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More Air Sir?

The more we emphasise that *Asian Defence and Diplomacy* is a magazine for Asia and not about Asia, the more significance this seems to have. Particularly relevant to this is the on going debates about air power.

While very few doubt that air power is highly relevant to Asian defence thinking and planning, the thorny issue of cost will constantly raise its head. In very stark terms, if bigger economies mean bigger defence budgets, then Asian countries will become the main markets for military aircraft in the foreseeable future.

Russia, India and China are all set to be leading world economies. Indonesia's economy is building, as is Vietnams, and Japan's and South Korea's economies are likely to remain significant. Moreover, recent events and disputes have shown Asia to be not as politically stable as some seemed to have thought. China's street level anger with Japan may be age-old, but it is still powerful and apparent, to the degree that it might drive policy. Who owns what island does seem to be a potential source of conflict, that could provide a reason for war, just as seemingly mundane as that which sparked at least two recent wars, in the Lebanon in 2006 and in Georgia 2008.

In this environment air power cannot be discounted, as has been the case in some recent conflicts, in terms of one air force seriously challenging another with near parity in capabilities. Thus how money gets spent now, or how it may have been spent in the recent past could well have a significant imp act of the nature of any air operations, which take place. A small number of very capable aircraft may suffer when faced with a greater number of less capable opposition. This is not just true for air-to-air engagements, but almost every role you can apply airpower to.

Arguably, Asia is set to become the potential air power laboratory of the future, with the money and the defence need to spend it because it matters in ways that simply do not exist elsewhere or just remain unrealised! What gets procured now and how air arms see it as being deployed deserves close attention, and *Asian Defence and Diplomacy* will certainly be watching closely.

Asian Defence & Diplomacy
William F. Owen, Editor

Breaching The Great Wall – China's Snowballing Military

By Gordon Arthur

TOP: Thanks to rapid shipbuilding in recent years, the modern Type 054A frigate now forms the backbone of the PLAN inventory. (PHOTO: Gordon Arthur)

OPPOSITE PAGE: Entering operational service in 2005, the J-10A fighter is China's most modern truly indigenous fighter in PLAAF service. (PHOTO: Gordon Arthur)

SEPTEMBER WITNESSED UNPRECEDENTED Chinese ury after regional competitor Japan took steps to nationalise three Diaoyu (Senkaku in Japanese) islands in the East China Sea. In a wave of nationalistic fervour, thousands of protestors took to the streets to condemn Japan. The hawkish *Global Times* published a joint statement by ten retired generals calling for military operations against Japan. Meanwhile, the state-run *Beijing Evening News* wrote this chilling statement: "Just serve [Japan] with the main course of nuclear missiles and all the troubles will be saved." These reactions are testament to both the growing capability of the People's Liberation Army (PLA) and to a new national assertiveness. This article examines the growing might of the Chinese military and its 2,355,000 personnel.

onally been a land power, as typified by the 21,196km Great Wall constructed to keep out would-be invaders. Even today, China relies on landlocked buffer zones such as Tibet, Xinjiang and Inner Mongolia. Only now, as China has grown into the world's second-largest economy, has Beijing's focus turned outward. The country is dependent on imported oil and natural resources, plus 90% of its exports travel by sea. The leadership is anxious about foreign containment as the USA implements its "strategic pivot" to the Asia-Pacific region. This concern is understandable – US Marines in Darwin, naval vessels in Singapore, more submarines in the Western Pacific, and closer alliances with South Korea, Japan and the Philippines – as the USA buttresses its regional strategic position.

China is no longer willing to rely on others to safeguard its economy and guarantee freedom of movement. This explains the PLA's involvement in multinational anti-piracy operations in the Gulf of Aden since December 2008, which incidentally has provided China the perfect opportunity to establish a longstanding presence in the Indian Ocean. It has also established commercial ports in Bangladesh, Myanmar, Pakistan and Sri Lanka that could potentially offer future bases of operation. Furthermore, the PLA Navy (PLAN) has demonstrated a capability to conduct limited deployments of modern warships beyond the second island chain in the Pacific.

China has become a major contributor to United Nations (UN) peacekeeping missions, with 1,797 troops currently deployed. The communist country is also becoming a serious exporter of arms, which helps generate revenue and cultivate friendships with other countries. China offers generous repayment options, technology transfer and increasingly sophisticated weaponry at affordable prices. Arms exports to 36 countries last year amounted to USD1.35 billion. Approximately half this total went to Asian nations, with ally Pakistan the largest market.

Islands

China has been involved in increasingly ugly spats regarding maritime territorial claims. There are ongoing disputes with Vietnam, while a naval standoff occurred with the Philippines in April over Scarborough Shoal. In June, China nominated Sansha on Woody Island as the administrative centre of the Paracel and Spratly Islands, with the associated announcement of a PLA garrison there. China does not employ PLAN vessels in these confrontations as this would come across as heavy-handed. Instead it typically uses China Marine Surveillance vessels from the State Oceanic Administration (SOA), an organisation operating 400+ boats. The SOA director announced in June that 36 patrol vessels would be built over the next two years. In September, an SOA spokesman also stated it would start using unmanned aerial vehicles (UAV) for surveillance by 2015.

China has been aggressively pursuing

UAVs for military use. For example, the last Zhuhai Air Show featured around 25 UAV designs, although few have progressed into service. The WJ-600 is known to be in PLA Air Force (PLAAF) service, while hangars for BZK-005 high-altitude long-endurance (HALE) craft have been identified in Guangdong and Beijing. A larger HALE maritime surveillance platform is the Xianglong that is described as the "Chinese Global Hawk". Its expected range of 7,000km is sufficient to reach Guam.

An issue that still looms large in Chinese strategic thinking is Taiwan. China has never renounced the use of force to reunify this "renegade province" with the motherland. Although relations have thawed somewhat since President Ma Ying-jeou was elected in 2008, China still concentrates weapons and personnel across the Taiwan Strait. For example, some 1,200 DF-11, DF-15 and DF-21 missiles are currently aimed at Taiwan. In this regard, China is extremely wary of the USA, which has the ability and (although increasingly questionably) the willingness to come to Taiwan's aid.

Water

China is not a traditional seafaring nation, but that is changing as the PLAN grows at a prodigious rate with a host of new platforms; its aim is to become a blue-water navy. The newest destroyer is the Type 052C, the sixth of which is under construction. It is equipped with Type 346 active phased-array radar. The mainstay of the PLAN's three fleets is the Type 054A frigate, of which number fourteen is being built. Shipbuilders are also busy amassing an impressive fleet of up to 80 catamaran-hulled Type 022 fast attack craft. There are also new designs on the way, including a more advanced Type 052D destroyer with a purported displacement of 6,000+ tons due in 2014. Another numerically important class is the Type 056 corvette, which will be ideal for patrolling coastal waters. Presently, six corvettes are under construction. The amphibious-warfare force is also expanding, with the current focus on 18,000-ton Type 071 landing platform docks (LPD). The fourth of class is under construction. In the near future, attention will turn to the 22,000-ton helicopter carrier design known as the Type 081.

The navy's most noteworthy advancement was the commissioning of China's first ever aircraft carrier *Liaoning* on 25 September. A massive effort succeeded in refurbishing the 33,000-ton carrier, which China claims will serve as a training vessel. However, this assertion is belied by the fact that it carries a complete suite of weapons. Premier Wen Jiabao said it will "be of great and far-reaching significance in inspiring patriotism, national spirit and driving national defence technologies" and "in enhancing national defence power and the country's comprehensive strength." China is the final permanent member of the UN Security Council to possess a carrier. Meanwhile, it is

PLA special forces conduct a counterterrorism drill. These troops are aboard a Chinese copy of the American HMMWV. (PHOTO: Gordon Arthur)

also developing an indigenous carrier likely to be of similar design to the *Liaoning*. Experts predict the PLAN could have two conventional and two nuclear-powered carriers by 2020, although much remains to be learnt in the science of operating carrier task groups. Of course, carriers are no good without aircraft, with the J-15 earmarked for this role. The first official J-15 photos appeared in April, and pilot training for carrier operations is taking place at Xian and Huludao. The J-15 is not expected to enter service until 2014.

China's 60-craft submarine fleet is also modernising. The PLAN already owns the world's largest diesel-electric fleet, of which the newest type is the Type 041 Yuan class that reportedly has air-independent propulsion (AIP). The number of nuclear-powered submarines remains small, with the Type 094 SSBN and Type 093 SSN being current types. However, the future Type 095 SSN could enter service around 2015, with perhaps five platforms to be constructed. It will likely also spur a Type 096 SSBN with better acoustic performance. China has a shallow continental shelf that is not ideal for underwater operations. Submarines need access to deep-water trenches, and as well as potentially rich undersea resources, this is why the South China Sea figures so prominently in Chinese naval thinking. China has created the 2nd Nuclear Submarine Base at Yalong Bay on Hainan Island, which includes extensive underground facilities.

Earth

The most important advances in ground forces are occurring in the realms of "informationisation" and "mechanisation". Advances in digital networks and command and control (C2) are improving overall coordination and 'jointness'. The PLA operates a theatre-level Group Army Automatic Command System known as Qu Dian, similar in function to the American Joint Information Distribution System (JIDS). Phase 3 was completed last year, which established automatic command systems at the divisional and regimental level. Qu Dian uses fibre-optic cables, microwave, HF and VHF communications, plus it relies on Fenghuo satellite data-exchange support and communication relays.

Mechanisation can be seen in the widespread introduction of new vehicles like wheeled ZBD09 8x8 and ZSL92B 6x6 infantry fighting vehicles (IFV), as well as tracked vehicles like the ZBD97 IFV and ZTD-05/ ZBD-05 amphibious IFV and Type 07B amphibious self-propelled howitzer. Main

battle tanks are also being enhanced, with the most modern and capable version being the ZTZ99A1.

Air

The most stunning revelation in recent times was the maiden test flight of the Chengdu J-20 stealth fighter on 11 January 2011, coinciding with the visit of the US defence secretary no less! This event took the West completely by surprise because none suspected China would fly a fifth-generation fighter so soon, even though it will take some time before it officially enters service. It will likely be powered by indigenous WS-10-based engines with thrust vector control. A second J-20 prototype took to the air on 16 May 2012. Commentators predict the PLAAF may have some 50 J-20s by the end of this decade. In the meantime, the air force relies on modern fighter designs like the J-11 (a copy of the Su-27) and J-10A. More than 200 J-10s have been fielded so far, and an improved J-10B with active electronically scanned array (AESA) radar is under development.

Other important new platforms entering service in recent years are KJ-200 and KJ-2000 airborne early warning & control (AEW&C) aircraft, as well as the H-6K bomber that carries six under-wing 2,000km-range DH-10A cruise missiles. The H-6K is China's first strategic bomber capable of carrying nuclear weapons, thus adding another element to the country's nuclear-weapon triad. While high-tech systems are being inducted, the PLAAF remains weak in many basic areas. For example, it lacks sufficient numbers of transport aircraft, air-to-air refuellers and helicopters. China is developing a new Y-20 heavy transport aircraft with Ukrainian help but this will not come to fruition for a number of years. The helicopter fleet relies on Eurocopter-based designs like the Z-8 and Z-9. The next stage is the Z-15/Eurocopter EC175; although nominally a civilian design, it is certain to be adopted by the PLA.

Space is a new frontier occupying Chinese attention too. Its space programme, which this year successfully docked a spaceship with an orbiting station, offers a multitude of military applications. China is establishing its home-grown BeiDou-2 GPS network that currently offers regional coverage with ten satellites in orbit. By 2020, 35 satellites will provide global coverage. Of great American concern was China's destruction of an ageing weather satellite with a direct-ascent anti-satellite (ASAT) weapon in January 2007, something obviously designed to give a pointed message to the USA that its satellites were not beyond Chinese reach.

Missiles

China has a very active ballistic-missile development programme. The latest major event was the test launch of a DF-41 intercontinental ballistic missile (ICBM) on 24 July. This new type is distinguished by a

DF-31A intercontinental ballistic missiles appeared during China's 2009 grand parade celebrating 60 years of nationhood.
(PHOTO: Gordon Arthur)

warhead with up to ten multiple independently targetable re-entry vehicles (MIRV). Meanwhile, the principal ICBM overseen by the Second Artillery Corps is the truck-mounted DF-31A that gives unprecedented mobility. This missile can hurl a 1,000kT-yield warhead as far as Washington DC. The US estimates China has 55-65 ICBMs in its inventory, but numbers could grow to exceed 200 ICBMs and intermediate-range ballistic missiles (IRBM) by 2020. Meanwhile, a new IRBM was reported by Taiwan in March 2011. The 1,000km-range DF-16 allegedly possesses a faster re-entry speed and multiple warheads.

The DH-10, which participated in Beijing's 2009 parade, is a land attack cruise missile (LACM), and a navalised version has been reported recently. China also possesses the world's first anti-ship ballistic missile (ASBM). Known as the DF-21D, it has a range of 2,000km and serves as an anti-access/area-denial weapon against US Navy aircraft carrier groups. US intelligence sources say the DF-21D is in limited production and up to 80 could be available by 2015. This so-called 'carrier killer' was designed specifically to prevent the kind of intervention performed by US carriers in the Taiwan Strait Crisis of 1995-96. Development of the JL-2 submarine-launched ballistic missile has been protracted, and the Type 094 SSBN has been awaiting missiles since 2009.

China yet again dramatically increased its defence budget - by 11.2% in 2012. Nevertheless, this amount of USD106.4 billion trails the USA by a long shot, but it should be remembered that this refers only to the official budget, with true spending perhaps 50% higher. The last annual US report to Congress about China's military stated: "By the latter half of the current decade, China will likely be able to project and sustain a modest-sized force, perhaps several battalions of ground forces or a naval flotilla of up to a dozen ships, in low-intensity operations far from China.

This evolution will lay the foundation for a force able to accomplish a broader set of regional and global objectives." The PLA is indeed snowballing in capability, and its forces are indeed looking far beyond the historic confines of the Great Wall. Not only that, but the PLA's growing confidence is now influencing Chinese foreign policy. □

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Flying Dragon Rising

How Will China Build A Future Air Force?

By Reuben F. Johnson

ABOVE: The J-20 seen here during flight-testing. Much about the aircraft remains speculation (PHOTO: Reuben Johnson)

OPPOSITE: A J-10 formation take-off with notably prominent air-to-air refueling probes. (PHOTO: Reuben Johnson)

IN HIS BRILLIANT ANALYSIS OF THE modern-day Chinese state published in 2010 and entitled The Party: The Secret World Of China's Communist Rulers, Financial Times correspondent and former Beijing bureau chief Richard McGregor points out just how much of how the nation runs and what makes it run can be attributed to the Chinese state having originally been born out of its then-fraternal communist relationship with the Soviet Union.

The trappings of a modern, economically-liberated society that has figured out how to make "state-sponsored capitalism" actually work, he writes, "betray one of the most overlooked facts about the modern Chinese state – that it still runs on Soviet hardware."

McGregor's use of the word "hardware" here is more symbolic than concrete – referring to the state apparatus that controls government appointments, assigns personnel, and controls the all-powerful Central Military Commission (CMC). But when speaking of the two main air power arms of the nation's armed forces – the People's Liberation Army Air and the People's Liberation Army Naval Air Force the term can be applied literally.

To gain insight into what China's military leadership has in mind for the future of its air power it is almost necessary to look to Russia, Ukraine and other former USSR republics to see what Beijing is buying from where and why. There are two basic reasons for taking this more or less roundabout tour to come up with some clues.

One is that most of what China knows about designing and building modern fighter aircraft has been gained through the more than two decades of purchases of military hardware, co-production contracts and training of its designers and specialists in the former Soviet Union. There is no question that this long-term "military-technical cooperation," to use the Russian euphemism for arms exports, has transformed Chinese industry from a institution that seemed to be incapable of progressing beyond endless re-worked variants of the Mikoyan MiG-21 – a 1959 design – to the ability to design and build something like the Chengdu J-20.

Moreover, despite numerous protestations to the contrary, China's military still remains deeply dependent upon its Russian and Ukrainian tutors to keep its generals and admirals supplied with shiny, new toys to build their modern military machine with. There would be practically no significant aircraft design work taking place at either the Shanyang Aircraft Works (SAC) or Chengdu Aerospace (CAC) without the steady flow

of design drawings, specialists, engineering expertise and years of insight provided to Chinese industry by Russia and Ukraine.

More importantly, for all of the impressive accomplishments of Chinese industry it has thus far failed to be able to design and produce a reliable, combat aircraft jet engine design. While SAC have been capable of making reasonably capable copies of the Sukhoi Su-27SK they have been licence-producing for years, which they designate the J-11B, and Chengdu has been able to build their own developed version of the Israel Aircraft Industries (IAI) Lavi, the different versions of what they have called J-10, no jet engine comparable in performance to the Su-27's Lyulka AL-31F power plant has been developed by China's jet engine sector.

Russian-Ukrainian Jet Power

Thus far, almost the entirety of China's new fighter designs are powered by Russian-designed engines, and in the case of two of these aircraft the engines are variants that were modified by Russian industry to fit specific Chinese design requirements. The AL-31FN engine that was built by the Salyut plant in Moscow for the Chengdu J-10 has the "N" suffix as part of its designation to signify the Russian word nizhniy or "low."

This designator means that the engine was re-designed with its accessory pack rotated from the top – as it is when installed in the Su-27 - to the bottom of the engine frame. This modification was made in order for the engine to be able to be used in a single-engine application for the Chinese-developed Chengdu J-10A fighter aircraft.

The other fighter aircraft developed at the Chengdu plant, the JF-17/F-1, which is being jointly-manufactured in Pakistan, also uses a St-Petersburg-based NPO Klimov RD-93 Russian-designed engine. This is a version of the Isotov RD-33, which is installed in Russia's other major fighter aircraft, the Mikoyan MiG-29, again with the accessory pack rotated to the bottom of the engine frame.

China also has an almost equal dependency on Ukraine, where the Zaparozhe-based Motor Sich production plant and Ivchenko-Progess engine design bureau have had years of steady orders for the Klimov TV3-117 series of helicopter engines used in the Mil Mi-17s operated by the PLAAF. Another growing business area has been the AI-222-25/28 engines that are installed in the Hongdu L-15 jet aircraft, which has become the PLAAF most advanced jet trainer.

The Ukrainian firm also state that they do not see their business with China's aerospace industry dropping off any time soon and that there is potential other programmes for them to be involved in beyond the L-15 project.

"We have been promised at that this year's Air Show China in Zhuhai that AVIC [the Chinese state aviation industrial monopoly] will present an indigenous engine of their own design that would replace the AI-222-25 for the L-15," said an Ivchenko-Progress design bureau representative. This is not the first time we have heard this from our Chinese colleagues, so are waiting to see their engine if it does indeed form part of their exhibit this year, but we are not worried about being displaced from this market anytime soon and we think our business with China will continue on for some years."

At Aviation Expo China in Beijing in 2011 the Ukrainian firm unveiled the design for a new jet fighter engine AI-9500F design that has been displayed at several shows since as an engine for an as yet-unspecified future tactical fighter design. The engine's thrust is almost equal with the GE F404-414 engine used in the Saab GripenNG demonstrator, "but in a twin-engine application it could power an aircraft in the weight class of a MiG-29," according to Ivchenko-Progress representatives.

Although China might be a potential customer for this design, Ivchenko-Progress do not claim that there is any one specific programme that this engine has been designed for. "We have been in discussions with Chinese industry about this programme," said a design bureau representative, but we also have discussed applications for this engine in Russia as well."

One of the possible applications is a new design that has emerged recently from Chinese web sources that has been called both F-60 and J-21 that appears to be a Shenyang programme or design study. However, sources in China design state that this aircraft is really known as Project 310, which explains the number "31001" on the nose of the aircraft, meaning aircraft no. 01 of this programme.

The first time there was any hint of this programme was when a radio-controlled subscale model of a similar-looking aircraft that displayed at the same time as the biennial Aviation Expo China show in September 2011. The model, which was in a separate outdoor exhibition under a large tent, was organised by the Shenyang University of Aeronautics and Astronautics (SUAA).

The F-60/J-21 has an external appearance that would appear to be a lighter-weight and smaller variant of the Lockheed Martin (LM) F-22 Raptor in some respects, although this would be a different aircraft and not a copy of the Raptor. It's role ostensibly would be to supplement the much larger and heavier

Development of New Chinese Jet Engine Models

PRODUCED BY DESIGNATOR	MODEL	TYPE OF ENGINE	THRUST	FINAL TESTING	AIRCRAFT APPLICATION(S)
Guizhou Liyang	WS-12 (Taishan)	Medium Thrust Turbofan	80KN	2008	J7, JL9/FTC-2000, J8
	WS-12B	Medium Thrust Turbofan	100KN	2009	JH7B
	WS-12C	Medium Thrust Turbofan	80KN	2010	Med-Range Airliner, Airbus Regional Jets
	WS-13 (Tianshan)	Medium Thrust Turbofan	85KN	2009	FC1/JF17, J9
Shenyang Liming	WS-10A (Taihang)	High Thrust Turbofan	132KN	2005	J11
	WS-10B	High Thrust Turbofan	135KN	2008	J10, J11
	WS-10C	High Thrust Turbofan	100KN	2008	H6 (Redesign)
	WS-10D	High Thrust Turbofan	120KN	2008	Widebody Airbus, Large Pax Jet
	WS-10G	High Thrust Turbofan	155KN	2009	J10, J11, J13
	WP-14C (Kunlun-3)	Medium Thrust Turbojet	82KN	2005	J7, JL9/FTC-2000, J8 Upgrade
	QC70 (WS10A Hardcore)	Low Power Gas Turbine	7000KW	2007	
	QC128 (Kunlun Hardcore)	Medium Power Gas Turbine	12800KW	2008	
	QC185 (WS10A Hardcore)	Medium Power Gas Turbine	18500KW	2008	
Xi'an Aeroengines	WS-9 (Qinlin)	Medium Thrust Turbofan	92KN	2002	JH7A
	QC260	High Power Gas Turbine	25000KW	2007	

Chengdu J-20 and creating the same heavy-light/hi-lo mix that the US Air Force has employed for years with the Boeing F-15 and LM F-16.

Russian designers who have many years of experience of working with Chinese industry point out that having the Project 310 produced by the Shenyang Aircraft Works (SAC) is consistent with the type of projects that SAC produce and what they produce is quite a bit different from what the Chengdu plant No. 132 have been building for years.

"What you see at SAC are aircraft that are analogues - copied from other aircraft designs - so the J-11B is the SAC analogue to the Russian Su-27, the J-15 is the analogue to the carrier-capable Su-33 flown by the Russian carrier wing, and so on," explained one Russian designer I spoke to. What goes on at Chengdu is more in the way of looking for ways to combine various design concepts into aircraft that become more or less 'hybrids. In places they bear some similarities to other aircraft, but are unique designs in their own right."

Sources inside of China state that the Project 310 is a completely SAC-funded project that currently has no government support. The programme has supposedly been put out into the open by the Shanyang plant in order to try and attract attention – and to presumably try to make sure that it is not the Chengdu plant that becomes the primary supplier to the PLAAF in the future.

New Developmental Efforts

Based on open-source technical publications and other statements by Chinese military and industrial officials, there appears to be progress made towards China achieving autonomy in production of jet engines. However, the best estimates are that the country is 5-10 years away from achieving the technical proficiency necessary to create a 5th-generation fighter aircraft engine. In 2008, an unofficial programme chart was released by Chinese industry sources that purported to show the plans for developing several new models of jet engines to try and cut their ties of dependency to the Russians and Ukrainians.

As you can see from the chart almost none of these plans have been realised. Like so many other military jet engine programmes in the past – the required timelines for development are too hard to predict and always end up being longer than originally projected.

More than just the evidence that these best-laid plans have not turned out as originally hoped, more recent proposals by the Chinese indicate that they are still a ways off from being able to produce their own jet engines.

During the final days of Air Show China 2010, Russian Defence Minister Anatoliy Serdyukov returned to Moscow from an official visit to China and was reported in a Moscow paper to be "carrying a number of proposals in the sphere of military technical co-operation."

The Russian daily newspaper Vedomosti - in an article entitled "China Has Not Copied Everything" quoted sources from inside both the Ministry of Defence (MoD) and Rosoboronexport, the Russian arms export monopoly as stating that the list of items that China's military was seeking to purchase from Russia included an unspecified but large number of the Saturn/Lyulka117S jet engines and Almaz-Antey S-400 air-defence systems.

The assessment of Russian industry sources is that the 117S models can only be intended for use on the new Chengdu J-20 fighter, the aircraft that it seems is destined to become the next-generation workhorse of the PLAAF. Currently, there are two flying prototypes of the new jet, one of which is equipped with Russian engines and one which is reported to be fitted with some version of the Chinese Liming WS-10A that was developed for the SAC J-11B programme.

But, Russian commentators also point out that there any hysteria about the J-20 being a near-term threat to China's neighbours and potential adversaries is misplaced.

Ilya Kramnik, a military analyst for Russia's RIA Novosti news agency, commented that the Chengdu aircraft was a major advancement, but that China is still far behind the rest of the world in building a stealth fighter. What everyone is calling the J-20 fighter "was produced nearly 20 years after the US YF-22, 17 years after the Russian MiG-1.44/1.42 MFI and 14 after Russia's S-37/Su-47. If the J-20 is accepted as the prototype for a new series, China will be able to produce a fifth-generation fighter aircraft within 10 years. If not, it will begin batch production no sooner than 15 or 20 years from now," he said.

Future PLAAF Force Structure

The PLAAF is currently poised between two phases of its development. First of all, it is

WS-10A-04
Chinese engine technology development has not been an easy road, but may soon reap real benefits.
(PHOTO: Reuben Johnson)

working as rapidly as possible to transition from being a small to medium-sized force that is almost entirely focused on air defence of the Chinese mainland to a much larger and more high-technology force that is fielding modern equipment, doctrine, and capabilities. New generation aircraft now coming on line, PGM, support aircraft, advancements in EW, more modern battle management and C4ISR capabilities act as force multipliers. The PLAAF is thus able to move beyond more traditional missions such as air defence and close air support, to the ability to carry out offensive strikes against ground and naval targets well beyond China's borders and even territorial waters.

Secondly, the PLAAF have to come to some resolution on the technological bottlenecks it has encountered thus far – most specifically the problem with aeroengines – and to make some long-term procurement decisions concerning future platforms. At present the PLAAF operate a large number of Su-27SK/J-11, Su-30MKK, and J-10 fighters, but there are still a number of older model F-8II and J-7s still in inventory.

The original plan of the PLAAF is that these legacy aircraft would be replaced with current-generation J-11B and J-10B, a modernised version of the Chengdu aircraft that is more stealthy and features a modified, oval-shaped inlet that supposedly reduces the aircraft's signature. But both of these programmes have been reported by multiple sources to have serious problems. There have been sources stating that the programmes are being slowed down and that the J-11B might even be cancelled.

Beyond the fighter force there is an even older fleet of attack and bomber aircraft in the PLAAF – aging Xian H-6 models (copies of the old Tupolev Tu-16), at least five regiments of Xian JH-7A aircraft, but still obsolete aircraft like the old Nanchang Q-5 in service that need to be replaced. Transport and tanker aircraft are also another requirement to be addressed along with other more advanced ELINT capabilities.

Dependence on Russia has been part of the problem here. Ilyushin Il-76 transports and Il-78 tanker aircraft have been order for more than 7 years, but Russia has no capacity to produce these aircraft at present – and has not had for some time. In the meantime, Chinese industry are working with Ukraine's Antonov to develop a new-generation platform that could perform this role, but this is years away from being a real programme.

But China's dependence on Russia is a lesser and shorter term problem than the overall shortcoming that the PLAAF face in trying to build a more modern force. For all of its pretentions to modernity, China still has not been able to utilise its economic prowess to develop deeper and more significant capabilities in its industry and society.

In the process of writing his book Richard McGregor interviewed one of the more vocal Chinese foreign policy hawks known for his outspokenness, Yan Xuetong of Tsinghua University on Beijing. Yan commented that there is no deeper motiviation by either the government or the society that is conducive to creating centres of technological excellence.

"At this moment, the sole, dominant ideology shared by the government and the people is money worship," he told the Financial Times correspondent. But, wealth does not in and of itself translate into strength on autopilot, he continued.

"Our military budget is 1.6 times that of the Russians but we cannot build the same military. Our education spending is much larger than India's but we cannot have one single person win a Nobel Prize. They already have ten. We have more rich people than Japan and we have more first-ranked companies, but we can't build world-class products. We have more foreign reserves than anyone in the world but we cannot build a financial centre even like HK," he said, and the list of other equally unflattering comparisons goes on and on.

It is perhaps this structural and social defect in developing China's technology sector that holds back the modernisation of the PLAAF. In the end, the continuation of a political and government administrative apparatus that "runs on Soviet hardware," may – for different reasons – be the cause of the PLAAF being unable to achieve its ambitions in the time frame desired. The level of technological sophistication and innovation cannot be achieved given the system under which China's defence sector has to operate. □

AFV Whole Fleet Management – Gaining Greater Results?

By Francis Tusa

Good information technology is key to AFV fleet management. High operational use of AFVs has led to a proliferation of new sub-systems, as well as higher wear and tear. To maintain and support fleets properly, this needs to be accurately tracked. (PHOTO: Lockheed Martin UK)

WHOLE FLEET MANAGEMENT (WFM) HAS BEen a topic much discussed by armies - it is armies that have seen the most heated debate - for well over a decade. And yet in most cases, WFM has still not been rolled out, and is often regarded with something akin to suspicion. Such mistrust seems strange. After all, WFM promises greater AFV/vehicle availability, greater fleet capability visibility, easier support, but at lower cost. Commercial organisations have operated WFM concepts for vehicle fleets for many decades, and can show that the idea has major merits, but die hard armies are still proving difficult to persuade.

The problem about AFV/equipment management when WFM is not the underlying systems is easy to describe, especially with the operational experience of the past decade and more. Equipment is deployed to an operational theatre (Iraq, Afghanistan, Lebanon). Equipment is sent overseas either with special modifications, or urgent operational requirements are added in-theatre. As soon as this happens, you have non-standard fleets at the home base, in training fleets, and on operations.

If AFV fleets are rotated from operations back to home bases, they can be returned with the previous set of upgrades, different ones from the newer fleets being deployed. If AFV fleets are kept in-theatre for longer times (mainly as a way to save money), then upgrade/modification can be pilled upon upgrade. Often, the work is undertaken so rapidly that the exact details of the work - which wiring has been changed, where holes have been drilled, etc - are not recorded centrally. And lack of central management of vehicle fleets can lead to obsolescence of systems, which if not controlled in a timely fashion, can be very expensive to manage.

New options for WFM involve manufacturers dealing with all vehicles of a type that they produce as part of a virtual fleet. The Hagglunds CV90, with 6 user nations, has a common System Design Board, which pools support and management best practice between all parties.
(PHOTO: BAE Systems Hagglunds)

One example of this effect comes from the reset/recapitalisation of US Army AFVs which had seen action in Iraq in the 2003-08 timeframe. On return to the USA, for work at Army depots and BAE Systems/General Dynamics' facilities, M1 Abrams and M2 Bradleys could see well over 30 major different variations in equipment, many times more than would have been the case. This leads to longer overhaul times, to cope with the non-standard equipment, and that comes with a cost added. Also, having to provide support for all of the different sub-systems that have proliferated in AFVs deployed over the past decade also has a cost, albeit one that is often only recognised too late.

A solution in the US Army has been to standardise as far as is possible, and ensure that all vehicles are kept - where possible - to the same standard. So for the M2 Bradley, the A2 and Operation Desert Storm standards have been the prescribed levels to which all of the ICVs are to be modified and sustained. Similar programmes are also in place for other AFV fleets, such as the 8x8 Stryker AFV. It has to be noted that in the case of US standardisation via reset-overhaul, the costs are far from low up-front: an M2 Bradley reset an cost over $3-million, and even if this leads to savings later, this operation is very much at the Rolls Royce end of the spectrum.

This level of problem is even more daunting when you consider the rapid proliferation of mine-protected ambush-protected (MRAP) vehicles. The US military have procured over 25,000 of these for Iraq and Afghanistan, and these have been bought from seven different companies, and in close to a dozen variants, although extra operations-specific equipment mans that the number of fleets-within-fleets is even higher than that. The US Army (and Marine Corps) is now studying firstly how many MRAPs they bring back into their core forces, and then how they try to eliminate the costly fleet differences, to allow the MRAP forces to become supportable in the medium term.

It: The Glue For WFM

A key to making WFM work is information technology. If you don't know what you have, let alone what state it is in - how many miles it has driven, what software configuration it is in - then users will be unable to effectively manage their vehicle fleets.

One of the first programmes to try to address this on a wide scale was the UK's Joint Asset Management and Engineering Solutions (JAMES). Rolling out in an echeloned manner, it is intended to provide as wide as possible visibility on the location, physical status, and configuration of every vehicle in the British Army (and associated Royal marines/RAF fleets). Previously, there had been no such IT backbone, so AFV fleets were managed locally and on unit-by-unit, short-term fixes, leading to a mass of expensive configurations.

JAMES was initially rolled out in 2005 to provide vehicle visibility of 128,000 different items, and became fully operational in 2010. The progression to the latter stages involved the expansion of the network both into the deployed area (Afghanistan), but also into industry. This means that a common picture of equipment status is now possible. In turn, this is a major enabler for WFM. Under the British Army's plans, WFM means that units "lose their own" vehicles - they will no longer have, or need, vehicle sheds packed with the war stock of equipment. These, anyway, have tended to be fairly bad places to store equipment if you want to keep it in the best working order.

Instead, the necessary vehicles will be issued, and picked up en route to training or operations. So if an armoured regiment only needs one squadron of tanks for training, then that is what it will be issued with - it will not hold 58 tanks, with the other 44 sitting inside draughty vehicle sheds. The vehicle fleets will, instead, be stored centrally, in environmentally controlled facilities. The new storage conditions mean that vehicles are kept in the optimal condition, permitting for the best, or most relevant levels of availability to be maintained.

Such IT systems are becoming more and more common. The US Army has to manage pre-positioned equipment, often on-board ships in the Middle East, Indian Ocean, and Pacific. To manage these, companies such as ITT have been introducing IT backbones to allow for accurate systems logging and tracking. This is especially important for forward deployed/pre-positioned equipment, as its very location can mean that it gets forgotten about when upgrades and modernisation programmes are drawn up.

The CH-47F Chinook is the most versatile, mission-capable heavy-lift helicopter in the world. More powerful than ever with advanced flight controls and avionics, the CH-47F is in a class by itself, whether it's transporting troops and equipment, on deep combat assault, performing search and rescue, or delivering disaster relief. Extraordinary performance—it's what you expect from Chinook.

BOEING

A Growing Trend

Despite persistent military worries about WFM, especially units "losing" their own vehicles, the system is gaining traction in a number of armies.

In Germany, a large WFM system was introduced as a public-private partnership to provide better, and better-value support for AFVs, such as the Leopard 2 MBTs, Marder MICVs, and newer Boxer AFVs. Originally, this was an organisation owned 49% by the German MoD, and 51% by industry (17% each for Krauss Maffei Wegmann, Rheinmetall Landsysteme, Diehl Land Systems). The combined company, Heeresinstandsetzungslogistik Ltd (HIL) undertook a massive inventory stock take to enable a rationalization of maintenance and storage facilities of close to 10,000 AFVs, as well as vehicle status, leading to a streamlined and improved support chain, with an aim of average 70% availability. The overall cost as intended to be some €200-million, substantially lower than previous costs. An existing, underlying ERP software package from SAP was used to help enable the new processes and systems. The SAP system is being introduced as a military-wide IT network, with an emphasis on the services adapting their business processes to meet the software, rather than trying to constantly change the IT system to match quirky military requirements. Although the German MoD now intends to buy back the industry-owned stake in HIL, it still intends to manage the AFV fleet in a WFM manner, showing that lessons have been learned and appreciated about the advantages of the system.

France, too, has also been gently undertaking aspects of WFM for its AFVs. The Leclerc MBT fleet saw a contract in late 2009 (three years plus seven one year extensions) to cover fleet-wide, turnkey support and management of the fleet. The lengthy production programme of the Leclerc - well over 16 years for 380 tanks - meant that several early tranches were so old, that were unsupportable due to sub-system obsolescence. The 2009 support contract covers this, and configuration management as a result. Similar support systems are also being put in place for the VBCI 8x8 ICV, learning from the earlier mistakes with Leclerc, and France looks set to take WFM forward as a key trend for the Army, both to increase availability and usage, as well as to keep costs down.

Widest Wfm Support

One can also look outside of an individual army to see how AFVs might be managed, internationally, on a WFM-type manner. BAE Systems Hagglunds Swedish-based business unit has developed international support solutions for its key products. For the CV90 MICV, the operators (Sweden, Norway, Denmark, Finland, Netherlands, Switzerland) started what was called the "CV90 Club" close to a decade ago, to exchange operational experiences and concepts. But BAE Systems Hagglunds then introduced the Systems Development Board this year, to work "on top of" the Club, to provide support, leadership and direction for the support, development and upgrade for all CV90 users. A key concept is to

be able to pool operational use data to identify how CV90s could be better used/operated, and to arrive at better support/maintenance solutions.

One example of how the SDB works is in a common study being run by Hagglunds today. This is running a trials CV90 with rubber tracks, as opposed to conventional steel ones. Rubber tracks have been used by the Danish Army on M-113s, and by the Norwegian Army on a handful of CV90s in Afghanistan. But the SDB is undertaking the trials to provide the accurate data on all aspects of the advantages of the technology. This is not just wear-and-tear of the tracks themselves, but there are advances in electronics mean times between failure as a result of lower vibrations. After the trials are over in late 2012-early 2013, the CV90 SDB users can work out how they could cooperate to buy and fit the tracks to their different fleets.

An organisation such as the CV90 Club/SDB can also track use data, and provide prognostic data on use trends to any user that wishes to subscribe to such services, with the intention of learning valuable - and cost-saving - lessons from a wider user community. Hagglunds point out that, while taking due consideration of individual users' security concerns, they can compare and contrast CV90 use rates, and so build up an international fleet picture.

Krauss Maffei Wegmann, too, with a user community of the Leopard 2 MBT of 16 users and thousands of vehicles, are also able to provide international WFM services. As uses have generally required very similar upgrades as operational experiences have driven them in similar ways, so KMW has been able to deal less with individual clients, and more on a group basis. This trend has been reinforced by the fact that the Leopard 2 has proved to be a very good secondhand purchase, and so KKMW has become very involved in refurbishment and upgrade of secondhand vehicles as they move from second to third parties.

Although these types of support system are, when compared to air systems, at a far lower level of maturity, it seems certain that more companies will offer international WGFM support services, so as to offer better capabilities to customers. Taking on dissemination of maintenance/support best practice, companies are likely to start to offer spare parts pooling, and even storage and support of AFVs for more than one country, alongside common upgrades.

It is strange that with so many commercial examples of the advantages of WFM, that armies are still proving to be a tough sell. The visceral desire to "own" equipment at unit level has proved to be a very hard argument to be dispatched with cold business facts. But as budgets fall across the western world, including the USA, so the financial advantages of WFM will grow in importance and visibility. This trend is likely to accelerate as operations in Afghanistan come to an end, and thousands of AFVs and other items of equipment are brought back to home bases for reset/recapitalisation - the desire to undertake reset at the lowest reasonable cost, as well as lower operational tempo will help the roll-out of WFM. □

Marching towards the sound?
Gunfire location systems

By Peter Donaldson

ABOVE: A US SOF soldier engages an enemy sniper during a clearing operation in Wardak province, Afghanistan, Oct. 9, 2011. Fixed to his helmet is the acoustic sensor module of a Qinetiq Ears/SWATS gunfire location system.
(PHOTO: US DoD)

OPPOSITE :Radiance Technologies' WeaponWatch system uses MWIR sensors to detect muzzle flash and rocket motor plumes, applying hypertemporal processing to reject false alarms and classify threats.

NUMEROUS GUNFIRE DETECTION Systems (GDS) fielded in Iraq and Afghanistan have proved their worth, but have limitations, particularly when small enough to be carried by soldiers. Now, research and experimentation into networking gunfire location sensors using tactical communication systems is beginning to demonstrate worthwhile improvements in the accuracy of the most portable systems. In parallel, alternative sensor technologies are opening rewarding new directions.

All GDS exploit threat signatures. These include muzzle flash, muzzle report and projectile shock wave, which is unique to supersonic projectiles. With supersonic rounds, the 'crack' of the shock wave arrives before the 'bang' of the muzzle report, the interval between the 'crack' and the 'bang' revealing range. Other parameters, such as the difference in the time of arrival at different microphones a known distance apart, yield the angle from which the shot came. Muzzle flashes have infared, visible and ultraviolet components that can be detected and – with triangulation between sensors – located. Weapon system optics can also be revealed by sun glint or by systems that scan threat sectors with lasers. Acoustic systems are the most widely deployed because the technology has been smaller, lighter and cheaper than optical alternatives.

AAI's Projectile Detection and Cueing (PDCue) system locates single shots, bursts or multi-shot events, in urban and rural battle spaces, in static installations and from vehicles. PDCue relies on acoustic sensor clusters in modules mounted at the four corners of a vehicle to provide 360° coverage and redundancy along with a 'definitive' line of bearing, even with a limited signature, says AAI. The fixed site version consists of a tetrahedral array that can be mounted on a tripod or fixed to a structure and networked. The company claims accuracy of +/- 1° in both azimuth and elevation, better than +/- 25% in range (beyond 300 m) and

maximum tested range of 1.2 km, along with a false alarm rate of less than 0.1% and a response time of under 0.1 sec.

PinPoint and PEARL

Biomimetic Systems and Cobham together developed PinPoint acoustic systems for manned ground vehicles, UGVs, UAVs, unattended ground sensors and soldiers. The companies emphasise performance improvements over earlier systems in noisy, echoing environments thanks to advanced architecture, time-domain acoustic processing and the application of neuroscience. With short response times and adaptable sensor arrays, PinPoint can also identify sniper round types.

PinPoint for dismounts consists of a shoulder-mounted 3 x 3 x 1 detector with interfaces for audio, visual and digital alerting including a wrist display, although it can also be used with PDAs and laptops etc. A GPS interface enables it to update the relative positions of the soldier and detections as the

soldier moves. PinPoint was also used in recent US Army trials aimed at improving the threat detection capability available to combat units through leverage from comms networking and data fusion.

Metravib's PILARw acoustic antenna is integral to the SLATE counter-sniper systems on French Army VAB armoured personnel carriers serving in Afghanistan, having been delivered in November 2011 under an urgent operational requirement by Renault Trucks Defense. SLATE integrates the PILARw sensor with the TOP 12.7 version of Kongsberg's M151 Protector RWS and an operator interface to enable very rapid responses to sniper attack. On detecting an incoming round, SLATE can automatically slew the RWS onto the threat bearing. The system can also categorise projectiles into small or medium calibres. It also stores threat coordinates, enabling the vehicle to move into cover while keeping its weapons on target. "Ultimately, the SLATE system could be connected to information and command systems to improve the sharing of information gathered at the tactical level", says Renault.

Metravib's Personal Equipment Add-on for Reactive Localisation (PEARL) is a new low-cost, weapon mounted acoustic system launched at Eurosatory in June. PEARL mounts on assault rifles, sniper rifles, vehicle-mounted and crew served weapons including machine guns and automatic grenade launchers. PEARL's display guides the soldier's aim with red directional arrows and distance bars centred on a light that glows green when on target.

Qinetiq North America has carved a niche in acoustic gunfire detection with its Ears line and, in June, announced that the French MoD had selected the Shoulder-Worn Acoustic Targeting System (SWATS) version, initially ordering 250 sets through NATO.

"Our expansion into the European market shows that SWATS is quickly becoming the global standard for wearable gunfire detection," said Qinetiq North America's Technology Solutions Group President JD Crouch. "With over 16,000 units sold, and thousands of systems deployed in theater since 2007, SWATS is a proven system that has saved the lives of US warfighters in both Iraq and Afghanistan."

SWATS includes a 7.6 x 7.6 x 1.9 cm shoulder-mounted sensor, a spoken warning system and a wrist display. SWATS keeps track of the relative positions of the wearer and the hostile shooter as the soldier moves and records the locations of all shots for sharing over combat networks. The combat weight of the whole system is 0.45 kg.

Raytheon BBN Technologies, known for its Boomerang systems, has been chosen by the US Special Operations Command to provide Acoustic Hostile Fire Indicator (A-HFI) systems for the 160th Special Operations Aviation Regiment's helicopters. In a July announcement, SOCOM said that the A-HFI systems would be used to detect small arms fire up to and including RPGs. The requirement calls for full integration into aircraft systems including the ASE suite and the mission computer.

In a separate announcement in March, SOCOM revealed its intention to integrate a Hostile Fire Indicating System (HFIS) into ITT Exelis' Suite of Integrated Radio Frequency Countermeasures.

Rheinmetall Defence announced a year ago that the basic vehicle-mounted version of its Acoustic Shooter Locating System (ASLS) was ready for market. The company is also working on a wearable version.

Ultra Electronics' self-contained, 500 g Gunfire Locator (GL) mounts to a weapon's Picatinny rail and displays a clock face pointer for coarse alignment with the target, after which the pointer becomes a set of crosshairs on which the soldier lines up a reticle. The soldier can then fire with that solution or switch to a scope for a better view of the target.

Laser scope detectors

CILAS's network-ready SLD400 and SLD500 systems exploit the cat's eye effect, forcing threat optics to reflect coded laser pulses. The combat proven SLD 400, for example, includes a wide-angle scanning laser and a receiver with a low-light amplifier to detect the weak reflections in a pan/tilt turret. CILAS quotes detection ranges of 1,000 m in daylight and 3,000 m at night. The system comes with a remote control and display unit and is soldier transportable.

The vehicle transportable SLD500 adds a high-definition daylight camera and/or an infrared camera to help identify the target, plus a laser designator, a rangefinder, a compass and an inclinometer. Weighing less than 120 kg, the standard system splits into loads of less than 30 kg and occupies less than 300 litres.

Rafael's Spotlite passive electro-optical systems use infrared cameras to detect muzzle flashes. The Spotlite P (Portable) system is generally tripod-mounted and focused on smallarms fire, offering detection ranges greater than 1,000 m. Designed for stationary operation, it offers a 48° field of view, supplementing the infrared camera with a daylight camera, a laser rangefinder, laser marker and a GPS receiver. The standard system includes two sniper units for use in counter-sniper operations. Spotlite M (Mobile) is designed for vehicles and detects

a broader range of weapons including small arms, RPGs, anti-tank missiles and tank shells.

SWIR and MWIR solutions

IAI Elta has built expertise in Short Wave Infra-Red (SWIR) technologies and its range of sensors includes the ELO-5230 SWIR Gunshot Detection Module (GDM). GDM detects the transient IR signals from muzzle flashes within its 60° FoV and indicates direction. Elta describes the GDM as an easy-to-integrate subsystem for operation in environments including open and urban areas. It weighs less than 1.2 kg, measures 98 x 117 x 105 mm and consumes less than 9 Watts. Installation options include tripods, watchtowers, light vehicles, UAVs, UGVs and helicopters. It can also be integrated with RWS and can show detections on a situational awareness display.

By combining GDM with a high-definition camera, IAI Elta created the ELO-5230A GDS, which can be mounted on a light tripod and carried by a dismounted soldier. Controlled via a PDA, laptop or tablet, the system weighs less than 6 kg plus around 1 kg of batteries and provides a field of view greater than 60°.

IAI Elta has extended its range with the Othello optical fire locator, which detects ATGM and RPG launches as well as cannon and smallarms fire and comes in vehicle-mounted and soldier-portable configurations. The latter consists of a single sensor covering 96° in azimuth and 60° in elevation that can be deployed as a part of an array. The vehicle-mounted version includes four such 5 kg sensors and can be linked to RWS as well as soft-kill and hard-kill countermeasures.

US company Lucid Dimensions offers Short Wave Infra-Red (SWIR) and Medium Wave Infra-Red (MWIR) variants of its ShotSense3D GDS, which are designed for high-speed detection, tracking and classification of weapons fire in three dimensions. Lucid claims advantages over other systems in terms of speed, accuracy, threat identification and situational awareness. Designed to calculate 'extremely accurate' angular coordinates to multiple gunfire sources simultaneously, ShotSense3D also features weapon type classification to help with friend or foe determination and target prioritisation.

ABOVE: Raytheon BBN's Boomerang system fitted to a Humvee; the company's acoustic technologies have also been chosen by the US SOCOM for the 160th SOAR's helicopters. (PHOTO: Raytheon BN Technologies).

OPPOSITE TOP: Acoustic gunfire detection systems are now key elements of counter-sniper operations. Here, a sensor mounted on a Cougar MRAP truck locates a threat for a US soldier with a .50 Barrett M107 rifle. (PHOTO: US DoD)

Tactical UAVs such as this AAI Shadow are very capable platforms for gunfire location systems as they can pinpoint threats over wide areas and feed their locations into command and control systems.
(PHOTO: AAI)

Using broadband MWIR sensors, Radiance Technologies of Huntsville, Alabama, has developed ground based ('WeaponWatch') and airborne Hostile Fire Indication (HFI) systems. These exploit hypertemporal processing to provide a robust rejection of false alarms and classification of detections by weapon types including small arms, RPGs, mortars, Man-Portable Air Defence Systems (MANPADS). On 1 April, the company was awarded a contract worth more than $7.2 million for WeaponWatch sensors for the AH-64D Apache's Ground Fire Acquisition Systems (GFAS). Here, it will be integrated with the helicopter's Modified Target Acquisition and Designation Sight (MTADS) and its 30 mm cannon, with a threat detection icon on the aircraft's multifunction displays. By clicking on the icon, the pilot or co-pilot-gunner slews the helicopter's optics onto the target, enabling the crew to confirm it and continue with a normal engagement procedure.

WeaponWatch can also be integrated with rotorcraft spherical 360° vision systems, overlaying weapon detection icons on the helmet-mounted display.

While radar has not featured much in the detection of small arms fire (although it is the primary sensor for artillery and mortar location systems), Cassidian in Germany is working on Ka-band Frequency Modulate Continuous Wave (FMCW) radar technology.

With the range of sensors growing, combining different types in integrated multi-sensor systems is a natural development that promises greater reliability through sensors with different strengths compensating for one another's weaknesses. Radiance Technologies, for example, has presented an analysis of a system that combines its MWIR WeaponWatch with an acoustic system.

For example, WeaponWatch has no inherent ranging capability (although triangulation between two or more sensors would determine range) and because it detects all muzzle flashes within its field of view it does not declare shots fired at the sensor platform itself. Likewise, acoustic systems detect only supersonic projectiles, are limited in their ability to classify threat weapon signatures and provide no image of the event. Together, however, they offer the ability to detect all types of weapons, achieve multiple simultaneous detections, improve accuracy to within fractions of a degree in both azimuth and elevation and within a few percent in range, this last thanks to flash-bang correlation. What's more, flash-bang and 'flash-crack' correlation offer 'near perfect' elimination of false alarms, says the company.

Fused future

Sensor fusion is also beginning to demonstrate the ability to circumvent the trade-off between a low SWaP burden and high performance, particularly in the most stressing cases such as soldier wearable systems. For example, US Army organisations including the Research, Development and Engineering Command (RDECOM) and the Army Research Laboratory have demonstrated a Data Fusion Module (DFM) that enhances the performance of acoustic systems, gaining leverage from existing soldier comms networks. The DFM is a software application designed to work with any sensor-platform combination while adding 'negligible' extra SWaP and cost burden. With access to all acoustic GDS information across a combat unit, the DFM synergistically calculates "highly accurate solutions more consistently than any individual GDS".

While the DFM revealed some vulnerability to range errors from small numbers of 'outliers' that affected the average accuracy, the authors drew positive conclusions from tests that encompassed about 100 shots against networked PinPoint sensors in 'wedge' and 'squad-symmetric' formations. "The sensor fusion approach provided very accurate shooter detection and localization, enabling quick and effective responses to hostile fire with sufficient accuracy to neutralize the threat with as little information as a single shot", they wrote. "In general, the fused performance was significantly better than the individual system performance while minimizing false alarms and extending range and mission scope. While radial error was improved, angular error for individual systems was also improved when provided with fused solutions." □

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Passive to Active - Analogue to Digital:
Modern Fighter Radar Upgrades

By Reuben F. Johnson

IN THE WORLD OF FIGHTER AIRCRAFT design most of the major aircraft design and production companies working on either a fifth-generation design or a "developed" variant of an existing model, such as the modernised version of the Eurofighter Typhoon that has been proposed in the Japanese and now South Korean fighter competitions. These aircraft are so state-of-the-art that they are in the category of "definitely nice to have" but they also have two other characteristics that are a bit problematic.

One is that they have some very high price tags. No one seems to know for sure what the final price of programmes like the Lockheed Martin F-35 or the Sukhoi T-50/PAK-FA or China's Chengdu J-20 might actually be. This is chiefly because it is impossible to predict costs on a programme that has so many cutting edge technologies involved that are on the of what is the domain of the known in various exotic specialties like materials and low-observables.

What is clear is that the price of these aircraft is going to be much higher – not only to acquire in the first place but also to maintain and operate on a cost-per-flight-hour basis – than those of the preceding generation. Most objective analysts are therefore projecting that these aircraft will not be purchased (at least not initially) in the numbers that the customer air forces have been planning to. Procurement of these aircraft is likely to be stretched out for years longer than originally intended.

The other factor that is also symptomatic of these kinds of programmes is that there developmental timelines stretch on and on far beyond the IOC dates that were projected once they had entered into the prototype development phase. Again the problems of cutting-edge technologies make the ability to accurately predict when these aircraft will be in series production.

The consequences of these present-day realities are that there is an ever-rising market demand to retrofit current-generation

213 AESA sans array-2
The AESA radars are a game changer for aircraft such as the F-15
(PHOTO: Reuben Johnson)

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technologies into the previous-generation fighter aircraft that are currently in inventory. These upgraded aircraft will be needed in the short term to fill the gaps created by the later-than-planned entry of these fifth-generation aircraft into service.

More importantly and in the longer term is that these upgraded aeroplanes will have to be in service for an indeterminate period of time for the simple reason that the numbers of fifth-generation aircraft that will eventually be in service will not be adequate to fulfil the operational requirements of their air forces.

Focus On Radar

The most important system on-board any fighter aircraft in service right now today has to be the radar and other sensors of the aircraft, said a senior Boeing design engineer. "The real truth about fighter aircraft in the present day is that we do not fly any faster than we did 30 years ago, we do not fly any higher. All we do now is that we are more manoeuvrable and we are more fuel-efficient. What makes the difference are the radar, electronic warfare and avionics – and it is the only factor that makes these aeroplanes survivable in the current air combat environment."

What this situation translates into when speaking of the US Air Force is that there will have to be a full fleet upgrade of the Boeing F-15C/D and F-15E Strike Eagle aircraft to equip these aircraft with Active Electronically Scanning Array (AESA) radar. "The upgrade of these fighters from their current Raytheon APG-63(V)1 Mechanically-Scanning Array (MSA) radar to an APG-82 AESA is a necessary measure since the production of the [Lockheed Martin] F-22 Raptor was truncated by the Obama Administration at such low numbers," said a Raytheon marketing representative.

"Because of the very low numbers of F-22s that will be inventory due to the cut-off of the programme's production line, the USAF are going to have deploy AESA-equipped F-15s to act as the support aircraft for certain F-22 missions," explained another Raytheon specialist with long-term experience in radar for fighter that are optimised for long-range intercept missions. "This is the major factor that makes refitting almost the entire F-15 fleet cost-effective."

Other customers for the F-15 outside of the US are in agreement, most notably Saudi Arabia. When the desert kingdom ordered 84 new-build F-15SA aircraft that would be built and would come off the production line with the Raytheon AESA radar that is cleared for export with the aircraft, the APG-63(V)3, the US Defense Security Cooperation Agency (DSCA) also requested 170 of the radar sets, around half of which would be used to retrofit F-15S aircraft already in service with the Saudi air force.

Another slower in developing but potentially larger market are the programmes in several nations operating the Lockheed Martin F-16s that are planning to change out their MSA in late-model variants of the aircraft and fit them with AESA radars. There are two major contenders here, one being the Raytheon Advanced Combat Radar (RACR) and the other being Northrop Grumman's Scalable Agile Beam Radar (SABR).

Both of these radar sets are derivative designs based on the radar sets that are in production at the two companies for new-build aircraft. SABR is a combination of a back end of modules and signal processing technology combined with a version of the AESA array from the F-35's APG-81 radar set that has been sized for the F-16 radome. RACR takes the array from the F/A-18E/F Super Hornet's APG-79 AESA set that is also sized for the F-16 and combines it with a back end that is derived from the APG-63(V)3.

Both company's radars are designed so that the liquid cooling required to be able to operate an array with such a large number of T/R modules is self-contained within the radar unit itself. The airflow normally used to cool the radar and avionics on-board is pumped into the radar unit, where a liquid-cooling module lowers the temperature even further. This makes the upgrade far less invasive into the aircraft's internal configuration than it would otherwise be.

RACR has one added feature that SABR does not in that it has been built and flown in two variants – the version that is intended for use on the F-16 and as second variant that can be installed in older-model F/A-18 model aircraft. "This would allow nations operating the F/A-18 to be able to more effectively link and share air battle data with other AESA-equipped fighters – an important consideration in the current-day, coalition warfare environment," said a Raytheon representative.

European Programmes

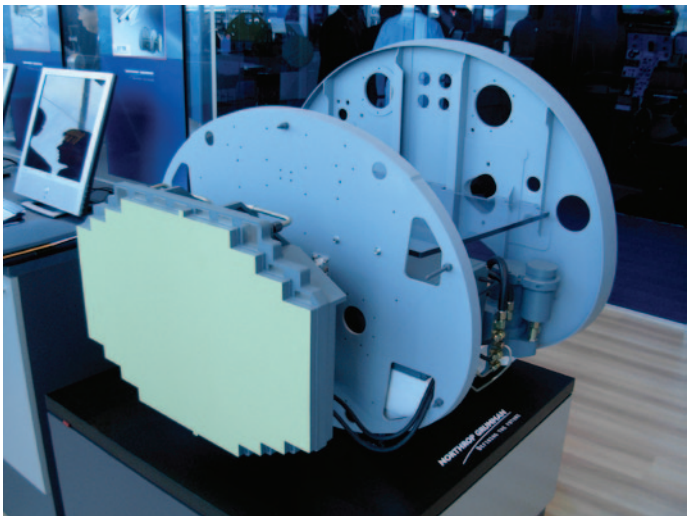
Unlike these US radars, none of the European firms are currently looking to "back-fit" an AESA into a legacy platform that is other than the aircraft these radars were built for. But the three major European fighter aircraft firms all have an active-array model that is being installed in the current-production aircraft, and in some cases they may also be retrofitted into aircraft that were originally produced with an MSA on-board.

Of the three companies currently building AESA radar sets for a current-day fighter programme, France's Thales has the most straightforward retrofit with its Radar à Balayage Electronique 2 (RBE2) airborne radar set. Originally developed for the Dassault Rafale fighter aircraft in a passive (PESA) variant, the RBE2 was designed from the ground with a spiral development growth that permits the older PESA array to be replaced with the AESA one.

Replacing the PESA with the AESA takes about two hours and is totally a "plug and play" operation, said Jean-Noël Stock, Thales Vice-President in charge of the company's radar design and production center in Pessac. "Once the AESA is installed there will be a continuous process of creating new modes for the radar. Switching to these new modes will strictly be a matter of software, and that software can be downloaded direct to the aircraft." Stock estimated that overall Thales is 4-5 years ahead of its competitors in AESA technology, particularly in software and in the design of chips that are capable of simultaneous digital processing and high-frequency management.

Part of swapping out the PESA for the AESA involves removal of the radar transmitter, one of the heaviest components of the PESA unit, but the final AESA variant is still more than 100 lbs heavier due to the large number of transmit/receive (T/R) modules in the array that do not exist in the PESA model.

"This is not a problem either," explained Stock. "The Rafale has dummy weight in the nose section that adjusts the center of gravity of the aircraft in order to enhance its manoeuvrability, so when the AESA is installed we just subtract some of that dummy weight so there is no net weight gain experienced in the process of upgrading to the newer array.



The four-nation consortium Eurofighter Typhoon has its own AESA programme called CAPTOR-E, which began with a Euroradar funded demonstrator program that ran from 2002-2007. The concept was similar to what Raytheon designed for its APG-63 model in that the radar combines a new AESA array with the previous CAPTOR MSA backend.

Successful flight demonstrations were conducted on the Eurofighter Typhoon DA-5 testbed aircraft in May 2007. The programme itself was officially announced at the Farnborough International Air Show on 20 July 2010. Marketing specialists for the programme claim that it has advantages over the Thales RBE2 AESA in that the radar's technology overall is more state-of-the-art and that this gives it a longer range with greater target acquisition capability.

Two other advantages that they credit the CAPTOR-E with is the engagement envelope is expanded by re-positioner that extends the radar's field of regard to ±100° which is some 50% wider than what the system designers call traditional, "fixed plate" AESA radars. Also the large nose of the Typhoon aircraft allows for a very high power aperture antenna coupled with a wide field of regard, making it what they call the best-performing AESA on offer in the export market.

Lastly, there is the Selex Galileo Raven ES-05 radar for the Saab Aerospace Gripen JAS-39E/F aircraft. This radar is equipped with the same type of roll-repositionable AESA antenna to also provide a ±100° field of regard. Company specialists state that "this allows the pilot to maintain the missile datalink and turn away while the scenario continues and the ES-05 is then acquiring other targets and tasks.

The Raven's T/R module technology significantly improves system availability and addresses all of the traditional problems of MSAs. What is perhaps the difference between the Raven and other upgrades from MSA to AESA is that the Raven radar's back end is probably the most well-developed and optimised for an active antenna, largely due to the fact that the designers have had previous developmental programmes with both the former Ericsson radar division and Thales in France to design an AESA for the JAS-39.

As of July, the Raven is currently flying on one of the Gripen NG demonstrator aircraft and is going to be part of the developmental effort for the 22 JAS-39E/F to be sold to Switzerland. The programme has the potential to be timed perfectly for the Non-Recurring Engineering (NRE) costs to be split between three nations: Brazil, Sweden and Switzerland. Switzerland has already announced its delay of two years in order procure its aircraft in parallel with Sweden.

The total Swiss requirement is only 22 aeroplanes, but the Royal Swedish Air Force intend to procure between 60-80 JAS-39E/Fs and the Força Aérea Brasileira (FAB) are planning to procure an initial tranche of 36 aircraft for a total of 100-120 new fighters. These numbers, plus any other export contracts that are secured in the meantime, provide the economies of scale necessary to capitalise the programme.

In addition, Saab have taken the step of developing a package of "retrofits for its current-generation C/D aircraft so that they can be upgraded to a configuration close to that of the E/F variant," said one Saab export executive. This would potentially include the installation of the same Selex Raven ES-05 Active Electronically Scanning Array (AESA) radar designed for the E/F-series aircraft in the older model C/Ds.

Future Russian Radar

The Kiev-based radar and electronic warfare company Radionix has become one of the most successful post-Soviet defence electronics firms in Ukraine by offering the most cost-effective and reliable upgrade packages for the radar and sensor suites of both the Sukhoi Su-27 and Su-30-model aircraft and the Mikoyan MiG-29.

LEFT: Gripen Radar-01
The Selex Raven, used in the Gripen comes from a solid stable of radar upgrade developments.
(PHOTO: Reuben Johnson)

RIGHT: Northrop Grumman's Scalable Agile Beam Radar (SABR), based on radar technology developed for new build aircraft.
(PHOTO: Reuben Johnson)

Maintaining a successful enterprise that is not easy, explained the company's General Director, Stanislav Borisovich Zavyalov, "because the main portion of the company's business has to be from export sales. Unfortunately, the Ukrainian MoD is not in a position now to spend a lot of money on modernising its fleets of aircraft, so we have had to look to countries where there are Russian-design aircraft still in inventory and where there is also a desire by those air forces to keep those fleets in service for the foreseeable future."

In the process the company have developed one of the most advanced upgrade packages that have a large number of common components, but can be used to replace outmoded modules in both the NIIP N001 radar used in the Su-27 and Su-30 series of aircraft and the MiG-29's Phazotron N019 radar. The company has - with its own personnel - designed, developed and manufactured several modules for these radar sets that inserted in the place unreliable, Soviet-era components.

The N001 and N019 fighter radars have different arrays due to the larger diameter radome of the Su-27 and Su-30 aircraft, but the design of the two are very similar in the back end due to that back in Soviet times the two radar houses were two divisions of the same enterprise. The Radionix modifications to the N001 radar set, for example, involve replacement of the microwave receiver with a new model, a replacement to the synthesizer unit/microwave, installation of Doppler filters and an air target detection unit replacement.

These modifications "increase detection ranges and accuracy of the N001 by 25-30 per cent and significantly improve reliability and ECCM against jamming," said Zavyalov, "and overall it extends the useful operational of this radar set – and the aircraft that it is installed in - for 10 years."

Of the two types of fighter aircraft radar that Radionix have developed upgrades for, the Su-27 and Su-30 models have been exported in far greater numbers: to the People's Republic of China (PRC), India, Malaysia, Vietnam, Indonesia, Venezuela, and Algeria among others. Therefore, in previous years the far greater market potential has been with operators of the Sukhoi-model aircraft.

Of these, the PRC's People's Liberation Army Air Force (PLAAF) have been one of biggest customers for Radionix and other Ukrainian aerospace firms. "Companies outside of Russia that are the original suppliers for Su-27/30 components or have developed modifications to the aircraft's on-board systems are in demand with the PLAAF. The Chinese force finds that it can 'customer-order' modifications to their Russian-designed hardware that a large Russian company might not want to devote the resources to developing and the prices in Ukraine are also better," explained on Ukrainian aerospace company executive who operates an aerospace firm in Beijing.

Not to be outdone by their neighbours in Ukraine, Russia's radar houses are also looking at options for improving these same aircraft. Russia's NIIR Phazotron, the primary supplier of airborne fighter radars for almost all models of Mikoyan fighter aircraft, are produing a prototype of an advanced variant of the MiG-35's Zhuk-A Active Electronically Scanning Array (AESA) radar set. The radar will be installed in one of RSK-MiG's 's experimental prototype MiG-29M2-9.15 aircraft.

The programme would be a joint project between MiG and the Russian Air Force (VVS) for as an upgrade programme for MiG-29s currently in inventory with the Russian service and the air force of what has been described as an "unspecified export customer." The export nation is actually India, which recently upgraded 62 of its land-based MiG-29 aircraft – 54 single-seat aircraft and eight two-seat combat-capable trainers.

As was said at the beginning of this article, what drives many of these radar upgrades is not only making these aircraft capable of surviving a modern-day air combat engagement, but it is also due to the fact that the costs and availability dates for so many new model fighters are such huge question marks in the present day. What remains to be seen is whether or not the significantly enhanced performance of, for example, an F-16 with an AESA radar will reduce the requirement for F-35 and other new-generation fighters.

The fact is that radar technology is advancing faster than the development of new platforms that can take adequate advantage of it. The promise of these and other upgrades is that fighter aircraft that would otherwise become obsolete within the next decade or more will be able to contribute to an air force's operational capability for many years to come.

Thales's Radar à Balayage Electronique 2 developed for the Dassault Rafale fighter aircraft. (PHOTO: Reuben Johnson)

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Skimming the Asian Oceans

Anti-ship missiles Development

By Ted Hooton

TOP: The anti-ship variant of Tomahawk is slow, but carries a very powerful punch.
(PHOTO: US NAVY)

OPPOSITE: The Teseo version of the Otomat, seen clearing the launcher
(PHOTO: MBDA)

THE ANTI-SHIP MISSILE HAS BECOME the prime weapon in naval Anti-Surface Warfare (ASuW) since the 1960s and has now given them the capacity to break the prerogative of air power and strike deep into hostile territory.

The surface-to-surface missile market in Asia has been dominated by American and European designs but there are growing signs that domestic designs and production may increasingly meet regional requirements. These requirements have been met with a wide range of weapons starting with the first naval surface-to-surface missile in the continent which was the Russian P-15 Termit, better known by the NATO designation SS-N-2 'Styx.'

Styx, which continues to be used by India and China, the latter producing and developing the weapon as HY-2 (CSS-N-3 'Seersucker'), as well as North Korea and Vietnam. This was a large (2.5 tonne launch weight) missile with simple autopilot guidance augmented by active radar (HY-2 can use an infra-red seeker) and is powered by a rocket motor fuelled by kerosene and nitric acid with a sub-sonic speed (Mach 0.9). It has a maximum range of some 21.5-43 nautical miles (40-80 kilometres), although HY-2 can reach 51 nautical miles (95 kilometres), but its use reflects the fact it was the first in the market. It is a crude, relatively dumb weapon, with a powerful (454 kilogramme) warhead while its corrosive fuel system requires careful maintenance.

Next generation

The next generation of weapons, notably Harpoon and Exocet used by eight and six Asian navies respectively, have similar

sub-sonic speeds (Mach 0.85-9) to 'Styx' but are more sophisticated while easier to maintain. Their guidance is based upon inertial navigation systems which receive inputs from launch platform co-ordinates and approximate target co-ordinates and then use accelerometer motion sensors and gyroscopic rotation sensors to provide data to a computer which continuously calculates the location, direction and velocity of the missile and compares own location with that of the target. Within proximity to the target the missile activates its own radar to detect it and to control the terminal phase, this sensor having the ability to guide the weapon into either the horizontal or the vertical centre of the radar image. These missiles also have a degree of intelligence approaching their target indirectly, turning at a predetermined way point or even way points, and at varying heights depending upon whether or not the mission requirement is for fuel efficiency, to achieve greater range or a covert approach, flying just above the waves to make them more difficult for the target's radars to detect. Alternatively, the missiles can be pre-set to dive upon the target at a steep angle for greater lethality.

Because they are designed to strike the most vulnerable part of a ship both Harpoon and Exocet have smaller warheads than 'Styx'; 221 and 165 kilogrammes respectively. The turbo-jet powered Harpoon had the longer range, up to 130 nautical miles (240 kilometres) compared with 38 nautical miles (70 kilometres) in the rocket-powered Exocet MM40. However, the latest Exocet Block 3 now has a turbo-jet engine giving a range of 97 nautical miles (180 kilometres) with greater accuracy thanks to the incorporation of a Global Positions System (GPS) unit using satellite navigation inputs. Both weapons can be launched from submarines or aircraft and the latest versions also have a limited land-attack capability, which evolved from a requirement for enhanced littoral naval warship performance to engage targets in harbour, within archipelagos or close to shore, all of which involve severe 'clutter' environments for radars.

Europe and Russia

A similar MBDA weapon is the Otomat Mk 2. This is a 762 kilogramme jet-powered missile with a range of 86 nautical miles (120 kilometres) and a 210 kilogramme warhead and was acquired by Bangladesh for the Korean-built frigate BNS Bangabandhu and by Malaysia for the Italian-built Laksamana class corvettes which were designed as the Assad class for the Iraqi Navy. The missile is supported by the Teseo weapon control system and the whole weapon system is often referred to as Otomat Teseo.

Russian designers were slow to catch up with their counter-parts on the other side of the Iron Curtain but produced two comparable weapons. The 3M24 Uran (Uranium), SS-N-25 'Switchblade', was externally so similar to the Harpoon that it was nick-named 'Harpoonski' but with a 480 kilogrammes (603 kilogrammes with booster) launch weight it is smaller, the American missile's figures being 519-621 kilogrammes (682-785 kilogrammes with booster). Also turbojet powered 'Switchblade' has a similar speed to the Exocet and Harpoon with a range of 70 nautical miles (130 kilometres. The weapon has been selected by India for the Delhi class destroyers, Brahmaputra class frigates as well as the Kora, Veer and new Kamorta class corvettes while Vietnam has selected it for Gepard class frigates ordered from Russia as well as for its Tarantul V and BPS 500 class corvettes, the earlier Tarantuls retaining 'Styx'.

A more sophisticated and versatile weapon system family is the Klub, available for surface combatants (Klub-N) and submarines (Klub-S). Klub consists basically of two sub-sonic surface-to-surface missiles; the 3M54 or SS-N-27 'Sizzler' and the 3M14 SS-N-30 which are both powered by turbojets and with international navigation system/radar guidance but they are distinguished from other weapons by their extended ranges. The former is specifically an anti-ship weapon with a range of 120 nautical miles (220 kilometres) with the cruising phase carried out by the turbojet and near the end of this phase the missile conducts a sea-skimming approach. However, the terminal phase is conducted from a distance of some 10.75 nautical miles (20 kilometres) by a supersonic rocket-propelled payload capable of Mach 2.9which climbs to conduct a high-angle diving attack with a 200 kilogramme warhead, kinetic energy compensating for the relatively small explosive mass.

Russian publicity material when this weapon was first displayed suggests the 'Sizzler', also known as Kh 35, and with a launch-weight of 1,920 kilogramme may have a limited land-attack capability. But the 1,770-kilogramme 3M14 is designed as a land-attack weapon with a 400 kilogramme warhead and, like 'Sizzler' is available in surface- and sub-surface launched versions. The latter are used in Russian-designed Kilo class submarines of the Chinese and Indian Navies and it is a possibility that these weapons might also have been acquired by Vietnam for its Kilos. The Indian Kilos, or Sindhughosh class, boats have been returning to Russia for upgrades since 2002 and the

INS Sindhughosh and Sindhuvijay have both received 3M14 land-attack missiles which, it is believed, will be introduced into the rest of the class by 2015.

Since the 1970s Asian navies have been seeking to reduce their dependence upon European and American surface-to-surface missiles. Japan's programme was initiated in 1973 initially for an air-to-surface weapon but from the mid 1980s the Type 90 or SSM-1B surface-to-surface weapon was developed by Mitsubishi Heavy Industries. Essentially this is a 660-kilogramme launch-weight, turbo-jet powered missile similar in capability to Harpoon with a range of some 80 nautical miles (150 kilometres) and a 225 kilogramme warhead. It is reportedly selected for the Atago, Takanami and Murasame class destroyers, although other destroyers and the frigates (as well as the submarines) have Harpoon, and this missile may also be found in some Marusames.

China

China decided to pursue a rocket-propelled solution with its YJ-83 CSS-N-6 'Saccade' whose export version is designated C-802. This is a 715 kilogramme weapon with a 165 kilogramme warhead and the usual inertial navigation/radar guidance system but the rocket motors reportedly provide a surprising range of 65 nautical miles (120 kilometres).

The Harpoon is a mature design, still going strong (PHOTO: US NAVY)

The weapon is used extensively by Chinese surface combatants ranging from destroyers to fast attack craft while a submarine-launched version, YJ-82, is reported used by most modern Chinese submarines both nuclear-and conventionally powered. The weapon has been exported in Chinese-built frigates to Bangladesh in the BNS Osman, Pakistan's Sword (F-22P) class as Thailand's Chao Phraya class frigates, it equips fast attack craft in Myanmar and Pakistan and it is being fitted into Indonesia's Todak class fast attack craft.

Indonesia announced in January 2012 that it plans to acquire a class of 24 fast attack craft from PT Palindo Marine and the first two were KRI Clurit and Kujang. These will receive Chinese designed C-705 surface-to-surface missiles with turbo-jet propulsion, a range of some 65 nautical miles (120 kilometres) and a 110 kilogramme warhead. Indonesia is the launch customer for these weapons which will reportedly be built in country under licence.

Across the Formosa Straits from the Chinese People's Republic, Taiwan has developed its own anti-ship missiles. Their development followed close co-operation with Israel with the result that the Hsiung Feng I (Brave Wind I) was a development of the Israeli Gavriel (Gabrial) II, a rocket propelled weapon also acquired by Sri Lanka for its Sa'ar 4 class fast attack craft. It is a 540-kilogramme weapon with semi-active radar and manual guidance, a 225 kilogramme warhead and a range of 19 nautical miles (36 kilometres). It was embarked in the Lung Chiang and Hai Ou class fast attack craft but the Taiwan Navy required a much longer-ranged weapon and for Hsiung Feng II provided a turbojet engine and the usual inertial navigation/radar guidance system, although augmented with an infra-red sensor. The new weapon retained the warhead of its predecessor but has a launch weight of 685 kilogrammes and a range of 70 nautical miles (130 kilometres) and was selected for frigates and newer fast attack craft.

Israeli assistance is also reported in India's submarine-launched missile Sagarika. Little information has been released about this programme, although testing is known to be continuing possibly for use in the nation's new nuclear-powered missile submarines, and it is reportedly aimed at having a capability

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similar to Tomahawk with a range of up to 650 nautical mile (1,200 kilometres).

South Korea has developed both an anti-ship missile and a land-attack weapon, the latter probably a counter to her northern neighbour's much vaunted capability of nuclear-tipped ballistic missiles. Development of these weapons began in the 1990s and the first to appear has been the LIG Nex1 Haeseong (Sea Star) or SSM-700K, a turbo-jet weapon reportedly slightly larger than Harpoon and with a range of 90 nautical miles (150 kilometres) and a 220 kilogramme warhead. The company have also produced the Cheon Ryong vertically-launched land attack missile although little information has been released about it apart from claims of a range of 270 nautical miles (500 kilometres) and a warhead of 450-500 kilogrammes. It is believed the Haeseong is embarked tin some of Seoul's destroyers but it is reported that the Sejong Daewang (KDX-3) class destroyers will carry up to 32 Cheon Ryongs.

Supersonic

With the exception of the 'Sizzler' terminal stage the majority of Asia's naval surface-to-surface missiles are subsonic. Three supersonic weapon systems are deployed in Asian navies because they have the advantage of reducing a target's reaction times, indeed they can halve the effective range of close-in weapon systems. But their very velocity is the problem, and the reason they are not more widely used for they have less time for their radar processors to evaluate information from the sensor and allow the guidance system to react indeed it has been suggested they may be more vulnerable to electronic counter-measures than sub-sonic weapons which have sufficient fuel to re-acquire lost targets.

The Russian 3M80/3M82 Moskit (Mosquito) or SS-N-22 'Sunburn' is a 4,150 kilogramme (3M82) weapon capable of Mach 3 and a range of 65 nautical miles (120 kilometres) and carries a 320 kilogramme warhead. These weapons were imported by China with the Russian-built Sovremenny class destroyers. Russian co-operation with India led to a development of the former's 3M55 Oniks (Onyx) as the PJ-10 Brahmos, a 3,000 kilogramme launch-weight, ramjet-powered weapon with 300 kilogramme warhead. This Mach 2.8 weapon, which can be vertically or slant launched, is reported to have a range of 157 nautical miles (290 kilometres) and has been selected for the Kolkata class and some of the Rajput class destroyers while a submarine version is being developed.

Taiwan has also developed a supersonic version of the Hsiung Feng III for use in Cheng Kung (Oliver Hazard Perry) class frigates. It is reported to have a range of 108 nautical miles (200 kilometres) a speed of Mach 2 and a 190 kilogramme warhead but it is interesting to note that the Keelung (Kidd) class destroyers use Harpoon Block 2.

China, India and South Korea are all reported to be developing long range (1,000 kilometre) naval cruise missiles as Dong Hai (East Sea) 10, Nirbhay (Fearless) and Hyunmoo (Guardian of the Northern Sky) 3 while Pakistan is reportedly developing the 700 kilometre Babur but there are few reliable details about these weapons. It seems likely that some, if not all, of these weapons will be deployed by the end of the decade bringing a new aspect to naval strategy. □

The shore-launched version of Brahamos gives a good indication of the overall size of the missile.

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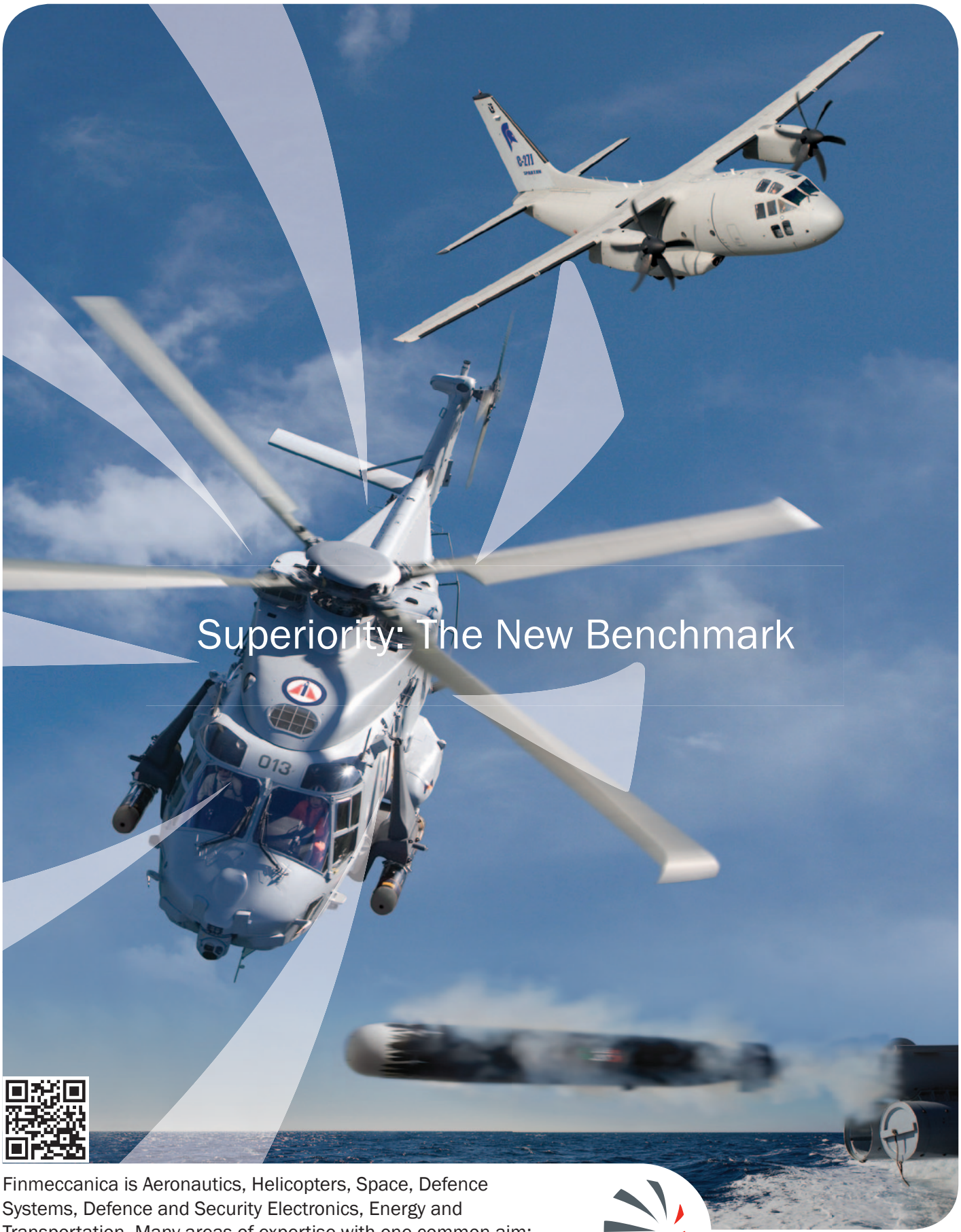

Superiority: The New Benchmark

Finmeccanica is Aeronautics, Helicopters, Space, Defence Systems, Defence and Security Electronics, Energy and Transportation. Many areas of expertise with one common aim: to build a brighter future together

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