China's 'Anti-ship Ballistic Missile' based Anti-access Concept : Implications of a Southward Re-orientation

Kamlesh K. Agnihotri

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Implications of a Southward Re-orientation

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The Chinese efforts towards actualization of the 'offshore defense' concept which entails the conduct of campaigns in distant waters, strategic deterrence and counterattacks, has an inherent risk of bringing its naval forces on a confrontational course vis-à-vis other maritime forces, particularly the US. To defend itself against overarching US maritime superiority in such a scenario, China has developed its Anti-access and Area Denial (A2AD) concept, predicated mainly around the DF-21D anti-ship ballistic missile. The inherently defensive Anti-access concept against the US in the western Pacific has the potential to transform into an offensive option for the northern Indian Ocean, should it undergo a southward reorientation. Situational assessment of such a possibility would provide an insight into the technological challenges which could be posed to the security of the resident northern Indian Ocean littorals. The possibility of such a challenge emerging in future should catalyse a vigorous maritime cooperative endeavour between commonly affected parties operating in the region.

Introduction

Driven by its steady economic growth, ongoing military modernization, financial robustness, and the consequent increase in the Comprehensive

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National Power (CNP), China is relentlessly pursuing its ambitions of emerging as a major power. Having overtaken Japan as the second largest economy in 2010, it is but natural for Beijing to aim at a superpower status. However, such ambitions would have a realistic chance of fruition only when the Chinese intent is backed by commensurate capabilities that it can bring to bear, first in the regional theatre and then at the global stage. While the economic capability and its spin-offs provide the initial and the most vital bulwark, the military muscle of the state actually decides the outcomes during crunch situations by being the most effective instrument of international persuasive diplomacy, coercive or otherwise.

China recognizes this axiom very well. Therefore, it has enunciated a three phase modernization plan[1] for the Peoples' Liberation Army (PLA). Having laid a solid foundation by 2010, the second phase of making major progress by 2020 is currently in progress, with the eventual objective of being able to win wars under conditions of 'Informationization'[2] by the mid twenty-first century. China has, accordingly, begun to increase its naval capabilities in consonance with the above timelines, by stressing upon integrated offshore operations, strategic deterrence, strategic counter-attacks, and conduct of international cooperation in distant waters.[3] The Chinese naval modernization efforts, though, have not gone unnoticed. A US Congressional Research Paper ascribes the following goals[4] for the PLA Navy modernization, in addition to its preparation for the Taiwan contingency:

(a) Asserting China's maritime territorial claims, particularly in most of the South China Sea.
(b) Defending China's interpretation of international laws relating to the freedom of navigation in exclusive economic zones (EEZ), which is at odds with that of the US.
(c) Displacing US influence in the Pacific Ocean region.
(d) Asserting China's status as a major world power.

The PLA's efforts to augment its capabilities to attain the above goals will eventually entail the adoption of a pro-active stance at some future time. This may bring it on some sort of a collision course vis-à-vis the powerful US military machine stationed in the Western Pacific in the first instance, and against the entire US National Power should the situation so demand. The immediate objective of the PLA in such a contingency would be to address its defensive vulnerabilities by preventing the US naval forces from approaching to within threatening distances from the

Chinese coast. Towards that end, the PLA seeks to establish a credible 'A2AD concept', which aims to force the US carrier task forces to stay well afar in the Pacific Ocean or risk an attack.

However, Beijing realizes that the PLA lags way behind the US military in terms of conventional hardware, platforms, technology, power projection wherewithal and the like. Therefore, the Chinese Anti-access concept is planned to be implemented and would possibly encompass detection and accurate tracking by Space-based assets and precision targeting of moving ships at sea by anti-ship ballistic missiles (ASBMs). Satellite jamming kinetic energy weapons, anti-satellite kill weapons (ASATs), Space-based micro-satellites and anti-AWACS[5] long range missiles, all capable of degrading the adversary's surveillance, air defence and anti-ballistic missile network, will also have to play a vital role. The nuclear submarines armed with anti-ship cruise missiles as also the air-launched cruise missiles would form a vital component of the Area Denial regime.[6]

This article lays out the key technologies and systems, and inter-dependent architecture of the ASBM-based Anti-Access concept. The Area Denial part of A2AD has not been stressed upon here as that has always been planned for by having traditional force structures and operating strategies, and is already being practiced by the maritime forces around the world. An empirical analysis of ASBM-related technologies and systems has also been attempted with a view to explore the viability of the concept to synergistically function as a 'system of systems'. A measured assessment of the possible re-orientation of the Chinese Anti-access concept southwards with regard to the current capability of its ASBM-related sub-systems has also been carried out, along with the attendant significance for the Indian Ocean and possible implications for India.

Anti-access: Key Technologies and Systems

China perhaps felt the need to develop a ballistic missile to specifically target US Navy aircraft carriers in the late 1990s after the Taiwan Strait crisis, wherein a US carrier task force sailed through the strait. Though there is no official acknowledgement, certain academic and media discussions tend to imply that China is on the threshold of a major technological and military innovation in the field of new types of ballistic missiles.[7] It is also asserted that the DF 21D Intermediate Range Ballistic Missiles (IRBM) have already been deployed in the PLA Army.[8]

Detection, Identification and Tracking Systems

The maritime threat to China may emanate from a wide arc extending from the north-east to the south-east, taking into account geographical and other factors, such as the presence of commercial shipping. Within this threat zone, considering the radius of action (ROA) of the existing carrier borne aircraft,[9] it would be absolutely essential for the PLA to prevent a Carrier Strike Group (CSG) from closing to less than 1,000 km off its coastline. To cater for an appropriate reaction time for initiating counter-measures, the detection, identification and tracking of the CSG would have to commence at ranges of 2,500 km or beyond. For such long distances, Space-based sensor systems would be the most viable option.

Space-based Systems

In the last decade, China has been engaged in creating a Space-based structure for enabling electronic, photographic and radar information over large areas of maritime interest. This structure is based on three types of 'Yaogan' series satellites with complementary functionalities, namely, the Synthetic Aperture Radars (SAR) satellites, Optical Remote Sensing satellites, and the Ocean Electronic Reconnaissance satellites. These synergistic systems would form one of the vital components for China's ASBM capability.

The SAR satellites generally provide reasonably high resolution[10] all-weather, day and night information. Operating in a combination of two modes—a broad swath, coarse resolution to cover a larger area and a narrow swath, high resolution to affect better identification—these satellites would provide the necessary flexibility to meet the situation-specific detection and identification requirements. The Optical Imagery Remote Sensing satellites would complement the SAR satellites in the target localization process. Such satellites orbiting at altitudes of between 500 km and 900 km would provide a typical swath width of about 100 km. However, the greatest operational limitation of these satellites relates to large temporal gaps between successive satellite passes and a gap of several days before the satellites revisit over a given area.

These limitations can be substantially overcome by the 'Large Area Electronic Ocean Reconnaissance' satellites, which monitor electronic and other radio-emissions from ships using broad-band receivers. A typical system involves a group of three satellites separated by known distance, so as to triangulate and fix the source of emission. Each cluster would typically cover an area of 3,500 km radius. Even with one cluster, a second fix on an object of interest would be available in the next pass, after about 107–108 minutes. The large coverage also makes revisit periods quite short. If the area of interest is limited to the Western Pacific, a single cluster of co-orbiting satellites at 63.5 degrees inclination may provide the required surveillance capability to detect and track a CSG well away from the Chinese coast.

Of the 16 remote sensing satellites of Yaogan series that China has launched, Yaogan 1, 3, 10 and 13 seem to have SARs. Yaogan 2, 4, 7 and 11 appear to be the older optical reconnaissance satellites and Yaogan 5, 6, 12 and 14 are the second generation higher resolution optical satellites. Yaogan 8 and14 are possibly different from the others in that they have a relatively wide-area coverage optical sensor having coarser resolution. Yaogan 9A, 9B and 9C, launched in March 2010, from China's Large Area Ocean Electronic Surveillance (ELINT) satellite cluster. Their orbital parameters are quite similar (1,100 km altitude, 63.5 degree inclination, 107 minutes orbital time) to the first generation US Large Area Ocean Electronic Surveillance System. Though the exact role of the Yaogan 16 satellite, launched on 25 November 2012, is not clear, it is probably the first satellite of the second ELINT cluster akin to the Yaogan 9 triplets.[11]

This deployment of the three-satellite Ocean ELINT capability possibly marks the transition from potential capability to operational capability for China, and may well have been the real reason for the US to term the ASBM as having reached the 'Initial Operating Capability'.[12]

Beidou Satellite-based Navigation System

All the above-mentioned satellites and every Chinese military asset in the maritime and the wider geo-spatial domain will require to know its precise position, and in most cases will have to know each others' position in order to facilitate network-centric warfare. China has, therefore, been developing its own 'Beidou' satellite navigation system since the mid-1990s to achieve the same in addition to providing a commercial alternative to the American Global Positioning Satellite (GPS) system. The first phase of the system started providing navigation, positioning and timing data to the Chinese mainland and extended maritime area of the Asia-Pacific region from 27 December 2011.[13] The latest report on the *China Daily Mail* website says that the Beidou network has already achieved the horizontal positional accuracy of 10 metres.[14] A unique feature of the system is that it can send the user's location information to others, if the user so desires.[15] Although no military applications for the system have been officially spelt out, it could significantly improve China's ballistic missile accuracies, provide vital inputs for mid-course guidance of manoeuvrable re-entry vehicles (MaRV) and cruise missiles, and augment command and control (C2) by integrating military assets, control centers, sensors, weapons, and satellites in the spatial domain.

The three space components mentioned above working in tandem with the Beidou navigational system would be key elements in the proposed Chinese Anti-access system. Other Space-based assets, such as communication and data relay satellites, would complement these capabilities. With the exception of a Tracking and Data Relay Satellite, the Chinese appear to have all these capabilities in place.

Over-the-Horizon (OTH) Radars

China has made significant progress in the developing OTH radars in the last decade. These radars operate at high frequency (HF) radio frequencies of 15 to 30 MHz,[16] thereby generating long ranges. As the received signals comprise the back-scatter reflections from the ionosphere, they are also commonly known as OTH-B radars. China has a number of OTH-Surface Wave and OTH-B radars, both on shore as well as inland, of which at least one operational radar is located in the coastal area of Shencheng in Zhejiang province (see Figure 1).[17]

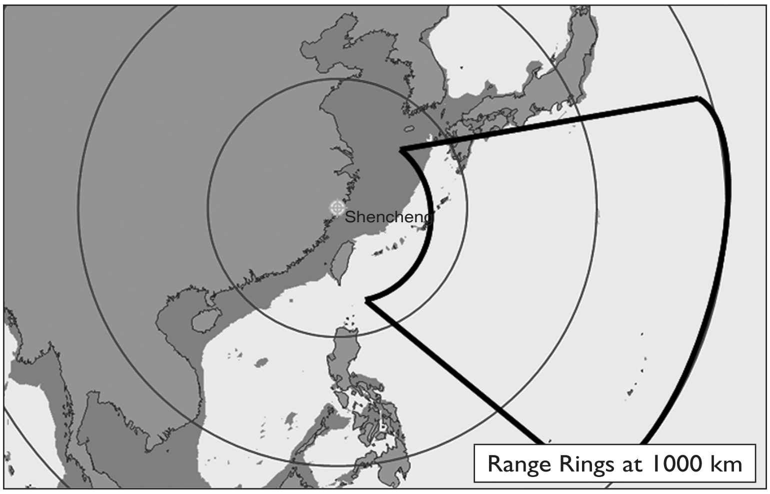

Figure 1 Seaward Coverage of Chinese OTH Radar

Source: Author.

A schematic map showing the likely maritime sector that can be kept under surveillance by this OTH-B radar is depicted in Figure 1.[18] This radar will be able to cover an envelope of about 800–3,000 km into the Pacific Ocean. The OTH radars normally have separate transmitter and receiver. The satellite imagery of the likely transmitter and receiver locations at Shencheng shows that they are spaced 3 km apart.[19] Since it is technically feasible to receive the backscatter signals on various receivers located at distant places from the transmitter, it is quite likely that other receivers dependent on this OTH Radar transmitter are located elsewhere too.

While OTH-B radars have long range, they have their own limitations, the main one being poor spatial resolution and the other being their heavy dependence on atmospheric conditions. Based on existing signal processing techniques, the spatial resolution of OTH radars is between 20–40 km. But the technique of Doppler frequency shift employed therein gives a reasonably accurate detection of the target. In fact, at a radar frequency of 20 MHz, 0.1 Hz doppler corresponds to a difference in relative speed of about 1.5 Knots (nautical miles per hour).[20] So the detection is circumstantial, but very accurate and reliable. While it may not be feasible to discern one ship from another on account of minor difference in relative speeds, it would be possible to discern aircraft taking off from the carriers and track them.[21] In such a situation, even if the spatial resolution is poor, the presence of both ships and aircraft at a specific location, tracked over a definite period—say over four to eight hours—would give a reasonable indication of the CSG's presence, albeit within a radius of 20–40 km. However, positive identification will be difficult as there is no way to differentiate the CSG from commercial shipping present in the ocean.

Aerial and Sea-based Surveillance Systems

The twin issues of poor spatial resolution and positive identification can only be resolved by having other independent means of supplementing the target data. Airborne and Sea-based Sensors (both surface and underwater) mounted on appropriate platforms such as early warning aircraft, naval ships and submarines can be useful in maintaining surveillance in specific areas for varying periods. At present, China has only limited means to deploy aircraft, ships and submarines with the necessary technical advancement to perform these tasks. However, with the fast-paced naval modernization in progress, it is expected that these shortages will be made up in the near future.[22] Since continuous monitoring at such distances poses major operational and logistical constraints, these units may be used more economically and efficiently towards the lower limit of the OTH radars, perhaps within 1,000 km from the coast.

Attack Systems

Anti-ship Ballistic Missile

The existing DF 21D ASBM is a derivative of the land based DF 21 IRBM, but differs in many ways. One fundamental difference is that it carries a conventional warhead instead of a nuclear one. While the IRBM intended against static land targets follows a typical ballistic unguided flight trajectory and has an accuracy of 200–300 metres, the ASBM would have to target moving objects at sea and achieve a direct hit in order to cause significant damage. This would entail the capability of maneuvring in mid-flight as also during terminal phase and for on-board sensors to detect and track the target in the final phase. The moving target could lie anywhere within the 'radius of uncertainty', which assuming OTH Radar's error of 20 km and a distance of 15 km traversed by the target during the missile's flight time, works out to about 25 km.[23]

Requirements of an ASBM

The ASBM may hence be characterized by three main technology issues: flight profile/manoeuvrability, terminal guidance, and the capability of the warhead. In the case of flight profile, during the descent phase, the missile's re-entry vehicle (RV) will have to obtain a better fix on the location of the target by means of onboard long range radar. It will thereafter have to carry out gradual manoeuvres well before the terminal phase, in order to bring itself within the said 'radius of uncertainty'. In principle, the manoeuvre could be carried out at any altitude. The speed correction required to hit the target in its future position will be proportionate to the speed of the RV at that point, which, in turn, would depend on its altitude as it descends towards its original impact point. If the manoeuvre is planned to be executed early in the descent phase, the speed correction and the corresponding requirement of fuel to be carried on the RV will be lesser. If the same is to be initiated later, the speed correction and the consequent fuel requirement are likely to increase.

To effect these manoeuvres at high speed and still maintain stability, the RV will need to be slowed down by using retro rockets, for the aerodynamic surfaces to be effective. There may also not be much time for the RV to fully execute significant manoeuvres at relatively lower altitude—conservatively estimated to be below 75 km—before it reaches the point of impact. One of the constraints that will determine the point at which the manoeuvre should be initiated will be the detection range of the onboard radar. The weight and the power needed for such radars are likely to increase depending on the range requirement.[24] These factors will have to be considered while designing the manoeuvrability aspects of the ASBM.

A missile with a conventional warhead needs to be far more accurate than a nuclear-tipped weapon. Therein comes in the requirement of effective 'terminal guidance'. The Circular Error Probability (CEP) of the ASBM should not be more than half the ship's beam (width) measurement if it has to strike the target. However, it would not be possible to strike a moving target with such precision at ranges exceeding 2,000 km unless there is terminal guidance from either onboard or external data sources. The last minute data input to nullify the accumulated errors—on account of OTH radar resolution, movement of the target, and the missile's deviation from the planned trajectory—would also have to be taken into account. Further, the onboard computer should be steering the missile towards the future position of the target through a system of thrusters and control surfaces, to convert the error signals into physical movement of the missile.

The conventional warhead for an ASBM would have to be specifically designed to penetrate and cause severe damage to the carrier with its reinforced flight deck. An alternative solution would be to rely on sub-munitions designed to spread lighter but widespread damage to aircraft on deck, the flight deck equipment and upper deck electronics, thereby achieving a 'soft kill'. Such an approach would have the advantage of reducing the criticality of pin-point accuracy.[25] For the present, though, it is believed that the Chinese are likely considering the option of the higher-mass 'deck penetration' warhead.

Modification for ASBM Capabilities

After analysing various image profiles available in the open domain, a 2007 study concluded that there were four variants of the land DF 21 IRBM, perhaps with different type of warheads for varied roles.[26] The assessed parameters of this missile's variants were as follow:

(a) Length Overall—9.3, 10.2, 10.7, 12.1 metres.
(b) Warhead Length—2.3, 3.2, >3.7, 5.1 metres.
(c) Warhead weight—about 700 kg.
(d) Missile liftoff weight—14.6 tonnes.
(e) Missile canister diameter—1.7 metres.

However, there are serious doubts about whether the existing DF 21 IRBM in the above configuration will be able to reach the designated range of 2,000 km or more. Hence, it would need significant modification for it to accommodate the RV with an extra-heavy conventional warhead, onboard sensor/s, control surfaces, thrusters, power supply units, and fuel for operating electrical and mechanical systems. In order to effectively convey this extra-heavy RV to a desired range of more than 2,000 km vis-à-vis the traditional DF 21, the engine, booster, and the two stages of the ASBM will have to be longer. This requirement becomes inescapable as more propellant has to be carried and a larger engine has to be housed, all within the same outer diameter, as far as possible. The booster also has to be suitably strengthened, leading to an increase in the ASBM's all-up weight.

This analysis has been substantiated by technical modelling carried out by independent experts in India.[27] Taking the above additional requirements into account, an ASBM will probably have the following physical parameters:

(a) Missile diameter—1.4 metres.
(b) Overall length—about 13.5 metres.
(c) Lift off weight—21 tonnes.
(d) Payload including Warhead—1,700 kg.
(e) Range with a payload of 1,700 kg—about 2,200 km.
(f) Total flight time of about 640 seconds for shallow and about 980 seconds for a lofted trajectory.[28]
(g) The RV must have a high thrust engine to provide quick speed corrections.

Advanced Anti Ship Cruise Missiles

China has developed and deployed the Donghai 10 (DH 10) Land Attack Cruise Missiles (LACM) and also the air launched version of the same. These missiles are said to have a range of 1,500–2,000 km and are currently configured to attack static land targets because of their pattern of homing, based either on GPS co-ordinates, inertial navigation, or the

Terrain Contour Matching (TERCOM). The air launched version of DH-10 can be fired from China's H-6k bomber.[29] The lethal range of DH-10 extends to 2,300–2,800 km when it is fired from the H-6k bomber. This would be the expected distance at which the Chinese will seek to target the adversary's maritime force in an Anti-access environment.

Beijing is in the process of reconfiguring its DH10 LACM/ALCM (Air Launched Cruise Missile) into the CJ10 Anti-ship Cruise Missile (ASCM) for fitting them onboard its latest ships, and conventional and nuclear attack submarines. This breakthrough, as and when achieved, will present China with another option to target ships up to 1,850 km from its coast.[30] Placed on the H-6k bomber, their anti-ship lethal range would increase further, to about 2,800 km.

American Strategy to Counter China's Anti-access Concept

The US has taken due note of the Chinese efforts to develop the A2AD concept and its associated systems and infrastructure. The ASBM found first mention in a US Department of Defense (DoD) report of 2005.[31] In 2009, the Office of US Naval Intelligence reported that the Chinese ASBM was probably nearing operational status.[32] The 2012 US DoD report to the Congress states that 'China has confirmed it is developing the DF 21 based ASBM.'[33]

An increasingly influential US think tank, the Centre for Strategic and Budgetary Assessments (CSBA) released a document titled *AirSea Battle: A Point-of-Departure Operational Concept* in May 2010, which suggested in detail as to how the US should counter the threat posed to its maritime forces, should the Chinese A2AD concept become operational in the Western Pacific. The executive summary of the ASBC states:

> The Chinese PLA's ongoing efforts to field anti-access/area-denial (A2/AD) capabilities are threatening to make US power projection increasingly risky, and in some cases, prohibitively costly. If this occurs, the US will find itself effectively locked out of a region that has been declared a vital security interest by every administration in the last sixty years. It will also leave longstanding US allies and partners vulnerable to aggression or, more likely, to subtle forms of coercion.[34]

Air Sea Battle, as evident from the under-mentioned excerpt, is comprised of two interactive stages: the first envisages repelling a preemptive Chinese strike and regaining the operational initiative, and the second aims at creating options to resolve a prolonged conventional combat on favourable terms.

> US and allied military forces can withstand initial large-scale Chinese conventional attacks, mitigate their effects, reduce the effectiveness of China's A2/AD system by rapidly blinding it, regain the strategic and operational initiative, and thereby set the stage for sustained follow-on operations."[35]

The ASBC has been debated extensively in the US DoD, particularly by the US Navy and the Air Force. While the Air Force and Navy have generally agreed on its broad principles and appear to have validated the ASBC, there do appear to be certain issues with regard to inter-service integration. In November 2011, sensing some discordance with respect to the ASBC issue, US Congressman J. Randy Forbes sought a briefing from the DoD to the Congress '...if this concept was to be both properly resourced and enduring....'[36]

Re-orientation of Chinese A2AD Southwards?

Sensor Coverage of Indian Ocean

In terms of radar coverage, the Indian Ocean sea space lies across the entire Chinese landmass measuring about 4,500 km from north-eastern boundary with Russia to south-western Indian border in Tibet. Across this continental landscape, the capabilities of conventional sensors of war fighting will simply be insufficient and highly limited at best. However, the sensors associated with the Anti-access concept, namely the SAR, Electro-Optical, ELINT and Beidou satellite systems and the OTH radars, do have the capability to transcend these limitations.

The complementary network of the Yaogan series of SAR, electro-optical and wide area ocean ELINT Satellites—with the capability to provide surveillance coverage against approaching maritime forces up to 3,500 km—is presently spread out over the Chinese east coast. China would have to erect an entire set of duplicate infrastructure similar to the Yaogan series with its focus on the Indian Ocean. The Chinese may or may not deploy more ELINT satellite clusters at present, spaced appropriately to provide continuous coverage around the world. However, considering the possibility of the recently launched Yaogan 16 satellite being the first satellite of the second ELINT cluster[37] and the past Chinese history of fast-paced satellite launches with the stated aim of launching up to 100 satellites by 2015,[38] one would not put it past them to manage this infrastructural feat in the Indian Ocean by then.

With 16 satellites in Space as of November 2012,[39] the Beidou system will progressively cover a wider area and eventually achieve global coverage by 2020 with a constellation of 35 satellites. Having established the navigation and positioning infrastructure over the Asia-Pacific in the first phase, it would stand to logic that the second phase will aim for seamless extension of the network on the other Chinese flank, namely, the Indian Ocean. Even if Beijing does not follow this expansion pattern, the global coverage timeline of 2020 will anyway make the inevitable happen in the IOR in that timeframe.

The current known deployment of OTH Radar is on the Chinese east coast. However, the deployment of other radars under speculation remains unknown. Though the OTH radars are capable of all-round radiation, practical considerations dictate the radiation pattern. Consequently, the coverage sector of OTH radars would generally extend in a semi-circle of interest. Going by this consideration, an OTH radar meant for Indian Ocean coverage would probably be facing the Sino-Indian land border in Tibet. It would, of course, be located well inland, given the coverage range of up to 3,000 km, thus also providing it the advantage of security in depth. The accurate ionospheric behaviour prediction system and use of advanced digital processing techniques will enable the OTH Radar to function quite effectively at long distances. Even the rugged Himalayan mountain range, comprising high peaks and deep valleys, will not affect the Radar's performance, as the HF radiation and reception follow the 'sky wave' principle of reflection from the ionosphere, rendering their propagation independent of terrestrial obstructions. These facilities when coupled with the Doppler frequency shift techniques to differentiate moving targets from stationery ones including interference from land, would enable such radars to detect moving ships and aircraft in the Indian Ocean[40] in the circumstantial manner explained earlier.

For instance, an OTH Radar placed near Lhasa would virtually cover the entire Bay of Bengal and most of the Arabian Sea abutting India. The same, if located in northern Tibet (Ali District) would provide comprehensive coverage of the Arabian Sea maritime space, extending from the horn of Africa till well beyond the southern tip of India, in addition to the Bay of Bengal. The area so covered is shown in Figure 2.

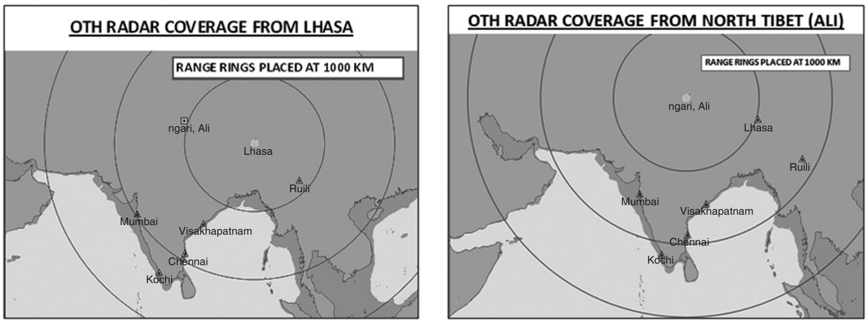

Figure 2 OTH Radar Coverage from Two Locations in Tibet

Source: Author.

Targeting Hardware

If the DF 21D ASBMs are also co-located in and around either of the above two areas, the circular area extending up to 2,000 km and depicted within the second range ring in Figure 2 would be under threat. Only the maritime space around Kochi and south of it would be just out of the danger zone. The Bay of Bengal could also be covered by the DF 21D ASBM if placed on the Sino-Myanmar border in Yunnan Province.

Another noteworthy challenge emanates from the Chinese ALCMs. A string of airfields are located at even intervals in the Tibet Autonomous Region and the contiguous Sichuan and Yunnan Province. In fact, there are 30 military airfields within a lateral range of 1,200 km from the India–China border and five operational civil airfields—Lhasa Gongga, Qamdo, Gunsa, Nyingchi and Xigaze—in Tibet itself.[41] Assuming a threat range of 2,300–2,800 km for DH-10 ASCMs[42] carried by the H-6K bomber aircraft and discounting up to 1,000 km for overland flight of the aircraft, the lethal radius at sea will still range between 1,500–1,800 km. Aircraft operating from north Tibetan airfields will be able to target the northern Arabian Sea and those from Sichuan and Yunnan will cover more than half of the Bay of Bengal. The threat radius will only increase if these bombers either get re-fuelled in mid-air or can be logistically supported by Myanmar's airfields.

Deployment of the Shang class SSNs in the IOR, possibly armed with the CJ 10 ASCMs (modified DH-10 LACMs) will add the third dimension to the threat. The existing SSN inventory, their limited range weapon suite, and more immediate employment imperatives closer home precludes the feasibility of their deployment in the IOR at present. But a progressive expansion of the Chinese maritime strategy to include IOR into their 'Far Sea Defense' ambit, duly backed by growth in numbers, capabilities and reach may see their eventual presence in the IOR.

Implications for the Indian Ocean Region: Situational Assessment

The ranges achievable by the Chinese sensors and weapon systems associated with the Anti-access concept, should it reorient southwards, clearly extend to a little beyond the southern tip of India in the IOR. Virtually the entire maritime space to India's east and west would fall under its surveillance umbrella, as seen in Figure 2. The Chinese Space-based systems, particularly the Wide Ocean ELINT satellites and the OTH Radars, will be able to locate and identify the Indian maritime forces in the Arabian Sea as well as the Bay of Bengal with reasonable degree of accuracy. The Beidou navigation and positioning system will be able to provide accuracy in targeting by ASBMs, LACMs, ALCMs and ASCMs, should the situation so warrant. Should Beijing decide to actively support our western neighbour during a contingency, it could establish an anti-access barrier of 1,000–1,500 km off the Makran coast against the Indian maritime forces and aircraft. This would render the entire Indian Naval forces as 'wasting assets' despite conventional superiority in numbers as well as capability. Worse still, should the western neighbour deploy OTH radar on the Makran coast with China's overt or covert support, the threat quotient could escalate manifold. The ASCM-armed SSNs approaching from the Sunda/Lombok straits[43] would comprehensively complete the threat circle for India. Such a development would be a cause for serious concern to India for obvious reasons.

While the position of India in this scenario would be quite unenviable, the US maritime interests in the IOR would also be threatened in equal measure. Given the American geo-political and security concerns, it is axiomatic that the Arabian Sea will continue to be a major arena for US maritime activities. With the US CENTCOM headquartered in Bahrain, two CSGs operating in and around the Persian Gulf, and US naval ships criss-crossing the Arabian Sea on transit to and from the Diego Garcia naval base and the Pacific, the strategic importance of this sea body for the US could not be emphasized more.

Avenues for Cooperation

The aim of this paper is not to present a scary scenario, but to highlight the need for more comprehensive cooperation against the backdrop of the Chinese Anti-access concept, within the ambit of the evolving India–US maritime partnership. While the specifics can be dwelt in greater detail separately, the immediate issues of cooperative endeavour that can set the ball rolling may comprise the following:

(a) Joint Space Data Gathering: OTH radar antennas extend from 300–3,000 metres on ground,[44] with various whip aerials linearly aligned and interconnected with lattice patterned wire mesh. Joint remote sensing satellite based reconnaissance of an area 500–2,000 km inland from the India-China border for locating such radars could be carried out and gaps in data could be plugged by mutual sharing of imagery.

(b) Intelligence Sharing: Continuous high resolution satellite-based scans of the above areas, as also other intelligence associated with the Chinese Anti-access developments could be shared.

(c) Capacity Building: For instance, export of advanced maritime surveillance and defence hardware, communication network connectivity along with associated technology transfer and greater accuracy access to the GPS system for military use could be considered.

(d) Sharing of American Counter Options in IOR Context: Information on operational strategies, specific hardware and other measures being contemplated by the US defence forces to counter the Chinese Anti-access concept—at least those relevant to the IOR—could be shared. Further, joint scenario-building and table-top exercises to explore suitable options to address the Chinese Anti-access concept in the IOR could be planned.

Conclusion

An empirical analysis of the modifications to the DF-21 missile leads to the conclusion that the DF 21D ASBM is theoretically capable of credible performance with respect to its assessed increased range and payload. With onboard radar and the addition of control surfaces, the re-entry vehicle can acquire terminal self-guidance and velocity correction capability which would enable precision targeting of moving ships at sea.

The development of associated Space-based capabilities, OTH Radar and assessed C41SR systems indicate that Beijing is well on its way to achieving an asymmetrical challenge to the US carrier-based power projection capability.

Though the technological challenges for China are tremendous, the scientific studies point out that the concept is very much workable. However, the eventual validation of the missile as a viable anti-ship weapon and the efficacy, reliability and the amount of redundancy built into the associated systems can only be established after trials, which are yet to be carried out. It would, however, be presumptuous to assume that this single concept will give China the regional supremacy it seeks. But China's ASBM backed Anti-access concept is forcing the US to make a critical appreciation of the emerging threat to its Navy's unassailable superiority in the Pacific Ocean.

The possibility of the Chinese Anti-access concept re-orienting southwards in the foreseeable future has ominous portends for the Indian maritime domain across both its coasts. The arguments presented in support of this eventuality, though in the realm of conjecture, are drawn out of a measured assessment of the present Chinese capabilities, and hence are considered to be very much possible. This vital area should be of particular interest to China since it encompasses virtually the entire maritime area of Indian influence, major areas of Indian Navy's operational space and exercise areas, all major Indian military and commercial ports, and the areas associated with the Indian Space and missile test launch programme.

Since the challenges for American and Indian maritime space in the IOR from the southward re-orientation of the Chinese A2AD would be similar, there should be a natural tendency towards congruence in planning the way ahead to meet this challenge synergistically. And, while proceeding along the maritime cooperative pathway so as to overcome common challenges, it might become possible for the two nations to become true strategic partners in future.

Notes

1. See Ministry of National Defense of Peoples Republic of China website, 'White Paper on "China's National Defense in 2006, Chapter II-National Defense Policy"', available at http://eng.mod.gov.cn/Database/ WhitePapers/ 2007-01/15/content_4004364.htm, accessed 21 July 2012.

2. The term 'Informationization' describes the Chinese military effort to incorporate modern technology into all aspects of operations and includes means to protect one's own information, such as own command and control systems, and the means to disrupt the information of the adversary, such as cyber attacks and electronic jamming. See US Office of Naval Intelligence, *The People's Liberation Army Navy: A Modern Navy with Chinese Characteristics*, July 2009, p. 7.
3. See White Paper on 'China's National Defense in 2008, Section V—PLA Navy', available at http://www.china.org. cn/ government/ central_government/2009-1/20/content_17155577_4.htm, accessed 11 July 2012.
4. O'Rourke, Ronald, *China Naval Modernisation: Implications for US Navy Capabilities—Background and Issues for Congress*, CRS Report for Congress, 17 October 2012, p. 5, available at http://www.fas.org/sgp/crs/row/ RL33153.pdf, accessed 17 December 2012.
5. AWACS stands for Airborne Early Warning and Control System.
6. Agnihotri, Kamlesh Kumar, 'Strategic Direction of the PLA Navy: Capability and Intent Assessment', *Maritime Affairs*, Vol. 6, No. 1 (Summer 2010), p. 89.
7. A *Global Times* article avers that a military source close to the development, speaking on condition of anonymity, confirmed to the newspaper that 'The subject under development is a medium and long-range conventional missile with a traveling distance of as far as 4,000 kilometers.' See Zhang Han and Huang Jingjing, 'New Missile Ready by 2015', *Global Times*, 18 February 2011, available at http://military.globaltimes.cn/china/2011-02/624275. html, accessed 15 July 2012.
8. Zhang and Huang, 'New Missile Ready by 2015', n. 7.
9. The mission radius of an armed F-18 Super Hornet, the US Navy's main carrier-borne attack aircraft, would be 522 nautical miles (about 800 km). See the Federation of American Scientists website, http://www. fas.org/programs/ssp/man/uswpns/air/fighter/f18.html, accessed 2 August 2012.
10. SAR permits the attainment of high resolution by using the motion of the vehicle to generate the antenna aperture sequentially rather than simultaneously, as with a conventional array antenna. The electrical signals at the radar output are converted to optical images on film by optical processing. The output of optical processor is a map like photographic film of the terrain. SAR produces images without the slant-range distortion that occurs with the photographic camera. The typical resolution of an X band SAR sensor at 12 km height would be 7–12 metres, depending on the speed of the aircraft. See Merrill Skolnik, *Introduction to Radar*

Systems, Second Edition, New Delhi: Tata-McGraw Hill, 1997, pp. 517, 523.

11. Information relating to the Yaogan series has been sourced from Rui C. Barbosa, 'Long March 4C Launches Yaogan Weixing-16 Spy Satellite for China', 25 November 2012, available at http://www.nasaspaceflight.com/2012/11/long-march-4c-yaogan-weixing-16-spy-satellite-china/, accessed 20 November 2012.
12. In December 2010, Admiral Robert Willard, the US Pacific Theatre Commander, asserted that the ASBM had attained 'Initial Operational Capability'. See Bill Gertz, 'China has Carrier-killer Missile, US Admiral Says', *The Washington Times*, 27 December 2010, available at http://www.washingtontimes.com/news/2010/dec/27/china-deploying-carrier-sinking-ballistic-missile/, accessed 17 December 2012.
13. See 'White Paper: China's Space Activities in 2011', Section II, 29 December 2011, available at http://www.china.org.cn/government/whitepaper/node_7145648.htm, accessed 23 July 2012.
14. See'China's Beidou GPS System is as Accurate as US GPS System', *China Daily Mail*, 2 December 2012, available at http://chinadailymail.com/2012/12/02/chinas-beidou-gps-system-is-as-accurate-as-us-gps-system/, accessed 17 December 2012.
15. Yang Jinghao, 'China's Beidou to Rival GPS', *Global Times*, 28 December 2011, available at http://www. globaltimes.cn/NEWS/tabid/99/ID/690206/Chinas-Beidou-to-rival-GPS.aspx, accessed 23 July 2012.
16. As the OTH radars operate at radio frequencies, the transmitters and receivers both consist of straight line elements spread out over a distance of 2–3 km, to cater for long wavelengths.
17. Chandrashekar, S., R.N. Ganesh, C.R. Raghunath, Rajaram Nagappa, N. Ramani and Lalitha Sundaresan, *China's Anti-Ship Ballistic Missile: Game Changer in the Pacific Ocean*, NIAS Report No. R5-2011, Bangalore: National Institute of Advanced Studies, November 2011, pp. 8–9.
18. Figure 1 has been prepared by the author. The range rings are spaced 1,000 km apart. The radar detection sector is also marked. For a similar assessment, see Sean O'Connor, 'OTH-B Radar Viewing Area: IMINT and Analysis', 11 November 2008, available at http://geimint.blogspot.com/2008_11_01_archive.html, accessed 17 July 2012.
19. The imagery of the OTH Radar transmitter and receiver can be seen at 27 Degrees 45.5 Minutes North Latitude and 120 Degree 45.2 Minutes East Longitude, and 27 Degrees 47 Minutes North Latitude and 120 Degree 46 Minutes East Longitude, respectively, on the Google Earth website.
20. Since the backscatter from the earth's surface is generally much larger in magnitude than the echo from desired moving targets, OTH Radar must

employ some form of Doppler processing such as MTI, pulse-Doppler, FM-CW, or CW radar to separate desired moving targets from clutter. Therefore, the resolution between two objects depends on the Doppler frequency difference between their back-scatter signals. See Merrill Skolnik, *Introduction to Radar Systems*, n. 10, p. 533.

21. The relative motion between the ships in a CSG is not significant. However, there would be aircraft sorties every two hours or so, which would be detectable. The OTH Radar resolution along the direction of range would be better than that across the range.
22. A 2009 US Office of Naval Intelligence report—*The People's Liberation Army Navy: A Modern Navy with Chinese Characteristics*—laid down a timeline of 10 years; see n. 2, p. 46.
23. The Root mean square of the two errors from the OTH Radar and the motion of the ship during the flight time of the missile is taken as the final error. The flight time of the missile has been taken as 640 seconds for covering a range of 2,200 km over a shallow trajectory. The moving ship travelling at a maximum of 32–35 knots would travel about 8 nautical miles in this duration, which roughly converts to 15 km at a conversion scale of 1 nautical mile to 1.8 km.
24. A range estimate of the typical radar that can be accommodated within the weight and power limitations of the missile would be of the order of 300 km. See S. Chandrashekar et al, *China's Anti-Ship Ballistic Missile: Game Changer in the Pacific Ocean*, n. 17, p. 20.
25. The idea was floated in a 1995 article in the context of ballistic missile defence. It referred to an intelligence analysis published in the United States which cast a doubt on the future development plans of anti-ballistic missile defense systems in the United States and Israel, and called for a reassessment of the policymakers' basic premises. It predicted that within a few years China would be able to develop ballistic missiles with blast fragmentation warheads containing a cluster of about 100 sub-munitions weighing about 5 kg each. See 'A New Threat to the Arrow', 15 October 1995, available at http://www.fas.org/news/israel/nes95199.htm, accessed 3 August 2012.
26. Chandrashekar, S., Sonika Gupta Rajaram Nagappa, *An Assessment of China's Ballistic and Cruise Missile Programme*, NIAS Report No. R4-2007, Bangalore: National Institute of Advanced Studies, 2007, pp. 36–7.
27. Chandrashekar, S. et al, *China's Anti-Ship Ballistic Missile: Game Changer in the Pacific Ocean*, n. 17, p. 25.
28. One of the articles quoted in literature on the subject assesses a flight time of 930 seconds, which could be a reference to the lofted trajectory case. See Note 66 in Andrew Erickson and David Yang, 'Using Land to Control

the Seas?', *Naval War College Review*, Vol. 62, No. 4, Autumn 2009, pp. 84–85. Indigenous analysis does not suggest any major differences in terms of manoeuvre requirements between the lofted and shallow trajectories. The time interval between manoeuvre and impact is also not very different. From a tactical perspective, a shallow trajectory may be preferred. For indigenous analysis, see S. Chandrashekhar et al, *China's Anti-Ship Ballistic Missile: Game Changer in the Pacific Ocean*, n. 17, p. 25.

29. The H-6k bomber has six under-wing hard points to carry large LACMs. See Ian Easton, 'The Assassin Under the Radar—China's DH-10 Cruise Missile', Project 2049 Institute, available at http://project2049.net/documents/assassin_under_radar_china_cruise_missile.pdf, accessed 24 July 2012.
30. US Department of Defense, *Annual Report to Congress on 'Military and Security Developments Involving the Peoples' Republic of China'*, 2011, p. 29.
31. US Department of Defense, *Annual Report to Congress on 'Military Power of the People's Republic of China, 2005'*, p. 33, available at http://www.defense.gov/news/jul2005/d20050719china.pdf, accessed 17 December 2012.
32. See US Office of Naval Intelligence, *The People's Liberation Army Navy: A Modern Navy with Chinese Characteristics*, n. 2, pp. 26–27.
33. US Department of Defense, *Annual Report to Congress on 'Military and Security Developments Involving the Peoples' Republic of China'*, May 2012, p. 22.
34. Van Tol, Jan, Mark Gunzinger, Andrew F. Krepinevich and Jim Thomas, 'AirSea Battle: A Point-of-Departure Operational Concept', Centre for Strategic and Budgetary Assessments, 18 May 2010, p. ix, available at http://www.csbaonline.org/4Publications/PubLibrary, accessed 29 July 2012.
35. Ibid., p. 95.
36. O'Rourke, Ronald, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, n. 4, p. 62
37. Rui C. Barbosa, 'Long March 4C Launches Yaogan Weixing-16 Spy Satellite for China', n. 11.
38. Xinhua, 'China to Launch 100 Satellites, 100 Rockets 2011–2015', 11 March 2012, available at http://china.org.cn/china/2012-03/11/content_24864996.htm, accessed 3 August 2012.
39. See *Xinhua News*, 'China Launches 16th Beidou-2 Satellite', 26 October 2012, available at http://news.xinhuanet.com/english/video/2012-10/26/c_131931831.htm, accessed 30 November 2012.
40. See explanation in n. 21.
41. Agnihotri, Kamlesh K., 'Modernisation of the Chinese Air Force and its Implications for India', *Maritime Affairs*, Vol. 7, No. 2 (Winter 2011), pp. 40–41.

42. Presently, ALCMs are yet to be modified into ASCMs.
43. The Chinese SSNs would probably use these wider and deeper straits for transiting to the IOR if they are to maintain a reasonable degree of stealth.
44. See Yang Jinghao, 'China's Beidou to Rival GPS', n. 15.

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