Spectrum Collaboration Challenge

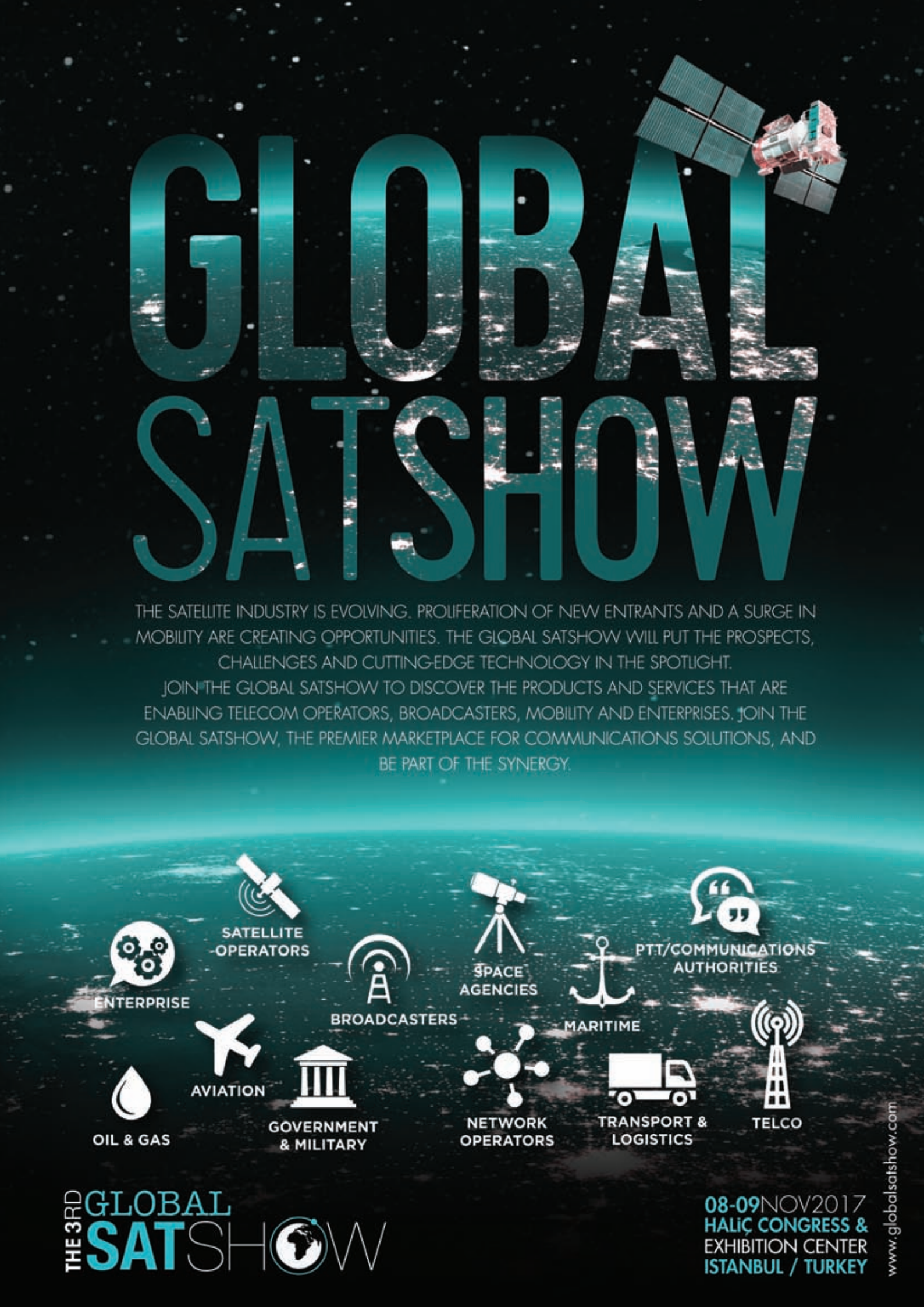
In March 2016, the Defense Advanced Research Projects Agency (DARPA) announced its Spectrum Collaboration Challenge to encourage the development of smart systems that can adapt in real-time to congested or contested spectrum, boosting overall RF communications.

DARPA expects developers to incorporate SDRs with other radios to optimise spectrum efficiency across an entire communications network. Emerging tools such as machine-learning software, when combined with SDR technology, will redefine traditional spectrum management. Machine learning will replace the practice of assigning frequencies for exclusive use, which is fast becoming ineffective as spectrum demand grows, especially in the military sphere.

"We want to radically accelerate the development of machine-learning technologies and strategies that will allow on-the-fly sharing of spectrum at machine timescales," said Paul Tilghman, Programme Manager for the Spectrum Collaboration Challenge.

The three-year competition begins in 2017, with the finalists set to compete in 2019 for a US$2 million prize. The challenge is open to individuals, universities, start-ups and companies. **GMC**

Codan Sentry-H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