HIGH TECHNOLOGY DEVELOPMENTS IN CHINA: LEVERAGING FOR MILITARY EFFECTIVENESS

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By

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Abstract

China has progressively developed a comprehensive industrial base over last three decades by sincere implementation of the 'Four Modernisations' theme propounded in the 1960s. The same, supported by associated infrastructure even up to mega-scale, and ever increasing availability of technologically skilled work force; all well backed by large investment in research and development under State's direct supervision; provides a solid material foundation for the manufacture of high end products. These products also have dual-use potential, both, in civil as well as in military domains. In fact, China's defense science and technology projects have often become more successful in generating innovative outputs as compared to those in the civilian sector. Some such 'leap-ahead technologies', include the artificial intelligence, robotics and quantum communications. Advanced Chinese military technology projects specifically include the hypersonic weapons, maneuverable re-entry vehicles, unmanned and artificial intelligence-equipped weapons (aerial drones, unmanned surface vessels and autonomous underwater vehicles), electromagnetic rail guns and electromagnetic aircraft launch systems. These new-age weapons programmes could yield potentially disruptive military effects, presenting challenges even for the technologically advanced militaries like that of the United States. In the event, impact of technologically enabled equipment in the Indian military and security domain will be quite substantial. Consequently, the Indian coping calculus will perforce, have to be reworked in order to address the emerging challenges.

Introduction

China has progressively developed a comprehensive industrial base over last three decades by sincere implementation of the 'Four Modernisations'[1] theme propounded in the 1960s. This industrial system covers almost all areas and domains – from low-end simple products to high-end complex 'system of systems.' In contrast, many developed countries are now only engaged in certain specialised and niche areas, having reaped the benefits of a complete industrial system of the past. According to the UN standards of manufacturing, China has the World's best thermal power plant (super-critical unit), hydropower station (largest stand-alone capacity), nuclear power plant (third and fourth generation), power grids (UHV power grids) and one of the best refineries (Sinopec Zhenhai Refining & Chemical Company).[2]

Two Chinese tele-communications enterprises figure amongst the world's five leading le-communications equipment manufacturers. [3]China's core electronic and IT industry is also developing rapidly. The research and development in high-end general-purpose chips, basic software, and large-scale integrated circuits are poised for major breakthroughs. China's industrial technology has continuously improved since it became the largest industrialised country in the world in 2010.[4]

This kind of comprehensive manufacturing and industrial base, supported by associated infrastructure even up to mega-scale, and ever increasing availability of technologically educated and skilled work force; all well backed by large investment in Research and Development under State's direct supervision; provides a solid material foundation for the manufacture of high end products. These products can also have dual-use possibilities, having both, civil and military applications.

With the above mentioned technological prowess of China acting as an overarching umbrella, this Paper is premised

on the ongoing reality of the Chinese Peoples' Liberation Army (PLA) modernising at a demonstrably rapid pace, with an aim of becoming a force capable of countering world class adversary under informationised conditions by 2050. The overall reform process of PLA, is also slated to bring in organisational changes and training pattern modifications, to promote jointmanship and synergise the combined resources of the Force. In this context, it has been considered that the PLA's operational effectiveness would increase manifold, if it was able to leverage certain high technologies in the national, military and maritime domains, by adapting them for military use.

Accordingly, the Paper carries out a broad-brush scan of certain prominent high technology developments in china which can be adapted for military applications; and follows it up with a few high technology developments, specifically in PLA's domain. Since President Xi Jinping,[5] has specifically singled out his vision for the Chinese Navy by stating that 'China needs a strong navy, as it is an essential pillar to the great rejuvenation of the nation'; [6] the Paper also surveys some high technology developments in the Chinese maritime domain as well as major ongoing high technology projects in the Chinese Navy which would enable augmentation of its operational effectiveness. The Paper concludes by assessing the implications for India, and particularly its maritime sphere, should China be able to leverage the above mentioned high technology developments into its military/security domain.

High Technology Developments in China Adaptable for Military Applications

As regards developments at the frontier end of high technologies, China may be transitioning from a phase of 'catching up' to one of pursuing 'leap-ahead advanced technologies.' Some technologists, citing cutting-edge advances made by China in emerging technologies like artificial intelligence, high-performance computing and quantum information science,

aver that China's capability to pursue independent innovation has increased considerably. Consequently, it is facing far fewer barriers in its efforts to innovate or to develop advanced technologies ab-initio.[7]

China has reportedly been testing space-based quantum communications technology, and experimenting with applications related to electromagnetic drives, [8] like the electromagnetic rail guns (EMRG) and the electromagnetic aircraft launch systems (EMALS). As and when a viable breakthrough in any of these technologies is achieved, it would have significant strategic implications for the Global security scenario. While the EMRG and EMALS will be covered subsequently, this section elaborates upon the following high technologies being developed and tested currently in China, which have the potential of dual-use role, particularly in enhancing Chinese geostrategic security to counter the adversary's efforts:-

- Artificial Intelligence Research
- Quantum Communication Network, both terrestrial and space based

Artificial Intelligence Research

Artificial Intelligence in its most basic sense, can be said to be the ability of a non-human entity to replicate human mental skills such as pattern recognition, understanding natural languages, adaptive learning from experience, strategising or logical reasoning. The Chinese are seriously engaged in researching this new technological domain, so as to find viable applications to improve productivity and efficiency.

In consonance with this vision, the Chinese State Council issued a guiding document in July 2017 titled, 'A next Generation Artificial Intelligence (AI 2.0) Development Plan'. The Plan aims to gain strategic opportunity for the development of Artificial Intelligence, build China's first mover advantage in

Artificial Intelligence programmes, and accelerate the process to make China emerge as an innovation global power in Science and technology (S&T) by 2030. [9] The plan envisages the development of Artificial Intelligence in accordance with the following numeric analogy principles:-

- Build one system (Artificial Intelligence technology innovation)
- Grasp two attributes (technological and social)
- Adhere to trinity (R&D, application and industry development)
- Strengthen four supports (economy, social development, S&T and national security)

Applications of Artificial Intelligence in Military Operations

The strategic objectives of 'AI 2.0 Development Plan', when applied into military domain, would enable the contemporary warfare to be taken to another level, that is, from 'informationisation' to intelligentisation'. The PLA foresees the future warfare to be 'unmanned, invisible, and silent' with higher degree of automation. The PLA thus, plans to utilise the features of Artificial Intelligence to enhance command and control capabilities – both at operational and strategic levels of warfare – in future. Its unique organisational characteristic can enable it to take full advantage of the disruptive potential of Artificial Intelligence without constraints. In fact, certain Chinese writings have discussed a concept of a 'battlefield singularity' in the far future, wherein the Command and Control itself would become intelligentised, when machines manage to surpass humans in battlefield decision making and planning.[10]

Though much of China's academic literature on military Artificial Intelligence has been abstract, speculative, and largely deals with US activities; it is still apparent that PLA strategists expect Artificial Intelligence enabled autonomy in

weapons to have a dramatic impact on traditional operational models. [11] In fact, advances in Artificial Intelligence have enabled the Chinese to show great progress in certain critical dual-use technologies. One such application includes swarming technique using unmanned aerial vehicles (UAV) or unmanned surface vessels (USV), which could be used in large numbers to saturate defences of high value targets like aircraft carriers and their escorts.

Further, China's development of different types of autonomous Unmanned Underwater Vehicles (UUVs) could result in a new generation of naval patrol vessels for guarding ships or drilling platforms in the off-shore areas. These autonomous UUVs could also be suitably equipped and armed for innovative offensive roles under certain conditions.

Artificial Intelligence Enabled Devices for Military Training

The Artificial Intelligence devices can enable the PLA Commanders to make pre-war plans, draft and modify strategies and coordinate human and material resources in different situations. [12] Such systems, fed with the intelligence about the enemy, acts as a simulated rival Commander. This way, the Artificial Intelligence device acts as 'personal coach', as it can vary the degree of difficulty according to the level of military trainee. Compared with traditional training methods, Artificial Intelligence enabled simulated games are cost beneficial in the long run and are being applied to a wider spectrum of troops. They also serve as a standard reference for evaluation of soldiers' performance, and for assessing their combat skills and abilities.

Integrating Artificial Intelligence into Air Operations

It is a well established fact that air superiority has been the top priority in the history of air warfare. However, it was traditionally predicated on the efficiency of fighter jets and skills and reflexes of fighter pilots. The PLA Air Force has, of late, come to realise that the order of air superiority and

air operations is undergoing changes, as more emphasis is instead, being placed on information agility - the priority and mobility of information - with the help of big data and Artificial Intelligence. Therefore, the key to winning air operations, electromagnetic operations, or cyber operations is 'information agility'. [13]

Open media assertions refer to the new era as "OODA 2.0," wherein machine-based information-gathering, analysis and decision-making systems will make the famous military theory of the OODA (observe-orient-decide-act) loop more automatic and flexible. The media discourse goes on to the futuristic "OODA 3.0" construct, which would be led by the technology of Artificial Intelligence. In fact, the AI technologists argue that this is where China can overtake others, because everyone is currently at the same start point. They also are convinced that big data could turn the tables in decision-making and strategic planning during air warfare.[14]

Use of Artificial Intelligence to Aid Submarine Commander's Decision Making

China is reportedly working to upgrade the older generation computer systems on nuclear submarines with artificial intelligence. While a nuclear submarine depends on the skill, experience and efficiency of its crew to operate effectively, the demands of modern warfare introduce variables that would cause even the best-planned operation to fall apart. In a high stress scenario which may adversely affect the Commanding Officer's decision-making powers, an AI decision-support system with 'its own measured thought process' would reduce his mental workload. [15] The thought process in the naval technical circles is that a submarine with AI-augmented brainpower would not only give the Chinese Navy an upper hand in underwater operations, but would also push applications of Artificial Intelligence technology to a new level.[16]

Quantum Communication - Terrestrial and Space Based

Quantum entanglement is a phenomenon in Quantum Physics, which is so confounding that Albert Einstein described it in 1948 as 'spooky action at a distance'. Scientists found that when two entangled particles are separated, one particle can somehow affect the action of the far-off twin instantly.[17] This technological marvel, if successfully harnessed, would open up bright prospects for practical quantum communication application; because a quantum photon can neither be separated nor duplicated, making it impossible to tap, intercept or crack information transmitted through it.[18] This is where the military significance of quantum communication assumes great relevance, because secure communications form the bedrock of modern 'informationised' warfare.

Physicists in China started research on quantum communication in right earnest in 2006 with the allocation of about one billion RMB by the Chinese Government through its central and provincial funds, as part of the 11th five year plan (2006-10). The Chinese Academy of Sciences at Beijing was nominated as the lead agency for the research. Subsequently, this project received huge allocations of five billion and two billion RMB in the 12th (2011-15) and 13th (2016-2020) five year plans respectively. [19] The project is being pursued in two domains i.e. land based, as also space/satellite based.

National Quantum Communication Backbone Project

The world's first secure quantum communication line in China was operationally proven on 4 September 2017. The line spans more than 2,000 km, linking four locations from Beijing to Shanghai via Jinan and Hefei. Construction of the line, approved by China's National Development and Reform Commission in July 2013, was completed by end 2016. The line was able to prove quantum key distribution, validate technology of single photon detection, and achieve reliable data transmission.[20]

Space Based Quantum Communication Project

Since the distance of quantum communication was limited by physical characteristics of the optical fibre cable over which it was carried, China sought to overcome this limitation by concurrently using space based assets also. Accordingly, China launched the World's first quantum communication satellite called Micius [21] on 16 August 2016 to carry out the Quantum Entanglement Distribution (QED), Quantum Key Distribution (QKD), and Quantum Teleportation experiments. Consequent to establishment of specialised ground stations in different locations nationwide, Chinese scientists achieved the satellite-based distribution of entangled photon pairs over a distance of 1,200 km in June 2017. [22] This was followed by successful experiment of inter-continental distribution of entangled photon series (as part of entanglement-based quantum key distribution) via Micius satellite on 29 September 2017, [23] wherein scientists held a 75 minutes video conference between Beijing and Vienna, Austria over a distance of more than 7600 km using this technology.

The Chinese scientists are yet to carry out the quantum teleportation experiments, which would enable instant transfer of superimposed data from ground to satellite after carrying out additional photon entanglement at the ground station. Since there is theoretically no limit to the distance over which this entanglement phenomenon persists, the Chinese scientists plan to expand the scope of this project in future to set up a global real-time wide-area network for quantum communication using a number of Quantum satellites, repeater/relay satellites, quantum ground stations and local-area fibre quantum networks. [24] When successfully implemented, this will be a game changing event as far as Chinese information security in future, both in civil and military domain, is concerned.

High Technology Developments in Military (PLA) Domain

China is pursuing a wide range of military technologies at the global technological frontier weapons either currently being developed or not yet developed by any country – so as to ensure that its Defence Forces are able to 'win informationized local wars'.[25] China has particularly undertaken the under mentioned six types of weapon projects that its leaders have specifically prioritised[26] :-

- Hypersonic Weapons
- Maneuverable Re-entry Vehicles
- Unmanned and Artificial Intelligence-equipped Weapons
- Electromagnetic Rail Guns
- Directed Energy Weapons
- Counter-Space Weapons

The Chinese government has taken a comprehensive and state-directed approach to the development of these key dual-use technologies. In order to ensure focused approach towards development of above cutting-edge military Technologies either through original research or by innovating upon existing technologies, the Chinese CMC established a new agency named as the Military Science Research Steering Committee (MSRSC) in mid 2017. This new Chinese agency is apparently structured along the lines of the American Defense Advanced Research Projects Agency, and would report directly to the Central Military Commission.

Although information regarding the above Chinese advanced weapons programmes is not readily available, numerous open source writings, government statements, and testing and deployment activities indicate vigorous efforts by Chinese defence technological set-up. The known details of

the Chinese hypersonic glide vehicle (HGV) and unmanned aerial vehicles (UAV) projects being pursued by the Chinese PLA – both of which can garner huge advantage over the adversary during hostilities are discussed in this section.

Chinese Hypersonic Glide Vehicle (HGV) Programme

Hypersonic speeds are usually defined as those exceeding five times the speed of sound, or Mach 5 (3,836 miles per hour). Hypersonic glide vehicles are launched from a large rocket on a relatively flat trajectory – that either never leaves the atmosphere or re-enters it quickly before being released – and then glide unpowered towards its target. [27] In the final attack phase, the HGV powers itself again to align on the target by making terminal corrections to its trajectory. The whole system, including the booster, is referred to as a 'boost-glide weapon'. The main advantage of a hypersonic maneuvering vehicle is that it can radically change its trajectory to avoid missile defences; and has 'gliding' capabilities that give it extended range as compared to a conventional ballistic missile warhead.

China is believed to be making rapid progress in the HGV technology. It has carried out eight tests of the HGV starting January 2014. While the second test in August 2014 reportedly 'failed', [28] all other tests were deemed to have been successful. Also, while initial six tests were carried out by projecting the HGV on an experimental missile called DF-ZF; the last two tests in November 2017 were carried out by DF-17 missile,[29] which reportedly has a range of 2200 km.

The HGV can be adapted to anti-ship role with conventional warhead, to overcome maneuvering and accuracy limitations associated with Anti Ship Ballistic Missiles. Such HGVs, armed with a nuclear or conventional payload, will pose great threat to the adversary's ashore and afloat assets, because in the contemporary time frame, suitable weapon systems for defending against them are not available. This factor may perhaps, have prompted Chinese media discourse about

using this weapon to threaten India, in addition to the US and Japan.[30]

Chinese Unmanned Aerial Vehicle (UAV) Projects

Unmanned aerial vehicles, by definition, operate without an integral pilot. They can be broadly classified into two categories as follows:-

- Automated or remotely piloted vehicles, which are firmly controlled by the operator and do not allow for self-deviations during operational deployment.

- Autonomous systems, which can independently assess the situation from pre-programmed AI algorithms, and choose between different courses of action.

China has made significant progress in developing and deploying automated unmanned systems, and has displayed strong interest and capabilities in developing autonomous programs. China's UAVs, including attack variants, have met military requirements and have entered the global market in great numbers. Though maximum number of Chinese UAVs consists of smaller, tactical models, China's defense industry is developing a range of 'cutting-edge' systems, including 'high-altitude long-endurance' (HALE) UAVs that variously have stealth or anti-stealth, supersonic, and precision strike capabilities.

The main UAVs which are currently known to be in the inventory of PLA are enumerated below, along with their brief details:-

- Wing Loong UAV. This low-to-medium altitude UAV has fully autonomous flight capabilities, and can carry both day and night electro-optical reconnaissance payload or laser designators. It can be used for surveillance and surface attack also. It can carry up to four guided missiles or bombs on under-wing hard points.

- CH-3 UAV. The CH-3 is a medium-altitude reconnaissance and strike system. A single system comprises three UAVs, one ground control station and one set of supporting equipment. It can carry out artillery fire adjustment, data-link relay, surveillance, reconnaissance, target location and precision strike missions.

- CH-4 UAV. CH-4 is the largest fixed wing UAV of the Rainbow series. It is designed primarily for reconnaissance and air-to-ground attack. The UAV has a dual redundant automatic flight control computer system which controls the UAV in automatic and semi- automatic mode. The external pilot can send commands to change the flight path if required.

In addition to the above existing UAVs, the known UAV development programs in the Chinese military which are underway are as follows:-

- High Altitude Solar Powered UAV.[31] This project designated as 'Feiyun' aims to build airborne communication networks based on near space solar powered UAVs. These UAVs, with a wingspan of 45 meters equipped with solar panels, are envisaged to perform as 'quasi-satellites', capable of undertaking certain functions of telecommunication satellites, like data relay. Test flight of the technology demonstrator UAV was reportedly carried out up to an altitude of 20 km in April 2018.

- 'WJ-600A/D' Stealth UAV.[32] China has begun to develop military drones that can evade radar and anti-aircraft weapons. The newest UAV, WJ-600A/D has an ultra-fast cruising speed of 700 km/hour. It resembles a cruise missile. It is launched from a vehicle and is retrieved after descending by parachute. It has a stealth design and appears like a bird on radar.

- Caihong-5 (CH-5) Rainbow UAV.[33] The CH-5 UAV is the most capable military drone in China in terms of

operational endurance and payload capacity. Twice as big as its predecessors in the CH family, the CH-5 can stay in the air for about 60 hours, go up to a range of 6500 km, and operate up to an altitude of 10 km. Made of composite materials, it is designed to perform reconnaissance, surveillance, targeting, intelligence gathering, electronic warfare, border patrol, highland defence and anti-terrorism missions. The CH-5 can carry up to 16 air to ground missiles and even small diameter bombs.

- 'Xianglong ' High Altitude Long Endurance UAV.[34] This unusually shaped drone with an innovative "joined tandem wing" design, is claimed to be China's answer to the American RQ-4 Global Hawk, considered as the most capable surveillance UAV in the world. Also known as 'Soar Dragon', the UAV will have a cruise speed of 750 km per hour and range of 7,000 km. It would be able to fly for 10 hours and reach an altitude of 18 km.

Innovative Applications of UAVs

- Swarming with UAVs. China demonstrated a record-breaking formation of 1,000 UAVs at the Guangzhou Air show in February 2017, using pre-programmed routes. The mini UAVs controlled by a single computer, flew as high as 120 meters and made various shapes, Chinese characters and numerals in a choreographed sequence. The previous record for a demonstration of this type was 500 UAVs launched by Intel in November 2016. [35] Leading state-owned Defense industry conglomerate, China Electronics Technology Group Corporation (CETC) reportedly operated a formation of 119 fixed-wing UAVs using small, inexpensive commercial drones in June 2017, which is also a record of sorts. The UAV formation demonstrated autonomous group control in sensing the proximity of each other and avoiding collision, even when altering course or altitude. [36] This development indicates that UAV swarms can be used for collaborative intelligence,

distributed wide area surveillance and saturation attack.[37]

- New Ground Launched Anti-Ship Weapon Demonstrator 'CH-T1'[38]. China has reportedly developed a new Ground Launched Anti-Ship weapon designated as the CH-T1. It is being referred to as Ground Effect UAV (GEUAV) demonstrator. The forward segment of the GEUAV demonstrator is shaped like a conventional missile, with a cylindrical fuselage. Towards the rear is an unconventionally designed main body featuring two thick, long but short-span stubby wing structures running along the sides, that combine to form a continuous wing-like under surface.

High Technology Developments in the Chinese Maritime Domain

The previous Chinese President Hu Jintao, during his keynote address at the National Party Congress in Beijing on 08 November 2012, called for *"enhancing the Chinese capacity for exploiting marine resources, resolutely safeguarding China's maritime rights and interests, and building China into a maritime power."*[39] President Xi Jinping, the present incumbent lent full support to this vision in July 2013, by stating that *"China's maritime cause has generally entered the best period of development after years of efforts …China will depend on the ocean to prosper and will steadily promote the building of its maritime power …"*. [40] These comments are particularly significant as it is the first time that two consecutive Presidents have clearly enunciated a decisive road map for expanding the scope of China's maritime development.

The above vision of apex leadership is well backed up by comprehensive maritime support infrastructure, both ashore and at sea. The Chinese shipyards are well diversified with good ship building rates. The Chinese harbours are well developed with elaborate connectivity with the hinterland. In addition to the restructuring of State Oceanographic Administration (SOA) commencing 2013, China has sought to exploit its large manufacturing base to lay greater impetus on maritime research and development (R &D).

While there are many R & D projects being pursued in civilian maritime domain by institutions like the Maritime Investigation Laboratory for merchants-marine, and international Arctic Cooperation and Research Institute; this Section restricts its scope to only two high technologies being developed in the Chinese maritime domain, which have the potential to be leveraged for naval applications. These are in continuation of unmanned systems, albeit in the surface and under-water domain – the unmanned surface vessels (USV) and the underwater research manned/unmanned submersibles.

Chinese Unmanned Surface Vessel (USV) Projects

The two categories of automated and autonomous systems being developed by China, are also applicable to the unmanned surface vessels (USV), though neither in such large numbers nor across the entire capability spectrum as the UAVs discussed earlier. The PLA Navy and some Chinese research institutes have made progress on these systems. For instance, the Underwater Engineering Research Institute at Shanghai University has tested multiple versions of the 'intelligent' Jinghai USV, during a project which began in 2010. The unmanned vessel can reportedly navigate and avoid obstacles autonomously, and was reportedly evaluated by the then PLA's General Armaments Department and PLA Navy's Equipment Department, indicating their possible intentions to acquire them. [41] In December 2017, China unveiled the world's fastest domestically-developed unmanned surface vehicle (USV), the Tianxing-1, at the fifth China Marine Economy Expo in Zhanjiang.

In fact, the most interesting development in this domain relates to Chinese maritime agencies conducting some path-breaking experiments which can have many military/security implications. one such project is the construction of World's largest 'unmanned cargo ship test range' off Zhuhai (Wanshan) in South China Sea, which is spread over a sea area of 771 square kms. The test range will have several levels, including

fields for virtual, model and actual vessels. Infrastructure and support facilities such as those for network communication, navigation radars, opto-electronic devices, and automatic mooring systems will also be erected for various tests. The final goal would be to build a global leading unmanned vessel centre for production, study and research. [42] The world's first unmanned cargo ship, Jindouyun (magical cloud), is also being designed and its trial will be carried out in the Wanshan test range in 2019. The vessel will be all battery-powered and would be able to sail 500 NM with one charge. Apart from Jindouyun, one of China's unmanned light boats will go for use in the Antarctic in 2018.[43]

In an innovative display of USV employment, a private Chinese Artificial intelligence and Surface drone company named 'Oceanalph' demonstrated coordinated formation maneuvers by 56 mini USVs in the same Wanshan unmanned ship test range sometime in 2018, a video of which was released by Global times news site on 31 May 18. [44] The mini USVs formed various patterns and shapes without colliding with each other. The mini USVs, while moving at high speeds, also formed the shape of an aircraft carrier, while another larger unmanned boat waded right into the formation at high speed, simulating the taking off of a fighter Aircraft from the carrier's flight deck. [45] The military potential of such USVs moving in large numbers at high speed to overwhelm the adversary warship's defences, by swarming all around it, are more than obvious.

Chinese Under-Water Research Manned/ Unmanned Submersibles

Chinese maritime scientific community is engaged in a comprehensive underwater manned and unmanned submersibles programme. The unmanned submersibles are also interchangeably known as autonomous underwater vehicles (AUV) or simply unmanned underwater vehicles (UUVs). China, at present, operates a number of manned and unmanned submersibles:-

- ‘Jiaolong’ Manned Submersible. China’s first deep sea manned submersible named ‘Jiaolong’ was launched in 2002, and unveiled in 2010. The manned submersible operates with an oceanographic research mother ship, ‘Xiangyanghong 09’. It is capable of reaching 99 percent of the World’s under-sea areas. The submersible manned by a three man crew, carried out a world record dive of 7,062 meters in June 2012, in Mariana trench area of the Pacific Ocean.[46] The submersible was thereafter operationally deployed along with its mother ship, for deep sea research in South China Sea and the Indian Ocean region.[47]

- ‘Shen Hai Yong Shi’ Manned Submersible. China’s new manned submersible, Shenhai Yongshi (Deep Sea Warrior), completed its first operational ocean expedition in April 2018. The manned submersible, which can reach a depth of 4,500 meters, has been deployed onboard its mother ship, ‘Tansuo-1’ since October 2017, to carry out deep sea testing missions off Sanya in Hainan Province.[48]

- Qianlong-1 Autonomous Underwater Vehicle (AUV). ‘Qianlong-1’ AUV is capable of diving down to a depth of 6000 meters. The vehicle is about 4.6 meters long, 1,500 kg in weight and 0.8 meters in diameter. It can be tasked to explore the sea bed and collect hydrological data. The autonomous underwater vehicle was used for first time for a scientific expedition in October 2013 in the Eastern Pacific Ocean.

- Qianlong-2 AUV. Qianlong-2 AUV has a length of 3.5 meters, height of 1.3 meter and breadth of 0.7 meter. It can dive up to a maximum depth of 4500 meter. It can conduct surveys including collecting data related to salinity, thermal layers, sea bottom mapping/topography and magnetic fields. It is presently carried by its mother ship research vessel, the ‘Xiangyanghong-10,’ which was deployed in the South Western Indian Ocean for eight months since December 2017. [49] Qianlong II AUV commissioned in

2015, will have a technology upgrade soon, which will enable it to work without the presence of its mother vessel.

- Qianlong-3 AUV. China's unmanned submersible Qianlong-3, has been undertaking diving trials from its research mother ship 'Dayang Yihao' (Ocean No. 1) since March 2018. The submersible, diving for its second sea test, operated in 3,850 meter deep sea area, and traversed 156 km during the nearly 43-hour trial on 21-22 April 2018. [50] Further details about this AUV are not yet known.

- Haiyi-7000 Underwater Glider.[51] Haiyi-7000 – the world's deepest-reaching underwater glider – carried out first test dive from its mother ship, Tansuo-1, in the Mariana Trench area of western Pacific Ocean in June-August 2017. It was able to glide down to a depth of 5751 meters. Haiyi means 'sea wings' in Chinese. The underwater glider is shaped like a yellow torpedo with a pair of wings. It can move noiselessly beneath the sea surface without human intervention for days, months, or a year – all the while collecting data for scientific research and environment monitoring.

High Technology Developments in PLA Navy for Increasing its Operational Effectiveness

The Global Times of 07 March 2018 cited a report to the 19th National Congress of the Communist Party of China in October 2017, which laid out an explicit roadmap of China's military progress in phased manner, [52] as follows:-

- By 2020, military mechanisation will basically be achieved, with IT application coming a long way, and strategic capabilities seeing a big improvement.

- By 2035, the modernisation of national defense and forces will basically be completed.

- By the mid-21st Century the armed forces would be fully transformed into world-class troops.

The PLA Navy, as part of the overall PLA organisation is also progressing along the above broad timelines set forth by the 19th National Congress of the Communist Party of China. The Chinese Navy is striving to improve overall fighting capacity by combining mechanisation and informationisation, strengthen both, offshore and high-sea forces, and balance its operational ability on the sea surface, underwater and in the air. While this effort is being progressed in a dedicated and planned manner over past two decades, added emphasis is currently being imparted towards leveraging of high technology.

Since the contemporary naval platforms are technology intensive, their capabilities keep on improving as the technology continues to undergo phased upgrades. In this context, it is relevant to carry out a scan of two noteworthy high technology applications being developed in the PLA naval domain – the Electro-magnetic Rail Gun (EMRG) and the Electro-magnetic Aircraft Launch System (EMALS) – to improve efficiency and augment operational effectiveness.

Electro-magnetic Rail Gun (EMRG) for Naval Ships

A retired Admiral Zhao Dengping, who is supposedly a former Director of the Equipment Department of the PLA Navy, gave quite an insight into incorporation of high technology in PLA Navy's modernisation plans. [53] He reportedly gave a presentation in August 2017 at an unidentified University in China, wherein, the following high technology equipments were included amongst others being developed for the Chinese naval vessels:-

- Electromagnetic Rail Gun (EMRG) for naval ships
- Electromagnetic Aircraft Launch System (EMALS) for Aircraft carrier
- Integrated Electrical Propulsion System (IEPS) for ships/ submarines

Installation of integrated electric-propulsion systems (IEPS) on naval vessels is a critical requirement for rail guns, due to the enormous power generation and storage capacity required for high-velocity rail gun shots, especially at rapid rates of fire. China finally appears to have fitted an EMRG on board Type 072 III amphibious ship, Haiyang Shan (936) and the system is presently undergoing sea trials. [54] If China successfully proves the EMRG installed on Haiyang Shan landing ship, it would mark the world's first warship to be equipped with an EMRG. Even though the US has been working on it for more than a decade, it has not yet installed the EMRG on any of its ships. Subject to the success of sea trials, a working EMRG is likely be installed on future versions (second batch) of Type 55 heavy destroyers in the 2020-2025 timeframe; as these vessels would reportedly have IEPS, to meet the electrical demands of EMRG and other directed-energy weapons.

Successful employment of EMRG would give the PLA Navy an extremely cost-effective weapon with high-volume, precise, and time-critical firing in all-weather conditions. Other augmented capabilities which would accrue to the PLA Navy ships are as follows:-

- Much greater power and range than traditional gas-expansion guns.
- Sustained, offensive power projection capability, complementary to missiles.
- Long-range shore bombardment capability in support of ground troops inland.
- Enhance China's A2/AD capabilities through distributed, low-cost platforms.

Electromagnetic Aircraft Launch System (EMALS) for Aircraft carrier

Chinese media reports indicate that IEPS would permit operation of the Chinese EMALS without equipping the PLA Navy's aircraft carriers with nuclear power plant. The same was reiterated by an official media report dated 08 November 2017. It quoted Rear Admiral Yin Zhuo, Director of the PLA Navy's Expert Consultation Committee, as stating that China was a leader in the research and development of IEPS; and had developed its own version of EMALS device previously possessed only by the United States. He went on to add that China now possessed proven technologies for both steam catapults and electromagnetic launch systems, and that the J-15 carrier-borne fighter aircraft had made hundreds of takeoffs using the EMALS installed on an airfield on land. [55] He claimed that the PLA Navy's second domestically designed carrier (Type 002) would use a catapult system rather than ski-jump for aircraft takeoffs.

In another related input, Rear Admiral Ma Weiming, PLA Navy's propulsion and power specialist, stated with confidence during a seminar in July 2017 that the EMALS will be installed on the 'Number 3 carrier.' [56] All these discussions in Chinese media discourse indicate that the PLA Navy is evaluating both the options viz. steam and Electro-magnetic catapults.

Implications For India and the Indian Maritime Sphere

As China continues to forge ahead without any fundamental barriers for developing advanced weapons technologies, the US and certain European nations cannot assume that they would continue to hold enduring advantage in frontier military technology for very long. When the US is faced with such a challenge vis-a-vis growing Chinese technological status, the case for India to deal with the Chinese technological ascendency becomes that much more arduous. As India seeks to bolster its preparedness to retain its primacy in its

primary areas of maritime interest and defend key interests in the northern Indian Ocean; recognising the fast emerging Chinese technological challenge to its objective will be crucial. In this context, the broad implications of key technological developments in China and its military realm surveyed in this Paper, for the Indian maritime domain are discussed in succeeding paragraphs.

Artificial Intelligence – Enabling Smart Weapons and Cyber Systems

Broader advances in AI could further expand the threat posed by China's precision strike arsenal, making the UAVs better equipped for blockade and denial missions. The advances may also enable better control of cyber weapons and defenses, with real-time discovery and exploitation of the Adversary's cyber vulnerabilities. In the long term, AI could contribute to navigation or even targeting solutions for China's future precision-strike hypersonic weapons. These smart systems will make it more difficult for the Indian naval assets to counter them in terms of both, time and technology.

Quantum Communications Network for Secure Military Communication

China has already validated ultra-secure and hack proof communication using Quantum technology over long distances on land, and at cross-continental range with the help of its Micius Quantum communications satellite. China now has plans to expand the scope of quantum communications to global real-time wide-area network by 2030, using more quantum communication satellites for interlinking with ground stations, and medium/ geostationary earth orbit satellites as repeaters/relays. Thus, the Project's coverage over IOR would just be a logical consequence of its expansion. Thus, in the grey-zone leading up to war-like situation, the Chinese quantum communication network will offer great operational advantage to the PLA in its 'informationised' warfare across all domains; and could consequently pose huge challenges for the Indian maritime forces.

Attack by Hypersonic Glide Vehicles (HGV)

Hypersonic weapons could, in the medium term, confer better manoeuvrability options to China as compared to the targeting capability of its existing ballistic and cruise missile arsenal. They would also be faster vis-a-vis its existing cruise missiles. In the long run, they could also enable increase in targeting ranges. Combination of speed and manoeuvrability by such vehicles; and their operation below the ballistic missile trajectory but above typical cruise missile operating altitudes, will be a critical factor in its ability to penetrate enemy defenses. Further, the possibility of nuclear or conventional capability on HGVs could complicate determination of China's strategic intent by the adversary, particularly when the HGV is launched on a ballistic missile. Thus, the HGV, even if adapted to intermediate ranges, will pose great threat to the Indian ashore and afloat assets. This is due to the fact that suitable systems for defending against these weapons are not as yet available with India.

UAVs – Swarming Techniques and Surveillance-cum-Attack

The Chinese unmanned/AI-equipped weapons in large numbers could pose great challenges for adversary's air defenses, when used in swarming technique. The adaptation of commercially available UAVs by Chinese military establishment could substantially improve China's capabilities in the fields of collaborative intelligence, surveillance and reconnaissance, target acquisition, and distributed wide-area surveillance and saturation attack. Chinese media has already gone to the extent of claiming that UAV swarms will become a 'disruptive force' [57] that will 'change the rules of the [warfare] game.'

A number of sophisticated UAVs, including those with stealth, anti-stealth, and supersonic capabilities, armed with multiple forms of precision weapons, and capable of flying at sea-skimming altitudes could reportedly enter service with the

PLA in near future. In fact, China seems to have tested a sea skimming drone-missile hybrid in June 2017, which can reportedly fly at about half a meter above sea level, giving it the capability to evade most radars. It can carry about 1000 kg of explosive payload, which would be enough to cause serious damage to a major warship. Some strategists have also speculated whether this UAV-Missile could be China's second 'carrier killer' after the DF-21 ASBM. [58] The UAV-Missile hybrid, with its speed and below-the-radar flight, will probably allow only about a minute's reaction time for the target ship; which may be beyond the defending capabilities of most contemporary naval ships of all nations, including of India.

Unmanned Surface Vessels (USVs) – Swarming and Collision Techniques

The USVs can be used for multiple military tasks like inundating the defences of a warship by high speed approach in large numbers, or carrying out high risk surveillance, often under the ruse of non military employment. China is in fact, testing autonomous navigation of large cargo ships in a major way. The potential of such large displacement unmanned vessels to block a narrow strait or waterway, particularly in entrance/ exit to harbours by controlled damage or scuttling is quite feasible. Worse still, such ships can be programmed for rogue behaviour when passing in close proximity of warships. The resultant collision could render that warship out of operational role for short to medium term. In the Indian context, Chinese unmanned cargo vessels when plying through IOR sea lanes, would render Indian Naval ships vulnerable to such tactics. Moreover, it will also enable China to explain the incident away as a technical malfunction, while still meeting its narrow military aim.

Manned/Unmanned Submersibles – Underwater Military Missions

China's ability to send manned and unmanned submersibles down to maximum depth of 11000 meters, and demonstrated missions down to more than 7000 meters depth, raise huge potential for their use, both in the civil research and military security domains. Apprehensions about this niche technology being used for military ends like interception of undersea communication cables, retrieval of foreign weaponry from the ocean floor, repair or rescue of submarines and conduct of clandestine missions in future, are all under the realm of possibilities. The unmanned submersibles equipped with artificial intelligence algorithms can also be used as UUVs to target ships and submarines. They can also act as under-sea mines and lie dormant till activated or trigged by a time control or remote signal.

Further, the presence of civil controlled Chinese deep sea research vessels with these submersibles embarked, in a given maritime area cannot be questioned. However, continual presence of Chinese research vessels like 'Xiangyanghong-10' in IOR for duration ranging from 6-8 months, and operating their submersibles, definitely causes serious vulnerabilities in underwater domain for the Indian naval forces. Even if the offensive potential of these submersibles and their mother ship research vessels is discounted, the mere fact of these ships engaging in extensive hydrographic survey and underwater hydrological data collection in the maritime area of vital interest to Indian Navy, will give tremendous advantage in anti-submarine warfare to the PLA Navy.

High Technology Equipment for PLA Naval ships for Increased Operational Effectiveness

The current capabilities of modern PLA Navy ships and submarines can be considered to be quite comparable to those of the Indian Navy, even though the absolute ranges of its weapon systems may be more than those of Indian navy in

some cases. However, considering the force level that China can possibly deploy in 'distant waters' of Indian Ocean after taking into account the naval force requirement to address the prevailing geo-strategic situation closer home, the Indian Navy's capability equation vis-à-vis that of PLA Navy does enjoy a certain amount of edge. However, development of certain high technology equipment has the potential to increase operational efficiency and effectiveness of under-construction new generation Chinese ships and submarines, manifold. Thus, when the PLA Navy vessels equipped with high technologies like IEPS, electro-magnetic rail guns, EMALS, and armed with vertical launch systems start operating in the IOR in near future; the capability differential between PLA Navy and the Indian Navy could become noticeably large.

Conclusion

In conclusion, it would not be far off-the-mark to posit that when viewed synergistically in conjunction with other technological advances in the national, defence and maritime domains, which have been discussed in the Paper and many more not finding mention , the operational effectiveness of the Chinese PLA and its Navy will tend to leapfrog to another level. In this context, the impact of the presence of PLA Navy's high technology enabled platforms in the IOR, with a mandate of 'high seas protection' will pose quite an overwhelming challenge. The consequent corollary to this axiomatic certainty will be the obvious implications for the Indian maritime security establishment and its maritime forces.

Therefore, the need of the hour for the Indian scientific and national security community is, to quickly analyse most of the high technologies mentioned here and accelerate a holistic process for integrating the most important of them into the national 'force multiplication matrix.'

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