China heads for a step change in naval capabilities

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In recent months there have been a number of indicators that China's military technology is on the verge of entering an era of innovation, rather than cloning or reverse engineering overseas designs. *Andrew Tate* considers developments within the naval environment and looks at what may be over the horizon

Over the past 10 to 15 years, the People's Liberation Army Navy (PLAN) has made remarkable progress, first in modernising the designs of its ships, aircraft, and submarines and subsequently in expanding not only the number of modern platforms but also the capabilities they can deliver. It is clear that it is only a matter of time before the PLAN will rank as one of the world's leading blue-water navies.

A common concept in Chinese thinking is that of 'leap-frog' development, drawing on ideas and resources, wherever they can be obtained, to make rapid progress in closing the technology gap between the world's most advanced countries and China. The arms embargo imposed on China in 1989 closed off access to European and US arms technology just at the point that China was starting to import key systems, such as those incorporated into the design of the Luhu-class (Type 051) destroyer. These included LM2500 gas turbines from General Electric, Tavitac combat data systems from Thomson-CSF, and AS-244 lightweight torpedoes and launchers from Whitehead Alenia.

The PLAN's aircraft carrier Liaoning is an ex-Russian Navy vessel. An indigenous carrier programme is under way. (AFP/Getty Images)

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As a consequence of the embargo, China turned to Russia to acquire the technology it needed to modernise. For the PLAN, key purchases were four Sovremenny-class destroyers (delivered 2000–06), 12 Kilo-class submarines (delivered 1997–2006), and about 100 Su-27SK fighter aircraft, built under licence in China between 1998 and 2004. In addition, the acquisition of the part-completed Kuznetsov-class aircraft carrier *Varyag* in 1998 laid the foundations for the PLAN's indigenous carrier programme.

Whether the sale agreements included technology transfer rights is questionable but Chinese derivatives of many of the systems supplied by Russia have been the foundation of recent PLAN developments. Examples include the Type 382 volume search radar fitted to the Type 054A frigates, with evident similarities to the Top Plate radar fitted to the PLAN's Sovremenny-class destroyers; the HHQ-9 vertically launched surface-to-air missile system, fitted in the Type 052C/D destroyers, derived from the S-300 system supplied to the People's Liberation Army Air Force (PLAAF); and the YJ-18 anti-ship cruise missile, which recent information indicates has much in common with the 3M54E Klub, which was supplied in the Kilo-class export deal. While these and other systems are wholly manufactured in China, avoiding dependency on overseas suppliers, and likely utilise more modern technology with associated design improvements, their lineage derives from systems developed in the Soviet Union in the 1970s and 1980s.

The Type 055 destroyer takes the PLAN a step further away from legacy technologies. (via haohanfw.com)

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Reverse engineering of equipment acquired from overseas has undoubtedly provided a short-cut to technology development but is constrained not only by what can be purchased (Russia was uncooperative in supplying the Su-33 carrier variant after clones of the Su-27 were built) but also has an inherent time lag. This does not meet the PLAN's aspiration to be on an equal capability footing with the US Navy (USN).

In the 1980s and 1990s, China was not only constrained by a lack of advanced manufacturing capabilities, but also by a paucity of innovation among its engineers and scientists. Open sources do not readily quantify how much technological know-how China has obtained illicitly. However, documents leaked by Edward Snowdon, for example, included an NSA presentation estimating that 50 terabytes of data were extracted from defence networks by China in more than 500 significant intrusions targeting defence programmes.

Whatever the degree of information acquired, there is no doubt that China has developed a number of capabilities that mirror concepts and technology developed by US and European companies. Examples include systems such as the Type 346A phased array radar installed on the Type 052C/D destroyers, the air independent propulsion system used by the Type 039A Yuan-class submarines and the active and passive towed sonar arrays now fitted to a number of corvettes, frigates, and destroyers. While the development of these examples may or may not have been accelerated by espionage, they have still lagged the in-service dates of comparable Western systems. As an example, the first PLAN ships equipped with a bi-static towed variable depth active sonar and passive line array were the Type 056 corvette (pennant number 593), which was commissioned in November 2014 and the Type 054A frigates 576 and 577, which entered service in January 2015. In contrast, Sonar 2087 was first installed in Type 23 frigate HMS *Westminster* in 2004.

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Carrier technology

The USS *Gerald R Ford* is also the first aircraft carrier to adopt the Electromagnetic Aircraft Launch System (EMALS) in place of a steam-powered system. In September 2015, satellite imagery showed that trenches had been excavated at the People's Liberation Army Naval Air Force's (PLANAF's) Huangdicun carrier-aircraft training facility, assessed to be development and trials facilities for steam-powered catapults and electromagnetic systems. While there is anticipation that the start of construction of China's first CATOBAR carrier is imminent, no evidence has yet emerged that work is under way. There have been unconfirmed reports that shipbuilding has been delayed because of a decision to incorporate an electromagnetic catapult, which if substantiated, would reflect a very significant 'leap-frog', completely by-passing the phase of employing steam technology.

It is also evident that the United States and China are pursuing parallel, competing paths in two other areas of major significance for naval combat – electromagnetic railguns and directed-energy weapons. Unsurprisingly, there is little firm open source intelligence on the PLAN's programmes, nor what progress has been made. Research into railguns appears to have started in the late 1980s, involving the Xi'an Electronic Engineering Research Institute (206 Institute) and the 27th Research Institute of the China Electronic Technology Group Corporation, but it is not known how far research has progressed towards a viable implementation.

Work on directed-energy weapons is led by the Changchun Institute of Optics, Fine Mechanics, and Physics. Poly Technologies has developed a vehicle-mounted Low Altitude Laser Defending System (LASS), which is claimed to be capable of disabling unmanned aerial vehicles (UAVs) out to a range of 4 km, but the real focus of China's laser weapon programme is as an anti-satellite weapon. The ability to incapacitate communications or GPS satellites would create a significant threat to potential opponents' combat capabilities. It is a matter of conjecture as to whether the United States or China will be the first to deploy an operational railgun or directed-energy weapon.

J-15 aircraft operating from Liaoning . (AFP/Getty Images)

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Indications are also emerging that China is pursuing technology development programmes that will result in the PLAN fielding new systems before the USN. The PLAN has yet to build a warship that adopts an integrated electrical propulsion system (IEPS), such as that used in the Zumwalt- or Daring-class destroyers, although it is reported that IEPS is used in some medium-size cutters of the China Coastguard. However, in a Chinese television (CCTV) programme that was broadcast in June 2017, claims were made that successful research and development (R&D) programmes put the PLAN ahead of the United Kingdom and United States in the field of IEPS. This may indicate that rather than adopting the high-voltage power distribution architecture employed in the Zumwalt/Daring designs, the first PLAN warship to adopt IEPS may utilise a medium-voltage DC architecture. This would enable a simpler, single-voltage distribution bus to be used and eliminate the need for complex power supply harmonic conditioning and filtering. IEPS not only maximises the efficient use of prime movers and provides improved flexibility in distributing power, but will also be essential to meet the peak power requirements of railguns and directed-energy weapons. At present there are no conclusive indicators pointing to the PLAN's first IEPS-powered warship, although the next class of frigate (the Type 054B) is a serious contender.

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Submarine technology

The CCTV programme that covered the IEPS development work also stated that the next generation of nuclear submarines (assumed to be either the Type 095 SSN or Type 096 SSBN) will be built with IEPS. Installation of a PMM in a diesel-electric submarine, which although beneficial, is not a technological leap forward, and may therefore be an interim step before installing a larger PMM in a nuclear submarine. Such a design, while still requiring a steam-driven turbo-alternator to provide the electrical power, could eliminate propulsion steam turbines and the gearbox. Use of an electric motor in a nuclear submarine is not a new concept – the French Barracuda-class will use an electric motor for patrol speeds, supplemented by a steam turbine for high speed, and is also planned for the US Columbia-class, which will enter service around 2030. However, the PLAN's next generation of SSNs and SSBNs may emerge in the next 2–4 years.

Compact high-torque PMMs are also key to developing shaftless, rim-driven propulsors. This form of propulsion has been developed for commercial ships but has not yet been used in submarines. They potentially offer the submarine designer much greater flexibility, as there may be no need to accommodate a propulsion shaft, bringing further potential noise reduction benefits. However, there are considerable challenges to overcome before a viable implementation could be incorporated into a submarine design, so the United Kingdom rejected this technology for the Dreadnought-class next-generation SSBN, to reduce programme and financial risk. In footage from the CCTV programme on IEPS, a model of a rim-drive propulsor was evident and it seems likely that the PLAN is pursuing this and other technological changes that could result in a step change in reducing their nuclear submarines' self-noise, which currently is reputed to be a significant weakness.

In June 2017, a report from the Chinese Academy of Sciences (CAS) announced that a significant advance had been made at the Shanghai Institute of Microsystem and Information Technology in applying the technology of superconducting quantum interference devices. Commonly referred to as SQUID sensors, they are exceptionally sensitive magnetometers, which respond to variations in magnetic fields and have a potential application in the detection of dived submarines. Notably, the greater sensitivity offers potentially greater detection ranges than the few hundreds of yards achievable with current airborne magnetic anomaly detector sensors.

Previous research in the United States on applying superconducting magnetometers as anti-submarine warfare (ASW) sensors was unable to resolve the problem of distinguishing variations caused by natural variations and those caused by the presence of a large steel object. The report from CAS claimed that the use of an array of SQUID sensors was able to make these distinctions in trial conditions. When online commentaries highlighted the potential value not only in geophysical prospecting surveys but also in hunting submarines, the CAS report was removed and no further information has been released. It is therefore difficult to assess how far this research has progressed towards a practical ASW sensor, but it is clear that this work reflects original research, not replicating what has been achieved elsewhere.

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Technology innovation

A key question is whether these developments are exceptional or whether China is now becoming innovative in technology research and acquiring a lead in important areas. The need to have indigenous leading edge technology, from economic and defence perspectives, has been recognised for many years by China's political leaders. In 1984, a programme was initiated to establish State Key Laboratories focused on conducting research to close the gap between China and the rest of the world. There are now over 250 State Key Laboratories in industry and academia covering the spectrum of R&D, for civil and military purposes, such as the Northwestern Polytechnical University in Xi'an, which hosts The State Key Laboratory for Torpedo Guidance Technology.

The PLAN's Type 052D destroyer Hefei (right) equipped with the Type 346A Dragon Eye phased array radar. (AFP/Getty Images)

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In 1992, this approach was extended and a number of National Defence Science and Technology (NDST) Key Laboratories were established, which now number over 50. Some of these have grown out of the previous military research institutes, such as Research Institute 14 - the Nanjing Research Institute of Electronics Technology (NRIET). This is now the NDST Key Laboratory for Antennas and Microwave Technology, the country's leading radar research establishment, behind developments such as the Type 346A Dragon Eye phased array radar. Other NDST Key Laboratories are affiliated to civilian universities, such as the lab for unmanned underwater vehicles at Harbin Engineering University or sonar technology at the Hangzhou Institute of Applied Acoustics.

Some of the PLA's 43 military education institutions also host NDST key laboratories, such as the National University of Defence Technology, which incorporates the precision guidance and automatic target recognition key laboratory. Having such focused and specialised laboratories does not lead inevitably to ground-breaking research but recent developments may reflect that the investment is generating a substantial return. The NDST key laboratory for naval integrated electric power technology at the PLA Naval Engineering University in Wuhan appears to be achieving significant results and is behind the developments in electromagnetic catapults, IEP, and PMMs.

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The PLAN has also invested in ships for development trials at sea, with two Type 909 Dahua-class ships (891 and 892) involved in radar, VLS, missile, and other surface weapon trials, and two other trial ships (893 and 894), which are thought to be dedicated to sonar and related trials. With the

Type 032 Qing-class submarine, the PLAN also has a dedicated platform for strategic ballistic missile trials.

The J-15 is the cutting edge of the PLAN's carrier capability. (AFP/Getty Images)

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Advances in R&D alone are insufficient to enhance China’s military capabilities; they must be paired with a dynamic and innovative production environment. China’s military industrial sector is still dominated by 10 state-owned conglomerates, parenting thousands of subsidiaries. China's political leadership is aware of the inefficiencies and lack of innovation inherent in this structure and is pushing hard towards greater civil-military integration, aimed at yielding economic and military benefits. A further departure from the past is the drive to encourage private sector investment in the defence sector, which is gaining pace from a negligible base. The expectation is that this will be a catalyst for competition among defence companies and will drive innovation.

Past efforts to introduce competition in the aerospace sector have had limited success. Competing solutions for the PLAAF’s and PLANAF’s advanced jet trainer were offered by the Guizhou Aircraft Industry Corporation (GAIC) and the Hongdu Aviation Industry Group (HAIG), both part of China’s state-owned Aviation Industry Corporation (AVIC). They respectively offered the JL-9 and L-15 (JL-10), the former a further development of the single-engine Mig-21 design, the latter a new twin-engine aircraft developed with technical assistance from Yakovlev.

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