INDO-PACIFIC STRATEGY SERIES

UNDERSEA DETERRENCE PROJECT

THE FUTURE OF THE UNDERSEA DETERRENT: A GLOBAL SURVEY

FEBRUARY 2020

Edited by Rory Medcalf, Katherine Mansted, Stephan Frühling and James Goldrick

Australian National University | NATIONAL SECURITY COLLEGE

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Published by the National Security College, The Australian National University, Acton ACT 2601, Australia

Available to download for free at nsc.crawford.anu.edu.au

ISBN (print): 9781925084146

ISBN (ebook): 9781925084153

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Cover design and layout by Black Bear Creative.

Cover photograph: AP Photo/Mark Schiefelbein, Pool.

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Foreword

Amid rapid geopolitical change at the start of the 2020s, nuclear weapons manifest grim continuity with the previous century. Especially persistent is a capability that has existed since the 1960s: the deployment of nuclear weapons on submarines. The ungainly acronym SSBN represents nuclear-powered ballistic missile submarines: the most destructive armaments carried on a supposedly undetectable, and thus invulnerable, platform.

In the new nuclear age, many nations are investing in undersea nuclear deterrence. In the Indo-Pacific region (the centre of strategic contestation), four major powers – the United States, China, India, and Russia – have SSBN programs, while Pakistan and North Korea are pursuing more rudimentary forms of submarine-launched nuclear firepower. This complex maritime-nuclear dynamic brings deterrence but also great risk. Yet the intersection of undersea nuclear forces, anti-submarine warfare (ASW), geostrategic competition, geography, and technological change is not well understood. This has a major bearing on peace and security, in terms both of crisis stability and arms race stability.

To illuminate these critical issues, the National Security College at The Australian National University, with the support of the Carnegie Corporation of New York, is conducting an international research project on strategic stability in the Indo-Pacific. The project's focus is on new technologies and risks relating to undersea warfare and nuclear deterrence over a twenty year timeframe. The present volume is the project's second publication, bringing together the insights of leading international scholars and next-generation experts to produce a comprehensive and authoritative reference. The book examines the interplay of strategic issues, including nuclear strategy and deterrence; maritime operational issues, including ASW; and technology issues, including new and disruptive technologies and potential game-changers in relation to deterrence.

The first four chapters set the scene strategically, explaining in particular the logic (or otherwise) of SSBN programs in terms of major-power interests, competition, and geopolitical objectives. The first chapter, in particular, draws the threads between the many country-specific analyses to follow.

The various undersea nuclear deterrence programs in the Indo-Pacific region cannot be considered in isolation or solely in relation to one another. As James Goldrick explains, nuclear strategy cannot be divorced from multi-layered maritime competition involving everything from territorial disputes to resource exploitation to conventional naval operations. Chinese and American investments in frontier technologies are also part of a broader strategic competition.

As context, the mature SSBN programs of Britain and France, as described by John Gower and Corentin Brustlein, offer insights regarding the sustained and intensive national effort required to achieve Continuous At Sea Deterrence, and the challenge of retaining that grail in the face of technological development and potential surprise. Bruno Tertrais makes the intriguing observation that France's submarine-launched nuclear deterrent also now operates in a global and Indo-Pacific context, raising the possibility that it may play a role in future in protecting French or even European interests against an assertive Asian power.

Even for existing SSBN operators, technology may change the role and value of these capabilities. A major consideration is whether investments in ASW, and the potential for disruptive scientific breakthroughs in this regard, could lead to fundamental new vulnerabilities for vessels carrying nuclear weapons. Sebastian Brixey-Williams sets out some of these game-changers. This could contribute to a new era of nuclear instability and cast doubt on undersea nuclear weapon programs or perhaps even submarine programs in general. Benjamin Zala goes further to look at the impact of other technological developments, notably in advanced conventional weapons, in contributing to a more general nuclear instability, which may both encourage SSBN programs as a more reliant deterrent than the alternatives yet render them less stabilising than they otherwise would be.

Yet analysis about 'transparent oceans' remains controversial, and the logic of countries persisting with their SSBN programs is well explained in several chapters in this volume, notably Norman Friedman's (drawn from the monograph that was the first publication by this project). Arguments are made as to why ASW will continue to favour some countries (notably the United States) over others (notably China), owing to particular combinations of geography and existing technological advantage. Nonetheless, the inherently stabilising effects of SSBNs may have long been less than advertised, as Stephan Frühling points out. Accordingly, the emerging undersea nuclear picture in the Indo-Pacific will be murky, meriting constant re-evaluations of risk and of related defence investment priorities.

In Asia, where regional countries have so far not operated such capabilities, strategic stability in future will thus depend on the complex interplay of a whole range of strategic, operational, geographic, and technological questions. For instance, will developments in strategy, geography, and technology push counties in a way that creates and accelerates direct action-reaction mechanisms between their SSBN and ASW forces, in terms of quantity, quality, or geographic disposition – such as in the South China Sea? Will this create the prospect, risk, or opportunity to push technological boundaries to seek a radical strategic advantage? Will the way SSBN and ASW forces are deployed and operate in peacetime, crisis, and war send signals that can miscommunicate intentions? Will it create pressures for escalation through use-it-or-lose-it situations? Will there be an incentive as part of this for horizontal escalation into theatres of war that might otherwise have been of a lesser priority?

We know that strategy, geography, and technology in relation to undersea nuclear deterrence had profound implications for stability during the Cold War, and can safely surmise that they will again in the future of the Indo-Pacific. This book seeks to make a start at answering these questions, with a view to generating insights of value to governments in anticipating and managing prospective future arms race and crisis instabilities. The deepening strategic competition, bordering on confrontation, between the United States and China is a reminder of the importance and urgency of these issues.

This book involved the efforts and expertise of many. In addition to the many contributing authors, I thank my fellow principal researchers James Goldrick and Stephan Frühling. Particular tribute goes to the project team of Katherine Mansted, Katherine Baker, and Samuel Bashfield, for the exceptional work of bringing this volume together. I also note the contributions of John McGarry, for leading strategic simulation activities to test our research, and of Roger Bradbury, who is leading a parallel process of technology assessment. Their work will be covered in future project publications.

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February 2020

Acronyms

AI
artificial intelligence

ASW
anti-submarine warfare

C2
command and control

CASD
Continuous At Sea Deterrence

DARPA
Defense Advanced Research Projects Agency (US)

EU
European Union

GPS
Global Positioning System

ICBM
intercontinental ballistic missile

INS
Indian Navy Ships

IRBM
intermediate-range ballistic missile

ISR
intelligence, surveillance, and reconnaissance

JMSDF
Japan Maritime Self-Defense Force

JSDF
Japan Self-Defense Forces

LIDAR
light detection and ranging

MAD
magnetic anomaly detection

MIRV
multiple independently targetable re-entry vehicle

MPA
maritime patrol aircraft

NATO
North Atlantic Treaty Organization

NPR
Nuclear Posture Review (US)

NPT
Treaty on the Non-Proliferation of Nuclear Weapons (1968)

NWS
nuclear-weapon state

PLA
People’s Liberation Army (China)

PLAAF
People’s Liberation Army Air Force (China)

PLAN
People’s Liberation Army Navy (China)

SLBM
submarine-launched ballistic missile

SLCM
(nuclear) sea-launched cruise missile

SLOC
sea line of communication

SOSUS
sound surveillance system

SSBN
nuclear-powered ballistic missile submarine

SSK
diesel-electric attack submarine

SSN
nuclear-powered attack submarine

UAV
unmanned aerial vehicle

UK
United Kingdom

UN
United Nations

US
United States

USAF
United States Air Force

USN
United States Navy

USV
unmanned surface vehicle

UUV
unmanned underwater vehicle

PART 1

Strategic Context

Chapter 1

Undersea Deterrence and Strategic Competition in the Indo-Pacific

Rory Medcalf

The various undersea nuclear deterrence programs in the Indo-Pacific region cannot be considered in isolation or solely in relation to one another. There is a large and complex strategic context to the decisions by China, India, Pakistan, and North Korea to invest in submarine-launched nuclear weapons programs, by the United States and Russia to modernise their own, and by the United States and its allies – notably Japan and Australia – to double down on their advantages in anti-submarine warfare (ASW). As James Goldrick explains in this volume, nuclear strategy cannot be divorced from multi-layered maritime competition involving everything from territorial disputes to resource exploitation to conventional naval operations. The contest for authority and control in the South China Sea is not simply about fish, energy resources, nationalism, and history, but has a bearing on the balance of military power and prospects for coercion or deterrence in a crisis, right up to the nuclear level. Meanwhile, Chinese and American investments in disruptive technologies – such as quantum computing, artificial intelligence, autonomous systems, and new sensing techniques – are part of a broader strategic competition related in part to deterrence in the maritime domain. This chapter offers some framing insights on how strategic competition connects with the 21st century ambitions of a range of Indo-Pacific countries to deploy – or neutralise – nuclear weapons below the waves.

A China-Centric Powerplay

The great power dynamics of the Indo-Pacific revolve around the rise of the People's Republic of China (PRC). This is a two-ocean region, with an increasingly multipolar character, as attested to by the prospect of its waters being plied by no fewer than six nuclear-armed submarine fleets: American, Chinese, Russian, Indian, Pakistani, and North Korean, with the first four countries fielding fully-fledged SSBNs (nuclear-powered ballistic missile submarines) and the other two improvising with diesel-electric boats and, in Pakistan's case, cruise missiles. Some non-nuclear powers are likely to play prominent roles in maritime strategy and ASW, notably Japan (as explained by our author Yoji Koda) and Australia, and in the long run the role of emerging players such as Indonesia as naval powers exploiting their central Indo-Pacific geography astride the sea-lanes cannot entirely be dismissed.

Nonetheless, although the region is not China-centric, some of its main strategic questions are. In particular, how can a powerful China be incorporated into a regional order in ways that sufficiently respect Chinese interests while respecting the interests and rights of other nations, large and small? How can America's protection of its own global interests, its allies, and its agenda to prevent hegemony be reconciled with Chinese ambitions? How can the Chinese Communist Party's self-imposed connection between maintaining domestic control and projecting national assertiveness abroad be squared with the preservation of a stable regional status quo? If the United States, under President Donald Trump or a different future administration, is intent on fully-fledged competition with China for regional influence, military superiority, and technological leadership, how can this settle into patterns of coexistence?

It must be borne in mind that, as the US conventional military edge over China comes under great strain – and is already open to question – there will be temptations for Washington to rely more heavily on its superior nuclear deterrent capabilities, and to double down on being able to neutralise China's, including SSBNs. At the same time, warnings are sounded – including in various ways by our authors James Wirtz, and Tom Mahnken and Bryan Clark – against the assumption that America's own next-generation SSBN fleet will always be invulnerable to adversary efforts to neutralise it in a conflict. The ripples of US–China nuclear rivalry flow further out still, affecting for example the dynamics of other strategic contests – notably India–China and India–Pakistan – as explored in this volume by Sudarshan Shrikhande, Raja Mohan, and Sadia Tasleem.

Nuclear weapons have played a limited role in China's dramatic growth in armed power over recent decades. Fiona Cunningham points out that accelerating military spending and the rapid development of maritime anti-access and power-projection capabilities have overshadowed the modernisation of Beijing's nuclear forces. Furthermore, at least until recently, the SSBN program was of secondary importance to the land-based nuclear arsenal, although Adam Ni argues this is changing, with SSBNs likely to end up carrying a larger proportion of China's warheads. In any event, nuclear armaments cannot be separated from China's overall defence policy and great power ambitions, as was so palpably highlighted in the flaunting of ballistic missiles in the October 2019 parade to mark the 70th anniversary of the Communist Party's victory in the Chinese civil war and the founding of the PRC. Despite these Cold War images fuelling speculation to the contrary, China maintains a declared position that minimises the role of nuclear weapons in its strategic posture, limiting them to missions of retaliation under a no-first-use policy.

Wide Horizons, Dark Waters

Serious complications arise, however, given the increased assertiveness of China's wider strategic activity. Even if the Pentagon's warnings of China's hegemonistic ambitions are less than fully substantiated, it is clear that Xi Jinping's China has set for itself strategic objectives that run counter to interests that other nations, and of course Taiwan, are willing to defend. Several of the region's long-standing 'flashpoints' involve these clashes of interests, including territorial disputes in the South China Sea (with Vietnam and the Philippines in particular, but potentially also with Malaysia, Brunei, and even Indonesia) and in the East China Sea (with Japan). The most obvious flashpoint involves Beijing's insistence, enshrined in the so-called Anti-Secession Law, that it will use force to prevent Taiwan formalising its independence.

The range of potential interstate frictions has grown further with the expansiveness of Xi's signature 'Belt and Road' geoeconomic initiative, involving infrastructure, influence, and security access across the Indian Ocean and much of the Pacific, as well as overland through Southeast, South and Central Asia. On the eve of the 2020s, the United States and China are in widely ranging strategic competition, with moments of confrontation and sustained potential for conflict. For the time being, China–Japan confrontation has eased, but a return to the near-war circumstances of the early 2010s is entirely plausible at some point. Likewise, after the prolonged tensions of the Himalayan military standoff at Doklam in 2017, China–India relations returned to a plane of wary stability. However, there is a high likelihood of further confrontations in future, not only on the disputed land border but in the Indian Ocean, as China seeks to consolidate and protect a security footprint in waters where Delhi claims dominance. The structures of China–India relations are of long-term competition, even rivalry, and India makes no secret of developing its own undersea nuclear force as an asymmetric deterrent against a much stronger and wealthier China that has coerced it in the past.

Thankfully, most of the many tensions that accompany China's strategic assertiveness are in themselves unlikely to lead to armed conflict, let alone escalation to nuclear threats. In the South China Sea, Beijing is generally careful to rely on paramilitary coastguard units and militias to bully Vietnam and the Philippines, rather than resorting to direct application of naval force. That said, Vietnam in particular has the emerging military capability (notably its Russian-built submarine fleets) to put Chinese forces at risk, at least in the early stages of a clash. More profoundly with regard to the nuclear issue, one credible explanation for China's campaign of building and militarising islands in recent years has been its wish to secure control of the South China Sea to make that area a bastion where its SSBN fleet can operate in relative safety from detection or attack by US and allied forces.

In the East China Sea, China has for the moment backed away from high-risk confrontations with capable (and now reinforced) Japanese forces, not least following clarification that the United States considers its security treaty to apply to clashes over the islands in question. In the Indian Ocean, it is difficult to imagine a China–India confrontation – for instance over the fate of a small island state such as the Maldives – escalating to war, although reports have surfaced (see Raja Mohan's chapter) that even the land-border clash at Doklam led Delhi to look for ways to remind Beijing of the nuclear factor. In North Asia, crisis scenarios involving the Korean Peninsula could lead to US–China confrontation, but they could also lead to a degree of US–China cooperation, with the principal nuclear threat being, as Mike Cohen explains, the regime in Pyongyang, not each other.

Some other plausible nuclear conflict scenarios in the Indo-Pacific do not involve China directly: the unresolved tensions between India and Pakistan, where both powers are now beginning to add a maritime dimension to their nuclear deterrence; the prospect of renewed confrontation between North Korea and the United States; and the possibility that a future crisis between Russia and the West would have a Pacific dimension (bearing in mind that part of Russia's nuclear-armed fleet is based in the Pacific, as Michael Kofman notes).

More than a Game: Assessing Resolve and Stability

In the end, however, the clearest prospect of armed confrontation between China and the United States leading to nuclear threats continues to revolve around the status of Taiwan. However bizarre it may seem, the political choice of a self-governing island democracy of 23 million people is the issue on which the leadership of a mega-state of about 1.4 billion people has staked its own regime credibility. Moreover, as James Goldrick's chapter suggests, there is a strategic logic to the PRC gaining military control over Taiwan, to break through China's geographic constraint by way of the so-called 'island chains' and secure access to the open Pacific. It would be an over-simplification to argue that a Taiwan crisis would escalate quickly to the nuclear level. There would be several ways for Chinese forces to initiate coercion, include economic blockade and cyber attacks. And the subsequent conflict could drag out on multiple levels, including international economic and diplomatic pressure on China. Nonetheless, a Taiwan crisis – or indeed another conflict, such as one arising from a US–China skirmish in the South China Sea – could lead to a wider mobilisation of forces, including Chinese SSBNs and US and allied ASW assets, perhaps with nations pre-empting each other rather than necessarily planning to attack.

The role of China's immature SSBN fleet in such a situation is unclear, but a few credible possibilities exist. It seems highly unlikely that China would threaten nuclear attack on Taiwan: it claims, after all, to be liberating its misguided compatriots. Nonetheless, wanting to reserve the right to retaliate to a future US nuclear attack, and thus seeking to discourage US conventional military intervention as well, Beijing could well choose to take precautions to protect its nuclear forces at an early stage. In the case of the SSBN fleet, this could involve putting boats to sea as soon as possible rather than keeping them inside their hardened 'dens' on Hainan. Nonetheless, such activity would be indistinguishable from commencing deterrent patrols – in other words, positioning in the maritime bastion for potential nuclear conflict further on. By the same token, the United States has a strategic imperative to curtail China's escalation options from the start, including by placing Chinese SSBNs at risk, or at least sowing meaningful doubt along those lines in the minds of Chinese military planners. This helps explain the long-standing activity of American submarine-detection assets in the South China Sea, and of what may be termed Chinese anti-anti-submarine warfare efforts (going back at least to the 2009 *Impeccable* incident, when Chinese fishing, militia, and naval vessels together harassed a US survey ship).

The SSBN and ASW dimensions of hypothetical US–China confrontations over Taiwan were analysed in a series of strategic simulation activities conducted as part of the present research project. One of these activities concerned the capability investment choices facing governments over the next few decades, including whether to invest more heavily in existing capabilities (both SSBNs and established ASW) or take a bet on disruptive technology breakthroughs, or to attempt both (with espionage and dual-use civilian research convenient ways to gamble on the game-changers). Our simulation activity proved a useful way to map the complexities and difficulties in assuming that new technologies will fundamentally change the strategic picture. Other forthcoming research in this project will complement these conclusions with an alternative view, with a team led by Roger Bradbury assessing the probability that a convergence of scientific breakthroughs will make the oceans transparent (or at least relatively more transparent), even if converting such advances to useable ASW capabilities may remain a more distant prospect.

Chapter 2
Maritime and Naval Power in the Indo-Pacific

James Goldrick

The maritime strategic balance in the Indo-Pacific is changing rapidly. The United States is facing a serious challenge to its military domination of the region for the first time since the collapse of the Soviet Union. Russia is attempting to revive its military capabilities in the Pacific, while China seeks, on the one hand, to create a defensive perimeter in its adjacent seas effective enough to prevent any potential opponent from striking at the mainland or blocking its ports, and on the other to develop sea control and power projection capabilities sufficient to dominate maritime Southeast Asia and the Indian Ocean. India must manage the continuing stand-off with Pakistan at the same time as it competes with China for predominance in the northern Indian Ocean. Japan and Australia are both faced with the need to strengthen their maritime capabilities as well as to make hard decisions about how their commitment to their alliances with the United States should affect their operational posture – and the extent to which they should cooperate with other middle powers to balance a rising China. Smaller powers, particularly those adjoining the South China Sea, are facing similar dilemmas, uncertain as to how far China will attempt to push its maritime claims and dominate local sea areas to the exclusion of others.

The future of undersea nuclear deterrent forces has strategic, operational, and force structure aspects for all the major powers in the Indo-Pacific. Its nuclear-powered ballistic missile submarine (SSBN) force is central to the United States' nuclear arsenal. While the US Navy (USN) cannot be complacent about threats to the survivability of its submarines, until there are revolutionary developments in sensor technology the combination of geography, oceanography, and platform and missile capabilities means that its at-sea deterrent will remain the most secure element of America's nuclear force and thus receive high priority in funding. The problem for the USN is that the current Ohio-class must begin being replaced within the next decade, but the cost of twelve new Columbia-class submarines will severely limit its ability to regenerate all the other force elements that will be required to meet the combined challenges of China and Russia.

It is more than a quarter of a century since the end of the Soviet Union and the disappearance of a serious threat to American dominance at sea, but the USN is suffering the consequences of many years of high operational tempo combined with inadequate funding and some poor acquisition decisions. The existing fleet needs more funds and more time to catch up on maintenance and training. To meet the new challenge of near-peer competition at sea, the USN will also have to spend much more effort on tactical development and innovation, raising its readiness for high-intensity operations. These demands are behind the changes in the USN approach to forward presence that had been implemented in recent times. The USN intends that its units spend more time in home waters, allowing a greater priority to training for complex scenarios. The Americans have made a virtue of necessity by emphasising the new unpredictability of their deployments, which are already being conducted with much greater emphasis on covert operations than in the recent past. The problem, as tensions in the Strait of Hormuz in mid-2019 demonstrated, is that the need to manage emerging crises may force the USN back into prioritising forward deployments ahead of training for possible contingencies. *See Chapters Five and Six.*

The USN's efforts represent just one part of a strategy to push the United States' competitors off balance and regain the strategic initiative. An important maritime element is likely to be the undermining of Chinese efforts to create an underwater bastion. Here the Americans must weigh the benefits of actively threatening the security of the Chinese SSBN force against the resource commitments that such efforts would involve, as well as the complications that it could represent for alliance arrangements, notably with Japan and Australia. Nevertheless, an anti-bastion effort was a key element of the successful "Maritime Strategy" of the 1980s, which saw the United States progressively force the Soviet Navy back into its home waters with the combination of an anti-SSBN campaign and the threat of direct strikes against the Soviet homeland. As the USN seeks to undermine China's "anti-access, area denial" capabilities, playing on any Chinese perceptions of their own vulnerabilities to force the People's Liberation Army Navy (PLAN) into a defensive posture and restrict its ability to deploy forces into the central Pacific must be an extremely attractive proposition.

In seeking to become the predominant maritime power in the western Pacific, China has its own problems of resources and technology. However attractive the concept of an at-sea deterrent force within its nuclear inventory, China must first extend the range of its submarine-launched missiles and considerably improve the stealth qualities of its missile submarines if it is to create a capability adequate of being a credible threat to the continental United States. This program must be balanced against the effort to dominate China's near seas within the first and second island chains, as well as to develop longer-ranged sea control and power projection forces in the form of carrier battle groups and amphibious units. If the missile problem can be solved, China's recent efforts to dominate the South China Sea and its development of a network of artificial islands in the Spratlys and Paracels will help make a local bastion in the South China Sea's deep waters an attractive concept, with the technological gap being compensated for by sheer numbers. In this regard, China's coast guard and its maritime militia forces are likely to be key, albeit low-technology, elements in the defence of SSBN patrol areas, but they cannot substitute for the high technology systems that will be essential to ward off potential attackers. *See Chapter Eight.*

The future of Taiwan is becoming an increasingly important problem for China, to the political and nationalist elements of which must be added a new strategic dimension. Possession of Taiwan would give China unfettered access to the deep waters of the Pacific Ocean, which would provide both an alternative for SSBN patrols to the South China Sea and the ability for covert deployments of naval forces for other purposes. Taiwan itself, with limited resources for its defence but vulnerable to long-range blockade as much as to outright invasion, has hard choices to make about the nature of its maritime forces. Focusing too much on purely coastal defence would leave China with the option, albeit with dire economic consequences for itself, of cutting Taiwan off completely from sea traffic – including its vital energy supplies – without necessarily firing a shot.

Russia's challenges are in some ways parallel to those of the United States, particularly its need to sustain a ballistic missile submarine force while modernising the remainder of its navy. Maintaining the at-sea nuclear deterrent remains the highest priority. However, replacement of the older SSBN with the new Borey-class must be consuming a very large share of the Russian Navy's resources. To the SSBN program must be added the need to renew the nuclear-powered attack submarine (SSN) force and continued development of the anti-submarine warfare (ASW) capabilities necessary to assure the bastions against potential attackers. The limited money available means that Russia's maritime power projection assets do not enjoy the same level of attention. There are reports that a refitted battlecruiser will join the Pacific Fleet in the near future, but its re-entry into operational service has been repeatedly delayed. As the Russians have only one other operational battlecruiser, which will soon require extensive refit, it is possible that its sister-ship will replace it in the Northern Fleet rather than coming to the Pacific. This sort of balancing affects all the Russian Navy's force elements as it struggles to allocate resources between widely distributed fleets, a problem shared by its maritime air elements. Given continuing conflicts in the Black Sea region and tensions in the Baltic, Europe is likely to remain a greater concern than the Pacific for the foreseeable future. The Russian forward presence in the Pacific is therefore likely to be much more diplomatic in nature than serious force projection, while its military planning will continue to focus on SSBN defence and domination of the sea areas close to the Russian coast. *See Chapter Nine.*

Japan's defence expansion, despite the tensions with China and the rise of the PLAN, has been relatively limited. Its most significant elements are focused on the development of amphibious forces capable of responding rapidly to any threat to the Ryukyus and to the contested Senkaku islands. The plan to embark fixed-wing strike fighters in the two largest "helicopter destroyers" must be seen in this context. Ten F35s in each ship will provide a measure of fleet air defence as well as close air support for a landing force but little more, and is certainly not a capability that threatens China's mainland. Japan's ASW efforts are much less visible but perhaps more significant for its maritime strategy. Japan's submarine force is slowly expanding, and the modernisation of its surface and air ASW forces continues. All constitute significant capabilities as well as key contributions to potential alliance operations that cannot be ignored by either China or Russia, and make the Japanese Maritime Self-Defense Force a formidable proposition in its own right. Where Japan faces hard choices is the extent to which its maritime forces move further afield as part of any effort to balance China, notably to the South China Sea. *See Chapter Seventeen.*

Australia faces equivalent dilemmas. While its defence expansion remains relatively constrained – and slow – its emerging force structure will provide both independent national capabilities as well as strategic weight in alliance terms in ways that are relatively new. Australia has been a regular presence in the South China Sea over many years, but the latest Indo-Pacific Endeavour task group deployments have been on a larger scale than the individual ship deployments of the recent past. As Australia is one of the few regional players with substantial high-technology capabilities, particularly in the ASW domain, the United States will be eager for Australian assistance. Singapore, possessing the only truly high-tech forces within the Association of Southeast Asian Nations (ASEAN) nations, will have an even more difficult task to accomplish in balancing a rising China and satisfying US requests, particularly as relationships with neighbouring Malaysia and Indonesia can be complex.

New Zealand's main concern remains the South West Pacific, but this sub-region is becoming increasingly exposed to great power rivalries, while the pressure on New Zealand to contribute to alliance operations can only increase in the present environment. The recent decision to replace the ageing P3-K Orion maritime patrol aircraft with four P8-A Poseidons confirmed that the New Zealand government recognises its potential coalition requirements as well as its own need to maintain surveillance of the country's huge areas of maritime strategic interest.

North Korea remains a wild card, with its efforts to develop an underwater nuclear deterrent only a small part of the increasingly complex problem its future presents for neighbouring countries and the region as a whole. *See Chapter Thirteen.*

India must balance its apparently unresolvable tensions with Pakistan against a developing strategic rivalry with China that has important maritime dimensions. The growing Chinese economic and military presence in the Indian Ocean threatens India's self-image as the dominant power in the region. India's interest in the South China Sea represents something of a riposte and a deliberate effort to complicate China's maritime strategy. On the other hand, the entry of the first Indian SSBN into operational service and its deterrent patrol commencement may have added to India's nuclear capabilities, but also creates a hostage to fortune that the Indian Navy must factor into its dispositions. Whether Pakistan will add to India's problems by embarking nuclear weapons in its submarine force is uncertain, as is the priority that the Pakistan Navy will give to locating and tracking Indian SSBNs. What is certain in any case is that India will give a high priority to improving its own ASW capabilities, an effort that may involve the quiet development of much closer links with both US and Japanese theatre ASW efforts. *See Chapters Ten, Eleven and Twelve.*

In sum, strategic competition in the increasingly competitive Indo-Pacific has a significant maritime element, which itself is profoundly influenced by the continuing importance – and progressive expansion – of the region's underwater nuclear deterrent. To an extent greater than the Cold War, both threatening and protecting such assets will be difficult to separate from other maritime campaigns. This particularly applies to potential ASW operations in the East and South China Seas, as well as to India and Pakistan and to North Korea, creating uncertainty as to the potential for unplanned escalations and outright accidents. Maintaining any kind of regional balance will, therefore, call for cool judgements on the part of all the players, judgements that will need to be continually revised in the light of technological innovation and force development.

Chapter 3
SSBN, Nuclear Strategy and Strategic Stability

Stephan Frühling

Almost three quarters of a century ago, the explosions at Hiroshima and Nagasaki in August 1945 ushered in the nuclear age in world affairs. And yet, these two explosions that merely hastened the end of World War II remain the only use of nuclear weapons in anger to date. So far, all nuclear powers have chosen to, in Fred Iklé's words, leave their nuclear weapons "encapsulated in a cocoon of non-use,"[1] and the unique destructive force of nuclear weapons thus continues to influence international affairs in an indirect, latent manner. No other weapon system embodies this menacing, but also out-of-sight presence of nuclear weapons better than the stealthy nuclear-powered ballistic missile submarines (SSBNs) that have, for six decades, ceaselessly prowled the world's cold ocean depths, waiting for an order that has never come.

SSBNs on Continuous At Sea Deterrence (CASD) missions remain the mainstay of the nuclear forces in the United States and France, and they are now the only platform on which British nuclear weapons are deployed. Despite Russia's significant investment in road-mobile missiles, they remain an important element of its nuclear forces. China has had a long-standing interest in developing SSBN technology, and in recent years has now also fielded its second generation of boats in numbers comparable to Britain and France. Israel has reportedly fielded nuclear armed (cruise) missiles on its conventionally powered submarines. Even newer, more prospective entrants to the SSBN club are India, Pakistan, and North Korea, which have all shown an interest in moving nuclear weapons under the sea. As these countries' programs mature, undersea nuclear deterrence will cease to be a preserve of the major powers, and the importance of SSBNs for regional order, stability, and deterrence in the Indo-Pacific area will only further increase.

What might be the consequence of the proliferation of SSBNs for strategic stability in the Indo-Pacific? "Strategic stability" itself is a concept that is generally understood to include crisis stability – in a narrow sense, the absence of incentives to use nuclear weapons first for fear the adversary might do so – and arms race stability – the absence of incentives to acquire additional nuclear forces to reduce incentives for the adversary to use nuclear weapons first.[2]

To understand the perceived and real benefits of SSBNs for strategic stability, it is worth recalling Bernard Brodie's famous 1946 dictum on the strategic impact of the "atomic bomb":

> The first and most vital step in any American security program for the age of atomic bombs is to take measures to guarantee to ourselves in case of attack the possibility of retaliation in kind. The writer in making this statement is not for the moment concerned about who will *win* the next war in which atomic bombs have been used. Thus far the chief purpose of our military establishment has been to win wars. From now on its chief purpose must be to avert them. It can have almost no other useful purpose.[3]

By the 1950s, deterrence based on massive nuclear arsenals had indeed become central to the avoidance of great power war. When studying the deployment pattern of the United States' Strategic Air Command in the early 1950s, however, a young RAND analyst by the name of Alfred Wohlstetter pointed out that the mere possession of atomic bombs was not sufficient for retaliation, as the ability of these arsenals to survive adversary attack was also necessary to maintain their deterrent value in crisis and war. Ever since, survivability – with a decent dose of inter-service rivalry – has been a major driving force for all nuclear weapons states' interest in placing nuclear weapons onto submarines, where they can disappear from view and hide from prying eyes in the vast emptiness of water.

Indeed, the lure of the SSBN as a technological solution to a strategic problem extends far beyond the naval and defence policy communities of the nuclear powers. In the international commentariat on nuclear weapons and international affairs, the idea that strategic stability could be "assured" by "mutually assured destruction," based on a relatively small number of large yield, survivable warheads; that retaliation is the main (if not only) role of any nuclear arsenal; and that the notion of "winning" in such a conflict was not worth contemplating, are still widely held and accepted by many. Survivable SSBNs, with large numbers of warheads for a countervalue, second strike, but also removed both geographically and conceptually from the messy temptation to escalate with so-called "tactical" nuclear weapons, thus seem an almost perfect fit and embodiment of Brodie's famous dictum on the "chief purpose" of military forces being, from now on, not to fight war, but to avert it.

In recent years, however, both elements that underpin this popular image of the SSBN in nuclear stability based on "mutually

[1] Fred C. Iklé, "The Next Lenin: On the Cusp of Truly Revolutionary Warfare," *The National Interest,* no. 47 (1997): 11.

[2] James Acton, "Reclaiming Strategic Stability," *Carnegie Endowment for International Peace*, February 5, 2013, https://carnegieendowment.org/2013/02/05/reclaiming-strategic-stability-pub-51032.

[3] Bernard Brodie, *The Absolute Weapon* (New York: Harcourt Brace, 1946), 76.

assured destruction" – survivability and their second-strike role – have come under open challenge. Commentators questioning the future survivability of submarines in general, and of SSBNs in particular, have been an important voice in the public debate on the construction of the next generation of SSBN, especially in the arguments on the replacement of the Trident nuclear submarines in the United Kingdom. A confluence of new technologies, such as unmanned vehicles and big data analytics, with improved sonar, signals, and imagery sensors, and the potential for completely new sensing technologies based on, for example, quantum effects, may render the oceans "transparent" to anti-submarine forces. If so, a central argument for the undersea nuclear deterrent may be invalidated, with potentially significant implications for the efficacy of defence spending in the nuclear powers and arms race stability between nuclear powers, and potentially catastrophic implications for crisis stability underpinned by nuclear deterrence. *See Part Three.*

In the United States, it was moves to diversify the operational roles of US SSBNs beyond the conduct of high-yield, nuclear strikes that have brought them to the centre of public debates. In the mid-2000s, the Bush administration's plans for a conventional "Prompt Global Strike" capability included proposals for a conventionally armed version of the Trident missile, which would have given SSBNs a completely new operational role. Many feared this would have led to the potential for catastrophic misunderstandings in a crisis and conflict, and Congress refused to fund the proposals.[4] More recently, the Trump administration's plans for a modified, low-yield Trident warhead (the W76-2) raised concerns that it would make SSBNs and their nuclear weapons more "useable," blurring the distinction between "strategic" and "tactical" strikes, and again could be mistaken for a much larger attack against an adversary's forces. While these new W76-2 warheads have already entered production,[5] the debates on the future role and capabilities of the US Navy's SSBNs are likely to continue.

And yet, the historical record regarding the vulnerability of SSBNs and their operational roles is already a lot more varied than often acknowledged in these debates. Technology is but one factor influencing the survivability of SSBNs, which has historically differed widely for different countries based on their geographic situation and adversary capabilities. During the Cold War, the United States developed long-range passive sonar systems that could track specific tonal frequencies of Soviet submarines in the North Atlantic and Pacific Oceans. These systems made Soviet undersea capabilities far more vulnerable than realised by the public at the time and, until the 1970s, even by the Soviet Union. Insofar as there was an undersea "arms race," it occurred not between adversaries' nuclear forces, but between Soviet SSBNs and US anti-submarine warfare (ASW) forces. In this and future contests, geography thus remains a central factor.[6] Control of shorelines and natural choke points will remain crucial to the deployment of permanent sensors as well as ASW forces, but whereas the SSBNs of the United States, France, Britain, India, and Pakistan have direct access to the world's ocean basins, those of China do not, and those of Russia only to the Arctic Ocean.

Hence, the ability (and incentive) to make use of new ASW technologies to increase the risk to those SSBNs that depend for their survival on undetected access to the ocean's great basins will differ for different powers, even before one takes national access to technology and resources into account. There are, however, also other ways of protecting SSBNs than relying on stealth alone: once the Soviet Union realised the vulnerability of its SSBNs and the range of its submarine-launched missiles allowed it to target the continental United States from the Arctic Ocean, it began to confine its SSBN deployments to "bastions" in the Barents Sea and Sea of Okhotsk that were actively defended against allied submarines by the Soviet Navy and by land-based aircraft. But if the survival of SSBNs depends not on stealth but one's own defensive ASW capabilities to protect them from adversary hunter-killer submarines, the implications of radical improvement of ASW for SSBN survivability and crisis stability also become less clear-cut. Indeed, this dynamic may in fact make SSBNs *more* survivable, not less – if at the cost of significant investment in defensive ASW forces.

Nor have SSBNs historically been used only for deterring nuclear attacks on the operating states' homeland. Since the 1960s, US and British Polaris submarines have been assigned to the North Atlantic Treaty Organization's (NATO) Strategic Commander in Europe as a contribution to the Alliance's regional deterrence posture, and provided an important part of his capability to conduct long-range strikes in the defence of Western Europe – an arrangement that continues to this day. In addition to range and survivability, using SSBNs for the defence of NATO had the additional advantage of reinforcing the "coupling" between the security of US allies and US strategic nuclear forces. The Soviet Union could only have reduced the threat from submarine-based missiles assigned to NATO by highly escalatory strikes against US (and British) SSBN and their bases, including those in North America.

[4] Congressional Research Service, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues* (Washington DC, 2019), 19–20, https://fas.org/sgp/crs/nuke/R41464.pdf.

[5] Julian Borger, "US Nuclear Weapons: First Low-Yield Warheads Roll off the Production Line," *The Guardian* (London), January 28, 2019. https://www.theguardian.com/world/2019/jan/28/us-nuclear-weapons-first-low-yield-warheads-roll-off-the-production-line.

[6] Owen R. Cote Jr, "Invisible Nuclear-Armed Submarines, or Transparent Oceans? Are Ballistic Missile Submarines Still the Best Deterrent for the United States?" *Bulletin of the Atomic Scientists* 75, no. 1 (2019): 30–35.

Whether submarines are to be used for retaliatory second strikes is thus primarily a question of intent and one where the historical role of SSBNs has also been more varied than reflected in popular conception. At a strategic level, the new W76-2 low-yield warhead variant is not a new capability for the Western alliance, as British submarines have long carried low-yield warheads on their Trident missiles,[7] providing a unique combination of range, promptness, and yield that is not available from any other system. After the Cold War, improvements to missiles, targeting systems, and fuses gave US SSBNs the ability to conduct counterforce strikes against hardened point targets.[8] Previously, the relative imprecision of submarine-launched ballistic missiles had restricted their use to larger area targets. US, Chinese, and a prospective North Korean SSBN may all be able to submerge and fire nuclear missiles, but the operational options that they provide remain very different. Only US SSBNs carry warheads in the numbers and with the precision required to enable a counterforce campaign against an adversary's nuclear forces.

Other more offensive operational roles, however, depend far less on technological sophistication and more on geographic positioning. For example, one advantage of using SSBNs for nuclear operations is the short warning time if submarines can approach their targets undetected – a concern that was particularly pertinent for the defence of North America against a surprise Soviet attack. In addition, the ability to launch missiles from unexpected angles also can help avoid the boresight of fixed missile defence and early warning radars. Moreover, China, Russia, and North Korea do not have allies (any more) from whose territory they could launch nuclear strikes onto US allies in Asia and Europe. For them, using sea-based nuclear forces for this task would have the strategic advantage of leaving their land-based missile forces out of the fight, and hence dedicated as a deterrent of US retaliation.

Whether the increased deployment of SSBNs in the Indo-Pacific will thus be stabilising or destabilising – in arms competition as well as in crises and war – remains an open and important question for regional security. Given the multiple centres of power in the Indo-Pacific, its connected conflict dyads, and regional order that lacks both the informal rules and clear dividing lines of the Cold War, conceiving of a regional concept for "stability" is fraught in general.[9] When assessing the current and future impact of SSBN technology and deployments on strategic stability in the Indo-Pacific, we thus need to look beyond superficial readings of Cold War history that equate SSBN forces with a supposedly stabilising way of deploying nuclear forces as a secure second-strike capability – for they may neither be intended for second strike, nor particularly secure. Rather than being a technologically deterministic relationship, the consequences of changes in ASW technology and of the deployment of SSBNs in the region will reflect the particular geographic and strategic circumstances of each adversarial dyad, and defy easy generalisation.

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[7] Austin Long, "Discrimination Details Matter: Clarifying an Argument about Low-Yield Nuclear Warheads," *War on the Rocks*, February 16, 2018, https://warontherocks.com/2018/02/discrimination-details-matter-clarifying-argument-low-yield-nuclear-warheads/.

[8] Keir A. Lieber and Daryl G. Press, "The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence," *International Security* 41, no. 4 (2017): 9–49.

[9] Robert Ayson, "Regional Stability in the Asia-Pacific: Towards a Conceptual Understanding," *Asian Security* 1, no. 2 (2005): 190–213.

Chapter 4

Arms Control and Sea-Launched Nuclear Weapons

Hans M. Kristensen and Matt Korda

Sea-launched nuclear weapons played a key role in the national security strategies of the United States, Russia (Soviet Union), Britain, and France throughout the Cold War,[1] and continue to do so today. By the late 1980s, five nuclear-armed states had a combined inventory of more than 14,500 naval nuclear weapons. After the Cold War ended, the number declined rapidly and significantly. Today, there are an estimated 3,980 naval nuclear weapons (see Table 1).

Table 1: Estimated Naval Nuclear Weapons, 1990 and 2019*

Country	1990	2019
United States	7,524	1,920
Soviet/Russia	6,410	1,540[a]
France	440	250
Britain	125	200
China	12[b]	48[b]
India	0	12
Pakistan	0	0[c]
Israel	0	(5-10)[d]
North Korea	0	0
Total	**14,511**	**3,975-80**

* Estimates based on Nuclear Notebooks, SIPRI Yearbooks, and authors' estimates.

[a] Russia's 1,540 naval nuclear weapons include 720 strategic and 820 tactical.

[b] Two more SSBNs are fitting out.

[c] Pakistan is developing the Babur-3 cruise missile for its submarines.

[d] Israel might have a small inventory of submarine-launched cruise missiles.

Even though the total number of naval nuclear weapons today is significantly smaller than during the Cold War, this category of weapons comprises nearly 30 per cent of the world's 13,890 nuclear weapons.[2] That is actually a greater share than in 1990, when naval nuclear weapons accounted for 24 per cent of the global nuclear weapons inventory. Furthermore, naval nuclear weapons constitute the most important leg of most nuclear-armed countries' strategic forces because nuclear-powered ballistic missile submarines (SSBNs) are considered virtually invulnerable and largely immune to a surprise attack. One country (the United Kingdom) has even converted to a nuclear posture that relies exclusively on SSBNs.

However, the naval nuclear arsenals of the nuclear-weapon states differ significantly, as do the strategies for their potential use. The United States has the largest number of naval nuclear weapons, but they are all strategic.[3] More than half of Russia's naval nuclear weapons are tactical, which has serious implications for their potential use.[4] The vast majority of France's nuclear weapons are for naval platforms, while Britain exclusively has naval nuclear weapons. In addition, more nuclear-weapon states are adding sea-based nuclear weapons to their arsenals. This includes China and India, while Pakistan and North Korea are developing their first naval nuclear weapons.

In the Indo-Pacific, naval nuclear forces are undergoing significant developments. The United States today homeports nearly two thirds of its SSBNs in the Pacific, a stark contrast to the Cold War when most were based on the US east coast. Russia has traditionally placed less emphasis on its Pacific SSBN fleet, which was allowed to atrophy after the Cold War. In recent years, however, most of the new Borei-class SSBNs have been moved to the Pacific to replace the ageing Delta-III SSBNs. China has launched an entirely new fleet of SSBNs, and India is beginning to build an SSBN fleet that will be homeported in the Indian Ocean.

One reason why naval nuclear weapons seem so attractive is that the submarine-based types promise near-invulnerability. SSBNs are consistently characterised as the most stable and reliable leg of the nuclear triad. Their stealth provides, in theory, the assured retaliatory capability that underpins deterrence and strategic stability. But this is only half the story.

[1] For an overview of naval nuclear weapons at the end of the Cold War, see Joshua Handler and William M. Arkin, "Nuclear Warship and Naval Nuclear Weapons 1990: A Complete Inventory," *Neptune Papers No. 5, Greenpeace International* (1990) https://fas.org/nuke/guide/nep5text.htm; Hans M. Kristensen, "Declassified: US Nuclear Weapons At Sea," *FAS Strategic Security* (blog), February 3, 2016, https://fas.org/blogs/security/2016/02/nuclear-weapons-at-sea/.

[2] For an overview of world nuclear forces, see Hans M. Kristensen and Matt Korda, "Status of World Nuclear Forces," *Federation of American Scientists,* https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/.

[3] For an overview of the US nuclear weapons arsenal, see Hans M. Kristensen and Matt Korda, "United States Nuclear Forces, 2019," *Bulletin of the Atomic Scientists* 75, no. 3 (2019): 122–134, https://www.tandfonline.com/doi/pdf/10.1080/00963402.2019.1606503?needAccess=true.

[4] For an overview of the Russian nuclear weapons arsenal, see Hans M. Kristensen and Matt Korda, "Russian Nuclear Forces, 2019," *Bulletin of the Atomic Scientist*s 75, no. 2 (2019): 73–84, https://www.tandfonline.com/doi/pdf/10.1080/00963402.2019.1580891?needAccess=true.

Although SSBNs used to serve a "stabilising" role, improvements in accuracy and fusing have transformed their role by giving them the capability to hold at risk even the hardest targets, a capability that only intercontinental ballistic missiles (ICBMs) used to have. While only a portion of the US SSBN warheads once had hard-target kill capability, today all of them have such a capability, thanks to improvements in missile accuracy and enhanced fuses with flexible height-of-burst capability. Such improvements have transformed retaliatory weapons into potential first strike ones, and, moreover, the technology and expertise are theoretically available to any country capable of building advanced ballistic missiles.

Stealth and invulnerability may be useful to maintain a secure retaliatory capability, but these are also invaluable traits for offensive nuclear operations. Stealthy platforms with highly capable nuclear weapons can be inherently destabilising because they can threaten a surprise first strike, while weapons with much longer flight times or lower speeds cannot. A modern SSBN can strike a target twice as fast as an ICBM. Moreover, while a strategic ballistic missile can be detected in flight by early-warning systems, tactical cruise missiles fly low and can be very hard to detect. As a result, offensive naval nuclear forces nominally intended to enhance deterrence will almost inevitably cause an adversary to try to develop countermeasures – including placing nuclear weapons on high alert – so that they have a chance to launch before being destroyed by a submarine-launched ballistic missile (SLBM) launched on a compressed trajectory. This dynamic could worsen in the future if nuclear-armed states begin to deploy nuclear-armed hypersonic cruise missiles.

Even the smaller naval nuclear weapon states in the Indo-Pacific are pursuing SSBN capabilities that appear to go beyond a mere retaliatory mission. After the first tests of India's K-15 SLBMs in August 2018, an Indian defence official stated that all three missiles reached their targets "with high accuracy, reaching close to zero circular error probable."[5] Although such statements might be hyperbole, they reflect an intention to perfect a capability that could be used for a first strike. In a similar vein, China's follow-on to its current class of JL-2 SLBMs might come with capabilities similar to the DF-21D and DF-26 that will enable near-precision nuclear strikes. And Pakistan's new Babur-3 submarine-launched cruise missile is capable of striking targets "with high accuracy" at a range of 700 kilometres.[6] As these countries continue to improve the quantity and accuracy of their sea-launched nuclear weapons – and particularly if China eventually decides to deploy multiple independently targetable re-entry vehicles (MIRV) on their submarines – their first strike potential could trigger an undersea arms race in the region.

Large military adversaries will try to develop capabilities to detect and destroy naval nuclear launch platforms that can threaten them. This effort intensifies the more capable the adversary's capabilities become. During the Cold War, the United States and the Soviet Union spent enormous resources on a cat-and-mouse game to hold at risk SSBNs and attack submarines. The US Navy developed capabilities to trail Soviet SSBNs without being detected and created a maritime strategy to hunt down and destroy the subs. The Soviet Union reacted by pulling their SSBNs into "bastions" protected by attack submarines and anti-submarine forces. China appears to be developing a similar SSBN posture. Experts have noted that such requirements may prompt China, and possibly also India, to shift from a sea-denial to a sea-control strategy near its coastal waters,[7] which could in turn trigger underwater arms races and growing tension in the region.

An SSBN bastion posture might signal stability, but it could also indicate deep invulnerability from being pushed into a corner. An aggressor would almost inevitably try to penetrate the bastion to hold the SSBNs at risk; after all, holding at risk what the adversary values most is the essence of deterrence doctrine.

The combination of increased threats against naval nuclear platforms and the growing counterforce capability of the weapons they carry might also erode the no-first-use policies of both India and China. India already has a doctrine that allows for nuclear use in response to non-nuclear attacks, an act that would be first use of nuclear weapons. And China's fear of the vulnerability of its retaliatory capability has caused it to develop nuclear weapons that are better to manoeuvre, quicker to launch, and more efficient against a wider range of not just countervalue but also counterforce targets. It is now developing new missile silos that appear intended for solid-fuel ICBMs that can launch quicker than the existing liquid-fuel ICBMs.

Command and control (C2) vulnerabilities should also pose significant concerns in relation to the proliferation of sea-launched nuclear weapons. Anxiety over the reliability of nuclear-related C2 during a crisis could prompt Indo-Pacific countries to disperse

[5] Franz-Stefan Gady, "India Test Fires Shirt-Range Ballistic Missiles From Submerged Sub," *The Diplomat*, August 22, 2018, https://thediplomat.com/2018/08/india-test-fires-short-range-ballistic-missiles-from-submerged-sub/.

[6] *The Express Tribune*, "Pakistan Conducts Successful Test of Enhanced Version of Babur Cruise Missile: ISPR," April 14, 2018, https://tribune.com.pk/story/1685586/1-pakistan-conducts-successful-test-enhanced-version-babur-cruise-missile-ispr/.

[7] Tong Zhao, "Tides of Change: China's Nuclear Ballistic Missile Submarines," *Carnegie Endowment for International Peace*, 2018, https://carnegieendowment.org/files/Zhao_SSBN_final.pdf.

their nuclear weapons to submarines on deterrent patrols during peacetime, potentially even pre-delegating launch authority as necessary. This would be a serious shift for China in particular, which safeguards its nuclear weapons within a highly centralised storage system. Warhead dispersal and pre-delegation of launch authority could lead to overreactions and accidental nuclear launches during a crisis, particularly if a country's C2 has been disrupted.

As detection technology and anti-submarine weapons become more advanced, the survivability of SSBNs will also be increasingly threatened. Recent scholarship suggests that Cold War submarines might have been much more vulnerable than previously believed,[8] and as new acoustic sensors, detection lasers, unmanned underwater vehicles (UUVs), and big data processors come online, the survivability of SSBNs might eroded even further. *See Part Three.*

How to manage these challenges? Strategic naval nuclear forces previously were limited by the SALT and START agreements and the Seabed Treaty prohibits deployment of nuclear weapons on the ocean floor. But the only nuclear arms control agreement currently in effect – the New START treaty – does not explicitly limit naval strategic forces at all. Similarly, the Intermediate-Range Nuclear Forces Treaty only limited land-based missiles, and it has now been abandoned. There are no limitations or regulations guiding naval non-strategic nuclear forces at all.

It seems highly unlikely that a new treaty could be drawn up under the current political conditions. On top of 2019's negative arms control trends, it would be a hard sell to convince the nuclear-armed states to limit what is perceived as the most "stabilising" leg of the triad, particularly for countries who utilise their SSBNs to offset any imbalances or absences of the other legs. The issue is compounded by the fact that countries with SSBNs use them for a variety of purposes, including a mixture of countervalue and counterforce missions. Strategic nuclear submarines are also a highly coveted status symbol for certain countries who have chosen to build them in spite of the exorbitant costs, risks, and relative inutility for their nuclear doctrines. They certainly aren't likely to give them up anytime soon. Finally, given the extreme secrecy surrounding each country's submarine program, it seems unlikely that any country would allow inspectors to inspect their boats, making it difficult to envision an agreement covering sea-launched missiles.

Having said that, it is worth thinking about what naval nuclear arms control could potentially look like.[9] There will potentially come a time when unbridled deterrence is no longer seen as sufficient and security conditions deteriorate so much that arms control again becomes an important tool to try to limit adversarial offensive nuclear capabilities.

One could imagine limits on how many nuclear submarines a country could have. SSBNs are huge and easy to detect when in port or surfaced. Although it seems difficult to envision an arms control agreement covering what exactly goes *inside* an SSBN's launch tubes, it might be possible to imagine one that covers the *number of tubes* present per submarine. Such an agreement could take the form of an international standard that limits submarines to only ten or even four launch tubes, which is more than enough to sustain a countervalue mission but would limit their first strike potential. Destroying superfluous launch tubes (for example, to bring a submarine with sixteen launch tubes down to the hypothetical standard of four) could be facilitated by international technicians, and subsequently monitored by satellites. The proliferation of high-resolution geospatial imagery has made it essentially impossible to conceal submarines or launch tubes from commercial and military satellites, so such an agreement could be easily monitored without physical inspections.

One could also envision remote visual inspection of the number of re-entry bodies on missiles. The current New START Treaty allows for that, although each re-entry body is hidden under a cover; the objective of the inspection is the number of bodies, not what they are.

In addition to SSBNs, non-strategic or tactical naval nuclear weapons present unique challenges for efforts to limit escalation and maintain the now 74-year-old taboo against using nuclear weapons. Tactical naval nuclear weapons might be seen as less controversial to use because they would be used at sea against other naval forces and cause relatively few civilian casualties. As a result, the oceans could potentially become the first place where the taboo of non-use of nuclear weapons could be broken.

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[8] Austin Long and Brendan Rittenhouse Green, "Stalking the Security Second Strike: Intelligence, Counterforce, and Nuclear Strategy," *Journal of Strategic Studies* 38, no. 1–2 (2014): 38–73, https://www.tandfonline.com/doi/pdf/10.1080/01402390.2014.958150.

[9] For insightful analysis of naval nuclear arms control, see James John Tritten, *A New Case For Naval Arms Control*, Naval Postgraduate School, 1992, https://apps.dtic.mil/dtic/tr/fulltext/u2/a259759.pdf; Richard Fieldhouse, ed., *Security at Sea: Naval Forces and Arms Control* (Oxford: Oxford University Press, SIPRI Publications, 1990), https://www.sipri.org/publications/1990/security-sea-naval-forces-and-arms-control.

Limiting or controlling non-strategic naval nuclear weapons is a lot more difficult because they are much smaller, more diverse, and because their launch platforms overwhelmingly are dual-capable. Nonetheless, the Presidential Nuclear Initiatives of the early 1990s were carried out without any form of verification – only declarations and national technical means. They were made easier by the destruction of entire systems and because weapons were offloaded from launchers and brought into central storage facilities that provided some degree of monitoring with national technical means.

One could also envision confidence-building measures by which countries agreed to certain types of behaviours to increase the transparency and predictability of naval nuclear forces. This could potentially involve disclosing the types of platforms that are nuclear-capable or disclosing the total number of platforms and weapons (the United States and France have declared their total number of nuclear warheads). One could imagine an agreement to notify others when platforms declared as nuclear-capable deploy from their home bases (the New START Treaty includes notifications of strategic bomber movements), an agreement to only load missiles in the open to enhance transparency and counter worst-case analysis, and to disclose long-term force levels plans – just to mention a few (see Table 2).

Finally, one could envision drawing up operational norms. One might be agreeing not to harass or trail SSBNs (the Incident at Sea Agreement between the Soviet Union and the United States included limitations on dangerous operations). One could imagine an agreement not to do large salvo-launches of missiles or not to surge large numbers of nuclear launchers in a short period of time (the 1994 de-targeting agreements between Russia, the United States, China, and Britain are other examples).

Five of the world's nuclear-armed states border the Indo-Pacific and all are either already operating naval nuclear forces or developing the capabilities to do so. All are modernising their forces and adding new or improved capabilities. This development is likely to increase in the years ahead. It is beyond doubt that naval nuclear weapons capabilities are undergoing significant changes that require the international community to seek to regulate, to some extent, their force development, operations, and dynamics.

Table 2:
Potential Arms Control Measures for Sea-Based Nuclear Weapons

Type	Description
Numerical limits	• Limit on missile launch tubes • Limit on re-entry bodies • Limit on total number of platforms
Operational norms	• Don't harass, trail, or hunt SSBNs • Don't deploy close to potential adversaries • Don't launch more than two missiles during flight tests • Don't surge large numbers of SSBNs
Confidence-building	• Disclose which platforms and weapons have nuclear capability • Disclose total numbers of platforms and weapons • Notify of deployment from home base • Load missiles in view of satellites • Exchange test-launch telemetry • Announce long-term force level plans • Limit warfighting mission • Limit strategy to truly retaliatory second-strike role

PART 2
Strategy, Policy and Capabilities

Chapter 5

The SSBN and US Nuclear Strategy: The Future of the Maritime Deterrent

James J. Wirtz

Today is an age of acceleration, a time when Moore's Law is creating profound changes at diminishing intervals, making it difficult to anticipate strategic, social, and technological developments.[1] Some organisations facing these cascades of change, however, continue to plan for the Keynesian long term by adopting programs intended to endure for many years. One of those organisations is the US Navy (USN), which sails a steady course, stabilised by personnel and program cycles and equipment lifetimes that unfold over several decades. As a result, the United States has a plan and an existing program to maintain a nuclear deterrent onboard a nuclear-powered ballistic missile submarine (SSBN) fleet until the end of the 21st century, and the USN is up to that task. Unless we truly encounter a black swan at sea – an unanticipated event that shifts the course of history in significant ways[2] – the USN will have twelve nuclear-capable Columbia-class (SSBN-826) submarines by the early 2040s.[3]

To unpack the elements that contribute to this certainty and the nuance inherent in the Navy's attitude towards its SSBN fleet, the chapter explores the doctrine, organisational culture, and programmatics that enable such precise predictions despite acceleration. The arrival of a black swan is admittedly unpredictable; however, the chapter will also survey which nest of technological or social changes might harbour that dark cygnet that will end the US commitment to the SSBN. The chapter also will identify some long-standing trends that might diminish the role of the SSBN by the end of this century. The conclusion offers a few reflections on why the SSBN is an anomaly in an age of acceleration.

The Commitment to the SSBN

SSBNs are extremely complex and costly machines that require highly trained and dedicated crews to operate in a most unforgiving environment. On a cost per warhead basis, they are probably the most expensive nuclear weapon basing scheme in existence. When deployed, their communications become problematic and potentially dangerous because they can reveal the location of the submarine. The fact that their weapons are fundamentally at the disposal of the crew raises positive and negative command and control issues. Generally accepted metrics can and do suggest that other delivery and deployment mechanisms offer cost, command and control, and even safety and surety advantages compared to the SSBN. Nevertheless, because they are considered to be survivable while deployed, thereby providing a secure second-strike capability, SSBNs, along with their submarine-launched ballistic missiles (SLBMs), are central to US nuclear doctrine and deterrence strategy. Americans are true aficionados when it comes to deterrence theory – they have taken the great works to heart and embrace the notion that the ability to hold targets at risk after suffering a nuclear attack or some other destructive insult is the *sine qua non* of nuclear deterrence.

The US national security establishment is in complete and enduring agreement about the imperative of maintaining the SSBN/SLBM system. Both the Obama administration's (2010) and the Trump administration's (2018) *Nuclear Posture Reviews* used virtually the same language to describe the benefits of retaining SSBNs as part of the nuclear deterrent: survivability, no near or medium-term threats, and the ability to upload warheads as a hedge against potential threats or failures affecting the other two legs of the US nuclear triad (bombers and intercontinental ballistic missiles).[4] Both administrations echoed the key finding of the Bush administration's (2002) *Nuclear Posture Review* by highlighting the need and endorsing the effort to replace ageing Ohio-class SSBNs.

By contrast, the Navy's organisational culture tends to hive off the SSBN force from "Big Navy" discourse about budgets, programs, priorities, and strategies. While the SSBN force has its place in the Navy, interest in the nuclear mission has been lukewarm since the so-called "revolt of the admirals" (the supercarrier vs B-36 imbroglio that occurred when the US Congress gave the nuclear deterrence mission to the newly created US Air Force) in 1949.[5] The Navy initially rejected the SSBN outright, fearing that funding for Navy priorities would eventually be used to acquire

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[1] Thomas L. Friedman, *Thank You for Being Late: An Optimist's Guide to Thriving in the Age of Accelerations* (New York: Farrar, Straus and Giroux, 2016).

[2] Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable* (New York: Random House, 2007).

[3] US Congressional Research Service, *Navy Columbia (SSBN-826) Class Ballistic Missile Submarine Program,* (Washington DC, 2019), 6, https://assets.documentcloud.org/documents/6183351/Navy-Columbia-SSBN-826-Class-Ballistic-Missile.pdf.

[4] US Department of Defense, *Nuclear Posture Review Report* (Washington DC, 2010), 21-22, https://dod.defense.gov/Portals/1/features/defenseReviews/NPR/2010_Nuclear_Posture_Review_Report.pdf; and US Department of Defense, *Nuclear Posture Review* (Washington DC, 2018), 44-45, https://media.defense.gov/2018/Feb/02/2001672886/-1/-1/1/2018-nuclear-posture-review-final-report.pdf.

[5] George W. Baer, *One Hundred Years of Sea Power: The United States Navy 1890-1990* (Stanford: Stanford University Press, 1994), 304-309.

and execute this "national asset and mission." No less a figure than Arleigh Burke persuaded his fellow admirals to accept the first-generation Polaris SSBN with the promise (lie?) that the new system and mission would not infringe on Navy budgetary and operational priorities.[6] Navy strategy and program documents dutifully reference the SSBN force and the important role the Navy plays in maintaining the US nuclear deterrent. However, for a blue-water Navy intent on exercising not just command of the sea everywhere, but its right to conduct flight operations in the Straits of Taiwan,[7] nuclear war, nuclear deterrence, and the SSBN is a contingency, strategy, and capability of middling institutional importance. To be fair, however, the Navy does identify the new SSBN as a budgetary priority,[8] although it does so without much strategic elaboration.

In terms of organisation and administration, the Navy is configured to develop and operate SSBNs as part of the fleet for the indefinite future because the Navy is organised to maintain internal stability in the face of external change. Each beat of "Navy-Time" is roughly 25 to 30 years long, which corresponds to the average length of an officer's career and the duration of the Navy's shipbuilding plan. The Navy's current 30-year Shipbuilding Plan (FY2019–FY2023) locks in the purchase of the first Columbia-class SSBN in 2021 and then surges spending in 2023 as the production of SSBNs increases around the middle of the next decade. The captain of the *Columbia*, the first of the new Columbia-class SSBNs that is expected to be deployed in 2031, is already serving as a junior officer in the SSBN fleet. In other words, the Navy is currently training and educating the first commander and the first executive officer of the *Columbia*. The Navy of today really is the Navy of tomorrow, and that Navy has 2031 as a hard target for the operational deployment of the first Columbia-class SSBN.

Regardless of partisan affiliation, there is strong consensus that the SSBN/SLBM weapons system provides the United States with the secure second-strike capability central to its strategy of nuclear deterrence. Navy officers acknowledge their deterrent mission, while keeping the SSBN fleet isolated from ongoing debates about strategy and force structure that are animated by concerns about the future of carrier aviation. The failure of the SSBN to figure prominently in debates about Navy strategy is not necessarily a bad thing for submarine proponents – the fact that SSBNs will be part of the fleet is not a matter of strategic debate within the US Navy. The Columbia-class already exists well within the current beat of "Navy-Time."

Trends and Black Swans

The latest *Congressional Research Service Report* (October 2019) on the Columbia-class SSBN highlights several issues confronting the program. Cost uncertainty, cost growth, scheduling and technical risks, and the fact that the Columbia-class are linked to the British program to build the Dreadnaught-class SSBNs are depicted as problems that could cause a delay in reaching an initial operational capability scheduled for 2031.[9] These types of problems often complicate big-ticket weapons programs, but the Columbia-class is also part of an enduring trend – specifically, the steady decline in the size of the US SSBN fleet. The US deployed 31 Lafayette/Benjamin Franklin-class SSBNs (616/640), eighteen Ohio-class SSBNs (726), and is now planning on twelve Columbia-class boats.[10] Admittedly, the Ohio-class carried more missiles (24) than earlier classes, but Columbia-class is designed to carry only sixteen SLBMs. This reduction in the size of the SSBN force thus mirrors the overall reduction in the size of the US strategic deterrent, which is down from about 10,000 deployed warheads at the end of the Cold War to the New Start Treaty level of 1,550 deployed warheads. It has been over a decade since the Prague Speech, when President Obama highlighted nuclear disarmament as a long-term US objective, and the law of diminishing returns affects everything, including force reductions, but each new generation of US SSBN contains approximately 40 per cent fewer ships than its predecessor. If this trend continues, the next class of SSBN, which would be under development around 2060, would contain only seven boats, which would yield an incredibly high cost-per-deployed-warhead. Given the many decades spanned by the Columbia-class program, what amounts to a trend towards disarmament might undermine support for the SSBN in the out-years. There is a chance that some combination of the high cost of deploying so few warheads on such an expensive system and the perception of diminished need might make the Columbia-class the last US SSBN. Already there is talk that the United States might be able to get by with only ten Columbia-class SSBNs.

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[6] Desmond Ball, *Politics and Force Levels: The Strategic Missile Programs of the Kennedy Administration* (Berkeley: University of California Press, 1980), 59-62; and Peter D. Haynes, *Toward a New Maritime Strategy: American Naval Thinking in the Post Cold War Era* (Annapolis, Maryland: Naval Institute Press, 2015), 21-22.

[7] Tal Axelrod, "Navy Official Says Carrier Could Be Sent through Taiwan Strait," *The Hill,* January 18, 2019, https://thehill.com/policy/international/china/425984-navy-officials-says-carrier-could-be-sent-through-taiwan-strait.

[8] US Navy, *A Design for Maintaining Maritime Superiority Version 2.0* (December 2018), https://www.navy.mil/navydata/people/cno/Richardson/Resource/Design_2.0.pdf. The Chief of Naval Operations' Navigation Plan 2015-2019, which identifies the Navy's budget priorities, placed maintaining "a credible, modern, and survivable sea-based strategic deterrent," at the top of its list: US Navy, *CNO's Navigation Plan* 2015-2019, https://www.navy.mil/cno/docs/140818_CNO_Navigation_Plan.pdf.

[9] US Congressional Research Service, *Navy Columbia (SSBN-826) Class Ballistic Missile Submarine Program: Background and Issues for Congress*, (Washington DC, 2019), https://fas.org/sgp/crs/weapons/R41129.pdf.

[10] Ibid., 45.

The longevity of the Columbia-class program is also an anomaly in an age of acceleration; the combination of longevity and acceleration creates a setting where the emergence of a black swan threat to the program appears likely. These black swans might have innocuous beginnings. For instance, so-called CubeSats now provide high-resolution imagery on a daily basis of the entire planet – this type of imagery, combined with appropriate search algorithms, might reveal SSBN operational signatures that have so far remained unobserved. By contrast, threats to the survivability of SSBNs might result from more deliberate technological developments. Advances in artificial intelligence might yield ways to identify SSBN operational signatures that remain unknown, even though they exist in currently available ocean surveillance data. There might also be brute force solutions to submarine surveillance – given sufficient computational power, the oceans might become increasingly transparent. Deliberate cyber-attacks, cyber context (for example, unintended and unauthorised interaction between classified and public computer and communication networks),[11] autonomous/robotic anti-submarine weapons, nano-technologies, nano-energetics, and various forms of insider threats alone or in unanticipated combinations could potentially pose a threat to the SSBN. In fact, these types of threats already exist over a decade before the first Columbia-class submarine is expected to be deployed. The US Navy's autonomous surface ship *Sea Hunter*, for instance, was designed with an ASW mission in mind, and China is developing underwater acoustic systems that might be used to coordinate attacks by swarms of cheap autonomous vehicles.[12] *See Part Three.*

Regardless of its technological or operational origins, a black swan that undermines the survivability of the SSBN will greatly undermine support for the SSBN/SLBM system. Survivability is the strength and the Achilles heel of the SSBN. The extraordinary cost of this nuclear weapons deployment scheme is only justified on the basis of survivability, and anything that calls that survivability into question will undermine support for the SSBN.[13] Given the relatively long lead-time before the deployment of the first Columbia-class SSBN, there is a chance that some new threat might materialise before the Columbia-class actually goes to sea, forcing naval architects and builders to integrate modifications quickly into existing designs. This sort of development, however, would have far-reaching consequences because the United States would be forced to undertake profound operational and materiel responses across its deterrent force to compensate for the emerging threat to its primary nuclear second-strike capability.

Conclusion

There is a paradox hovering around any assessment of the future of the US SSBN fleet. On the one hand, the US political and strategic commitment to the SSBN is firm and abiding, and the Navy has a long record of successfully building and maintaining systems over many decades. It is only a slight exaggeration to say that after death and taxes, you can assume that there will be a US SSBN fleet in your future. On the other hand, acceleration produces profound technological, social, and political changes at diminishing intervals, placing a premium on rapid innovation, adaptability, and diversity of systems that can respond to an increasingly chaotic environment. The SSBN bucks this trend. It is a big-ticket item that resists modification. It is intended to last for decades. The SSBN places the US secure second-strike capability into a few extremely expensive baskets despite the fact that trends in just about every other industrial and technological domain favour rapid production of low-cost systems optimised to exploit short-lived technological advantages. Oddly enough, those closest to the US SSBN programs do not seem to recognise that this paradox exists. The failure to recognise and somehow respond to this longevity-acceleration paradox might, in fact, be the greatest threat facing the future of the next generation of SSBNs.

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[11] Andrew Futter, *Hacking the Bomb: Cyber Threats and Nuclear Weapons* (Georgetown University Press, 2018).

[12] US Government Accountability Office, *National Security: Long-Range Emerging Threats Facing the United States as Identified by Federal Agencies*, GAO-19-204SP, (Washington DC, 2018), 4.

[13] Tactical boldness, operational dexterity and technological ingenuity have been combined in the past to hold SSBNs at risk. There is no reason to think that these efforts are not ongoing and pervasive, see Austin Long and Brendan Rittenhouse Green, "Stalking the Secure Second Strike: Intelligence, Counterforce, and Nuclear Strategy," *Journal of Strategic Studies* 38, no. 1-2 (2015): 38-73.

Chapter 6
The US Sea-Based Nuclear Deterrent in a New Era

Thomas G. Mahnken and Bryan Clark

The US undersea deterrent is the most survivable leg of America's nuclear triad of ground, air, and sea-based nuclear capabilities. American allies France and the United Kingdom also rely on nuclear-powered ballistic missile submarines (SSBNs) for nuclear deterrence. The sea-based leg, however, is also the most brittle of the nuclear triad, as losing the ability for an alert SSBN to launch on order renders all its missiles unusable. With the return of great power competition between the United States, China, and Russia, the importance of the undersea deterrent has led to increased efforts by US adversaries to develop new ways to find and hold at risk nuclear submarines. US and allied leaders will need to assess how their own deterrent, and US extended deterrence, may need to evolve.

Nuclear Deterrence in US Strategy

Although nuclear deterrence forms the bedrock of US defence strategy, its importance has varied over time. The collapse of the Soviet Union led some to question the continued utility and purpose of US nuclear forces. In the post-Soviet era, challenges posed by regional actors and nuclear proliferation shifted US attention away from Russia's nuclear arsenal. Deterrence, although still important, moved to the margins of US national strategy.[1] Conventional weapons were sufficient to deter most potential US adversaries and, as a result, nuclear deterrence seemed to some superfluous. Ultimately, however, each successive presidential administration has continued to assert the value of a strong nuclear deterrent and flexible triad to US national security. The nuclear capabilities that deterred Soviet aggression have been perceived as equally valuable in deterring the lesser adversaries and rogue states that posed many US national security challenges in the post–Cold War era. Moreover, the re-emergence of great power competition in recent years has refocused attention on the nuclear arsenal and prompted renewed discussion about the combination of capabilities, posture, and policy necessary to deter great powers in an increasingly multipolar world.

Although other nuclear states maintain arsenals primarily to deter attacks against their homelands, the US nuclear arsenal is also designed to extend US deterrence and defend US allies in Europe and Asia from both nuclear and conventional security threats. The historic refusal of US presidents to commit to no-first-use of nuclear weapons stemmed in part from the US reliance on nuclear forces to counterbalance the Soviet Union's conventional military superiority in an attack on Western Europe. The imperative to reinforce the credibility of US extended deterrence guarantees profoundly shapes US declaratory posture and force structure, and it represents a major asymmetry between the US and its nuclear competitors. If successful deterrence policy is understood as a function of perceived will and capability, extended deterrence is particularly sensitive to the will side of the equation. The perception of US willingness to use potentially devastating capabilities in response to a non-homeland threat determines the credibility of the US commitment.[2]

As a result, alliance politics have been more embedded in US nuclear decision-making than in that of any other nuclear state, both during the Cold War and in the current era. Declaratory policy and the composition and posture of US forces can reinforce or erode the perceived credibility of the US nuclear guarantee, as evidenced by increasing European anxiety during the détente period as leaders wondered if nuclear "sufficiency" would adequately preserve European security amid an ever-expanding Soviet arsenal. Consequently, the provision of extended deterrence requires that the United States maintains a certain level of transparency about the size, scope, and intended use of the US nuclear arsenal that is not required of either China or Russia.[3] The US government cannot keep its nuclear doctrine and the contents of its arsenal secret and simultaneously reassure allies that it is both willing and able to act as their security guarantor. Consequently, throughout the Cold War, US policy reflected far less "calculated ambiguity" than that of the Soviet Union.

The tension between US willingness to defend its allies' territorial integrity but not necessarily their overseas interests has at times soured US allies on the extended deterrence arrangement. After the United States signalled its selective commitment to French security interests during the 1956 Suez Crisis, the French government opted instead to pursue an independent nuclear capability that would better preserve the country's defence and its interests.

US nuclear strategy relies on extended deterrence guarantees to deter countries from pursuing indigenous nuclear capabilities, even

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[1] Lawrence Freedman, *Deterrence* (Cambridge: Polity Press, 2004), 1.

[2] See Phillip A. Karber and Jerald A. Combs, "The United States, NATO, and the Soviet Threat to Western Europe: Military Estimates and Policy Options, 1945–1963," *Diplomatic History* 22, no. 3 (Summer 1998): 399–429; Albert Wohlstetter, "Nuclear Sharing: NATO and the N+1 Country," *Foreign Affairs* 39, no. 3 (April 1961), 355–387; and David N. Schwartz, *NATO's Nuclear Dilemmas* (Washington DC: The Brookings Institution, 1983), 136–192.

[3] Timothy W. Crawford, "The Endurance of Extended Deterrence: Continuity, Change, and Complexity in Theory and Policy," in *Complex Deterrence: Strategy in the Global Age*, ed. T.V. Paul, Patrick M. Morgan and James J. Wirtz (Chicago: University of Chicago Press, 2009), 277.

in the case of US allies like Germany, Taiwan, and South Korea.[4] The imperative to prevent proliferation was great enough that the United States pursued Soviet cooperation to establish both the 1963 Partial Test Ban Treaty and the 1968 Nuclear Non-Proliferation Treaty, which constrained the acquisition of nuclear forces by US and Soviet allies alike.[5] In addition to improved global security and crisis stability, non-proliferation also encouraged the convergence of US and allied security concerns and dissuaded US allies from pursuing actions contrary to US interests.

Role of the US Nuclear Deterrent

The Trump administration's *Nuclear Posture Review* (NPR), released in early 2018, takes a mainstream position on the role and use of nuclear weapons as part of the US national strategy, and its continuities outweigh its changes to US strategic direction and policy.[6] It also reflects a return to a traditional bipartisan consensus on the value of the US nuclear arsenal by removing objectives for the eventual elimination of both US and global nuclear weapons. As all post–Cold War presidencies have done, the 2018 NPR emphasises the enduring value of a flexible and capable nuclear triad. The document affirms prior declaratory policy reserving the right of the United States to use nuclear weapons to deter both nuclear and "non-nuclear strategic attacks." It also implicitly suggests that an extreme cyber-attack, in addition to other non-nuclear weapons of mass destruction threats, could warrant a nuclear response.[7]

The NPR does not explicitly name either Russia or China as an adversary; however, it frames US deterrence challenges in the context of renewed great power competition and the specific challenges posed by Russian and Chinese national strategies. In an effort to address Russia's potential use of non-strategic nuclear weapons to "escalate and win" a heretofore conventional conflict, the 2018 NPR advocates development of a new low-yield submarine-launched ballistic missile (SLBM) warhead and the deployment of (nuclear) sea-launched cruise missiles (SLCMs). The intent of the former is to provide lower-yield options for US escalation that Russian leadership would perceive as more credible than strategic weapons due to the comparatively minimised destructive impact of a low-yield SLBM. The renewed deployment of nuclear SLCMs, which were retired in 2010 by the Obama administration, aboard US nuclear attack submarines in the Pacific, would enhance extended deterrence in Asia by returning a routine US nuclear presence to the region as a signal of the US government's commitment to its Asian security guarantees.[8] The 2018 NPR argues that SLCMs could also incentivise Russian cooperation on non-strategic nuclear weapons reduction initiatives and establish a specific negative consequence for Russia's persistent violations of the Intermediate-Range Nuclear Forces (INF) Treaty. Given the subsequent US withdrawal from the INF Treaty, it remains to be seen whether the United States will view the nuclear SLCM as a bargaining chip.

Future of the Undersea Deterrent

The US military deploys its nuclear weapons in SLBMs, land-based intercontinental ballistic missiles (ICBMs), air-delivered gravity bombs and cruise missiles, and (prospectively once again) SLCMs. This triad of capabilities is intended to serve different functions and increase the resilience of the US nuclear deterrent. Aircraft allow the use of smaller nuclear weapons and provide the ability to signal intent and control escalation. SSBNs and SLBMs provide a survivable second-strike option to deter a first strike against land and air-delivered nuclear systems. Although land-based ICBMs are in known locations and vulnerable, eliminating them would require a large-scale attack against the US homeland that would be beyond the capability of smaller nuclear powers.

The undersea leg of the US nuclear triad is the most survivable; however, it is also the most brittle. If an SSBN is prevented from launching its missiles, communicating with commanders ashore, or is destroyed, all of its SLBMs become unavailable at once. If only one SSBN is on alert patrol, this could eliminate an entire leg of the triad. In contrast, eliminating the land and air-based legs of the triad would require a large-scale attack to destroy weapons or command and control (C2) systems in detail. With the planned US fleet of twelve new Columbia-class SSBNs by the 2030s, only one would likely be on alert patrol at a time in Atlantic and Pacific Oceans, and between one and two at sea as a backup. This brittleness of the undersea deterrent and its role as the survivable US second-strike option incentivises adversaries to develop ways to hold it at risk or suppress its effective operation. These efforts could result in disruptive shifts or discontinuities in the deterrence and escalation dynamics between the United States and its great power competitors. For example, if US leaders perceive the undersea deterrent as vulnerable, they may be more likely to launch a first strike using air or land-based nuclear weapons before an adversary could destroy them with their own first strike.

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[4] See F.C. Ikle et al., "The Diffusion of Nuclear Weapons to Additional Countries: The 'Nth Country' Problem," RAND Research memorandum, February 15, 1960, https://www.rand.org/content/dam/rand/pubs/research_memoranda/2018/RM2484.pdf; Robert McNamara to President John F. Kennedy, "The Diffusion of Nuclear Weapons With and Without a Test Ban Agreement," February 12, 1963, https://fas.org/man/eprint/dod1963.pdf; and Francis J. Gavin, "Strategies of Inhibition: US Grand Strategy, the Nuclear Revolution, and Nonproliferation," *International Security* 40, no. 1 (Summer 2015): 9–46.

[5] Gavin, "Strategies of Inhibition," 17.

[6] John R. Harvey, Franklin C. Miller, Keith B. Payne, and Bradley H. Roberts, "Continuity and Change in U.S. Nuclear Policy," *Real Clear Defense*, February 7, 2018, https://www.realcleardefense.com/articles/2018/02/07/continuity_and_change_in_us_nuclear_policy_113025.html.

[7] US Department of Defense, *Nuclear Posture Review Report* (Washington DC: Department of Defense, February 2018), vii.

[8] Harvey, Miller, Payne and Roberts, "Continuity and Change in U.S. Nuclear Policy."

The US is recapitalising its undersea deterrent by replacing its fleet of fourteen ageing Ohio-class SSBNs with twelve Columbia-class SSBNs in cooperation with the UK Successor-class SSBN program. The two countries' SSBNs will use a common missile compartment, similar fire control systems, and the same Trident II SLBM. If any of these components experience delays or technical failures, both programs will incur the associated risks. For example, flaws found in common missile compartment welds during 2019 have already created delays, although the US Navy argues it can stay on schedule to begin its Columbia-class construction in 2021 with the goal of going on its first patrol in 2031.[9]

The projected Columbia-class cost of US$6–7 billion per boat is more than twice that of the Ohio-class SSBN, when adjusted for inflation.[10] It is also about one third to one quarter of the US Navy's annual shipbuilding budget, and will constrain the ability of the Navy to reach its goal of 355 ships.[11] To increase the funding available for other programs and constrain defence spending, leaders in the US Congress argue the US military should reconsider its plans for recapitalising the US nuclear deterrent, including reducing the number of SSBNs. Further reductions in the SSBN fleet, however, would lower the number of backup submarines at sea, increase the brittleness of the force, and further incentivise adversaries to develop new anti-submarine warfare (ASW) capabilities that could hold SSBNs at risk.

Most submarine designs, including that of the Ohio-class, are optimised for acoustic quieting to reduce their vulnerability to passive sonar, the predominant type of ASW sensor. The Columbia-class SSBNs will continue this focus, and will incorporate electric propulsion at great expense to further reduce its signature. New ASW technologies, however, are reducing their reliance on noise generated by a target submarine. Low-frequency active sonars, such as those carried by many North Atlantic Treaty Organization (NATO) navies and the US Littoral Combat Ships (LCS), are improving their range and accuracy and could be employed by unmanned surface vehicles (USVs) as part of a large-scale ASW operation. Several navies, including those of Russia and China, are experimenting with detection of submarine wakes. Large networks of civilian government, military, and research institution sonar sensors deployed in littoral areas can enable passive detection of SSBNs, or their location to be inferred by the reaction of nearby marine life.[12]

An SSBN detection does not need to result in a successful attack for the submarine to be neutralised. The inherent limitations of submarines – lack of self-defence and slow speed – require a submarine to evade even ineffective attacks, and if the SSBN continues to be prosecuted it may be unable to establish conditions for launch, which normally require slow speed and shallow depth. An adversary could exploit these limitations by using a network of active sonars and simple, inexpensive torpedoes or depth bombs to find and suppress possible SSBNs over an area of hundreds of square miles. The range of the Trident SLBM enables SSBN patrol areas to cover thousands of square miles, but they would still be vulnerable to detection when they leave and return to their home bases in Kings Bay, Georgia, or Bangor, Washington.

New ASW threats would have a greater impact on the United Kingdom and France, which only have an undersea nuclear deterrent. They would likely increase their reliance on US extended deterrence, which would compound the risk created by new threats to SSBNs. These risks are mitigated by the US nuclear triad, which the US government is recapitalising at a cost of more than US$300 billion during the next two decades.[13] The cost of sustaining a nuclear triad is a concern for US leaders, but the risks created by moving to a dyad or a single undersea leg would be borne not only by the United States. Allies such as the Republic of Korea, Japan, and Australia that depend on US security assurances would be affected as well. These Indo-Pacific nations can be threatened by a larger number and variety of Chinese and North Korean nuclear weapons compared to the United States, increasing their reliance on US extended deterrence. As a result, future vulnerabilities to SSBNs that could arise with the rapidly improving Chinese Navy may convey more risk to allies than to the United States.[14]

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[9] Ben Werner, "'Substantial' Columbia-class Missile Tube Weld Fix Will Cost $27 Million, Take a Year," *USNI News*, November 7, 2018. https://news.usni.org/2018/11/07/columbia-class-missile-tube-weld-issues-to-cost-27-million-take-year-to-fix.

[10] US Congressional Research Service, *Navy Columbia (SSBN-826) Class Ballistic Missile Submarine Program: Background and Issues for Congres*s (Washington DC, 2019), 10, https://fas.org/sgp/crs/weapons/R41129.pdf.

[11] Office of the Chief of Naval Operations Deputy Chief of Naval Operations (Warfare System Requirements – OPNAV N9), *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2020* (Washington DC, 2019), https://assets.documentcloud.org/documents/5777236/PB20-30-Year-Shipbuilding-Plan-Final.pdf.

[12] Kyle Mizokami, "DARPA Wants to Turn Sea Life into a Giant Submarine Detection Network," *Popular Mechanics*, March 5, 2019, https://www.popularmechanics.com/military/research/a26670455/darpa-wants-to-turn-sealife-into-a-giant-submarine-detection-network/.

[13] Todd Harrison and Evan Braden Montgomery, *The Cost of U.S. Nuclear Forces: From BCA to Bow Wave and Beyond* (Washington DC: CSBA, 2015), https://csbaonline.org/research/publications/the-cost-of-u-s-nuclear-forces-from-bca-to-bow-wave-and-beyond.

[14] US Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2019* (Washington DC, 2019), 64, https://media.defense.gov/2019/May/02/2002127082/-1/-1/1/2019_china_military_power_report.pdf.

Chapter 7
The Role of Nuclear Weapons in China's National Defence

Fiona S. Cunningham

Nuclear weapons play an important but limited role in China's national defence. China has restricted the role of nuclear weapons to countering other states' attempts to coerce it with threats to use nuclear weapons, and retaliating in the event that an adversary conducts a nuclear attack against China. It does not plan to use, or threaten to use, nuclear weapons first to gain a military or coercive advantage over an adversary in a conventional conflict. The limited role that nuclear weapons play in China's national defence is reflected in its operational doctrine for its nuclear weapons and small but survivable nuclear force structure.

China's capability to retaliate using nuclear weapons depends primarily on its land-based strategic missile force, although it has been developing its nuclear-powered ballistic missile submarine (SSBN) capability since 1958. In recent years, Chinese strategists have emphasised the role of its sea-based deterrent as a hedge against US missile defence developments. In the absence of major technological changes that reduce the effectiveness of China's land-based missile force, however, Beijing is likely to continue to rely primarily on the land-based leg of its nuclear deterrent. Unfavourable maritime geography, a lack of allies, and strong US anti-submarine warfare (ASW) capabilities pose important obstacles to the effectiveness of China's sea-based deterrent. Further, developing operational doctrine for SSBNs could challenge some of China's command and control arrangements and warhead handling practices that have reassured other countries of its nuclear restraint.

China's Nuclear Policy and Doctrine

China's nuclear no-first-use policy, adopted in 1964, has guided the development of its nuclear force structure and operational doctrine throughout the Cold War until today. While Chinese leaders and strategists have debated changes to that no-first-use policy at various points throughout the past five decades,[1] there is no sign that China plans to abandon it any time soon. The policy was most recently reaffirmed at the official level in China's 2019 Defence White Paper.[2]

China's no-first-use policy sets the requirements for the operational doctrine of China's nuclear forces, which is implemented by the People's Liberation Army (PLA). PLA publications outlining campaigns for China's missile force only describe one type of campaign for using nuclear weapons, to retaliate for an adversary's nuclear attack, regardless of whether they were published in 1987 or 2017. The PLA Rocket Force, formerly the Second Artillery, describes two key principles for China's nuclear counter-strike campaign. The first is the "close protection" (*yanmi fanghu*) of nuclear weapons and their delivery systems to ensure the force can survive an adversary's attempt at a disarming first strike.[3] The second is to conduct "key point counter-strikes" (*zhongdian fanji*) to ensure that a retaliatory nuclear strike inflicts unacceptable damage on an adversary through striking strategic targets. No influential PLA text discusses the first use of nuclear weapons for warning shots, to destroy military targets to achieve operational goals in a military campaign, or to "escalate to de-escalate" a conventional conflict. By contrast, credible sources do describe a first use role for China's conventional missile force to gain coercive and military advantages in conventional conflicts.[4]

China's nuclear force structure is optimised to ride out an adversary's nuclear strike and then retaliate against an adversary's strategic targets. The guiding principle for China's nuclear arsenal development is a "lean and effective" (*jinggan youxiao*) force,[5] which is reflected in its small arsenal of roughly 290 nuclear warheads,[6] compared to the 3,800 nuclear warheads stockpiled

[1] Alastair Iain Johnston, "China's New 'Old Thinking': The Concept of Limited Deterrence," *International Security* 20, no. 3 (Winter 1995/96): 5–42; Fiona S. Cunningham, "Maximizing Leverage: Explaining China's Strategic Force Posture Choices in Limited Wars" (PhD Dissertation, Political Science Department, Massachusetts Institute of Technology, 2018), chap. 2, 3; Evan S. Medeiros, "'Minding the Gap': Assessing the Trajectory of the PLA's Second Artillery," in *Right-Sizing the People's Liberation Army: Exploring the Contours of China's Military,* ed. Roy Kamphausen and Andrew Scobell (Carlisle, PA: Strategic Studies Institute and Army War College Press, 2007), 143–190; Michael S. Chase, Andrew S. Erickson, and Christopher Yeaw, "Chinese Theater and Strategic Missile Force Modernization and Its Implications for the United States," *Journal of Strategic Studies* 32, no. 1 (2009): 96–98.

[2] Information Office of the State Council of the People's Republic of China, *China's National Defense in the New Era* (Beijing: Foreign Languages Press, 2019), 9.

[3] Yu Jixun, *Di'er Paobing Zhanyi Xue [The Science of Second Artillery Campaigns]* (Beijing: Jiefangjun Chubanshe, 2004), 303–304.

[4] See Fiona S. Cunningham and M. Taylor Fravel, "Dangerous Confidence? Chinese Views of Nuclear Escalation," *International Security* 44, no. 2 (Fall 2019): 61–109. The *Science of Second Artillery Campaigns,* a classified campaign manual for China's nuclear missile force that was published in 2004 and leaked to Western libraries, has drawn a lot of attention among Western experts for its discussion of nuclear signalling options available to Chinese leaders, but does not discuss the first use of nuclear weapons. For descriptions of conventional and nuclear missile campaigns, see Yu, *Di'er Paobing Zhanyi Xue,* 292; Xue Xinglin*, Zhanyi Lilun Xuexi Zhinan [Campaign Theory Study Guide]* (Beijing: Guofang Daxue Chubanshe, 2001), 393.

[5] State Council Information Office of the People's Republic of China, *China's Military Strategy* (Beijing: Renmin Chubanshe, 2015).

and deployed by the United States.[7] US counterforce capabilities provide a benchmark for what an "effective" arsenal must look like in practice to be able to retaliate after a nuclear or conventional disarming strike.[8] Although a larger arsenal would be consistent with a retaliatory nuclear posture, and within China's financial means, Chinese leaders and nuclear strategists have to date preferred to maintain a "lean" arsenal to avoid nuclear arms racing.[9]

There is some uncertainty as to whether China will maintain as lean a nuclear arsenal in the future. In 2019, US intelligence officials suggested that China's arsenal could double over the next decade,[10] but acknowledged that there is no evidence that Beijing is seeking quantitative parity with the United States. Nor would it be able to build an arsenal as large as the United States with its current fissile material stockpile. One official estimated that China was probably seeking to narrow, match, or in some cases exceed the US nuclear arsenal qualitatively but not quantitatively.[11] The basis for these US intelligence estimates are not clear but are consistent with China's pursuit of a more robust retaliatory capability as US counterforce capabilities, especially missile defence capabilities, improve.

China's nuclear delivery systems include JL-2 submarine-launched ballistic missiles (SLBMs), DF-21 medium-range ballistic missiles (MRBMs), and a range of intercontinental ballistic missiles (ICBMs), including the silo-based DF-5 and road-mobile DF-31, DF-31A, and DF-31AG missiles.[12] A new, highly accurate, DF-26 intermediate-range ballistic missile (IRBM) is dual-capable, but at the time of writing only conventionally tipped DF-26 missiles have been deployed to PLA Rocket Force brigades.[13] Some variants of China's DF-5 ICBM and its new mobile DF-41 ICBM are armed with multiple independently targetable re-entry vehicles (MIRVs).[14] There is no evidence that China's large arsenal of short-range ballistic missiles (SRBMs) are equipped with nuclear warheads.

Two new missiles recently added to China's nuclear arsenal have longer ranges than older missiles, but those range increases are unlikely to prompt changes to nuclear strategy. The addition of the DF-26 IRBM to China's arsenal is unlikely to alter China's nuclear strategy as it already has the capability to strike US bases and other regional targets with a dual-capable missile, the DF-21.[15] Nor is the addition of the mobile DF-41 ICBM to China's nuclear arsenal likely to alter its nuclear strategy. Although it has a longer range than China's older DF-31 road-mobile ICBM, which could not strike all targets on the continental United States, the range of the DF-41 is similar to the existing silo-based DF-5 ICBM, which could strike targets anywhere in the continental United States. These new missiles do, however, enhance the survivability of China's nuclear arsenal. The PLA would be able to base the longer-range DF-26 missile deeper in its hinterland than the DF-21, while its longest-range ICBMs are now mobile and therefore more difficult for an adversary to find and destroy.

China's top leaders on the Politburo and Central Military Commission exercise strict control over both the formulation of nuclear strategy and the authority to alert or use nuclear weapons.[16] To ensure that weapons are not used accidentally, mistakenly, or without authorisation, China's nuclear weapons are kept off alert in peacetime and warheads are stored separately from delivery systems in a central depot deep in China's interior.[17] A higher peacetime alert status for China's nuclear arsenal would be consistent with China's retaliatory force posture. However, an arsenal kept on high alert for retaliation would be difficult for an adversary to distinguish from a force ready to carry out a surprise

[6] Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2019," *Bulletin of the Atomic Scientists* 75, no. 4 (2019): 172.

[7] Hans M. Kristensen and Matt Korda, "Status of World Nuclear Forces," Federation of American Scientists, May 2019, https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/.

[8] M. Taylor Fravel and Evan S. Medeiros, "China's Search for Assured Retaliation: The Evolution of Chinese Nuclear Strategy and Force Posture," *International Security* 35, no. 2 (Fall 2010): 48–87.

[9] Xiao Tianliang, ed., *Zhanlue Xue [The Science of Military Strategy]* (Beijing: Guofang Daxue Chubanshe, 2015), 364.

[10] Lt Gen. Robert P. Ashley Jr, "Russian and Chinese Nuclear Modernization Trends," remarks at the Hudson Institute, Washington DC, May 29, 2019, https://www.dia.mil/News/Speeches-and-Testimonies/Article-View/Article/1859890/russian-and-chinese-nuclear-modernization-trends/.

[11] Daniel K. Taylor, Acting Defense Intelligence Officer for East Asia, Defense Intelligence Agency, testimony at hearing on "A 'World-Class' Military: Assessing China's Global Military Ambitions," US-China Economic and Security Review Commission, United States Congress, June 20, 2019, https://www.uscc.gov/Hearings/%E2%80%98world-class%E2%80%99-military-assessing-china%E2%80%99s-global-military-ambitions.

[12] Kristensen and Norris, "Chinese Nuclear Forces, 2019," 290.

[13] See Cunningham and Fravel, "Dangerous Confidence?"

[14] Office of the Secretary of Defense, "Annual Report to Congress on the Military Power of the People's Republic of China" (Washington DC, 2018), 36–37.

[15] Cunningham and Fravel, "Dangerous Confidence?"

[16] M. Taylor Fravel, *Active Defense: China's Military Strategy Since 1949* (Princeton, NJ: Princeton University Press, 2019), chap. 8; Jiang Tiejun, ed., *Dang de Guofang He Jundui Gaige Sixiang Yanjiu [Research on Party Defense and Military Reform Thought]* (Beijing: Junshi Kexue Yuan Chubanshe, 2015), 79.

[17] Mark A. Stokes, "China's Nuclear Warhead Storage and Handling System" (Washington DC: Project 2049 Institute, March 12, 2010), 8. Warheads are believed to circulate between the central warhead storage and handling base and missile base storage facilities, but do not remain at those bases for extended periods of time.

first strike. China's choice to instead ride out an adversary first strike and retaliate at a time of its choosing demonstrates the sincerity of its no-first-use policy.[18] The low alert status of China's land-based nuclear force also avoids the risk that leaders could accidentally order a retaliatory nuclear strike based on false warning of an incoming attack. To ensure the survivability of its arsenal if an adversary tries to carry out a disarming first nuclear strike, China has invested in the mobility and concealment of its delivery systems. Examples include its development of DF-31AG land-based mobile missiles with an off-road capability[19] and missile force training exercises in underground facilities to simulate riding out nuclear strikes.[20]

The Future of China's Nuclear Strategy

Will China change its nuclear strategy in the future? In particular, could China expand the goals of its nuclear strategy to include the first use of nuclear weapons to gain an advantage over an adversary in a conventional conflict? Could it expand the size of its nuclear arsenal to reduce the vulnerability of its second-strike capability? The answers to these questions depend on the factors driving China's nuclear strategy decision-making. Changes to China's threat environment are the most likely driver of change in its nuclear strategy.

In the past, the kinds of wars China envisaged fighting and the intensity of the threat posed by its nuclear adversaries have determined the goals and implementation of China's nuclear strategy. China's past nuclear decision-making suggests that economic and organisational factors are less likely drivers of change. Despite three decades of impressive economic growth, China has not expanded the goals or substantially increased the size of its nuclear arsenal. The dramatic growth of China's conventional military power, in comparison to the relative stability of China's nuclear arsenal size over the past three decades, strongly suggests that China's modest arsenal size is a choice, not a fiscal necessity.[21] China's military and strategic missile forces have also advocated for a more ambitious nuclear strategy and larger arsenal in the past.[22] However, China's civilian leaders have successfully suppressed those organisational drivers of change. Historically, China's defence scientific and engineering community has had much greater influence than the PLA over nuclear strategy decision-making and force structure planning. The PLA Rocket Force and its predecessor, the Second Artillery, in particular, has had little influence over China's national nuclear strategy.[23] While it is always possible that China's leaders could be swayed by organisational interests of the PLA and its Rocket Force, those interests are unlikely to drive changes to China's nuclear strategy goals in the near future.[24]

China's threat environment has allowed its leaders to maintain a limited role for its nuclear weapons in its national defence since 1964. Contrary to the example set by NATO during the Cold War, Russia in the post-Cold War era, France, and Pakistan,[25] China has not compensated for its conventional military inferiority by threatening to use nuclear weapons first in a conventional war. Since the end of the Cold War, Chinese leaders have planned to fight local wars on their periphery against nuclear powers with advanced conventional militaries.[26] As China formulated a military strategy for local wars in the early 1990s, defence leaders reasoned that China's nuclear arsenal would prevent adversaries from coercing China in conventional conflicts with threats to use nuclear weapons.[27] However, if China could prevent its adversaries' nuclear coercion with a retaliatory nuclear capability, it would not gain much leverage from threatening to use nuclear weapons first either.

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[18] China's decision to ride out an attack is, however, more likely due to be a result of its leaders' desire to maintain strict control of the use of nuclear weapons than a desire to signal restraint to adversaries. See further Fiona S. Cunningham, "Nuclear Command, Control, and Communications Systems of the People's Republic of China," NAPSNet Special Reports, Nautilus Institute for Security and Sustainability, July 18, 2019.

[19] Alex Lockie, "Watch China Debut an ICBM That Can Hit the US with Multiple Nuclear Warheads," *Business Insider*, August 1, 2017, http://www.businessinsider.com/china-df-31ag-icbm-rollout-parade-2017-7.

[20] Kenneth W. Allen and Jana Allen, "Building a Strong Informatized Strategic Missile Force: An Overview of the Second Artillery Force with a Focus on Training in 2014" (Washington DC: Jamestown Foundation, 2015), 20–21.

[21] Fravel and Medeiros, "China's Search for Assured Retaliation," 82.

[22] Johnston, "China's New 'Old Thinking'"; Chase, Erickson, and Yeaw, "Chinese Theater and Strategic Missile Force Modernization," 94–98.

[23] Fravel, *Active Defense*, chap. 8; Fravel and Medeiros, "China's Search for Assured Retaliation," 70–73.

[24] Eric Heginbotham et al., "China's Evolving Nuclear Deterrent: Main Drivers and Issues for the United States" (Santa Monica, CA: RAND Corporation, 2017), 97–118.

[25] Charles L. Glaser, *Analyzing Strategic Nuclear Policy* (Princeton, NJ: Princeton University Press, 1990); Vipin Narang, *Nuclear Strategy in the Modern Era* (Princeton, NJ: Princeton University Press, 2014).

[26] Fravel, *Active Defense*, chap. 6.

[27] Mi Zhenyu, ed., *Qian Xuesen Xiandai Junshi Kexue Sixiang [Qian Xuesen's Thinking on the Modernization of Military Science]* (Beijing: Kexue Chubanshe, 2011), 77.

What changes to China's threat environment could prompt its leaders to re-consider the role of nuclear weapons in China's national defence? The two most likely scenarios are that their perceptions of US hostility increase dramatically, or technological breakthroughs allow the United States to threaten to conduct a disarming first strike on China's nuclear arsenal.

If Chinese leaders assessed that the United States posed an existential threat to the Chinese state in the future, its leaders may be more willing to consider threats to use nuclear weapons first to deter an unlimited conventional conflict. During the Cold War, when Chinese leaders faced that scenario, they rejected the option of nuclear first use to deter a conventional invasion from the United States and later the Soviet Union. They relied instead on the country's conventional military power, combined with its large geographical and population size, to exhaust an adversary in a conventional conflict.[28] Chinese strategists continue to stress China's strategic depth as a reason for its restrained nuclear strategy.[29] Its leaders may make the same calculation today as they did during the Cold War. However, they could also break from that tradition and decide that the country stands a better chance at preventing an existential conventional conflict with the United States if they threaten to rapidly escalate a conventional war to the nuclear level.[30]

A second possibility is that technological change makes a retaliatory force posture unviable for China in the future. Breakthroughs in the development of counterforce technology would have to allow the United States to credibly threaten to destroy most of China's retaliatory force, even if Beijing expands its nuclear arsenal, shifts to a launch-on-warning alert status, and employs cutting-edge countermeasures. Such radical technological change is, however, unlikely, despite persistent US efforts to improve its counterforce capabilities.[31]

A number of indicators may help Western observers determine whether China is expanding the goals of its nuclear strategy to consider the first use of nuclear weapons in a conventional conflict for any of the reasons above. First, it could move to arm its short-range ballistic and cruise missiles, which are currently conventionally armed, with nuclear warheads. Short-range nuclear delivery systems could be used to attack adversary military forces with nuclear weapons in a future local war. Such delivery systems could also give China a coercive advantage over an adversary if it used them first to demonstrate its willingness to risk all-out nuclear war.[32] Second, China may develop low-yield nuclear warheads for these short-range delivery systems to reduce the collateral damage that they would cause if used, to lower the cost of using those weapons first and reduce the risk of an adversary retaliating with a significantly more destructive nuclear strike. Third, China could improve the accuracy of its nuclear delivery systems, which could also limit collateral damage and enable Beijing to conduct precision nuclear strikes on military rather than strategic targets.[33] Fourth, delegating authority to use nuclear weapons from top leaders to commanders early in a conflict could telegraph a threat to use nuclear weapons first early in a future conventional conflict scenario, rather than waiting to absorb an adversary's nuclear strike before retaliating with nuclear weapons.[34] These indicators would not provide definitive proof of an expansion in the goals of Chinese nuclear strategy because these capabilities and arrangements would also be useful for a limited or rapid counter-strike to increase the credibility of Chinese threats to retaliate for US first use of nuclear weapons.

Changes to China's nuclear strategy in the near future are most likely in the implementation of the strategy rather than its goals. The size of the US nuclear arsenal, missile defence, intelligence, surveillance and reconnaissance (ISR), and conventional long-range strike capabilities have already prompted a modest expansion in the size of China's nuclear arsenal, as well as major improvements in its mobility and penetrability.[35] As the United States continues to invest in those capabilities that trend is likely to continue. For example, an increase in the number of ground-based interceptors

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[28] Fravel, *Active Defense*, chap. 5.

[29] Cunningham and Fravel, "Dangerous Confidence?"

[30] For a discussion of why China is unlikely to consider a limited first use nuclear strategy, see Cunningham and Fravel, "Dangerous Confidence?"

[31] Brendan Rittenhouse Green and Austin Long, "Stalking Secure Second Strike: Intelligence, Counterforce, and Nuclear Strategy," *Journal of Strategic Studies* 38, no. 1–2 (2014): 38–73; Keir A. Lieber and Daryl G. Press, "The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence," *International Security* 41, no. 4 (Spring 2017): 9–49.

[32] Thomas C. Schelling, *Arms and Influence* (New Haven, CT: Yale University Press, 1966), 106–107.

[33] China's intermediate-range DF-26 missile is its only accurate missile that is officially and publicly designated as dual-capable. Richard D. Fisher Jr, "DF-26 IRBM May Have ASM Variant, China Reveals at 3 September Parade," *IHS Jane's Defence Weekly*, September 3, 2015, http://www.janes.com/article/53994/df-26-irbm-may-have-asm-variant-china-reveals-at-3-september-parade.

[34] See Narang, *Nuclear Strategy* in the Modern Era, 22–24.

[35] Fiona S. Cunningham and M. Taylor Fravel, "Assuring Assured Retaliation: China's Nuclear Strategy and US-China Strategic Stability," *International Security* 40, no. 2 (Fall 2015): 7–50.

deployed in the United States for homeland missile defence, from 44 to 64 by 2023,[36] is likely to prompt modest growth in China's arsenal size. Since at least 2013, Chinese strategists have been debating the wisdom of adopting a launch-on-warning alert status for its land-based missiles.[37] This debate appears to be driven by concerns about the future survivability and penetrability of China's nuclear force. According to the 2013 *Science of Military Strategy*, such a change in alert status "may effectively prevent China's nuclear forces from great destruction, increasing the survivable nuclear counterattack capability of China's nuclear missile forces."[38] Nevertheless, China's leaders do not appear to have decided to change the alert status of China's land-based nuclear force. Further, China does not yet have the early warning architecture in place to make such a change.

Another driver of change in the implementation of China's nuclear strategy will be the unique demands of operating a nuclear deterrent at sea or in the air, compared to a land-based force. Chinese strategists have pointed out that China will not be able to implement some of the current practices for the land-based missile force at sea if it keeps its SSBN force on continuous deterrent patrols.[39] For example, a sea-based deterrent that is continuously at sea cannot keep its warheads and delivery systems separated in peacetime. Similarly, if communications are severed between land-based missile forces and the national command authority, missile force manuals indicate that military officers could be dispatched to the missile force to personally deliver launch orders.[40] That option is not available for SSBNs if communications are severed while at sea. Developing an operational doctrine for SSBNs may therefore force Chinese leaders to consider the "always-never" dilemma of nuclear command and control much more seriously than they ever had to for the land-based missile force.[41] In 2018, the US Department of Defense reported that the People's Liberation Army Air Force (PLAAF) also expects to field a dual-capable bomber in the future.[42] Although it is too early to know whether and, if so, how that platform could be used for nuclear missions, it could pose additional, distinctive dilemmas for the implementation of China's retaliatory nuclear posture in the future.

The Role of SSBNs in China's Nuclear Strategy

Despite China's gradual but substantial investment in an SSBN capability since 1958, it is likely to continue to rely primarily on its land-based missile force for its retaliatory nuclear capability. Chinese strategy texts recognise the People's Liberation Army Navy's (PLAN) evolving nuclear capability, but continued to refer to the Second Artillery, now PLA Rocket Force, as "the main part of China's nuclear deterrent force and also the core of China's strategic deterrent force."[43] Strategists acknowledge the shortcomings of its existing generation of Type-094 submarines, which are noisy and therefore vulnerable to sophisticated US strategic ASW capabilities.[44] China could overcome these technological hurdles in the future, although it would be racing against simultaneous US ASW improvements, a task that the United States has proved very adept at since the Cold War.[45]

Regardless of China's technological progress in developing a next-generation SSBN force, it is unlikely to surpass the land-based missile force as the most survivable leg of China's nuclear deterrent for three reasons. First, China does not appear to have invested in its own strategic ASW forces, most likely because it does not have a counterforce nuclear doctrine. China may therefore lack confidence that SSBNs patrolling in the open ocean could evade detection by US ASW capabilities. The inability of US ASW forces to detect its own SSBNs gave the United States confidence that its SSBNs could evade detection from the Soviet Union. Chinese leaders will likely need to develop their own ASW forces or an alternative means of establishing confidence in the ability of their own SSBNs to evade US ASW forces if they plan to deploy SSBNs continuously at sea. Of course, China could choose to protect its SSBNs using conventional military forces, but doing so would prevent PLAN conventional forces from engaging in other missions. The United States exploited the conventional

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36 Office of the Secretary of Defense, "Missile Defense Review Report" (Washington DC: Department of Defense, 2019), xi.

37 Gregory Kulacki, "China's Military Calls for Putting Its Nuclear Forces on Alert" (Cambridge, MA: Union of Concerned Scientists, 2016); Xiao, *Zhanlue Xue*, 368; Shou Xiaosong, ed., *Zhanlue Xue [The Science of Military Strategy]* (Beijing: Junshi Kexue Yuan Chubanshe, 2013), 175.

38 Shou, *Zhanlue Xue*, 175.

39 Wu Riqiang, "Zhongguo Zhanlue He Qianting Kaishi Zhanbei Xunhang Le Ma? [Have China's Strategic Nuclear Submarines Already Commenced Operational Patrols?]," *Dangdai Jianchuan [Modern Ships]* 1 (2016): 34.

40 Yu, *Di'er Paobing Zhanyi Xue*, 349; Cunningham and Fravel, "Assuring Assured Retaliation," 45.

41 That dilemma concerns whether to take steps such as pre-delegating authority for commanders to use nuclear weapons to ensure those weapons are "always" used when a leader wants them to be used, when those steps also increase the risk of accidental or unauthorised nuclear use. Leaders may instead prefer to prevent the accidental or unauthorised use of nuclear weapons to ensure they are "never" used unless leaders want them to, which runs the risk that China will not be able to retaliate with nuclear weapons after it has suffered a nuclear attack. See Peter D. Feaver, *Guarding the Guardians: Civilian Control of Nuclear Weapons in the United States* (Ithaca, NY: Cornell University Press, 1992); Wu, "Zhongguo Zhanlue He Qianting Kaishi Zhanbei Xunhang Le Ma?" 34–35.

42 Office of the Secretary of Defense, "Annual Report to Congress," 55.

43 Shou, *Zhanlue Xue*, 221, 228.

44 Wu, "Zhongguo Zhanlue He Qianting Kaishi Zhanbei Xunhang Le Ma?"; *Shou, Zhanlue Xue*, 224.

45 Owen R. Coté Jr, *The Third Battle: Innovation in the US Navy's Silent Cold War Struggle with Soviet Submarines*, Newport Papers 13 (Newport, RI: Naval War College, 2003).

naval protection requirements of the Soviets' bastion mode of deploying SSBNs in its 1980s naval strategy.[46]

Second, China's geography makes its SSBNs more vulnerable to ASW than the United States and other naval nuclear powers because submarines must pass through choke points in the first island chain to enter the Western Pacific. The territory bordering those choke points belongs to US allies and partners, who may assist US ASW with shore-based signals processing. No technical improvements to Chinese submarines are likely to be able to overcome the disadvantages posed by its island chain geography.[47]

Third, as described above, developing operational doctrine for SSBNs poses distinctive challenges to strict control of top Chinese leaders over the use of nuclear weapons. Those leaders may simply not be comfortable with pre-delegating launch authority or mating nuclear warheads and missiles in peacetime. Without these two amendments to China's current operational doctrine for nuclear counter-strike campaigns, it would be difficult to reap the full benefits of deploying an SSBN force continuously at sea for securing a state's second-strike capability. Of course, those benefits would be contingent on China finding an adequate solution to the ASW vulnerability problems identified above.

Given the civil-military and vulnerability challenges that China's SSBN force faces, why has China continued to develop a sea-based nuclear deterrent? Speculatively, a mix of hedging and organisational interests are the most likely explanation for the persistence of China's SSBN program. SSBNs may help China to hedge against future improvements in US missile defence focused on intercepting missiles launched from the Chinese mainland. Chinese strategists have recognised that SSBNs have advantages over land-based forces in evading missile defences because they can launch from anywhere at sea. An adversary cannot deploy missile defence sensors to cover the entire ocean. As the 2013 *Science of Military Strategy* explains, "faced with the objective situation of the United States and countries on China's periphery actively developing missile defences, developing China's sea-based deterrent force is significant for the reliability, credibility and effectiveness of protecting China's nuclear deterrent and counterstrike."[48] A second possibility is that the PLAN is pursuing an organisational interest in greater resources and influence by expanding its mission set into nuclear deterrence, although no evidence is available to confirm this hypothesis.

Conclusion

The limited goals of China's nuclear strategy are unlikely to expand in the future without major changes to China's threat environment, but the implementation of China's nuclear strategy is likely to change to account for improvements in US capabilities as well as new Chinese nuclear delivery platforms. China's SSBN force will not be central to securing its second-strike capability unlike, for example, the United Kingdom, US or French sea-based deterrents. It could nevertheless have a strong influence on US–China strategic stability. In addition to the use-or-lose pressures resulting from fielding a vulnerable SSBN force in a crisis,[49] SSBNs could undermine confidence in China's nuclear restraint. If Chinese leaders decide to change their warhead handling practices, or pre-delegate authority to use nuclear weapons to submarine commanders if communications are severed, they will change long-standing practices of China's nuclear operational doctrine developed by its land-based missile forces. Those practices currently serve as signals of the sincerity of China's restrained, retaliatory-only nuclear posture. Muddying these signals of Chinese nuclear restraint could lead Washington or other regional states to conclude that Beijing's restraint is diminishing. As China formulates operational doctrine for its SSBN force, it should carefully consider the value of its existing nuclear operational doctrine as a signal of its restraint before making changes to that doctrine to accommodate a sea-based deterrent that can add little security to its second-strike capability, now or in the future.

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[46] Threatening SSBNs would have drawn Soviet conventional naval forces away from other conventional missions. John J. Mearsheimer, "A Strategic Misstep: The Maritime Strategy and Deterrence in Europe," *International Security* 11, no. 2 (Fall 1986): 3–57.

[47] Owen R. Coté Jr, "Invisible Nuclear-Armed Submarines, or Transparent Oceans? Are Ballistic Missile Submarines Still the Best Deterrent for the United States?," *Bulletin of the Atomic Scientists* 75, no. 1 (January 2019): 30–35.

[48] Shou, *Zhanlue Xue*, 224.

[49] Tong Zhao, "Tides of Change: China's Nuclear Ballistic Missile Submarines and Strategic Stability" (Washington DC: Carnegie Endowment for International Peace, 2018), 2.

Chapter 8
The Future of China's New SSBN Force

Adam Ni

China finally achieved an operational underwater nuclear capability in recent years after almost six decades since it first launched its nuclear-powered ballistic missile submarine (SSBN) program in the late 1950s. The deployment of Jin-class (Type 094) SSBNs armed with JL-2 submarine-launched ballistic missile (SLBMs) marks a new stage in the evolution of China's sea-based nuclear force. According to the Pentagon's 2018 annual report to Congress on China's military developments, this recent development constitutes "China's first credible sea-based nuclear deterrent."[1] However, the effectiveness of China's current sea-based nuclear force still faces serious challenges from geographic, operational, and technological factors.

Driven by Beijing's perceived nuclear insecurity, and enabled by the availability of resources to the People's Liberation Army (PLA), China's SSBN fleet, SLBM program, and supporting capabilities and systems have developed quickly since the early 2000s. Chinese military experts believe that developing an effective sea-based nuclear force is critical for ensuring the credibility of China's overall nuclear deterrent.[2]

Therefore, insights on China's sea-based nuclear force, including Beijing's aspirations for its SSBN fleet, could shed light on the possible pathways along which China's nuclear strategy and posture may evolve. Moreover, by looking at China's SSBN deployment strategies, we can better understand the interaction between China's strategic deterrence posture and the expansion of its maritime power.

Of course, the increasing size, sophistication, and activities of China's SSBN fleet should be examined within the context of China's expanding military, economic, and political footprint in Asia and beyond. The rise of China's sea-based nuclear force together with the reshaping of maritime geography in Asia will have important implications for strategic stability and great power competition in the Indo-Pacific for decades to come.

The Impetus for Modernisation

The development of China's sea-based nuclear force is predominantly driven by its perceived need to enhance the credibility of China's nuclear deterrent. By modernising its land-based nuclear force, developing a sea-based nuclear force and investing in an air-based nuclear capability, China hopes to better deter against a possible nuclear first strike or nuclear coercion by other states, especially the United States.

Some Chinese experts consider the diversification of China's nuclear deterrent, away from relying solely on land-based nuclear missiles, as the logical next step in the evolution of China's nuclear forces.[3] Developing an effective sea-based nuclear deterrent is considered to be critical for maintaining the credibility of China's nuclear deterrent in the face of technological advances made by foreign militaries. In particular, Chinese experts worry that advances in US military technology and capabilities, such as conventional precision strike, missile defence, space-based intelligence, surveillance, and reconnaissance (ISR), and cyber operations, can threaten China's strategic forces and erode the credibility of its nuclear deterrent.[4]

In theory, Chinese SSBNs operating in the open ocean could provide a more robust and credible nuclear deterrent than land-based missiles. In the future, a well-supported and advanced Chinese SSBN fleet operating in the vast waters of the Pacific Ocean may well be harder to detect, track, and destroy than the land-based nuclear missiles of the PLA Rocket Force.

Some observers argue that it is far riskier for China to deploy nuclear weapons at sea than to disperse its land-based nuclear force across its massive hinterland.[5] That may be true today; however, improved technology and logistics systems, and the ongoing reshaping of maritime geography in Asia, will improve the survivability of China's SSBN fleet in the decades to come.

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[1] Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018* (Washington DC: US Department of Defense, 2018), 29.

[2] See Hua Ling, "The Future of Strategic Nuclear Competition Will Occur Here," *Technology Daily*, January 17, 2018, http://www.81.cn/jskj/2018-01/17/content_7911486_2.htm; Xianrong Li and Min Yang, "What Are the Main Measures for Strengthening Nuclear Deterrence for the United States, Russia, and Other Nuclear Powers?" *China Military Online*, January 30, 2018, http://www.81.cn/jmywyl/2018-01/30/content_7925343.htm; Military Strategy Research Department, Academy of Military Science, *The Science of Military Strategy* (Beijing: Military Science Press, 2013), 174–176, 214.

[3] Ling, "The Future of Strategic Nuclear Competition."

[4] Riqiang Wu, "无导弹防御限制，便无稳定" ["No Missile Defense Restrictions, No Stability"], Bulletin of the Atomic Scientists Roundtable Entry, October 9, 2014; Weidi Xu, "China's Security Environment and the Role of Nuclear Weapons," in *Understanding Chinese Nuclear Thinking*, ed. Bin Li and Tong Zhao (Washington DC: Carnegie Endowment for International Peace, 2016), 19–50, 34–35; Xiangli Sun, "The Development of Nuclear Weapons in China," in *Understanding Chinese Nuclear Thinking*, ed. Bin Li and Tong Zhao (Washington DC: Carnegie Endowment for International Peace, 2016), 79–103, 91–92.

[5] For example, see Hans M. Kristensen and Robert S. Norris, "Chinese Nuclear Forces, 2018," *Bulletin of the Atomic Scientists* 74, no. 4 (2018): 289–295.

The Future of China's SSBN Fleet

The steady growth in the size and sophistication of China's SSBN fleet will continue. Indeed, by all indications, a larger and more survivable SSBN force is high on the PLA Navy's (PLAN) list of priorities.

China currently has four operational Jin-Class SSBNs, with two more current being outfitted.[6] The PLAN will likely build a total of six to eight Jin-class SSBNs before shifting production towards its next (third) generation SSBN, the Type 096, from the early 2020s.[7] From the mid to late 2020s onwards, the PLAN will likely operate an SSBN fleet consisting of both the Type 094 and the Type 096 SSBNs.

China's lack of transparency on the development of its sea-based nuclear force coupled with a range of uncertainties makes it difficult to estimate the size and capability of China's future SSBN fleet with a high degree of confidence. These uncertainties include future availability of resources, technological changes, deployment strategies, and operational concepts.

A critical determinant is China's threat perception. At one end of the spectrum, Beijing may believe that a small SSBN fleet that complements its land-based nuclear force is enough to maintain the credibility of its nuclear deterrent. On the other end, China may seek to address perceived vulnerabilities in its land-based force with a significant build-up of its SSBN force with supporting infrastructure and systems.

Another important determinant is whether China intends to pursue a Continuous At Sea Deterrence (CASD) capability with one or more SSBN on patrol at all times. China is unlikely to adopt such a posture in the near term due to operational constraints. Even if the PLAN was operationally able, there are doubts as to whether Beijing is currently ready to make such a major shift in its nuclear posture. Past experience suggests that we are likely to see incremental changes to China's nuclear posture instead of any sudden shifts.

The precise number of SSBNs required for CASD would depend on a variety of factors, including the efficiency of the PLAN's logistics support for its SSBN fleet, and the technical specifications of Chinese nuclear reactor cores. But if Beijing's aim is to achieve CASD with at least two or three SSBNs on patrol at all times, then China's SSBN force will need to expand to around twelve SSBNs.[8]

Ultimately, how China perceives, develops, and deploys its sea-based nuclear force will depend on the interplay of shifting strategic, technological, economic, and bureaucratic factors.

Nuclear Strategy and Strategic Stability

The growth of China's SSBN fleet, as part of its broader nuclear modernisation effort, has a number of implications for China's nuclear strategy and strategic stability in Asia. First and foremost, China's SSBN force has become more important to its nuclear strategy and posture than at any time in the past. With the diversification away from an exclusive reliance on land-based nuclear missiles, SLBMs have grown to constitute about half of China's total number of ballistic missiles that could target the continental United States.[9] This relative importance is likely to grow along with the size and survivability of China's SSBN fleet as China progresses along the path towards building an effective nuclear triad. Currently, China possesses a well-established, albeit relatively small, land-based nuclear force, a nascent sea-based nuclear force, and a program to develop a new strategic bomber, the H-20.

Given the growing importance of China's SSBN fleet, key decisions about how they are deployed may have far-reaching strategic implications. For instance, if Beijing adopts CASD in the future, this would constitute an important shift in China's nuclear posture. Currently, nuclear authority is highly centralised under the leadership of China's top military body, the Central Military Commission, with Chinese nuclear warheads stored separately from missile launchers; and China's land-based nuclear force does not maintain a high alert status under normal peacetime conditions.[10] With CASD, patrolling Chinese SSBNs will carry nuclear weapons to sea, and Beijing will need to work out crucial command and control questions, such as how much authority to delegate to submarine commanders.[11] Such a shift in posture may be interpreted by other states as evidence that Beijing is moving away from its policy to refrain from the first use of nuclear weapons.

Indeed, the implications of China's growing SSBN force for strategic stability will depend on the interactive dynamics between China, the United States, and others in the region.

In the long run, China's sea-based nuclear force could enhance strategic stability in Asia by assuring China itself and other states, including the United States, of the efficacy of China's nuclear second-strike capacity. This, however, would only be the case if

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[6] Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China* 2019, 66.

[7] Office of the Secretary of Defense, *Annual Report to Congress,* 29.

[8] On China's SSBN fleet projection and production capability, see Rick Joe, "Pondering China's Future Nuclear Submarine Production," *The Diplomat*, January 23, 2019, https://thediplomat.com/2019/01/pondering-chinas-future-nuclear-submarine-production/; Rick Joe, "Predicting the Chinese Navy of 2030," *The Diplomat*, February 15, 2019, https://thediplomat.com/2019/02/predicting-the-chinese-navy-of-2030/.

[9] Kristensen and Norris, "Chinese Nuclear Forces, 2018," 290; and Tong Zhao, *Tides of Change: China's Nuclear Ballistic Missile Submarine and Strategic Stability* (Washington DC: Carnegie Endowment for International Peace, 2018), 8–9.

[10] Mark A. Stokes, *China's Nuclear Warhead Storage and Handling System* (Washington DC: Project 2049 Institute, 2010), 2–3.

[11] See David C. Logan, "China's Future SSBN Command and Control Structure," *Strategic Forum*, no. 299, November 2016, https://apps.dtic.mil/dtic/tr/fulltext/u2/1022304.pdf.

the other states are convinced that China's nuclear modernisation has only limited and defensive objectives. In contrast, if they interpret the SSBN build-up as part of an aggressive effort to shift the strategic balance in China's favour, the risk of arms races would rise significantly. Importantly, this may push the United States, its allies, and others to enhance anti-submarine warfare (ASW) capabilities and intensify ASW efforts against China's submarines.

China's growing sea-based nuclear force gives Beijing the option to adopt new nuclear strategies and postures, such as CASD. However, this does not mean that it would be prudent for Beijing to adopt some of these options in the near term. There is a significant risk that what appears to Beijing as reasonable and defensive efforts to shore up the variability of its nuclear deterrent will increasingly be viewed with alarm by the United States and others.

Chinese SSBN Deployments and Maritime Asia

There are two main deployment strategies for China's SSBN fleet commonly discussed by Chinese and foreign experts: coastal deployment in protected areas (the so-called "bastion" strategy) and open-ocean deployment.[12]

In the short to medium term, the PLAN will continue to adopt a strategy that heavily emphasises SSBN deployments to selected "bastions" near Chinese mainland, including areas of the South China Sea, East China Sea, and the Yellow Sea. But, over the long term, Chinese SSBNs are likely to be increasingly active in conducting open-ocean patrols in the Pacific Ocean.

To be sure, the PLAN's current focus on deploying SSBNs in "bastion" areas close to the Chinese mainland has a number of important advantages over sending its SSBNs to the Pacific. First, patrol areas in the South China Sea are close to China's SSBN base on the southern coast of Hainan Island. This reduces the risk to Chinese SSBNs on transit to patrol areas, and maximises the time that SSBNs could spend in patrol areas. In contrast, in order to reach patrol areas in the Pacific, Chinese SSBNs will need to travel undetected through routes closely monitored by the United States, Japan, and others into the Western Pacific. The reported noisiness of China's SSBNs is a key weakness that makes them unlikely to be able to avoid detection on route.[13]

Second, China could protect its SSBNs better against enemy ASW forces in waters close to the Chinese mainland than those farther away. The PLA can deploy a high concentration of maritime, air, missile, and other defensive and power projection forces to protect SSBNs operating in the South China Sea, for example. Despite rapid recent improvements in the PLAN's ASW capabilities, including organic shipboard sensors and weapons, ASW helicopters, land-based fixed-wing ASW platforms, seabed sensors, and unmanned underwater vehicles, it still cannot adequately protect its SSBN force operating in the Western Pacific against advanced foes.[14]

Third, the proximity of "bastion" areas to Chinese mainland or island features with dual-use infrastructure means that Chinese SSBNs could rely on existing logistics, communications, and command and control systems. The same systems would be stretched or ineffective in providing operational support to Chinese SSBN patrols in the Pacific.

Despite the above advantages, the "bastion" strategy also has key weaknesses that limit the deterrence potential of China's SSBN force. Importantly, the range of China's JL-2 SLBM, estimated to be just over 7,000 kilometres,[15] is not enough to reach the continental United States from Chinese coastal waters. This means that Chinese SSBNs armed with JL-2s will need to navigate further west into potentially hostile waters in order to maximise deterrence.[16] This limitation could be ameliorated by JL-2's follow up, the JL-3, which is reportedly under development and includes a range upgrade.[17] However, it is unlikely that the PLAN's next-generation Type 096s armed with JL-3s would have sufficient range to hold targets on the continental United States at risk from waters in the Chinese "bastions."

In addition, whereas the vast waters of the Pacific Ocean provide flexibility in terms of patrol areas and launch locations, the "bastion" areas only give limited options. It would be far easier to monitor Chinese coastal waters than the vastness of the Pacific for Chinese SSBN activities. Moreover, Chinese SLBM launches could be easier to track and intercept when they are launched from Chinese coastal waters (where they are expected) as opposed to a surprise launch location somewhere in the Pacific.[18]

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[12] For a more comprehensive discussion, see Zhao, *Tides of Change*, 25–33.

[13] Hans M. Kristensen, "China's Noisy Nuclear Submarines," *Federation of American Scientists Blog*, November 21, 2009, https://fas.org/blogs/security/2009/11/subnoise/.

[14] On PLAN's growing ASW capabilities, see Rick Joe, "The Chinese Navy's Growing Anti-Submarine Warfare Capabilities," *The Diplomat*, September 12, 2018; and Rick Joe, "Chinese Anti-Submarine Warfare: Aviation Platforms, Strategy, and Doctrine," *The Diplomat*, October 16, 2018.

[15] National Air and Space Intelligence Center, US Air Force, *Ballistic and Cruise Missile Threat*, July 2017, 33.

[16] Kristensen and Norris, "Chinese Nuclear Forces, 2018," 293.

[17] Bill Gertz, "China Flight Tests New Submarine-Launched Missile," *The Washington Free Beacon, December* 18, 2018, https://freebeacon.com/national-security/china-flight-tests-new-submarine-launched-missile/; and Ankit Panda, "China Conducts First Test of New JL-3 Submarine-Launched Ballistic Missile," *The Diplomat*, December 20, 2018, https://thediplomat.com/2018/12/china-conducts-first-test-of-new-jl-3-submarine-launched-ballistic-missile/.

[18] Zhao, *Tides of Change*, 29.

Lastly, a survivable SSBN force that can operate independently in the open waters of the Pacific would free up the substantial conventional force that would otherwise be needed to protect and support Chinese SSBN patrols, if confined to coastal waters.

The "bastion" areas will probably continue to be the primary patrol areas for Chinese SSBNs until the PLAN overcomes the technological and operational challenges that limit the survivability of China's SSBN fleet. Given the advantages of open-ocean deployment, the PLAN will continue to develop the capabilities and experience required for effective deterrence patrols, especially in the Pacific Ocean.

Conclusion

China's SSBN force and supporting capabilities have advanced significantly since the early 2000s. Fuelled by the availability of resources, this progress has been mainly driven by the need to enhance the effectiveness and credibility of China's nuclear deterrent.

Looking forward, developing a larger and more survivable SSBN force is a high priority for the PLAN. In fact, China's SSBN fleet will need to double from six to twelve if Beijing wants to carry out CASD with two or three SSBNs on patrol at all times.

A key risk to strategic stability is that Beijing's self-perceived defensive build-up could be interpreted by the United States and others as aggressive efforts aimed at altering the relative strategic balance of force in China's favour. This would be especially likely if Beijing rushes to adopt CASD in the near future.

Chapter 9
The Role of Nuclear Forces in Russian Maritime Strategy

Michael Kofman

Although Russia is one of the world's preeminent continental powers, Russian leaders have historically rendered considerable attention to sea power. Through sea power, Moscow could establish Russia as a great power in international politics outside of its own region. Sea power served to defend Russia's expansive borders from expeditionary naval powers like Britain or the United States, and to support the Russian Army's campaigns. With the coming of the atomic age, the Soviet Navy took on new significance, arming itself for nuclear warfighting and strategic deterrence missions. The Soviet Union deployed a capable nuclear-armed submarine and surface combatant force to counter American naval dominance during the Cold War. The modern Russian Navy retains legacy missions from the Cold War, but has taken on new roles in line with the General Staff's evolved thinking on nuclear escalation, while adapting to the inexorable march of technological change that shapes military affairs.

The Russian Navy has four principal missions: (i) defence of Russian maritime approaches and littorals; (ii) executing long-range precision strikes with conventional or non-strategic nuclear weapons; (iii) nuclear deterrence by maintaining a survivable second-strike capability at sea aboard Russian nuclear-powered ballistic missile submarines (SSBNs); and (iv) naval diplomacy, or what may be considered to be status projection.[1] Naval diplomacy in particular rests with the surface combatant force, chiefly the retinue of inherited Soviet capital ships (cruisers and destroyers), which while ageing remain impressive in appearance. Meanwhile, the Russian Navy, like the Soviet Navy before it, is much more capable beneath the waves, arguably the only near-peer to the United States in the undersea domain.[2]

Regionally, Russian policy documents convey a maritime division in terms of the near-sea zone, the far-sea zone, and the "world ocean," while functionally the Russian General Staff thinks in terms of theatres of military operations. The Navy is naturally tasked with warfighting and deterrence in the naval theatre of military operations, defending maritime approaches, and supporting the continental theatre.[3] Russia's navy remains a force focused on countering the military capabilities of the United States, and deterring other naval powers with conventional and nuclear weapons. Over time, it has also acquired an important role in Russian thinking on escalation management, and the utility of non-strategic nuclear weapons in modern conflict.[4]

Continuity in Naval Strategy: The "Bastion" Concept Endures

Russian naval strategy has proven to be evolutionary, taking its intellectual heritage from the last decade of the Cold War. Nuclear and non-nuclear deterrence missions are deeply rooted in concepts and capabilities inherited from the Soviet Union; namely, the bastion deployment concept for ballistic submarine deployment, together with the more salient currents in Soviet military thought derived from the late 1970s and early 1980s, being the period of intellectual leadership under Marshal Ogarkov, Chief of Soviet General Staff at that time.

Strategic deterrence and nuclear warfighting in theatre proved anchoring missions for the Soviet Navy during the Cold War. In the 1970s it had become widely accepted that the Soviet Union adopted a "withholding strategy," as opposed to an offensive strategy to challenge US sea lines of communication. The Soviet Northern and Pacific Fleets would deploy ballistic missile submarines into launch points in the Barents Sea and the Sea of Okhotsk, protected by attack submarines, and a surface force geared around anti-submarine warfare (ASW). US analysts termed these protected ballistic missile submarine operating areas "bastions," and the name stuck.[5]

The merits of the strategy were always questionable, since the Soviet Union was geographically short on unconstrained access to the sea, unlike the United States, while having a plethora of land available for land-based missiles. However, the Soviet Navy

[1] Michael Kofman and Jeffrey Edmonds, "Why the Russian Navy Is a More Capable Adversary Than It Appears," *The National Interest*, August 23, 2017, https://nationalinterest.org/feature/why-the-russian-navy-more-capable-adversary-it-appears-22009 and http://cimsec.org/russian-navy-strategies-missions-force-transition/20144; see also Richard Connolly, "Towards a Dual Fleet? The Maritime Doctrine of the Russian Federation and the Modernisation of Russian Naval Capabilities," NATO Defense College, 2017, http://www.ndc.nato.int/news/news.php?icode=1061.

[2] Eric Schmitt, "Russia Bolsters Its Submarine Fleet, and Tensions With U.S. Rise," *New York Times*, April 20, 2016, https://www.nytimes.com/2016/04/21/world/europe/russia-bolsters-submarine-fleet-and-tensions-with-us-rise.html.

[3] "Указ Президента Российской Федерации от 20.07.2017 № 327 'Об утверждении Основ государственной политики Российской Федерации в области военно-морской деятельности на период до 2030 года,'" Official Internet Portal of Legal Information, July 20, 2017, 14–15, http://publication.pravo.gov.ru/Document/View/0001201707200015?index=14&rangeSize=1.

[4] Jay Ross, "Time to Terminate Escalate to De-escalate – It's Escalation Control," *War on the Rocks* (blog), April 24, 2018, https://warontherocks.com/2018/04/time-to-terminate-escalate-to-de-escalateits-escalation-control/.

[5] Walter M. Kreitler, "The Close Aboard Bastion: A Soviet Ballistic Missile Submarine Deployment Strategy," (Master's thesis, Naval Postgraduate School, 1988), 19–20, https://apps.dtic.mil/dtic/tr/fulltext/u2/a201696.pdf.

deployed a sizeable ballistic missile submarine force (more than 60 strong) as part of a nuclear triad. Defending these bastions to maintain an effective survivable deterrent drove shipbuilding requirements for a surface combatant force, and a large submarine force to fend off penetrating US attack submarines. Consequently, ballistic missile submarines proved the linchpin in Soviet naval procurement, and capital ships were designed to defend the SSBN bastions rather than simply enhance anti-carrier warfare or forward strike missions.[6]

Although from a competitive strategy standpoint it might have made sense for Russia to walk away from SSBNs, leveraging road-mobile intercontinental ballistic missiles (ICBMs) as a cheaper survivable nuclear deterrent, this was not the direction elected by the Russian General Staff. Russia's military clings to a sea-based nuclear deterrent that is incredibly expensive, arguably indefensible from adversary counterforce attacks, and makes little strategic sense in light of the country's current nuclear force structure. Russia's current ballistic missile submarine force includes three Delta III-class (only one of which is operational), six Delta IV-class and three of the newer Borei-class SSBNs, for a total of ten operational SSBNs.[7] The likely deployed warhead count at sea is somewhere in the range of 600–800.[8] The bulk of the force, nine submarines, are stationed in the Northern Fleet, while three submarines are currently assigned to the Pacific. The Borei-class SSBN program, together with the newer Bulava SLBM, is the single most expensive item in Russia's State Armament Program. Russia is set to procure eight to ten Borei-class submarines by the early 2020s, first phasing out the ageing Delta III-class, and subsequently the Delta IV-class.

The problem with this strategy is that in the 1990s the Soviet Navy melted away, reducing in strength from approximately 270 nuclear-powered submarines in the late 1980s to about 50 or so today, at an operational readiness that likely cuts those numbers further in half. Similarly, the large surface combatant force has declined precipitously, transitioning to a green-water navy, with limited ASW capability.[9] Russia's submarine force is less than twenty per cent the size of the late Soviet Union's, and the surface combatant force is much smaller, to say nothing of maritime patrol aviation. Russia's focus on the Arctic is driven in part by a desire to better secure this vast domain from aerospace attack, and provide the infrastructure to better defend SSBN bastions, especially as passage becomes passable for surface combatants.

It is worth noting that Russian submarine operations have recovered after declining precipitously in the early 2000s. Since then, the Russian Navy has been buoyed by a sustained level of spending on training and operational readiness, military reforms leading to almost complete contract staffing in the Navy, along with procurement of new platforms. Senior Russian commanders frequently issue pronouncements about increased time at sea, training, and patrols, though a high operational tempo eventually inflicts a cost to readiness.[10]

Russia continues to modernise its existing ballistic missile submarines, and field new ones, as part of a legacy strategy inherited from the Soviet Union. Continuity in the "bastion" strategy may provide the Navy with an argument for spending on Russia's general-purpose naval forces, more so than it provides a survivable nuclear deterrent. Comparatively, Russia now fields a large force of road-mobile ICBMs, including RS-24 YARS (SS-27 Mod 2), and Topol-M (SS-27 Mod 1), with two regiments still upgrading to this missile. Despite the fact that a growing share of Russian nuclear forces is becoming road-mobile, reducing the need for sea-launched ballistic missiles, the Navy retains a prominent strategic deterrence mission, enshrined in key documents outlining national security policy in the maritime domain.[11]

New Roles: Non-Nuclear Deterrence and Escalation Management

Relatively unchanged operational concepts for deploying SSBNs disguise tectonic shifts in Russian thinking about nuclear escalation, and the role of naval forces in strategies aimed at escalation management and war termination. There are profound changes occurring at present in Russian military strategy stemming from the debates in Russian military thought as far back as the Nikolai Ogarkov period of 1977–1984. In the 1980s, the Soviet General Staff began focusing on the rising importance of long-range precision-guided weapons, particularly cruise missiles, and their ability to attack critical objects throughout the depth of the adversary's territory. Ogarkov, the Chief of the Soviet General Staff at the time, advocated for the belief that precision conventional weap-

[6] Ibid., 22.

[7] This blog resource provides good open-source coverage of the current state of Russian naval forces, particularly operational readiness. See: Александра Шишкина, "Флот открытого океана: третья попытка," *Navy Korabel* (blog), September 20, 2015, https://navy-korabel.livejournal.com/tag/Корабельный%20состав%20МСЯС%20РФ.

[8] Hans M. Kristensen and Robert S. Norris, "Russian Nuclear Forces, 2018," *Bulletin of the Atomic Scientists* 74, no. 3 (2018): 189, https://www.tandfonline.com/doi/pdf/10.1080/00963402.2018.1462912.

[9] Michael Kofman and Norman Polmar, "New Russian Navy: Part 1 – Toward Smaller Ships and Professional Sailors," *Proceedings*, December, 2016, https://www.usni.org/magazines/proceedings/2016-12-0/new-russian-navy-part-1-toward-smaller-ships-and-professional-sailor.

[10] Atle Staalesen, "Northern Fleet Conducted 4,700 Exercises This Year," *The Barents Observer*, November 30, 2017, https://thebarentsobserver.com/en/security/2017/11/northern-fleet-conducted-4700-exercises-year.

[11] "Указ Президента Российской Федерации," 14; see also Richard Connolly and Mathieu Boulègue, "Russia's New State Armament Programme: Implications for the Russian Armed Forces and Military Capabilities to 2027," *Chatham House*, May, 2018, https://www.chathamhouse.org/sites/default/files/publications/research/2018-05-10-russia-state-armament-programme-connolly-boulegue-final.pdf.

ons could be assigned missions similar to that of tactical nuclear weapons from the 1960s–1970s.[12] These were the fountainhead of present-day Russian discourse on non-contact warfare, the dominance of precision-guided weapons on the battlefield, and their ability to decide the conflict during an initial period of war.

Observing modern conflicts in the 1990s and 2000s, the Russian General Staff came to adopt the need to establish "non-nuclear deterrence," premised on the strategic effect of conventional weapons, and the consequent shift of non-strategic nuclear weapons into the role of escalation management.[13] Nuclear weapons originally meant for warfighting at sea, and in Europe, were hence valued for their ability to shape adversary decision-making, by fear inducement, calibrated escalation, and management of an escalating conventional conflict.[14] Non-strategic nuclear weapons were subsequently incorporated into strategic operations designed to inflict tailored or prescribed damage to an adversary at different thresholds of conflict.[15]

The Soviet Navy was never designed to fulfil this vision, but the modern Russian Navy seeks to centre its role along these doctrinal lines as part of joint operational concepts called strategic operations. Soviet naval forces retained a strong nuclear warfighting mission, seeing tactical nuclear weapons as a critical offset to US naval superiority, and contributing land attack nuclear-tipped cruise missiles to general plans for theatre nuclear warfare in Europe. However, by acquiring the ability to conduct precision strikes on land with cruise missiles, along with other types of multi-role weapons, the Russian Navy could now contribute to both the conventional deterrence and the non-strategic nuclear employment mission.

Official statements by Russian military leaders, and doctrinal documents, emphasise the importance of precision-guided weapons in the Russian Navy, and the belief that under "escalating conflict conditions, demonstrating the readiness and resolve to employ non-strategic nuclear weapons will have a decisive deterrent effect."[16] According to different estimates, Russia retains roughly 2,000 non-strategic nuclear weapons, a significant percentage of which are assigned for employment in the maritime domain, either by the Russian Navy or land-based forces supporting the naval theatre of military operations.[17] The means of delivery are decidedly dual capable, with the same types of missiles being able to deliver conventional or nuclear payloads with fairly high accuracy.

Russian strategic operations envision conventional strikes, single or grouped, against critical economic, military, or political objects. These may be followed by nuclear demonstration, limited nuclear strikes, and theatre nuclear warfare. To be clear, theatre nuclear warfare is not new to Russian nuclear doctrine, but was always the expected outcome of a large-scale conflict with NATO during the Cold War.[18] For much of the 1960s through to the 1980s, the Soviet Union anticipated at best a two to ten-day time window for the conventional phase of the conflict. However, unlike the nuclear weapons of the Cold War, precise means of delivery, together with low-yield warheads, have rendered nuclear weapons more usable for warfighting purposes with a substantially reduced chance for collateral damage. Scalable employment of conventional and nuclear weapons leverage the coercive power of escalation, whereby strategic conventional strikes make the actor more credible in employing nuclear weapons in order to manage escalation. In the context of an unfolding conflict, these weapons are not necessarily meant for victory, but to break adversary resolve and terminate the conflict.

The Russian Navy, although limited in the number of missiles it can bring to bear due to constrained magazine depth, retains a prominent role in the execution of these missions, particularly in the early phases of conflict. In this respect, submarines like the Yasen-class, and others able to deliver nuclear-tipped cruise missiles to distant shores, should be considered as important elements of sea-based nuclear deterrence at a different phase of conflict, and perhaps no less consequential than SSBNs.

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[12] Soviet writings on this subject are covered extensively in Mary C. Fitzgerald, "Marshall Ogarkov and the New Revolution in Soviet Military Affairs," *CNA*, CRM 87-2, January, 1987, 9–15, https://apps.dtic.mil/dtic/tr/fulltext/u2/a187009.pdf.

[13] See statements by Russian Navy Commander-in-Chief: "Russian Navy to Focus on Strategic Non-Nuclear Deterrence – Commander-in-Chief," *TASS*, January 1, 2019, http://tass.com/defense/983872.

[14] See analysis of the statements and views of the Chief of Russian General Staff, Valery Gerasimov, on modern character of warfare: Roger McDermott, "Gerasimov Outlines Russian General Staff's Perspectives on Future Warfare," *Jamestown Foundation*, April 3, 2018, https://jamestown.org/program/gerasimov-outlines-russian-general-staffs-perspectives-on-future-warfare/.

[15] These concepts are explored in detail throughout Dave Johnson's report on Russia's Conventional Precision Strike Capabilities: Dave Johnson, "Russia's Conventional Precision Strike Capabilities, Regional Crises, and Nuclear Thresholds," *Center for Global Security Research*, February, 2018, https://cgsr.llnl.gov/content/assets/docs/Precision-Strike-Capabilities-report-v3-7.pdf.

[16] Author's translation: "Указ Президента Российской Федерации," 15.

[17] See Igor Sutyagin, "Atomic Accounting: A New Estimate of Russia's Non-Strategic Nuclear Forces," *RUSI*, November 7, 2012, https://rusi.org/publication/occasional-papers/atomic-accounting-new-estimate-russia%E2%80%99s-non-strategic-nuclear-forces; Kristensen and Norris, "Russian nuclear forces, 2018," 186.

[18] *Soviet Nuclear Doctrine: Concepts of Intercontinental and Theater War*, CIA, June, 1973, https://www.cia.gov/library/readingroom/docs/DOC_0000268107.pdf.

Novel Weapons Meet a Force in Transition

Russia's newest line-up of ships may seem relatively small and unimpressive, but, in truth, it is a green-water navy able to implement both the defence of maritime approaches and the strategic deterrence missions envisioned by the General Staff. Indeed, the current line-up of corvettes, heavy corvettes, and light frigates is in many respects no less capable than Soviet destroyers.[19] However, technology bottlenecks and chronic problems in shipbuilding, in part due to two decades of underinvestment in the Russian armed forces, have left the service dependent on legacy Soviet platforms well into the 2020s. The financing and shipbuilding capacity is simply not there to restore a blue-water force, which is somewhat to Russia's benefit since it effectively checks the traditional megalomania of the Russian Navy and instead focuses the service on the core missions described above.[20] Despite its best intentions, the Russian Admiralty is simply unable to waste vast resources in building large and expensive surface combatants, like aircraft carriers, that have no discernible role in Russian naval strategy (and arguably never did).

Beyond the ballistic missile submarine force, and nuclear-armed general purpose forces, the Russian Navy retains boutique capabilities in the Main Directorate of Deep-Sea Research 10th Department (GUGI). GUGI is a separate force, co-located with the Northern Fleet in Murmansk. This de facto second navy maintains a growing force of modified nuclear-powered submarines, able to serve as mother ships for deep-diving submersibles, and a fleet of ocean-going deep-sea research ships. GUGI's vessels work on undersea infrastructure, map communications cables lying on the ocean floor, and conduct various special missions for the Russian General Staff. Of particular note are GUGI's modified submarines designed to deliver novel nuclear weapons, like the Poseidon nuclear-powered torpedo (previously known as Status-6). According to official Russian statements, and seemingly leaked documents, Poseidon is a nuclear-armed, and nuclear-powered, long-range weapon intended to take out coastal cities or economic infrastructure in a retaliatory strike.[21] A recently launched multipurpose GUGI submarine, *Belgorod*, will be one of the early carriers of this torpedo. Follow-on submarines like *Khabarovsk* are likely to serve as dedicated carriers, part of Russia's strategic nuclear submarine force. US abrogation of the 1972 Anti-Ballistic Missile Treaty and investment in missile defence is the driving impetus behind Poseidon. Fearing that the credibility of Russia's nuclear deterrent may someday be compromised, Russian leaders chose to fund alternative means of nuclear delivery to retain an assured second-strike capability in the coming decades. The Poseidon weapon system represents one of Russia's most expensive next-generation nuclear weapons programs, along with the Avangard hypersonic boost glide vehicle, and Burevestnik nuclear-powered cruise missile.

Today's Russian nuclear forces are postured to inflict a retaliatory-meeting or retaliatory strike in the event of a confirmed attack, thereby guaranteeing that any strategic nuclear or conventional strike will be met with costs unacceptable to the adversary. The Russian Navy has a firm hand in both strategic and non-strategic nuclear missions, together with the procurement of big-ticket platforms and capabilities required to execute them. As Russian conceptions of conflict phasing, escalation, and escalation management place greater emphasis on conventional and non-strategic nuclear weapons, the Russian Navy has taken on these new missions as part of force integrating strategic operations. Technological progress, including universal vertical launch tubes and long-range precision guided missiles, has given even smaller combatants a potentially "strategic" role.

The role of nuclear weapons in Russian maritime strategy represents continuity and change, evolving together with Russian views on nuclear escalation and the importance of conventional weapons in modern conflict. However, the Russian perspective on the nature of conflict between nuclear peers remains unchanged from that of Soviet leaders. Moscow expects a great power war to inevitably result in nuclear escalation, and as long as this remains true, nuclear weapons will retain a strong role across the Russian armed forces.

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[19] Kofman and Polmar, "New Russian Navy: Part 1."

[20] Dmitry Gorenburg, "Shipbuilding Constraints Drive Downsized But Potent Russian Navy," *CIMSEC*, November 25, 2015, http://cimsec.org/shipbuilding-constraints-drive-downsized-potent-russian-navy/20150?fbclid=IwAR0KpgI1NQIbDTGufgrn1oWdSjeyECxIgUDCyF4Y87VEaTltOhXyD5hG5XA.

[21] Valerie Insinna, "Russia's Nuclear Underwater Drone is Real and in the Nuclear Posture Review," *Defense News*, January 12, 2018, https://www.defensenews.com/space/2018/01/12/russias-nuclear-underwater-drone-is-real-and-in-the-nuclear-posture-review/.

Chapter 10

India's Deterrence Posture: The Role of Nuclear Strategy

C. Raja Mohan

This chapter offers a historical review of the role of nuclear weapons in India's deterrence posture. It divides the evolution of India's nuclear strategy into five distinct phases marked by the shifts in the external security environment, the thinking about atomic issues, and doctrinal considerations about the nature of deterrence. The division into five phases is a tool for analytical convenience that helps capture the changing nature of India's nuclear strategy.

In the first phase (1947–1961), India's independence along with the partition of the subcontinent coincided with the dawn of the atomic age. The liberal international ideals of the Indian national movement coupled with the misreading of the international situation as well as the nature of nuclear weapons produced a set of consequences that India has struggled to overcome since. India's first Prime Minister Jawaharlal Nehru (1947–1964) was convinced that independent India did not face an existential threat. He believed that a policy of peace and engagement would overcome any potential dangers from Communist China, which had become India's neighbour after its annexation of Tibet. Nehru's Delhi also considered Pakistan as a weak and transient entity that did not present any real threat to India. This relaxed threat assessment meant India did not see the need to build up a strong conventional deterrent against either Pakistan or China. Meanwhile, Delhi's foreign policy of moralpolitik rejected the logic of Cold War alliances (especially with Pakistan) and chose to adopt and promote the idea of non-alignment as a better path to peace. It also involved a trenchant critique of nuclear weapons and diplomacy focused on universal disarmament and concrete steps to freeze and reverse the atomic race among the great powers.

India's ingenuous strategic framework in the first decade after independence was redeemed to some extent by three factors. One was Nehru's strategic investments in advanced technologies, including in nuclear technology. Second was the expansive science and technology collaboration with the United States and the West that boosted the first. Third was the strategic decision not to close the nuclear weapon option that helped retain the choice to develop atomic weapons at a future date.

The second phase (1962–1979) saw a crisis in India's deterrence posture. If the wars with China (1962) and Pakistan (1965) exposed the weakness of India's conventional deterrence, China's first test of a nuclear weapon in 1964 reframed the nuclear question for India. The vigorous domestic debate on national security resulted in four outcomes: tentative scientific effort to develop nuclear weapons capability; the pursuit of nuclear security guarantees from the United States, United Kingdom, and Russia; the campaign for a nuclear disarmament treaty; and the long overdue modernisation of the military.

The results were mixed. The new investments in defence capabilities paid dividends by 1971, when Delhi successfully turned Pakistan's eastern half into Bangladesh and affirmed India's regional primacy. On nuclear strategy though, matters became more complicated than before. India's quest for nuclear security guarantees turned out to be elusive and its quest for multilateral nuclear disarmament resulted in the 1968 Treaty on the Non-Proliferation of Nuclear Weapons (NPT), which constrained India's nuclear policy for decades despite not ever being a signatory to the NPT. India's efforts to develop nuclear weapons capability culminated in the testing of an atomic bomb in May 1974. However, India muddied the waters for itself by calling the test a "peaceful nuclear explosion." The decision to demonstrate nuclear weapons capability, without actually moving towards nuclear weapons, produced multiple negative consequences for India. It reinforced Pakistan's case for a nuclear arsenal after the loss of Bangladesh. It encouraged China to counter "Indian hegemony" by helping Pakistan develop nuclear and missile capabilities. The United States and the West which had encouraged India to develop advanced technological capabilities now targeted India with sanctions as part of the new non-proliferation policies triggered by Delhi's 1974 nuclear test. Yet, Delhi seemed utterly oblivious of the transformation of its nuclear environment, thanks to the absence of any immediate security threats after 1971 from Pakistan's and China's self-imposed isolation. One source of India's complacency was the de facto alliance with the Soviet Union – forged in 1971– that seemed to provide a balance against both China and Pakistan in the 1970s.

In the third phase (1980–1998), Delhi could not avoid addressing the multiple contradictions of India's nuclear strategy. As reports of Pakistan's nuclear weapons program and China's support for it became difficult to ignore in the 1980s, Delhi began to have a fresh debate about its nuclear strategy. The argument that the time had come for India to "close" its nuclear options began to gain ground. Prime Minister Rajiv Gandhi (1984–1989) ordered the building of a nuclear arsenal in 1988. He also stepped up investments in India's missile program that would produce the delivery vehicles for its nuclear weapons. However, Mr Gandhi's successors would not go public with this decision for the fear of inviting the wrath of the United States and the potential negative impact on India's economic reforms that were launched at the turn of the 1990s. A strong section of the Indian establishment argued that there was neither a need to conduct any nuclear tests nor deploy nuclear weapons so long as India maintained its capability to quickly develop nuclear weapons should it feel necessary.

India's "virtual arsenal" was presented as a "recessed deterrent." It insisted that deterrence works well enough through uncertainty.

The assumption was that India's adversaries knew about India's nuclear weapons capability and were unable to conclude that Delhi can't deliver its nuclear weapons to inflict unacceptable damage. The credibility of this strategy came under intense scrutiny from others in the establishment who eventually prevailed on Prime Minister Atal Bihari Vajpayee (1998–2004) to conduct a series of nuclear tests in May 1998 and formally declare India a nuclear weapons power. However, the ideas of the former school – centred around the notion of credible minimum deterrence and nuclear restraint – endured in the articulation of India's nuclear strategy.

The fourth phase (1999–2014) saw not only the maturation of India's nuclear strategy but also the emergence of a fresh set of challenges. On the positive side, India's anomalous position in the global nuclear order set around the NPT was resolved through intensive diplomatic engagement with the United States (including amendments to domestic laws as well as the guidelines of the Nuclear Suppliers Group) to end restrictions against international cooperation with India's civil nuclear energy development. Implicit in the bargain was the willingness of the United States to live with India's nuclear weapons and Delhi's explicit commitments to separate its civilian and military nuclear program and abide by global non-proliferation rules despite still not being a signatory to the NPT. Internally, Delhi strengthened, slowly but surely, the capabilities needed for nuclear deterrence.

In moving towards a triad of delivery systems, Delhi prioritised the development of longer-range missiles that could reach Chinese territory. It also accelerated the building of sea-based deterrents. This phase also saw the consolidation of command and control systems, strengthening the procedures for safety and security, and the development of national technical means. Delhi also sought to improve the coordination between the three key institutions involved in the operational management of nuclear weapons – the Department of Atomic Energy, the Defence Research and Development Organisation, and the Strategic Forces Command of the armed forces – and between them and the civilian leadership – bureaucratic and political.

On the more problematic side, India's nuclear doctrine issued in 2003 continues to raise as many questions as it answers. The arguments are about three core tenets of India's nuclear doctrine – credible minimum deterrence, massive retaliation, and no-first-use (NFU). There is widespread – at home and abroad – questioning about each of these elements and the compatibility between them. Credible minimum deterrence is about the quality and quantity of the nuclear arsenal. Some in India worry that the emphasis on "minimum" may limit the size of the arsenal to levels well below the level needed for credible deterrence. Many external critics argue that India's reluctance to define what is "minimum" will lead to an open-ended arms race with Pakistan and China, and generate endemic strategic instability in the region. Despite the expansion of Pakistani and Chinese nuclear arsenals, there is no evidence that India is stepping up the effort to produce weapons-grade fissionable material or accelerating the build-up of nuclear weapons. Others insist that India does not need parity with its adversaries – in numbers, yield, or types of nuclear weapons – but the certainty of retaliation and a survivable force that can ensure it.

Some critics point to the promise of the official doctrine to "retaliate massively" to a nuclear attack might be inconsistent with the idea of a credible minimum deterrence. They also point to the problems of credibility that the threat of massive retaliation has always generated. Some analysts argue that of "assured retaliation" might be more in consonance with the idea of credible minimum deterrence. The idea of non-use against non-nuclear weapon states and NFU against other nuclear weapon states has been a central element of India's nuclear doctrine. It also aligns with India's foreign policy tradition of moralpolitik and the strategic culture of restraint.

Realist supporters of the idea point to the operational benefits of NFU, including helping avoid costly warfighting strategies and the need to develop highly sophisticated command and control systems. Critics, however, point to three weaknesses. One is the exception made in the 2003 doctrine to the NFU that the promise does not apply in the event of an attack involving chemical weapons. Critics say Delhi might have undermined the arguments on the operational benefits of the doctrine with this exception. Second, with India's posture rooted in NFU and deterrence through assured retaliation, critics say this demands a very robust crisis management system and point to India's bureaucratic difficulties in constructing one. Third, some play back India's own argument to China that has an NFU pledge of its own – that the NFU is a declaratory doctrine for peacetime that might be utterly irrelevant in the time of war.

If the first four phases were devoted to sorting out India's manifold difficulties with nuclear weapons, the question of defining an appropriate relationship between nuclear strategy and larger problems of deterrence came into sharp view in the final phase, which began in 2014. Delhi's technical and doctrinal discourse on nuclear weapons has been rooted in the proposition that their only purpose is to deter others from using them against India. While the proposition is appealing in theory, it has done little to address India's deepening strategic challenges with Pakistan and China. In the case of Pakistan, nuclear weapons seemed to constrain Delhi's options in countering Pakistan's relentless support for terrorism in India since the late 1980s. If the Pakistan Army seemed to revel in the presumed impunity offered by nuclear weapons, the Indian political leadership, unwilling to escalate to the nuclear level, was hesitant to respond with punitive use of conventional military force against Pakistan.

Since Prime Minister Narendra Modi took charge in May 2014, his national security team have underlined the importance of enhancing India's deterrence vis-a-vis Pakistan's support for cross-border terrorism and the need to overcome nuclear constraints. This approach has led to three distinct responses: raising the intensity of artillery fire across the Line of Control (LoC) in Kashmir; expanding the cross-LoC operations of the Indian Army (culminating in the so-called surgical strikes on terror launch pads in Pakistan-controlled Kashmir in 2016); and the use of the Indian Air Force to bomb a terror camp at Balakot in Pakistan's territory outside Kashmir in February 2019 in response to a terror attack that killed 40 Indian security forces in Kashmir. Some would add a fourth: a deliberate political effort to weaken the commitment to the NFU. In August 2019, following the change in the constitutional status of Jammu and Kashmir, the Defence Minister of India, Rajnath Singh, created a furore by suggesting that the policy was conditional: "Till today, our nuclear policy is 'no first use.' What happens in future depends on the circumstances." This statement should not be seen as a definitive tilt away from the NFU, but as a reminder to Pakistan that the Modi government will not submit itself to what Delhi sees as "nuclear blackmail."

The aerial attack on Balakot was the first time India had used its air force against Pakistan since the Indo-Pakistani War of 1971, and widely seen as a major effort by Delhi to break out of the restraint imposed by nuclear self-deterrence. That the crisis did not escalate into either a full-blown conflict or a nuclear crisis has also been interpreted in Delhi as expanding India's conventional military options in responding to Pakistan-supported terror attacks. Sceptics, however, question the claim that Pakistan's nuclear bluff had been finally called. They point to the facts that Pakistan did use its air force in retaliation a day after Indian attacks and that India lost an aircraft in the aerial skirmishes and its pilot was captured by Pakistani forces. The truth could be somewhere in between – the Balakot attack showed there might be room for Delhi between doing nothing in response to terror provocations and drifting towards rapid nuclear escalation. To be able to take full advantage of the room, Delhi needs a stronger conventional capability than it currently has.

The complex relationship between nuclear and conventional deterrence also came into view in India's confrontation with China in the Doklam plateau on the China–Bhutan border in the summer of 2017. As Beijing sought to nibble away at its border with Bhutan, Delhi stepped in to confront the People's Liberation Army (PLA) with a massive deployment of the Indian Army on the contested border. After nearly three months of standoff, China agreed to defuse the crisis. Some policy makers in Delhi involved in the negotiations with the Chinese to resolve the crisis believe that the potential escalation of the confrontation to the nuclear level is one of the factors contributing to the Chinese decision to disengage in Doklam. However, China has not given up its claims on the border, and as it modernises its conventional capabilities, it is by no means clear that India's direct or implicit threats of nuclear escalation can be repeated with success every time there is a provocation from the PLA. In other words, nuclear weapons on their own are not adequate in coping with the security threats from China and Pakistan.

As India turns its attention to the challenges of building credible conventional deterrence vis-a-vis Pakistan and China, the maritime dimension has begun to loom large. If the modernisation of its conventional armed forces is critical for raising the nuclear threshold, the credibility of its nuclear deterrence will continue to rest, in essence, on the credibility of India's sea-based nuclear deterrent. India's first nuclear-powered ballistic missile submarine (SSBN) has reportedly begun deterrent patrols at the end of 2018. Delhi needs at least four SSBNs to demonstrate continuous deterrent patrols. Meanwhile, the dramatic expansion of China's People's Liberation Army Navy (PLAN), the emerging integration of the Pakistani Navy with the Chinese naval forces, and the prospects for Beijing acquiring a naval base in Pakistan for the deployment its forces, including nuclear submarines, presents a whole new set of challenges. The growing pace and reach of the PLAN suggests that India must devote a higher share of its defence resources to the navy that offers greater flexibility in coping with the challenges from an assertive China.

Finally, there is the question of alliances in India's deterrent posture. Delhi had vehemently denounced alliances in the first decade after independence but sought them in the wake of the border war with China in 1962 and Beijing's emergence as a nuclear weapon power in 1964. When the effort with the United States failed, it developed a close alliance-like relationship with the Soviet Union, culminating in the Indo-Soviet Treaty of Peace, Friendship and Cooperation of 1971. The United States' support for India's integration into the global nuclear order during 2005–2008 initiated a new strategic partnership between Delhi and Washington. Convergent global interests, the imperative of structuring a stable balance of power system in Asia amidst the rise of China, and the interest in countering terrorism and religious extremism in the subcontinent have given a new framework for growing security cooperation between India and the United States. Implicit US support to India during the Doklam crisis with China in 2017 and the explicit tilt towards Delhi in the Balakot confrontation with Pakistan in 2019 had some effect in strengthening India's deterrence vis-a-vis its two regional rivals.

The traditional literature on India's nuclear strategy tends to downplay the importance of strategic partnerships, but the salience of strong Indian cooperation with the United States, Japan, and Australia is likely to become an important element of India's nuclear strategy as well as its deterrence posture. This might be at odds with the proposition that US alliances in Asia are weakening amidst the rise of Chinese military power. Nevertheless, the logic of collaboration between China's neighbours and between them and the United States is unlikely to disappear any time soon. That India needs to develop coalitions with other powers, especially the United States, Japan, and Australia, to cope with the growing gap between its own national power and that of China is widely accepted. The atomic domain too is now in flux, thanks to the breakdown of the traditional nuclear arms control framework, the difficulties of drawing China into any regime of regional restraint, and the uncertain impact of cyber and space technologies on nuclear deterrence between major powers. This means that India and the other members of the Quadrilateral Security Dialogue (United States, Japan, and Australia) will have to begin to coordinate their military policies that have a bearing on regional nuclear stability in Asia and the broader Indo-Pacific.

Chapter 11
Atoms for Peace? India's SSBN Fleet and Nuclear Deterrence

Sudarshan Shrikhande

India does not gain anything by escalating the nuclear arms race in the region with INS Arihant.
Chinmaya Gharekhan[1]

India is developing sea-based nuclear deterrence in accordance with its nuclear doctrine … to reinforce nuclear deterrence, supported by corresponding operational capabilities and procedures for optimal deployment, in keeping with national policy.
Indian Maritime Strategy[2]

On 5 November 2018, some of the crew of INS *Arihant,* India's first nuclear-powered ballistic missile submarine (SSBN), were congratulated in New Delhi by Indian Prime Minister Modi after India's first deterrent patrol. Indeed, it was an occasion to mark: "The surge of national pride at the recent completion of 'deterrent patrol' by the Indian Navy's first home-built [SSBN] INS *Arihant*, is fully justified," wrote Admiral Arun Prakash, though not without adding some cautions.[3]

India's journey in building its own nuclear deterrence capabilities has been a long one – a bit too long and a bit too slow. Strategic indecision and perhaps inadequate cohesion more than technological impediments were factors that led to lost opportunities in terms of permanent membership of the UN Security Council; becoming a nuclear-weapon state (NWS) before the non-proliferation treaty of 1968; and, in general, finding a seat at the high table of world politics.[4] Some scholars have thought of a nuclear India more as a matter of "prestige" than a necessity.[5] This is a charge often made about those nations that play catch-up with early starters, as seen in the case of battleships, aircraft carriers, space flight, and even in winning Olympic medals.

Historical Rationale for Indian SSBN Construction

Space does not permit tracing the history of India's SSBN program; however, a brief but authoritative account by Admiral Prakash can be recommended.[6] We should draw out four key points from history as outlined below. First, it is difficult to agree that India stumbled into making an SSBN while trying to develop reactors for nuclear attack boats.[7] Until the May 1998 nuclear tests, India had never admitted to a nuclear weapons capability at all. Therefore, to indicate that there indeed was an diesel-electric ballistic missile submarine (SSB)/SSBN program would have been ill-advised. One can imagine the effort put into deception that led to beliefs that only nuclear-powered attack submarines (SSNs) were on the drawing board. The very name, Advanced Technology Vessel Programme (ATVP), seemed opaque, but less so than the Manhattan Project (1939–1946). There is insufficient understanding in the West about Indian deception strategies (and even strategem) used to keep the SSBN and other programs covert. Today, the ATVP remains focused on SSBNs, but SSNs could well follow. While deception strategies were largely successful, not all decisions on delivery vehicle development were cohesive and beneficial. Second, we can infer that covert developmental strategies of the other legs of the triad were underway before the 1998 nuclear tests, so that when India went overt with its capability, the tasks of operationalising delivery vehicles would be quicker. Therefore, while the grand vision and will for going nuclear may have been constrained, delivery development was

[1] Chinmaya R. Gharekhan, "Deterrence or Danger," *The Hindu*, January 3, 2019, https://www.thehindu.com/opinion/op-ed/deterrence-or-danger/article25892848.ece.

[2] Integrated Headquarters, Ministry of Defence (Navy), *Ensuring Secure Seas: Indian Maritime Security Strategy*, (New Delhi, 2015), 48.

[3] Arun Prakash, "One Arihant Does Not Make for a Credible Nuclear Deterrence," *The Economic Times*, December 21, 2018. Admiral Prakash was closely involved with the SSBN project as the Navy Chief and Chairman, Chiefs of Staff Committee. Later, as a member of the National Security Advisory Board and the Naresh Chandra Committee on Defence Reorganisation, he has written extensively on nuclear security issues. The author acknowledges Admiral Prakash's generosity in sharing many of his personal papers.

[4] See Bharat Karnad, *Why India is Not a Great Power (Yet)* (New Delhi: Oxford University Press, 2015), 10–13; Jasjit Singh, ed., Nuclear India (New Delhi: Knowledge World, 2007), 20–25.

[5] Diana Wueger, "India's Nuclear Armed Submarines: Deterrence or Danger?" *The Washington Quarterly* 39, no. 3 (2016): 80. However, Wueger does not necessarily hold this view. Her article and preceding Master's thesis form comprehensive studies of the maritime leg of India's deterrent and the Indian Ocean's nuclear environment, which she generously shared with the author.

[6] Arun Prakash, "The Arihant in Perspective," *Livefistdefence.com*, September 18, 2009, https://www.livefistdefence.com/2009/09/admiral-arun-prakash-arihant-in.html. This was written soon after the launch of Arihant by the then prime minister. While no media were present, nor any pictures of the boat published, the event was given wide publicity. This author was present at the event.

[7] Wueger, "India's Nuclear Armed Submarines," 80. She terms it more "accidental than intentional."

relatively well-conceived. The problems lay in slow manufacturing and testing processes. The need to gain experience in operating nuclear submarines led to the leasing of the first SSN from the USSR in 1988. At this time, India's defence strategy focused its energy on the maritime leg of the envisaged triad.

Third, many features of the command and control (C2) framework necessary for sea-based nuclear deterrence to deploy operationally, survive tactically, and launch strategically were also applicable for C2 of conventional boats and the leased SSN. Accordingly, a very low frequency (VLF) radio communications program was put in place in the mid-1980s. The key partner for this was an American company.[8]

Fourth, the assumed change of type from SSN to SSBN as the focus of India's nuclear submarine program has been called an afterthought. As explained, this was not the case. Nonetheless, there are parallels elsewhere that underscore SSN/SSBN compatibilities. For example, the first US Navy SSBN, *George Washington*, and four follow-on Polaris boats were derived from the *Skipjack* SSN design. The *Washington* (SSBN 598) was laid down as SSN 589 (*Scorpion*) on 1 November 1957, but re-designated SSBN 598 on 31 December 1957.[10] On the contrary, the French began – like India – with SSBN construction. The *Redoubtable* was laid in 1963 and commissioned in 1971. However, France was not under any constraint to keep this covert.[11]

Towards Deterrence

In the weeks after *Arihant's* launch in 2009 and its first deterrent patrol in 2018, the media in India, and its similarly raucous counterparts in Pakistan, did end up chest-thumping and fist-shaking. Chinese media were less noisy but angry and dismissive.[12] This, along with high-pitched Indian political messaging in 2009 and 2018, ended up conveying that there was a game-changer on the scene. Shorn of the hyperbole, *Arihant* is not yet part of the deterrence architecture in a meaningful way. After all, for any nation, deterrence is about substance, not symbolism; spin is not necessarily nuclear signalling; and adversaries always have a vote on feeling deterred. Yet, the *Arihant* is an important first step towards establishing sea-based nuclear deterrence.

An aspect this author examines in his doctoral research relates to the interplay of quantitative and qualitative factors that feed into the effectiveness of sea-based nuclear deterrence. This seems to be especially important in India where quantitative factors regarding the number of delivery vehicles possibly "pointed" towards India are a bit too easily explained away by the quality that Indian credible minimum deterrence, or even just credible deterrence, is supposed to provide.[13] Hence, here are some aspects to consider as we later examine the impact of India's SSBN fleet.

It would be logical that in case of a single-front conflict with either Pakistan or China, the nuclear alert posture of the other non-engaged adversary would also be higher. In a two-front situation – and good strategic planning implies that hardly any scenario should be off the table – the seriousness of the issue increases. Going by data from the *Bulletin of the Atomic Scientists,* the number of China's warheads is 280 (X), Pakistan's 140–150 (Y), and India's 130–140 (Z). Pakistan and India are almost matched, but Pakistan's accretion rate is presumed to be higher.[14] The gap may grow. China alone or (X)+(Y) creates quantitative challenges for credible or credible minimum deterrence for India with Z vectors.

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[8] G.M. Hiranandani, *Transition to Eminence: The Indian Navy 1976–1990, Official History of the Indian Navy* (New Delhi: Lancer Publishers LLC, 2004), 174. The US company was Continental Manufacturing Company.

[9] Wueger, "India's Nuclear Armed Submarines." Yogesh Joshi's inferences about this point as an afterthought need some rethinking. See Yogesh Joshi, "The Imagined Arsenal India's Nuclear Decision-Making, 1973–76," *NPIHP Working Paper 6 June 2015, The Wilson Center*, https://www.wilsoncenter.org/sites/default/files/wp6-the_imagined_arsenal_-_ver_2.pdf. That Joshi, in his considerable research, did not find evidence of SSBNs is more due to successful deception and disinformation than strategic blundering, which led not only scholars but even insiders to draw some off-the-mark inferences. For example, see Vijay Shankar, *Covenant Sans Sword* (2014), Lawrence Livermore National Laboratory, online video, 1:18:11, https://www.youtube.com/watch?v=OZpIrZvP0Co.

[10] Norman Polmar and K.J. Moore, *Cold War Submarines: The Design and Construction of U.S. and Soviet Submarines* (Virginia: Potomac Books, 2004), 117, https://fas.org/wp-content/uploads/2016/12/Frances-Choice-for-Naval-Nuclear-Propulsion.pdf. In the US Navy, the classification SSGN (guided-missile submarine) came about again when decades later some SSBNs of the Ohio-class were converted to fire land-attack cruise missiles. In fact, the 24 silos were converted to carry 154 Tomahawks per boat, which is very high firepower and excellent reuse of SSBNs being scaled back. With the US actively considering re-introduction of newer variants of nuclear-tipped cruise missiles, and now the collapse of the Intermediate Nuclear Forces Treaty, interesting times surely lie ahead.

[11] Alain Tournyol du Clos, "France's Choice for Naval Nuclear Propulsion: Why Low Enriched Uranium was Chosen," *Federation of American Scientists*, 2016, https://fas.org/wp-content/uploads/2016/12/Frances-Choice-for-Naval-Nuclear-Propulsion.pdf. France built SSNs later, and it seems that India too is mirroring that sequence. The French tested their first nuclear bomb in 1960. That the French also prioritised resources for SSBNs before SSNs is not widely known in India. For example, see Ajai Shukla, "India Debates, China Struggles," *rediff.com*, September 2, 2010, https://www.rediff.com/news/report/nuke-subs-india-debates-china-struggles/20100902.htm.

[12] Examples are too numerous for references.

[13] India's public nuclear doctrine is titled *The Cabinet Committee on Security Reviews Operationalisation of India's Nuclear Doctrine*, dated January 4, 2003. See Manpreet Sethi, *Nuclear Security: India's March Towards Credible Deterrence* (New Delhi: Knowledge World Publishers, 2009), 247–248.

[14] Hans M. Kristensen and Robert S. Norris "Chinese Nuclear Forces, 2018," *Bulletin of the Atomic Scientists* 74, no. 4 (2018): 289–295; Hans M. Kristensen, Robert S. Norris and Julia Diamond, "Pakistani Nuclear Forces, 2018," *Bulletin of the Atomic Scientists* 74, no. 5 (2018): 348–358; Hans M. Kristensen and Matt Korda "Indian Nuclear Forces, 2018," *Bulletin of the Atomic Scientists* 74, no. 6 (2018): 361–366.

Deterrence stability is not about arithmetic, but vector numbers do matter. Z«X+Y could be seen as a curious twist of the Royal Navy's "two-power standard" for force structuring at the zenith of British power.[15]

Numbers matter, they always have, even when they reached high five-digits at the peak of the Cold War. The Indian architecture of deterrence is weakened by the possibility of a counterforce first strike and the resulting loss of delivery vehicles. It is at such a time that the other adversary's arsenal would be at a higher state of readiness – and therefore a greater threat. With reduced capabilities and shrinking windows for retaliation, India's quantitative disadvantage increases and the qualitative value of credible minimum deterrence declines, since massive retaliation or a variant (unacceptable damage) both rest on evaluation of surviving retaliatory capability.[16]

Given the distinct possibility that either or both likely adversaries may launch a certain number of conventional missiles against nuclear and non-nuclear targets in India, the limited future ballistic missile defence capability may deplete rapidly. Is a non-nuclear strike against India's nuclear forces to be a trigger for massive retaliation, especially when either adversary retains some capabilities for follow-on counterforce or countervalue strikes?

These are uncomfortable scenarios, but very much part of strategic planning and force-structuring that actually feed into deterrence itself. Comforting as it may seem to think of nuclear weapons as political rather than military weapons, the stability of deterrence and effectiveness of any country's nuclear arsenal depends on its organisation, C2, readiness, training, lethality, spread, and survivability. It is also useful to remember that even an assassin's/commando's bullet, grenade, or explosive vest is a political weapon in so far as some ends of political purpose were envisaged in its very existence and use.[17]

Bolstering Deterrence Stability

Therefore, India's choice to build SSBNs before SSNs was wise, accepting the great cost, and technological and operational challenges. Doctrinally, the Indian Navy has long acknowledged the criticality of deployed SSBNs for deterrence stability.[18] Undoubtedly, risks are inherent in nuclear deterrence architectures in any environment. Among others, these are argued well by Medcalf and Thomas-Noone. Yet, as they point out, Indian SSBNs could be part of long-term stability. One observation is particularly profound: "Not everything in geopolitics gets worse all the time. Assuming that lessons are learned and potential crises managed in the decade ahead, advances in Chinese and Indian SSBN and SLBM [submarine-launched ballistic missile] technology may eventually contribute to a new phase of relative strategic stability where the existence of nuclear weapons keeps the peace and prevents their use."[19]

Deterrence instability requires watching, prevention, and sometimes even leveraging it for getting the upper hand in the deterrence matrix. Pakistan has used such leverage a few times. However, instability ought not be conflated with either a collapse of deterrence or bringing matters closer to collapse. Collapse could occur even under conditions of stability and balance of nuclear power.

To Deploy Operationally, Survive Tactically, and Launch Strategically …

For at least two more decades, India's sea-based nuclear deterrence capability will fall short in qualitative and quantitative terms, unless India puts in more resources. Specifically, *Arihant* seems to have twelve very short-range K-15 SLBMs with a reported range of 700–1,000 kilometres.[20] However, Medcalf and Rehman both mention that *Arihant* could be modified to launch four of the K-4 SLBMs of 3,000–3,500-kilometre range. Options to deploy *Arihant* periodically seem to be limited. It can only patrol against Pakistan,

[15] Andrew Gordon, *The Rules of the Game: Jutland and British Naval Command* (Annapolis: USNI Press, 2012), 194. *The Naval Defence Act of 1889* institutionalised the principle that the Royal Navy should be at least equal to the two largest navies combined. While neither fleet effectiveness nor deterrence is strictly about arithmetic, the Indian situation of having fewer vectors than either of the two adversaries is worrisome. The pace at which China seems to be closing the large gap with the United States in warheads is also something to think about. For China, too, quality–quantity (Q–Q) matters.

[16] Arka Biswas, "Credibility of India's Massive Retaliation," *Observer Research Foundation Commentaries,* January 9, 2017, https://www.orfonline.org/research/credibility-indias-massive-retaliation/.

[17] The idea of the prefix political to nuclear weapons in the Indian discourse comes from two related misconceptions. One, that its use can be only by exclusive political authority. That, of course, is very much so in India and shall remain. In most military matters, political control overrides, be it surgical strikes, mobilisation, etc. The second relates to the feeling that in Pakistan, it is the military that controls the arsenal. That may be so, but it is a matter of political detail in Pakistan that political power often originates from GHQ Rawalpindi than from Islamabad. That makes Pakistan's nuclear weapons political as well. The argument could be applied to North Korea's arsenal. It is under political control, albeit of one man. Deterring or fighting a war has to be about politics.

[18] Wueger, "India's Nuclear Armed Submarines." It may be argued that the apprehensions she discusses are similar to those expressed at various stages of the Cold War. Her analysis has several useful points.

[19] Rory Medcalf and Brendan Thomas-Noone, "Nuclear-Armed Submarines in Indo-Pacific Asia: Stabiliser or Menace," *Lowy Institute*, September, 2015, https://www.lowyinstitute.org/publications/nuclear-armed-submarines-indo-pacific-asia-stabiliser-or-menace. This is a very insightful analysis and, more than three years later, it retains great validity.

[20] Prakash, "The Arihant in Perspective." Iskander Rehman, in his very comprehensive study, puts the range of the K-15 SLBM at 750-800 kilometres in Iskander Rehman, "Murky Waters: Naval Nuclear Dynamics in the Indian Ocean," *Carnegie Endowment,* 2015, https://carnegieendowment.org/2015/03/09/murky-waters-naval-nuclear-dynamics-in-indian-ocean-pub-59279.

and at significant risk of being "marked" frequently.[21] Therefore, four of the K-4s, rather than twelve of the K-15s, make for better deterrence capability and the sooner this is done the better. Yet, *Arihant* has its uses to hone skills, test C2 frameworks, and yet be boldly deployed when and where imperative.

Bastions for SSBN patrol seem inevitable for India until missile ranges go beyond intermediate-range ballistic missile (IRBM) to intercontinental ballistic missile (ICBM) levels.[22] Bastions are not really a virtue. Soviet/Russian bastions in Northern waters and the Sea of Okhotsk, and for the Chinese in the South China Sea, remain vulnerable to offensive anti-submarine warfare (ASW) operations. They remain preferable for these countries because maritime geography is/was a constraint, as were sonar barriers, like along the Greenland–Iceland–United Kingdom (GIUK) gap.[23] As sketched by Rehman, it seems logical that deterrent patrols even for K-4 SSBNs would have to be within the Bay of Bengal.[24] One hopes that the larger SSBN designs would be capable of doing well in qualitative and quantitative terms with SLBMs of 7,000-kilometre-plus range, about sixteen capacity (desirably with multiple independently targetable re-entry vehicles (MIRV)), and a refuelling cycle that permits about ten to fourteen-year intervals, thus giving about 40 years patrolling life with two interruptions for refuelling.[25] Like the United States, India has geographic advantages for SSBNs to go on open ocean patrol, once they field long-range SLBMs. We need to move beyond bastions where an enemy's offensive ASW is effective, as well as our own resources needed for defensive ASW, would be reduced.[26] Continuous At Sea Deterrence (CASD) for India may need to be a bit different from the models that the United Kingdom and France follow.[27] Their "one-in-four" systems puts one of the four SSBNs on patrol. Their SLBMs have multiple warheads such that one single SSBN has the potential to launch several dozen warheads. This makes the "weight" of their deterrence with just one boat on patrol quite different from that of the India's SSBN. For India's considerations, six to seven boats with a two-boat CASD and surge of up to four SSBNs could give a measure of deterrence effectiveness for two purposes: via retaliatory counter-value strikes; and, given increased accuracy, the threat of counterforce strikes. India's no-first-use doctrine could change and potentially strengthen stability. In any case, no nuclear weapon state can really gain through nuclear high-handedness. Pakistan slowly will realise this. Its moves for getting its own low-cost, sea-based nuclear deterrent based on nuclear-tipped cruise missiles are a major concern. India and its friends around the globe could cooperate in strategic ASW to keep Pakistani boats marked. Redundancy and survivability of the C2 systems including their cyber-hardening is probably an ongoing priority for the government and the Indian Navy. Talk in India, and occasionally elsewhere, about the risks of mated missiles in India's SSBNs are just red herrings. One imagines that robust Permissive Action Links and safeguards are in place.[28] Finally, for India, there is much work and expense ahead as the reliance on sea-based nuclear deterrence in terms of its quantitative and qualitative effectiveness is enhanced. There may be some phases of instability that need to be evaluated, countered, and even leveraged. On balance, Indian SSBNs could become the most critical leg of the "atoms for peace" triad.

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[21] In terms of strategic offensive anti-submarine warfare (SOASW), marking would mean being aware of the enemy's boats much of the time. In conflict, it would be feasible then for the adversary to target SSBNs with conventional ordnance (or nuclear as well in some cases) before launch.

[22] Strictly speaking, India currently fields only IRBMs (i.e. less than 5,500-kilometre range). ICBMs of about 6,500– 7,500-kilometre range at the lower end of the ICBM scale would indeed open up deployment options and enhance strategic defensive anti-submarine warfare (SDASW) for India's SSBN fleet and contribute to deterrent stability.

[23] It is in this context as well that if China succeeds in improving its maritime geo-strategic position, its SSBN fleets would move out of the bastion into more open waters. Among other matters, navies of Australia and Japan should expand their SOASW capacities for the vastness of the Pacific. GIUK is the Greenland–Iceland–UK gap used for transits of Russian SSNs and, earlier, SSBNs when their missile ranges were shorter.

[24] Rehman, "Murky Waters," 12–13.

[25] Prakash, "The Arihant in Perspective."

[26] One of the concerns India should have is the number of Chinese People's Liberation Army Navy (PLAN) diesel-electric attack submarine (SSK) and nuclear-powered attack submarine (SSN) boats, and SSK of other navies that could someday patrol in the Bay of Bengal and Arabian Sea. These other littoral nations need not be anti-India necessarily. Their submarines would pose "friend or foe" quandaries and loss of signatures issues.

[27] Sudarshan Shrikhande, *India Completes Nuclear Triad*, Strategic News International (2018), online video, 12:21, https://sniwire.com/defence-security/india-completes-nuclear-triad/. In the UK and French case, their CASD Q–Q is also influenced by the deterrent cover provided by the United States.

[28] Wueger, "India's Nuclear Armed Submarines." She observes that "India has not yet explained how it intends to retain active civilian control over its SLBM arsenal." This author feels that India is not under any obligation to explain how civilian leadership exercises control over SLBMs. While general protocols may be inferred, the details would be highly classified for any navy that deploys nuclear weapons to sea. What can be taken for granted is that the safeguards are rigorous and would match best business practices.

Chapter 12
Pakistan's Nuclear Capabilities and Prospects for Sea-Based Deterrence

Sadia Tasleem

Deterrence is a complex phenomenon. It is unwise to isolate it to the military domain alone. A totality of technological, economic, social, political, military, and diplomatic realities, if properly understood and utilised, can make up for the asymmetry in a nuclear dyad between a weak state and a strong adversary. However, the debate on the capabilities required for nuclear deterrence in Pakistan has been influenced by assumptions mainly drawn from a selective reading of the nuclear deterrence literature produced in the United States during the Cold War. Similar assumptions guide Pakistan's view of nuclear weapons at sea. Consequently, Pakistan's articulation of deterrence requirements is narrowly shaped by military considerations.

Therefore, this chapter will begin with an outline of Pakistan's assumptions about its deterrence requirements. It will provide a summary of Pakistan's existing nuclear capabilities. It will also map out Pakistan's existing and emerging sea-based capabilities followed by a survey of the key arguments about Pakistan's rationale behind sea-based nuclear forces. It will then critically examine the potential of Pakistan's sea-launched capabilities vis-a-vis the expected deliverables in view of existing institutional limitations and evolving technological challenges.

Pakistan's Nuclear Capabilities

Pakistan's assumptions about the requirements of an effective nuclear deterrent include rejection of a no-first-use policy, a dynamic nuclear arsenal with a wide-range of weapons and delivery platforms, and a survivable second-strike capability (preferably based on a triad).[1]

A relentless pursuit of the capabilities that Pakistan perceives as essential to supplement its nuclear deterrence needs is clearly manifested by the ongoing trends in Pakistan's nuclear weapons–related developments, as well as its evolving nuclear posture. Pakistan has developed a diverse nuclear arsenal with a variety of warheads as well as delivery systems including medium and short-range ballistic missiles and cruise missiles capable of carrying both conventional and nuclear warheads.[2] Pakistan has also successfully tested a multiple independently targetable re-entry vehicle (MIRV) in 2018.[3] These trends indicate a persistent effort to strengthen the credibility of Pakistan's nuclear options in the wake of India's missile defence program and Pakistan's fear of a decapitating strike. Although the efficacy of India's missile defence remains contestable,[4] and incentives for a decapitating nuclear strike are difficult to conceive, Pakistan's threat perception, largely modelled on the parameters developed in the Cold War United States, focuses on these developments seriously.[5]

Similar tools of threat perception and resultant preference for diversifying weapon systems as well as delivery platforms instigated Pakistan's interest in sea-based nuclear capabilities. Sea-based nuclear capabilities have been part of Pakistan's nuclear imagination from the early years of overt nuclearisation in South Asia.[6] This is not meant to deny the fact that Pakistan's concerns have been exacerbated by India's growing naval capabilities as well as speculation about India's aim to develop a first strike capability.[7]

However, Pakistan's earlier neglect of sea-based capabilities could be attributed to several factors, including Pakistan's historical sea-blindness, financial and technological limitations, and diplomatic pressures. Even today, Pakistan does not have a formidable presence at sea. The Pakistan Navy has modest conventional capabilities by global standards.[8] Pakistan's nuclear capabilities at sea are also at an embryonic stage.

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[1] Sadia Tasleem and Toby Dalton, "Nuclear Emulation: Pakistan's Nuclear Trajectory," *The Washington Quarterly* 41, no. 4 (2018): 135–155, https://www.tandfonline.com/doi/abs/10.1080/0163660X.2018.1558662.

[2] For details, see Hans M. Kristensen, Robert S. Norris and Julia Diamond, "Pakistani Nuclear Forces, 2018," *Bulletin of the Atomic Scientists* 74, no. 5 (2018): 348–358, https://www.tandfonline.com/doi/pdf/10.1080/00963402.2018.1507796?needAccess=true.

[3] ISPR Press Release No. PR34/2017-ISPR, January 24, 2017, https://www.ispr.gov.pk/press-release-detail.php?id=3705.

[4] For a detailed analysis of the debate, see Balraj Nagal, "India and Ballistic Missile Defense: Furthering a Defensive Deterrent," *Carnegie Endowment for International Peace*, June 30, 2016, https://carnegieendowment.org/2016/06/30/india-and-ballistic-missile-defense-furthering-defensive-deterrent-pub-63966.

[5] Tasleem and Dalton, "Nuclear Emulation."

[6] Agha Shahi, Zulfiqar Ali Khan and Abdul Sattar, "Securing Nuclear Peace," *The News,* October 5, 1999.

[7] For example, see ISPR Press Release No. PR34/2017-ISPR. It states, "Development of this capability also reflects Pakistan's response to provocative nuclear strategies and posture being pursued in the neighborhood through induction of nuclear submarines and ship-borne nuclear missiles; leading to nuclearisation of Indian Ocean Region."

[8] For details of surface warriors and submarine force, see Pakistan Navy's official website https://www.paknavy.gov.pk. Also see Alex Calvo, "Pakistan's Navy: A Quick Look," *CIMSEC*, March 23, 2016.

At this point, Pakistan's sea-based deterrence is largely dependent on dual-use platforms. For instance, Pakistan's nascent delivery system Babur-3 (nuclear) sea-launched cruise missile (SLCM) – a naval version of the land-based cruise missiles Babur 1 and 2 – is capable of carrying both conventional and nuclear warheads. Announcing the successful test of the cruise missile, the press release issued by the Pakistan Army's media arm, the Inter-Services Public Relations (ISPR), on 29 March 2018 stated, "SLCM Babur is capable of delivering various types of payloads and incorporates state of the art technologies including underwater controlled propulsion advance guidance and navigation features."[9]

In addition, given the fact that Pakistan does not possess a nuclear-powered submarine, Pakistan is expected to place the Babur-3 SLCM on its conventional naval platforms, both surface vessels and submarines. Most defence analysts claim that Pakistan will likely use the three Agosta-90B diesel-electric submarines purchased from France in 1999, 2003 and 2006 under an agreement inked in 1994.[10] These submarines have been modified with the integration of the air-independent propulsion system that has enhanced their endurance.[11] These submarines are currently being upgraded under a Turkish state-owned defence contractor with the first upgraded Agosta 90B submarine due for delivery by 2020, with the other two ready by 2021.[12] However, it is unclear whether these upgrades include modification of the launch tubes to carry Babur-3 SLCMs.

Although Pakistan test-fired a Babur-3 SLCM from an underwater dynamic platform, the capability to use the Agosta 90B as a launch pad for the cruise missile remains untested.[13]

It can be safely argued that the testing of Babur-3 has only validated Pakistan's interest and intent to build a sea-based nuclear force. Nonetheless, the existing capabilities remain far from operational. The capability of Babur-3 SLCMs to carry a nuclear warhead is untested, its yield unknown, and its tested range as limited as 450 kilometres. Such a short-range inhibits Pakistan's targeting options, containing any prospects of establishing sea-based deterrence vis-a-vis India, with most of India's mainland beyond Babur-3's range.

However, Pakistan will, in all likelihood, work towards increasing the range of its SLCM over the next decade, bringing Pakistan some flexibility in terms of its targeting options. It is also widely assumed that Pakistan will use the next-generation air-independent propulsion-equipped Yuan-class Chinese submarines to carry the Babur-3 SLCM in the future.[14] According to a 2016 agreement between Pakistan and China, China will provide eight modified Type 093 and Type 041 Yuan-class diesel-electric submarines to Pakistan, with the first batch comprising four submarines arriving in 2023 and the last four to be assembled in Karachi by 2028.[15] The addition of these Chinese submarines will tremendously boost Pakistan's ability to defend its coastal areas as well as sea lines of communication. However, the ability of these submarines to augment Pakistan's second-strike capability remains deeply contested.

Several retired Pakistan Navy officials have argued that Pakistan would require nuclear-powered submarines capable of carrying ballistic missiles for an assured second-strike capability.[16] There have been sporadic media reports hinting at the possibility of

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[9] "Pakistan conducted another successful test fire of indigenously developed Submarine Launched Cruise Missile Babur having a range of 450 kms," ISPR Press Release No. PR125/2018-ISPR.

[10] "Pakistan Says Second Strike Capability Attained," *Dawn*, March 30, 2018, https://www.dawn.com/news/1398418; Zafar Nawaz Jaspal, "Babur-III tested: Pakistan becomes a Nuclear Triad," *Global Village Space*, April 12, 2018, https://www.globalvillagespace.com/babur-iii-tested-pakistan-becomes-a-nuclear-triad/; Shervin Taheran, "Pakistan Advances Sea Leg of Triad," *Arms Control Toda*y, June 2016, https://www.armscontrol.org/act/2018-06/news-briefs/pakistan-advances-sea-leg-triad.

[11] Ali Osman, "Pakistan's Tool of War: Agosta 90B, Our Submarine in the Deep," *Dawn*, October 19, 2015, https://www.dawn.com/news/1213256.

[12] Bilal Khan, "Pakistan Signs Contract to Upgrade Second Agosta 90B," *Quwa,* February 28, 2018, https://quwa.org/2018/02/28/pakistan-signs-contract-to-upgrade-second-agosta-90b/.

[13] Bilal Khan, "Pakistan Announces Babur Sub-launched Cruise Missile (SLCM) Test," *Quwa*, March 29, 2018, https://quwa.org/2018/03/29/pakistan-announces-babur-sub-launched-cruise-missile-slcm-test/.

[14] Tom Hundley, "India and Pakistan Are Quietly Making Nuclear War More Likely," *Vox,* April 4, 2018, https://www.vox.com/2018/4/2/17096566/pakistan-india-nuclear-war-submarine-enemies.

[15] Franz-Stefan Gady, "China Confirms Export of 8 Submarines to Pakistan," *The Diplomat*, October 19, 2016, https://thediplomat.com/2016/10/china-confirms-export-of-8-submarines-to-pakistan/.

[16] Anjum Sarfraz, "Importance of Nuclear Submarines for Pakistan," *Eurasia Review,* July 2, 2019, https://www.eurasiareview.com/02072019-importance-of-nuclear-submarines-for-pakistan-oped/; Azam Khan, "Pakistan Launches First Formal Maritime Doctrine," *Global Village Space*, February 12, 2019, https://www.globalvillagespace.com/pakistan-launches-first-formal-maritime-doctrine/.

Pakistan exploring such an option.[17] At least one of Pakistan's senior defence analysts and former Director at the Arms Control and Disarmament Affairs at the Strategic Plans Division also speculated in a 2016 article that Pakistan may have indigenously developed nuclear-powered submarines by 2025.[18] The veracity of such claims is far from established. Based on publicly accessible information, it appears highly unlikely for Pakistan to successfully develop a nuclear-powered submarine in the next ten years – even if it aims to build one.

A retired officer of the Pakistan Navy, and one of the leading commentators on Pakistan's sea-based capabilities, Muhammad Azam Khan proposed an alternative option. He opined that Pakistan could acquire a nuclear-powered submarine from China on lease.[19] A Western diplomat has also reportedly highlighted such a possibility.[20] However, there is no verifiable data indicating any development in this regard.

In the next decade, Pakistan will likely improve upon its existing sea-based nuclear capabilities. For this purpose, Pakistan may attempt to increase the range of its submarine-launched cruise missiles, diversify the delivery means, work towards better integration of the missiles with the conventional submarines, and take measures to enhance the stealth capabilities of its submarines.

Commenting on Pakistan's nuclear capabilities, US-based nuclear expert Iskander Rehman notes, "Unlike their Indian counterparts, Pakistani security managers appear to have opted for a more unconventional naval nuclear force structure, strongly emphasising dual-use platforms and strategic ambiguity."[21] It remains unclear whether Pakistan's "unconventional naval nuclear force structure" is a strategic choice or a provisional arrangement based on availability and expediency.

Sea-Based Capabilities: Pakistan's Objectives

There is little public knowledge in Pakistan about the Navy in general, and sea-based nuclear capabilities in particular. However, defence analysts in Pakistan have been advocating the development of sea-based nuclear weapons to ensure "second-strike capability."[22] This argument predates any institutional arrangements for the sea-leg of Pakistan's nuclear program.

A similar rationale was put forth in the two press statements issued by the ISPR after the two tests of the Babur-3 SLCM in 2017 and 2018. As stated earlier, it was claimed that Pakistan's sea-based capabilities are meant to augment minimum credible deterrence by providing second-strike capability.[23]

A survey of Western and Pakistani writings brings out several possible roles of Pakistan's emerging sea-based capabilities. These roles vary from "limited and defensive" aims like bridging the growing asymmetry between India's conventional forces and the Pakistan Navy,[24] preventing a naval blockade by exercising sea-denial,[25] and diversifying the range of options to minimise risks to more expansive objectives like escalation dominance and warfighting.[26]

One may argue that by developing sea-based nuclear capabilities, Pakistan is hedging its bets, but do Pakistan's existing and projected capabilities correspond with the possible objectives listed above? Although Western analysts have attempted to address some of the questions relating to effectiveness, requirements, and challenges of sea-based second-strike capabilities, these issues receive little attention in the small Islamabad-based strategic community.

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[17] Usman Ansari, "Pakistani Navy to Develop Nuclear-Powered Submarines: Reports," *Defense News*, February 11, 2012; also see Mansoor Ahmed, "Trends in Technological Maturation and Strategic Modernisation: The Next Decade," in *Nuclear Learning in South Asia: The Next Decade*, ed. F.H. Khan, R. Rayn Jacobs and E. Burke (Monterey, CA: Naval Postgraduate School, 2014), 58–70; also see Shahid Raza, "Pakistan Navy's Blue Water Ambitions," *Global Village Space*, February 14, 2019, https://www.globalvillagespace.com/pakistan-navys-blue-water-ambitions/.

[18] Naeem Salik, "Pakistan's Nuclear Force Structure in 2025," *Carnegie Endowment for International Peace*, June 30, 2016, https://carnegieendowment.org/2016/06/30/pakistan-s-nuclear-force-structure-in-2025-pub-63912.

[19] Muhammad Azam Khan, "S-2: Options for the Pakistan Navy," *Naval War College Review* 63, no. 3 (Summer 2010), https://digital-commons.usnwc.edu/nwc-review/vol63/iss3/7.

[20] Farhan Bukhari, "India's Nuclear Submarine Provokes Pakistan to Renew Arms Race," *Nikkei Asian Review*, November 12, 2018, https://asia.nikkei.com/Politics/International-relations/India-s-nuclear-submarine-provokes-Pakistan-to-renew-arms-race.

[21] Iskander Rehman "Murky Waters: Naval Nuclear Dynamics in the Indian Ocean," *Carnegie Endowment for International Peace*, 2015, https://carnegieendowment.org/2015/03/09/murky-waters-naval-nuclear-dynamics-in-indian-ocean-pub-59279.

[22] Muhammad Azam Khan, "S-2: Options for the Pakistan Navy."

[23] ISPR Press Release No. PR125/2018-ISPR and ISPR Press Release No. PR10/2017-ISPR.

[24] Iskander Rehman, "Murky Waters."

[25] Saima Aman Sial, "Rationalising Pakistan's Quest for a Sea-based Deterrent Force," *Pakistan Politico*, October 18, 2018, http://pakistanpolitico.com/rationalizing-pakistans-quest-for-a-sea-based-deterrent-force/.

[26] Iskander Rehman, "Murky Waters."

Second-Strike Capabilities and Survivability

Is Pakistan's sea-based capability, constrained by the nature of its delivery platforms, limited targeting options, and advancements in anti-submarine warfare (ASW), capable of guaranteeing assured second-strike?

The ISPR hailed the successful testing of the Babur-3 SLCM as a demonstration of Pakistan's second-strike capability. The ISPR press release issued on 29 March 2018 claimed, "SLCM Babur provides Pakistan Credible Second-Strike Capability, augmenting the existing deterrence regime."[27] The press release further states that "Pakistan eyes this landmark development as a step towards reinforcing the policy of Credible Minimum Deterrence through indigenisation and self-reliance."[28]

Second-strike capability has for the longest time been dependent on nuclear-powered ballistic missile submarines (SSBNs). It was assumed that the endurance of SSBNs enhanced their ability to hide, increasing their survivability. Long-range ballistic missiles atop a "non-detectable" submarine hold a wide range of enemy targets, both at sea and on land, at risk, reducing incentives for the enemy to strike first, and strengthening deterrence as a result.

Today, confidence in the survivability of SSBNs is rapidly eroding because of the evolving technologies that may make the oceans and seas more transparent.[29] Contemporary literature explores technological possibilities that may undermine the survivability of submarines in the deep sea. The likelihood of these technologies travelling to the strategic partners of the United States, or beyond, cannot be overlooked. *See Part Three.*

Pakistan does not have an SSBN fleet. As mentioned earlier, Pakistan's nascent sea-based capabilities depend upon cruise missiles with a range of 450 kilometres, to be integrated with its diesel-electric submarines. Diesel-electric submarines are not ideal weapons for concealment or operations in the deep sea. India's growing ASW capabilities will pose a huge challenge to Pakistani submarines carrying nuclear warheads in the deep sea.[30] On the other hand, operating in coastal areas would make the submarines even more vulnerable by disclosing their location.

Sea-launched cruise missiles might enhance Pakistan's ability to hit India's naval vessels, but their limited range and operability would keep the significant targets inside the enemy's territory safe. Given Pakistan's existing and expected trajectory of weaponisation at sea, SLCMs might increase Pakistan's options at sea but may not necessarily guarantee an "assured retaliation" or "second-strike capability."

Deterrence Through Ambiguity

Iskander Rehman claims that Pakistan's use of dual-capable launching platforms and delivery systems is meant to augment deterrence by generating ambiguity.[31] In other words, the risky entanglement is Pakistan's calculated choice to make up for the conventional asymmetry caused by Pakistan's financial and technological limitations. However, the dual-use platforms tremendously enhance the chances of miscalculation and inadvertent escalation perpetuating instability.

Escalation Dominance or Sea Denial

One of the motivations attributed to Pakistan's sea-based nuclear capabilities is to achieve escalation dominance at sea. Irrespective of Pakistan's motivation, or lack of it, escalation dominance does not appear achievable in the next two decades. Escalation dominance would require Pakistan to have a wide variety of technologically advanced weapons and anti-weapon systems and detection capabilities, as well as operational training. Pakistan's Navy does not have the financial and technological resources to develop such capabilities.

Given India's conventional and nuclear advantage at sea, some scholars highlight Pakistan's concerns of a naval blockade and the likelihood of Pakistan pursuing a sea-denial strategy.[32] There is no gainsaying the fact that SLCMs carrying nuclear warheads are effective against counterforce targets at sea. These will strengthen Pakistan's sea-denial potential. However, it is also important

[27] ISPR Press Release No. PR125/2018-ISPR.

[28] Ibid.

[29] This vulnerability would depend on several factors. For a detailed discussion see Owen R. Cote Jr, "Invisible Nuclear-Armed Submarines, or Transparent Oceans? Are Ballistic Missile Submarines Still the Best Deterrent for the United States?" *Bulletin of the Atomic Scientists* 75, no. 1 (2019): 30–35, https://thebulletin.org/2019/01/invisible-nuclear-armed-submarines-or-transparent-oceans-are-ballistic-missile-submarines-still-the-best-deterrent-for-the-united-states/. Regarding issues of survivability during the Cold War, see Austin Long and Brendan Rittenhouse Green, "Stalking the Secure Second Strike: Intelligence, Counterforce, and Nuclear Strategy," *Journal of Strategic Studies* 38, no. 1–2 (2015): 38–73, https://www.tandfonline.com/doi/abs/10.1080/01402390.2014.958150.

[30] "Boost for India's Navy's Firepower: INS Kadmatt, Anti-Submarine Warfare Corvette, Commissioned," *Economic Times Online*, July 14, 2018, https://economictimes.indiatimes.com/news/defence/boost-for-indian-navys-firepower-ins-kadmatt-anti-submarine-warfare-corvette-commissioned/articleshow/50482501.cms; Shishir Gupta, "India Set to Clear $2 Billion Deal for US Anti-Submarine Warfare Choppers," *Hindustan Times*, June 22, 2018, https://www.hindustantimes.com/india-news/india-set-to-clear-2-billion-deal-for-us-anti-submarine-warfare-choppers/story-J4uFAwmQbtT2WN2wovGAaI.html; Sanjeev Miglani and Greg Torode, "Wary of China's Indian Ocean Activities, U.S., India Discuss Anti-Submarine Warfare," *Reuters*, May 2, 2016, https://www.reuters.com/article/us-india-usa-submarines-idUSKCN0XS1NS.

[31] Iskander Rehman, "Murky Waters."

[32] Saima Sial, "Rationalizing Pakistan's Quest for a Sea-based Deterrent Force," *Pakistan Politico*, October 18, 2018, http://pakistanpolitico.com/rationalizing-pakistans-quest-for-a-sea-based-deterrent-force/.

for Pakistan to explore the political viability of a naval blockade for India. Once the China–Pakistan Economic Corridor becomes operational, any attempt to carry out a naval blockade will make China a direct stakeholder in the conflict.

Hedging

It is also argued that Pakistan is hedging its bets by developing sea-based nuclear capabilities. But it is important to examine how Pakistan's existing and emerging sea-based capabilities would alter Pakistan's position at sea vis-a-vis India or augment Pakistan's land-based deterrence posture. Pakistan can, at best, complicate India's options at sea but its sea-based capabilities may not have a decisive role in India's decisions to a significant extent.

In all likelihood, Pakistan's sea-based nuclear forces will have a limited utility in the near future. However, the challenges associated with it are numerous.

Challenges

There are some widely held concerns about sea-based nuclear capabilities. For example, the threat of nuclear terrorism, the risk of accidents, or inadvertent use of nuclear weapons because of high readiness levels, as well as the likelihood of external interference with or breakdown of command, control, and communication (C3) systems, and ASW dominate the literature on sea-based deterrence.[33] Likewise, the risk of nuclear use at sea is considered much higher than on land because of the possibility of containing the causalities. Western literature on Pakistan's sea-based capabilities considers nuclear terrorism and the breakdown of C3 as prominent risks.[34]

Pakistani analysts dismiss these concerns, arguing that Pakistan has made all the requisite arrangements to keep its nuclear weapons safe at sea.[35] There are claims about robust and formidable C3 systems also, but it is too difficult to verify the viability of such claims due to the lack of information. For instance, after the 2012 ISPR press release that announced the establishment of Pakistan's Naval Strategic Force Command,[36] nothing has been revealed about its institutional practices and functioning. Also, little is known about the mechanisms developed to ensure inter-institutional harmonisation among all three military services as well as civilian decision-makers during peacetime, crisis, and war.

Pakistan's unique circumstances compound its challenges even further. Pakistan's technological backwardness means continuous reliance on foreign countries for buying naval vessels as well as defensive systems. On the other hand, Pakistan's precarious economic condition restricts its options.

Pakistan might be able to develop or acquire the contemporary textbook requirements of a "credible" and "effective" sea-based second-strike capability over the next fifteen years – including adequate numerical strength of submarines, a reliable communication system, long-range missiles, and sufficient fissile material to feed a large number of warheads. However, rapid technological advancements in cyber capabilities, submarine hunting tools, and remote sensing and reconnaissance with artificial intelligence could make such an arsenal redundant. These technologies may change the nature of future wars at sea.

In a way, Pakistan is preparing to deter and if deterrence fails, to fight a war of the past in a future that is unfamiliar and unpredictable. Under such circumstances, will Pakistan continue to pursue a path that leads to nowhere? The past two decades of Pakistan's nuclear weapons development indicate that there is limited possibility of Pakistan containing its sea-based capabilities in the years ahead.

The ongoing Indian efforts to have a larger footprint in the Indian Ocean to deal with China's growing sea presence and Pakistan's threat perception vis-a-vis India informed by its peculiar threat assessment criteria and deterrence-related assumptions leave little room for a rational debate on unilateral arms restraint as an option. On the other hand, the likelihood of bilateral arms control agreements between India and Pakistan appears thin because of the complex triangular nuclear relations amongst the US–China–India and China–India–Pakistan.

Any change in Pakistan's nuclear trajectory would require a paradigmatic shift in Pakistan's strategic thinking and a deeper engagement with the emerging geopolitical and technological realities. This would also require revisiting fundamental assumptions about the viability of nuclear deterrence in future.

Investment in understanding game-changing advanced technologies (possibly risk-free and more practical in their value for defence in coastal areas) along with ASW capabilities will be more useful than developing costly, vulnerable, and risky weapons.

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[33] Desmond Ball, "Nuclear War at Sea," *International Security* 10, no. 3 (Winter 1985–1986): 3–31, https://www.jstor.org/stable/2538940; Christopher Tingle, "Submarine Accidents: A 60-Year Statistical Assessment," *Professional Safety* 54, no. 9 (September 2009); Bruce Blair, *Strategic Command and Control: Redefining the Nuclear Threat* (Washington DC: Brookings, 1985). Also see Peter Hayes, "Off the Beach: Underwater Warfare in the 21st Century," *Global Asia* 13, no. 1 (March 2018), https://globalasia.org/v13no1/cover/off-the-beach-underwater-warfare-in-the-21st-century_peter-hayes.

[34] For a detailed analysis of threat of nuclear terrorism and challenges regarding C3 systems, see Christopher Clary and Ankit Panda, "Safer at Sea: Pakistan's Sea-based Deterrent and Nuclear Weapons Security," *The Washington Quarterly* 40, no. 3 (Fall 2017): 149–168, https://www.tandfonline.com/doi/abs/10.1080/0163660X.2017.1370344?journalCode=rwaq20.

[35] Muhammad Azam Khan, "Sea-Based Nuclear Weapons," *The News*, January 8, 2018, https://www.thenews.com.pk/print/265829-sea-based-nuclear-weapons.

[36] "Naval Chief Inaugurates Naval Strategic Force Headquarters," ISPR Press Release No. PR122/2012-ISPR, May 19, 2012, https://www.ispr.gov.pk/press-release-detail.php?id=2067.

Chapter 13

North Korean Nuclear Weapons: Posture, Submarines and Deterrence

Michael Cohen

How would North Korean submarine-launched nuclear missiles influence North Korea's nuclear posture, foreign policy, and deterrence on the Korean peninsula? North Korea may have over 80 older Russian-designed submarines but it also has one more advanced Gorae-class submarine, launched in 2014, that may soon be capable of launching a ballistic missile.[1] The Gorae-class' reliance on diesel-electric engines and lack of air-independent propulsion means that it can only stay submerged for a few days, limiting it to an estimated range of 1,500 nautical miles; it could therefore hold US allies and bases at risk but not the US mainland.[2] In August 2016, North Korea test-fired a solid-fuel submarine-launched ballistic missile – the KN-11 – from this submarine. This missile may become operational by 2020.[3] In 2017, the regime launched a larger land-based solid-fuel missile.[4] It is possible that North Korea is constructing a successor to the Gorae-class submarine to carry this more advanced missile.[5] Images released by the regime in July 2019 may reveal such a new vessel, or an older Romeo-class submarine converted to be able to launch at most three ballistic missiles that presumably have a nuclear payload.[6]

While it is hard to predict where North Korea's rapidly evolving nuclear delivery systems will get to, this chapter assumes that the key driver of strategic instability regarding North Korean nuclear submarines is their ability to target US allies and bases in the region. The ability to target the US mainland with sea-launched nuclear weapons would produce similar dynamics to those outlined below, but this appears to be many years away. However, North Korea needs neither submarines nor nuclear weapons to credibly threaten turning Seoul into a sea of fire. This chapter tends to equate North Korean foreign policy decision-making regarding nuclear weapons, nuclear posture, and nuclear submarines with the person of Kim Jong Un, the current leader of North Korea. Specifically, the assumption is that he either authorises, or is aware of, most North Korean nuclear developments. The glaring exception to this, discussed below, are those responsible for using tactical nuclear weapons on the mainland or commanders of submarines at sea who would both be likely, in any armed conflict, to lose contact with the central leadership very quickly and have to make their own use-it-or-lose-it decisions.

North Korea has an asymmetric escalation nuclear posture.[7] This doctrine uses nuclear weapons to deter not only nuclear but also conventional attacks. Pakistan and France have successfully used this posture to deter conventional attacks from India and the Soviet Union/Russia. Other postures that use nuclear weapons to deter only nuclear attacks or usher in third-party intervention do not tend to deter conventional challenges. However, this posture is also the most likely to strain command and control systems and increase the probability of inadvertent nuclear escalation because deterring conventional attacks requires "the ability to disperse and deploy nuclear assets quickly, pre-delegating authority for their release to military end users on the front edge of the battle."[8] Asymmetric escalation postures tend to be chosen by states with unreliable allies facing more powerful nuclear-armed adversaries.[9]

In what is often mistaken as an irrational strategy, North Korea has very rational incentives, given its relative military weakness against South Korea or the United States, to threaten to respond to great or lower uses of military force against the North Korean regime or even North Korean nuclear weapons with rapid nuclear escalation. The logic here is that the detonation of one nuclear weapon at the outset of any conflict, or as a crisis escalates, perhaps away from main conflict theatres, signals resolve to fight a nuclear war that reduces the probability of US intervention – while increasing the probability of nuclear escalation – in what would inevitably lead to the crushing defeat of North Korea. As North Korea would lose any armed conflict, the regime has incentives to authorise such limited uses of force to ensure that its adversaries back away from causing one. Ironically, if North Korea had more

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[1] "North Korea Submarine Capabilities," *Nuclear Threat Initiative*, 2018, https://www.nti.org/analysis/articles/north-korea-submarine-capabilities/.

[2] Ibid.

[3] "KN-11 (Pukkuksong-1)," CSIS Missile Defence Project, 2016, https://missilethreat.csis.org/missile/kn-11/#en-625-3.

[4] H.I. Sutton, "North Korea's Polaris: Gorae Class Ballistic Missile Submarine (SINPO Class)," *Covert Shores*, August 27, 2016, http://www.hisutton.com/Analysis%20-%20Sinpo%20Class%20Ballistic%20Missile%20Sub.html; "The CNS North Korea Missile Test Database," *Nuclear Threat Initiative*, 2019, https://www.nti.org/analysis/articles/cns-north-korea-missile-test-database/.

[5] Ankit Panda, "The Sinpo-C-Class: A New North Korean Ballistic Missile Submarine is Under Construction," *The Diplomat*, October 18, 2017, https://thediplomat.com/2017/10/the-sinpo-c-class-a-new-north-korean-ballistic-missile-submarine-is-under-construction/.

[6] Choe Sang-Hun, "Kim Jong Un Inspects New Submarine that could Increase Range of Missiles," *New York Times*, July 22, 2019; H.I. Sutton, "New North Korean submarine: ROMEO Mod," *Covert Shores*, July 23, 2019, http://www.hisutton.com/ROMEO-Mod_Submarine.html.

[7] Vipin Narang, *Nuclear Strategy in the Modern Era: Regional Powers and International Conflict* (Princeton, NJ: Princeton University Press, 2014).

[8] Ibid., 19.

[9] Ibid., 32.

relative power vis-a-vis its adversaries, it would face fewer incentives to not only develop nuclear weapons but to also integrate them into an asymmetric escalation posture. North Korea's nuclear posture thus poses dangerous risks of inadvertent escalation without sea-launched nuclear missiles, and the development of nuclear submarines would be unlikely to change this posture. Just as the development of nuclear-armed submarines would be the logical next step in North Korea's nuclear journey, it would also exacerbate an already very dangerous strategic environment.

One crucial question regarding the impact of nuclear-armed submarines on North Korean foreign policy concerns is whether Kim believes having nuclear weapon-armed submarines increases the probability that his nuclear arsenal can survive a US first strike. The more North Korean nuclear weapons that Kim believes could survive such a strike and therefore use to retaliate, the more he is likely to believe that he himself can coerce and pester the United States, confident that Washington would not make a retaliatory move that would increase the risk of nuclear escalation. Given that sea-launched nuclear weapons tend to be harder to detect and destroy than land-based ones, and the publication in a leading journal of an argument that US counterforce capabilities offer a reasonably high probability of targeting and destroying North Korea's entire land-based nuclear force, it seems safe to assume that Kim would believe that nuclear-armed submarines would reduce the vulnerability of his nuclear force.[10] Other research has shown that leaders who have invested significant resources in technologies or weapons systems have dangerously strong political and psychological pressures to believe that these systems will yield tangible benefits.[11] It seems likely that nuclear-armed submarines would, conditional on the ability of the United States and its allies to detect them and Kim's awareness of this vulnerability, allow Kim to more reliably target US bases in Guam and elsewhere and increase the probability that he may threaten to do so.

Two central variables here, as Table 1 demonstrates, are whether the United States can detect and thereby destroy North Korean nuclear submarines at sea and whether Kim is aware of the vulnerability of his nuclear submarines. In the first and perhaps the most desirable world, the United States can detect and target North Korean submarines and Kim believes this. North Korean provocations would be most likely to be restrained in such a world, but Kim would face incentives to overcome detection. The challenge for the United States and its allies would be to forestall an arms race through demonstrating to North Korea that their nuclear submarines would always be within detection range of US sensory capabilities.

In the second world where Kim incorrectly believes that his submarines can be detected, he would likely try to overcome this vulnerability through building and/or diversifying his undersea arsenal. Because the initially smaller arsenal was invulnerable, the larger one would pose a more formidable threat to US bases, allies, and interests in the region. The challenge for the United States here would be to develop the capability to detect North Korean submarines as quickly as possible and credibly signal this knowledge to Kim without precipitating a crisis. In the third world where Kim correctly believes that the United States cannot detect his submarines, he would likely be emboldened to further challenge the United States and/or South Korea to elicit concessions that the summitry with President Trump will be unlikely to deliver. The most dangerous fourth world involves Kim incorrectly believing that his submarines are not detectable. Kim would likely learn of the vulnerability of his nuclear submarines having previously believed otherwise and authorised policies that he believed would leverage concessions. Having raised the risk of escalation through making threats and then learning of the vulnerability of his nuclear submarines, Kim would be most likely to believe that a US strike on his undersea nuclear force would be forthcoming. Also destabilising is that Kim may correctly reason that the elimination of his undersea deterrent is a prelude to attacks on his land-based nuclear weapons, which may well be a prelude to regime change. Under these conditions he would be most likely to authorise use of his nuclear weapons; this world involves the greatest strategic instability and risk of nuclear es-

Table 1:
Submarine Detection Technologies and Leader Beliefs

	The United States ***can*** detect North Korean (nuclear) submarines with anti-submarine detection technology	The United States ***cannot*** detect North Korean (nuclear) submarines with anti-submarine detection technology
Kim believes that the United States ***can*** detect his state's (nuclear) submarines with anti-submarine detection technology	**1.** Attempts to overcome detection technologies through building more submarines and/or investing in technology to overcome detection	**2.** Incentives to overcome detection technologies through building more submarines and/or investing in technology to overcome detection
Kim believes that the United States ***cannot*** detect his state's (nuclear) submarines with anti-submarine detection technology	**3.** Most dangerous world: Crisis instability as Kim learns that his nuclear submarines are detectable	**4.** Anti-submarine detection technologies have little effect on strategic competition, although would encourage heavy investment in detection

[10] Keir Leiber and Daryl Press, "The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence," *International Security* 41, no. 4 (2017): 9–49.

[11] Michael Cohen, *When Proliferation Causes Peace: The Psychology of Nuclear Crises* (Washington DC: Georgetown University Press, 2017).

calation. The challenge for the United States would be to deter Kim from making further challenges whilst reassuring him that the United States would be willing to live with a nuclear submarine-armed North Korea.

North Korean nuclear submarines exacerbate the dangers of its asymmetric escalation posture in at least two ways. The dangers of inadvertent escalation on the Korean peninsula are already high without any North Korean nuclear-armed submarines. Washington has to worry that even if North Korea does not detonate a nuclear weapon at the outset of a crisis, a conventional exchange could inadvertently hit a North Korean nuclear facility.[12] This could precipitate significant North Korean escalation. Why would Kim not conclude from this that further attacks are likely and prepare for nuclear war? North Korean nuclear submarines exacerbate this problem. In 2016, a North Korean submarine went missing and, according to a US official, was presumed to be sunk.[13] If this happens in the future with Pyongyang's Gorae-class nuclear submarine, or a successor, would Kim conclude that it was an attack by South Korea or the United States and that more such attacks are imminent? How would he view the loss of any North Korean nuclear submarines given that South Korea launched its first missile-capable attack submarine in September 2018 as President Moon headed to Pyongyang for another summit with Kim?[14] If the United States cannot know which of the regime's future Gorae-class fleet are equipped with nuclear weapons, how should it pursue and deal with North Korean vessels to convince Kim that coercive demands will not be met, limited use of force will be severely dealt with, but that the United States can ultimately live with nuclear North Korea and its nuclear-armed submarines?

Command and control raises another set of dangers. Given the extremely limited resources at the disposal of the North Korean regime, it is hard to escape the conclusion that North Korean submarines would be more likely than those of any other country to lose contact with their base command and amidst a crisis make the decision to use rather than lose their nuclear weapons. North Korea's nuclear posture keeps its region closer to a nuclear crisis than most other nuclear powers do. North Korea's only submarine currently capable of launching a ballistic missile can, after all, only remain submerged for three days. The probability that a future North Korean nuclear submarine would lose contact with its commander amidst a Trump and Kim tweet storm – two unrelated but individually likely events – may herald unprecedented dangers on the Korean peninsula.

If predictions are generally hard, predictions regarding North Korean nuclear submarines are very difficult. North Korea can be expected to pour significant investments into a successor to the Gorae-class to firm up the second leg of a survivable nuclear deterrent. Given the regime's extant achievements under significant political and economic constraints, it would seem foolish to assume that this goal will be elusive. A perhaps more critical variable here is the fate of the Trump–Kim summitry, whether some or all of the sanctions directed against North Korea get loosened or removed, and whether the regime can find other sources of revenue that can be channelled to its nuclear submarine program. At the extreme, a return to the hostile threat-making between the United States and North Korea could plunge the two into a crisis that could lead to nuclear escalation that would put an end to North Korea and its nuclear weapons and submarine program. It is hard to predict whether North Korea will have achieved one or more successors to the Gorae-class by 2020, 2030, or 2040. It is not beyond the realm of possibility that one or more may be created by 2030. Much will depend on how the United States engages with the regime and whether Kim can avoid a war.

A proliferation of North Korean nuclear submarines throughout the peninsula and Indo-Pacific would presumably increase the probability of inadvertent, accidental or otherwise, North Korean nuclear escalation. The probability of escalation resulting from an incident with US or Japanese vessels that will surely now spend more time in waters near the Korean peninsula would also increase. These dynamics may also attract China's submarine fleet to spend more time in Korean waters to monitor if not support North Korea's new underwater nuclear deterrent. It seems safe to assume that North Korean nuclear submarines will inject yet another source of danger and instability into Sino-US competition in the Indo-Pacific.

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[12] James Acton, "Escalation through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risks of an Inadvertent Nuclear War," *International Security* 43, no. 1 (2018): 56–99.

[13] Sam LaGrone, "US Official: North Korean Submarine is Missing, Presumed Sunk," *USNI news*, March 11, 2016.

[14] "South Korea Launches Its First Missile-Capable Submarine despite Improved Relations with the North," *The Telegraph*, September 14, 2018.

Chapter 14
France's Deterrent Strategy and the Indo-Pacific

Bruno Tertrais

Although clearly Soviet and then Russia-centred, France's nuclear deterrent strategy has taken into account the evolution of the global strategic landscape. Given long-standing and growing French security interests in the Indo-Pacific, there are scenarios where its nuclear weapons could play a role to protect the country's, and possibly Europe's, interests.

France's Deterrence Concept

France developed the atomic bomb in the face of a major threat, but as much for political reasons – to gain strategic autonomy from the United States – as for security ones. French discourse no longer highlights the diplomatic advantages that could be conferred by the possession of nuclear weapons. It now emphasises the responsibilities linked to the status of a nuclear-weapon state (NWS) under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) of 1968, in the fields of disarmament, non-proliferation, and stability. In 2001 the French president, Jacques Chirac, assigned three functions to the deterrent force: (i) ensuring that France's survival could not be called into question by a major power; (ii) preserving the country's freedom of action in the face of regional actors seeking to blackmail it; and (iii) contributing to the security of Europe and the Atlantic Alliance.[1] These principles remain largely valid today.

The deterrent force is considered an indispensable tool for France's freedom of action and strategic autonomy and must exist in relation to any potential adversary that could threaten its vital interests. Nuclear weapons make it possible to ensure that it will not be subjected to coercion intended to prevent it from acting militarily or politically. Deterrence makes it possible to guarantee that France would preserve its freedom of manoeuvre in the face of a country that seeks to exercise serious blackmail aimed at preventing France from fulfilling its international commitments (for example, under Article 5 of the North Atlantic Treaty), or attempts to hold France's strategic interests (including protection of territory, security of supplies, and freedom of navigation) at risk. One could say that in such a scenario, France's nuclear arsenal would have a sort of "counter-deterrence" function: it would neutralise the deterrent power of the adversary in order to maintain the country's freedom of action. However, this freedom must also exist in relation to alliances. Through the possession of a deterrent force, France asserts that it does not depend on others for the defence of its essential interests and its survival. Could France have actively opposed the war in Iraq to the point of leading the anti-war protest in the Western camp if it had been reliant on Washington for its ultimate security? Some French politicians thus consider that the existence of an independent deterrent capacity "prevents us from being drawn into a war that is not our own."[2]

As stated by French President François Hollande in 2015, "Deterrence allows us to preserve our freedom of action and decision in all circumstances, because it is it that allows me to avoid any threat of blackmail of state origin that would aim to paralyse us."[3] He also justified France maintaining nuclear weapons by the scale of its commitments in the service of its allies and the international community by stating, "France is one of the few countries in the world whose influence and responsibility are precisely on a global scale ... the deterrent force enables us to ensure that France's international commitments will always be honoured."[4] France's 2017 Strategic Review of Defence and National Security reflected this growing insistence on the role of nuclear deterrence to negate "any threat of blackmail that might paralyse its freedom of action" given that "multiple powers are developing their nuclear forces for power demonstration, intimidation, or even blackmailing purposes."[5]

From the outset, France stated it maintained a comprehensive approach to deterrence in which conventional forces and territorial defence participate. It never conceived deterrence as exclusively nuclear. The 1972 White Paper on Defence[6] recognised the virtues of conventional deterrence and referred more broadly to "the overall deterrent effect of our military policy." But the almost systematic association between the terms "deterrence" and "nuclear" remains a fixture of French strategic culture. Also, nuclear deterrence has traditionally been associated in France with deterrence by punishment, not deterrence by denial. Deterrence is one of the five main strategic functions of France's security policy. Its role has been upgraded over time and was ranked third in the 2008 White Paper, second in the 2013 White Paper and first in the 2017 Strategic Review.

[1] Jacques Chirac, "Institut des hautes études de défense nationale" (speech, Paris, June 8, 2001).

[2] Jean-Pierre Chevènement, "L'avenir de la dissuasion française" (speech, Res Publica Foundation, July 10, 2006).

[3] François Hollande, "Address on Nuclear Deterrence" (speech, Istres, February 19, 2015).

[4] Ibid.

[5] Ministry of the Armed Forces France, *Defence and National Security Review* (Paris, 2017), 69–70, https://otan.delegfrance.org/2017-Strategic-Review-of-Defence-and-National-Security.

[6] Ministry of Defence France, *Livre blanc sur la defense nationale* (Paris, 1972), http://www.livreblancdefenseetsecurite.gouv.fr/pdf/le-livre-blanc-sur-la-defense-1972.pdf.

French Nuclear Strategy

Nuclear weapons are reserved for the defence of the country's vital interests. The head of state, who decides on the use of nuclear forces and is the only one capable of transmitting the authorisation code(s), would be the sole judge of whether these interests are called into question. The scale and potential consequences of the aggression, rather than the nature of the objectives targeted by the adversary or the means used, would determine the "vital" nature of the interests at stake. The peacetime definition of these interests remains vague to prevent an adversary from being able to calculate the risk inherent in his aggression because the nature of vital interests can evolve in time and space, and because the definition of vital interests is ultimately a matter for the head of state. Still, the public definition of core vital interests is part of the French concept. These are the three constituent elements of the state: territory, population, and sovereignty. The 1994 White Paper specified, "The integrity of the national territory, including the metropolitan part and the overseas departments and territories, its air and sea approaches, the free exercise of our sovereignty and the protection of the population, constitute its core today."[7] The 2008 White Paper referred in general terms to "the constituent elements of our existence as a nation-state" and, more specifically, in addition to the French territory and population, the "republican institutions of the country."[8] France has always considered that the security of its allies could be in its vital interests, but these alliances do not by their mere existence enter into the scope of such interests – Paris does not do "extended deterrence." Could a French president consider the territory of a Gulf monarchy, for instance, to be of "vital" interest? The question remains, by nature, open. Nevertheless, the French nuclear status can contribute to complicate the calculation of an adversary who would consider attacking it.

Since the end of the Cold War, two types of potential adversaries have often been identified. "Major" powers are countries that might have the will and capacity to threaten the vital interests of the country to the point of jeopardising its very survival. Among major non-allied countries, only Russia and China are technically in a position to threaten the survival of France as an organised entity. The other category is so-called "regional" powers. Planning has also evolved and focuses now solely on what President Hollande described in 2015 as the adversary's "centres of power, that is its political, economic and military nerve centres" to exercise the threat of inflicting "unacceptable damage."[9] French deterrence therefore no longer addresses other types of objectives. Nuclear planning options have been diversified accordingly, in particular through the modulation of the number of warheads per ballistic missile and the adaptation of the yield-accuracy equation. Regardless of the adversary and the circumstances of the crisis, France maintains the capacity to signal, if necessary, to a potential adversary that its vital interests are at stake and that it has determined to safeguard them, in order to restore deterrence. This is called the "final warning" option, a single strike on a military target or a high-altitude electro-magnetic pulse. As stated by Hollande in 2015, "the definition of our vital interests cannot be limited to the national scale alone, because France does not conceive its defence strategy in isolation, even in the nuclear field."[10]

The indirect contribution of French deterrence to the security of the North Atlantic Treaty alliance, which lies in the fact that the existence of an autonomous deterrent complicates the calculation of a potential aggressor, earned France official recognition of the value of its deterrent force in the eyes of its allies in the Ottawa Declaration of 1974. The terms of the declaration have since been taken up almost word for word in all the major North Atlantic Treaty Organization (NATO) texts. NATO's 2010 Strategic Concept states: "The supreme guarantee of Allied security is provided by the Alliance's strategic nuclear forces, in particular those of the United States; the independent strategic nuclear forces of the United Kingdom and France, which have their own deterrent role, contribute to the overall deterrence and security of the Allies." France agrees with its partners on a common understanding of allied nuclear deterrence: "The conditions under which the use of nuclear weapons could be envisaged are extremely improbable … As long as there are nuclear weapons, NATO will remain a nuclear alliance … Deterrence, articulated around an appropriate mix of nuclear and conventional capabilities, remains a central element of our overall strategy."[11] However, France has chosen to abstain from participating in the Nuclear Planning Group (NPG) and thus does not participate in the management of NATO's common nuclear assets.

Since the end of the Cold War and the creation of the European Union (EU), France has stressed more clearly than in the past the European dimension of deterrence. It clearly considers that French deterrence plays a European role and protects the EU's common interests, all the more so now that it is linked to its partners by a common defence clause in the Lisbon Treaty of 2009.[12] Two main ideas appear. On the one hand, French deterrence,

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[7] Ministry of Defence France, *Livre blanc sur la defense* (Paris, 1994), 57. The explicit mention of the overseas departments and territories was relatively new. In 1977, the then prime minister, in a public speech at the Mailly camp, implicitly excluded them.

[8] Office of the French President, *The French White Paper on Defence and National Security* (Paris, 2008), 69.

[9] Hollande, "Address on Nuclear Deterrence."

[10] Ibid.

[11] North Atlantic Treaty Organization, *Strategic Concept for the Defence and Security of the Members of the North Atlantic Treaty Organization* (Brussels, 2010).

[12] This includes non-NATO countries such as Finland and Sweden.

by its very existence, contributes to Europe's security – in other words, a possible aggressor would do better to take this into account. On the other hand, an attack on an EU member could be considered by France as an attack on its own vital interests. As Hollande put it in 2015: "France also has, with its European partners, a de facto and heartfelt solidarity. Who could believe that an aggression, which would jeopardise Europe's survival, would have no consequences?"[13]

France's Interests in the Indo-Pacific

A significant number of French territories, with various statuses – some of them being integral parts of French national territory and others associated territories – are located in the Indo-Pacific region, allowing France to claim the second-largest maritime domain in the world (11 million square kilometres, 93 per cent in the Indo-Pacific region). This includes Indian Ocean islands (La Réunion, Mayotte, and the Southern and Antarctic Lands[14]) and those in the Pacific Ocean (New Caledonia, French Polynesia, Wallis and Futuna, Clipperton). Around 1.5 million French citizens live in these islands and a further 0.2 million live in Indo-Pacific mainland countries.[15] France is also, on paper at least, bound to the security of the region by two Cold War defence commitments: one is the Korean Armistice Declaration of 1953, the other is the Manila Pact of 1954, which created the Southeast Asia Treaty Organization (which covers the South Pacific region and thus the French territories located there). The region is a major trade partner representing one third of French exports (fourteen per cent of the total) and more than 40 per cent of French imports (seventeen per cent of the total) to and from non-EU countries.[16] For these reasons, the region includes a significant French military presence with 7,000 French soldiers permanently stationed in the region, including 4,100 in the Indian Ocean and 2,900 in the Pacific Ocean.[17]

Evolution of French Strategy in the Indo-Pacific

Over the past 25 years, and even though France's strategic priorities remain its troubled eastern and southern neighbourhoods, there has been a growing interest in Asia in France's defence policy-making circles. French policy towards the Indo-Pacific region has been marked by a rapprochement with India and Australia, a certain amount of defiance towards China, and a tough line towards North Korea. France's rapprochement with India happened more or less in parallel with that of the United States. Refraining from sanctioning India for its nuclear tests, it has offered civilian nuclear cooperation and boosted its arms sales, in particular the *Rafale* fighter aircraft. In parallel, France's relations with Pakistan – once a significant defence partner – have degraded, notably since the assassination of eleven French personnel in Karachi in 2002. By contrast, the 2016 sales agreement to produce twelve attack submarines for Australia, one of the most significant French defence contracts ever, cemented the burgeoning strategic partnership between France and Australia. In parallel, France has officially embraced the Indo-Pacific concept, which was sanctioned at the highest level on the occasion of a visit by President Macron to Australia in March 2018.[18] France currently identifies nine strategic partners, including four major ones (India, Australia, the United States, and Japan), and five others: Malaysia, Singapore, New Zealand, Indonesia, and Vietnam.[19] France is a party to the Quadrilateral Defence Coordination Group created in 1992 comprising Australia, New Zealand, and the United States to manage security in the Southern Pacific region, and is also party to the FRANZ (France, Australia, New Zealand) agreement signed the same year to coordinate assistance to disasters in the area.

Since the beginning of the 2010s, France has been eager to defend freedom of navigation in the region by regularly sending navy ships to patrol in disputed areas of the South China Sea – a policy also upheld by the United Kingdom. Official language on this question has been toughened to reflect increasingly assertive Chinese policies, "in the South China Sea, the large-scale land reclamation activities and the militarisation of contested archipelagos have changed the status quo and increased tensions. The potential consequences of this crisis have a global impact considering that one-third of the world trade transits through this strategic region."[20] This does not mean that France would be ready to join the United States in cementing an alliance designed to contain China – a policy that France is keen to avoid. And, unlike the United States, French maritime patrols do not go beyond the twelve nautical mile line boundaries of territorial waters.[21]

Like the United Kingdom, France believes that as an NWS in the sense of the NPT, and as a permanent member of the United

[13] Hollande, "Address on Nuclear Deterrence."

[14] The Southern and Antarctic Lands include Crozet archipelago; Kerguelen archipelago; Saint-Paul island; Amsterdam island; Scattered islands (Europa, Glorieuses, Juan de Nova, Bassas da India, Tromelin); and Adélie Land on the Antarctic.

[15] Ministry of the Armed Forces, *France and Security in the Indo-Pacific* (Paris, 2018), 2.

[16] Ibid., 3.

[17] Ibid., 6.

[18] It has replaced "Asia-Pacific" in French official discourse.

[19] Ministry of the Armed Forces, *France and Security in the Indo-Pacific*, 2.

[20] Ibid., 4.

[21] Nathalie Guibert, "A bord de 'l'Auvergne', en mer de Chine du sud", *Le Monde*, October 31, 2017.

Nations Security Council, it should take a particular interest in the management of the North Korean nuclear problem.[22] While playing no direct role there, it has been a leader in hardening the stance of the EU when implementing United Nations sanctions. It also regularly participates in the *Pacific Shield* interdiction exercises organised under the framework of the Proliferation Security Initiative.

French Nuclear Deterrence and the Indo-Pacific Region: Scenarios

In the mid-1990s, the decision to replace the M45 submarine-launched ballistic missile (SLBM) with a future longer-range M51 SLBM was taken, and debates in French government circles began about the relevance of Asia-related deterrence scenarios. The Defence Ministry was asked to brainstorm on this question and imagined three different scenarios.[23] France's 1998–1999 nuclear deterrence review confirmed this relevance. In 1999, French Prime Minister Lionel Jospin stressed that French deterrence could concern a "distant" threat; this was codeword for China.[24] There has been no debate in successive French administrations about the need to be able to target East Asia, although the exact range/payload equation was revised several times.[25] As with all ballistic missiles, its maximum range depends on the payload, and no official figures have been given for the current M51.2 version of the SLBM: open sources often refer to 8,000–9,000 kilometres. Though no official list of potential adversaries is mentioned by French official discourse, it is clear that China and North Korea could be of concern.

The main scenario in which French deterrence could play a role vis-a-vis Asian countries is one where such a country would attempt to discourage (deter) France from intervening in a region of interest to the adversary or supporting an ally or a friendly country. It could do so by directly and overtly threatening France, or simply by reminding them of the range of its missiles. Chinese and North Korean missiles can now reach not only most of Europe but also some French territories such as New Caledonia. Such a threat could also be meant to influence the United States with the hope that threatened US allies would then pressure Washington. This could happen in four types of contingencies:

- A military crisis in the Indo-Pacific where the United States is not directly involved (e.g. a China–India or China–Vietnam crisis).
- A direct US military intervention in support of a threatened ally (such as the Philippines, Japan, Taiwan, South Korea, or Australia).
- A North Korean invasion of the peninsula, which would trigger the 1953 Armistice commitment.
- A French operation in the Middle East, a region that is increasingly of direct interest to China for economic reasons.

In such a scenario, France would exercise counter-deterrence, as suggested above. In all conceivable circumstances, France would not be on its own. This raises the question of whether and how the three Western nuclear powers would coordinate deterrence and possibly even planning.[26] However, the French would be keen to show that they could defend their vital interests on their own. French strategists have thought about the very hypothetical need to credibly deter *both* China and Russia at the same time. While it is hard to believe that a credible threat of "unacceptable damage" could be exercised on both countries simultaneously by France alone, options would exist to target both countries assuming that there are at least two nuclear-powered ballistic missile submarines (SSBNs) at sea.

The M51 SLBM entered service in 2010 and will be upgraded with successive new versions in the coming decades *(see Chapter Fifteen).* The Indo-Pacific is not the number one priority for French deterrence, resurgent Russia continues to have this place. Nevertheless, strategic developments in the Indo-Pacific will continue to be taken into account in French nuclear strategy and when designing the exact capabilities of the future versions of the M51.

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[22] Of note is also the fact that the multiplication of missile tests in the Pacific region could have an impact on tourism, or even on air travel safety.

[23] Personal notes.

[24] Lionel Jospin, "Institut des hautes études de défense nationale," (speech, Paris, October 22, 1999).

[25] Personal notes. The intercontinental range of the M51 missile was not only determined by the possible need to deter an Asian power, it also gives French submarines increased coverage of Russia and expands the size of possible patrol zones. *See also Chapter Fifteen.*

[26] See Jeffrey Lewis and Bruno Tertrais, "Deterrence At Three. US, UK, and French Nuclear Cooperation," *Survival* 57, no. 4 (2015): 29–52.

Chapter 15
The Role of SSBNs in French Nuclear Posture and Maritime Strategy

Corentin Brustlein

While they have never been the first leg of a developing nuclear deterrent, to become operational nuclear-powered ballistic missile submarines (SSBN) have generally been considered the most critical leg in the long run to ensure a survivable second-strike capability. While the Soviet Union/Russia and the People's Republic of China have been able to enjoy survivable land-based forces thanks to the strategic depth at their disposal, they are currently either maintaining or strengthening their reliance on the sea-based leg of their deterrents. France, on the other hand, due to its historical experience, has had an acute sense of its lack of strategic depth in the face of a potential attack. As a consequence, as it became a nuclear weapon state, the young Fifth Republic identified early the value of a sea-based nuclear deterrent and initiated the work on an SSBN force in its first military programming law for the years 1960–1964.[1]

The notion of strict sufficiency lies at the heart of France's nuclear posture. Simply put, the French nuclear force has been sized according to one criterion: the ability to inflict unacceptable damage on any adversary directly threatening its vital interests. Then-President Charles De Gaulle laid out the principle of strict sufficiency in 1964 when he stated that "beyond a certain [level of] nuclear capability, and as far as each country's direct defense is concerned, the proportion of the respective means no longer has any absolute value."[2] As a smaller nuclear power, France thus stated it could stay out of the "arms race" between the two superpowers, and would instead build the smallest nuclear force that would be credible enough to deter an aggression. Strict sufficiency, as a guiding principle, first led to the development of a strategic triad, backed by tactical – or "pre-strategic" – nuclear forces. Only through the combination of those four elements did the French political and military leadership believe that its threat of nuclear retaliation would be credible. Conversely, as the security and technological environments changed, strict sufficiency was also what brought Paris to reduce its nuclear force structure at the end of the Cold War, by abandoning its tactical/"pre-strategic" forces and its silo-based ballistic missiles, and by reducing the number of bombers and SSBNs it possessed, as well as warheads in the stockpile.

Geography, technology, and the overarching principle of strict sufficiency thus led Paris to give SSBNs a central and increasing role in its deterrence strategy, which now rests on two legs. In concrete terms, adhering to strict sufficiency has two main consequences for the French SSBN force: it has to constantly evolve to remain credible and it has developed a symbiotic relationship with the rest of the French Navy.

SSBNs' Unique Value for Deterrence

France's nuclear deterrent relies on two legs that operate continuously, as well as on a third one – the Nuclear Naval-Air Force (*Force Aéronavale Nucléaire*, FANu) – which is fully operational only when the aircraft carrier is. While technological progress has made both of these legs increasingly flexible over time, each retains a primary function and both shall remain complementary in the future. Complementarity between the air and sea legs of France's nuclear deterrent has been reaffirmed by all presidents since the end of the Cold War, on strategic, operational, and technological grounds. In his February 2015 speech on the Istres Air Force base, François Hollande also reaffirmed this, and came up with a formula that summed up at least part of the reason why it remains critical to keep two components: "one [leg] that cannot be seen, and one that is visible."[3]

SSBNs will predictably remain the bedrock of France's deterrent policy for two reasons: survivability and penetration. SSBNs' survivability is guaranteed by their very low acoustic and non-acoustic signatures combined with their ability to hide at various depths in vast oceans or seas, in a complex and opaque environment, all the while remaining within range of France's various nuclear command, control, and communications systems. Despite concerns about the future of SSBN survivability if artificial intelligence or other technological breakthroughs revolutionise strategic anti-submarine warfare (ASW) capabilities, submarines will remain intrinsically more survivable than any other strategic platform. *See Part Three.*

The second reason for SSBNs' centrality is their ability to launch means of delivery that can penetrate contested airspaces, reach very distant targets potentially located in the depth of adversary territory, and carry a very high number of warheads at once, thus making credible the threat of "inflicting absolutely unacceptable damage." Due to their velocity and increasing throw-weight, the sixteen submarine-launched ballistic missiles (SLBMs) carried by each vessel of the current generation of French SSBNs could penetrate and/or saturate any current or anticipated ballistic mis-

[1] Marcel Duval and Yves Le Baut, *L'arme nucléaire française. Pourquoi et comment ?* (Paris: SPM, 1992), 158.

[2] Charles De Gaulle, "Conférence de presse du 23 juillet 1964," quoted in Dominique David (ed.), *La politique de défense de la France. Textes et documents* (Paris: Fondation pour les études de défense nationale, 1989), 77.

[3] François Hollande, "Address on Nuclear Deterrence" (speech, Istres, February 19, 2015).

sile defence capabilities to reach their targets. At the same time, the maximum range of current[4] and future generations of SLBMs will continue to offer future French presidents enough flexibility to hedge against strategic surprises and the potential rise of new distant adversaries.

Starting in 1974 with the commissioning of its third SSBN, France has maintained a permanent second-strike capability.[5] Not only are SSBNs invulnerable to a first strike, they provide a retaliatory capability that is non-escalatory, which is extremely valuable from the perspective of French decision-makers. Were vital interests at stake during a crisis or a war, having at least one SSBN on deterrence patrol and ready to execute a launch order would give a French president confidence in his/her ability to retaliate, without having him/her take the risk of escalating the crisis by sending an SSBN on patrol.

Despite the trust political and military elites have placed in the SSBN force, the option of mimicking the British decision in the 1990s to move from a nuclear dyad to a monad is not seriously considered in France. Whether it is to keep some more flexible assets for strategic signalling, to conduct a nuclear warning strike, to hedge against the risk of technological surprise or simply because scrapping the air leg would allow for only limited budgetary savings, the current policy remains to maintain a strategic dyad in the foreseeable future.[6]

A Constantly Evolving SSBN Force

The characteristics of the French SSBN force reflect how the principle of strict sufficiency translates into constraints and guidelines in terms of force structure and frequency of updates. The current French SSBN force is made of four Triomphant-class submarines, with at least one of them on deterrence patrol at any given time. It has been assessed that four SSBNs is the lowest number required to enable deterrence patrols by at least one boat 100 per cent of the time. Given this, the force structure of the strategic submarine fleet is not expected to change. Triomphant-class submarines replaced previous generation Redoutable-class vessels between the mid-1990s and 2010. Since the first of these larger and more silent second-generation submarines will have to be replaced in the early 2030s, some initial decisions have already been taken regarding the design of the SN3G – the third generation of French SSBNs. Little is currently known about this design; however, President Hollande made the choice during his term (2012–2017) in favour of a design not substantially larger than the current class of vessels.[7] As a consequence, the latest design will not require wholly new infrastructures to be built at the Ile Longue SSBN base as well as in the naval yard where large overhaul work is conducted, but it will on the other hand constrain in the foreseeable future the dimensions of the SLBMs that will be equipping the deterrent and carried onboard throughout the submarine's operational life – until the 2080s. Research and development work on the SN3G is expected to commence in 2020, and production of the first boat to start in 2023.[8]

When in the operational cycle, each submarine currently carries sixteen M51 SLBMs tipped with up to six multiple independently targetable re-entry vehicles (MIRVs). While the expected security and technological environments, including the future of strategic ASW capabilities, have not led France to reassess the required volume of its SSBN fleet, sustaining the technological and operational credibility of the sea leg requires frequent updates of the means of delivery – the M51 SLBMs. Since the end of the Cold War, and as long as there is no technological surprise, France has considered frequent incremental updates to the design of its ballistic missiles to be the most preferable course of action since it allows the spreading of the research and development and procurement costs throughout the lifespan of the SLBM, while limiting the risks that would be associated with radical changes in SLBM design. Updating SLBMs one stage at a time approximately every ten years thus helps to limit the level of yearly spending required while renewing nuclear forces, making the whole process more financially sustainable,[9] or, some would argue, less unsustainable. Through these updates, the ability of French SLBMs to penetrate current and future ballistic missile defences has been improved over time and will continue to do so. The most recent update of the M51 SLBM (M51.2), equipped with the *Tête Nucléaire Océanique* (TNO) thermonuclear warhead, became operational in September 2016, while the M51.3 update should be fielded by the mid-2020s.

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4 Officially, the initial version of the M51 SLBM (M51.1) has a range of "more than 6000 km," a figure that is expected to have substantially increased with the newest M51.2 update. See "Missile balistiques stratégiques (MSBS)," French Ministry of Armed Forces, December 8, 2016, https://www.defense.gouv.fr/marine/equipements/missiles/missiles-balistiques-strategiques-msbs.

5 Bruno Tertrais, *French Nuclear Deterrence Policy, Forces and Future* (Paris: Fondation pour la recherche stratégique, 2019), 12.

6 For an overview of the current rationale for renewing the French nuclear deterrent and the challenges this effort faces, see Corentin Brustlein, "France's Nuclear Arsenal : What Sort of Renewal?" *Politique étrangère*, no. 3 (2017): 113–124, https://www.cairn-int.info/article-E_PE_173_0113--france-s-nuclear-arsenal-what-sort.htm.

7 Hollande, "Nuclear Deterrence."

8 Vincent Groizeleau, "La construction du prochain SNLE français débutera en 2023," *Mer et Marine*, October 22, 2018, https://www.meretmarine.com/fr/content/la-construction-du-prochain-snle-francais-debutera-en-2023.

9 Jean-Jacques Bridey and Jacques Lamblin, *Les enjeux industriels et technologiques du renouvellement des deux composantes de la dissuasion* (Paris: Assemblée nationale, Rapport d'information no. 4301, December 14, 2016), 38–39.

SSBNs and France's Naval Posture and Strategic Policy

The SSBN fleet is central not just to France's deterrent policy, but to its Navy's force structure and portfolio of missions and capabilities. There is a double connection between the SSBN fleet and the rest of the French Navy: (i) an operational and organisational connection; and (ii) a strategic connection.

Operationally and organisationally, the SSBN force is developed, manned and sustained in deep symbiosis with not only the overall French submarine force (*Force Océanique Stratégique,* FOST), which includes six nuclear-powered attack submarines (SSNs) in addition to the four SSBNs, but with the whole French Navy. For instance, like all strategic submarines, a French SSBN is most vulnerable when going on, or coming back from, a deterrent patrol – in this case while it gets closer to the Ile Longue naval base and has to travel through the Brest choke point. It thus needs support from numerous naval assets – SSNs, ASW frigates, mine countermeasures vessels, maritime patrol aircraft and helicopters – to protect it while it is most exposed.[10] The survivability of the SSBN force, which underpins the whole deterrence posture, should not be understood as being just a function of the submarine itself, it is also a function of the SSBN's operational environment and of the support it gets from other naval assets to perform the most critical mission assigned to any armed force. What is true for the French Navy as a whole is even more so for the whole submarine force, which is placed under the single command of an admiral (ALFOST) and manned by a common pool of manpower (roughly 3,000 people for the ten submarines and associated facilities). Before they are sent on deterrence patrols as SSBN commanders, Navy officers first have to command SSNs, so that their proficiency in tracking undersea targets later becomes a proficiency in evading and defeating undersea surveillance and tracking techniques.[11]

Finally, strategically, as a medium-sized nuclear power with a global role, France puts its deterrence policy and its conventional force planning in a coherent whole. Even if (nuclear) deterrence is identified as the "ultimate guarantee" of France's national security and as the "cornerstone" of its defence strategy, the latter has to take into account "the entire spectrum of threats, including those considered to be under the threshold of … vital interests." In this framework, nuclear deterrence is not sufficient per se, and conventional naval forces are necessary to tackle the wide array of non-vital threats through conflict prevention and military interventions, as well as to supplement the nuclear deterrent by defeating limited aggressions and by providing the French leadership with military freedom of action in distant theatres of operations. Conversely, the threat of nuclear retaliation posed by the French nuclear forces would heavily constrain the military options of any potential adversary, thus protecting the external freedom of action of French conventional forces – for instance, those involved in a force projection operation.[13] As a consequence, France's nuclear deterrence and conventional military posture mutually reinforce each other's credibility and effectiveness in protecting the nation's security interests.

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[10] Up to four ASW frigates and two SSNs can be requested at a given time to support SSBNs. Xavier Pintat, Jeanny Lorgeoux et al., *La modernisation de la dissuasion nucléaire* (Paris: Sénat, Rapport d'information no. 560, 23 May, 2017), 38–39.

[11] Ibid., 142.

[12] Ministry of the Armed Forces, *Defense and National Security Strategic Review*, (Paris, October 2017), 70.

[13] On France and its force projection capabilities, see Corentin Brustlein, "Entry Operations and the Future of Strategic Autonomy," *Focus stratégique*, Ifri, no. 70 (2017).

Chapter 16

UK Nuclear Deterrence: Security and Stability through SSBN CASD

John Gower

The Soviet Union pioneered the concept of setting ballistic missiles into submarines in 1955. Arguably only of strategic importance once the ballistic missile was married to a nuclear-powered submarine by the US Navy in 1959,[1] true SSBNs were fielded relatively quickly by four of the first five Treaty on the Non-Proliferation of Nuclear Weapons (NPT) designated nuclear-weapon states (NWS) – United States in 1959, Soviet Union in 1967, United Kingdom in 1968, and France in 1971. China's first successful SSBN became operational in 2010.

The Indian SSBN program, culminating in the first successful (albeit limited) patrol in November 2018 and continued Pakistani interest in fielding an element of its nuclear deterrent in submarines – with an intention to develop a nuclear submarine program – has reinvigorated interest in SSBN operations, particularly in the Indo-Pacific.

This chapter considers the development of the UK SSBN program from inception – initially as part of wider nuclear capabilities – to today's posture. It examines why the United Kingdom has maintained Continuous At Sea Deterrence (CASD), the value of other forces in support of SSBNs, and challenges some of the assertions of those who state that novel technologies mark the end of a submarine's strategic and tactical advantage. Finally, it shows how the unique qualities of SSBNs directly support the UK's position as the most forward-leaning recognised NWS regarding its obligations under Article VI of the NPT, particularly when set against the increasing challenges to strategic stability.

UK Pre-SSBN Nuclear History

The United Kingdom became a nuclear-armed state in 1952 with its first test; the first free-fall bomb – Blue Danube – was produced by late 1953 and the aircraft to deliver them entered operational service in 1955. Between 1954 and 2006,[2] the United Kingdom also hosted US nuclear weapons, first by providing forward bases for US Air Force (USAF) Strategic Air Command (SAC) nuclear bombers, then a forward base for US Polaris SSBN in Holy Loch in Scotland from March 1961. The Holy Loch base closed in 1992 as the longer range of US Trident submarine-launched ballistic missiles (SLBMs) made a forward SSBN operating base redundant. US tactical nuclear bombs for USAF NATO Dual-Capable Aircraft (DCA) remained in storage in USAF bases in the United Kingdom until 2006.

The UK strategic nuclear deterrent became vested in the SSBN force in 1968, with continuous patrols established from 1969. With the introduction of the WE177 gravity bomb a few years earlier in 1966 and its subsequent expansion to the Royal Navy strike aircraft and helicopters in 1971, the United Kingdom retained non-strategic nuclear weapons – in line with NATO doctrine at the time – until 1994 when they were decommissioned as part of the reappraisal of the threat following the collapse of the Soviet Union.

The United Kingdom has operated a submarine-based strategic deterrent through a force of four SSBNs since 1969. These are programmed in such a way as to retain a single SSBN at sea on strategic patrol in the deep ocean, relatively undetectable and invulnerable. This so-named Continuous At Sea Deterrence has made Operation RELENTLESS – the name later adopted for the deterrent mission – the UK's longest-running military operation. Operation RELENTLESS encompasses not only the SSBN, the warheads, and missiles, but also the assured delivery of the NC3 (nuclear command, control, and communications) systems, and the forces in support on the land, at sea, and in the air, which combine to ensure that CASD can safely and securely be assured through all competing hazards and challenges in peacetime, crisis, and war.

Current UK Policy, Posture, and Capability

In numerical terms, the United Kingdom is the smallest contributor to NATO nuclear deterrence, but its enduring nuclear relationship with the United States provides it with a strong voice within NATO nuclear deliberations. Like Paris, London offers NATO an alternative independent centre of decision-making to Washington. Since the arrival of President Trump, this independence has become more germane for nuclear deterrence.

In addition, the United Kingdom has been the most flexible in adjusting the composition of its arsenal and doctrine over time. The United Kingdom has significantly reduced its nuclear arsenal since the height of the Cold War. UK policy stresses the *in maximus extremis* nature of any UK decision to employ nuclear weapons, and maintains a policy of deliberate ambiguity, both for national purposes and as part of NATO policy.

UK SSBNs and their Trident D5 SLBMs are at several days' notice to fire and, since 1994, are not targeted. If the strategic situation dictates, and at the direction of the prime minister, the missiles

[1] USS *George Washington* with sixteen Polaris A1 missiles in December 1959.

[2] Although the Strategic Air Command bombers first deployed in 1949, and the bomb assemblies were available from 1950, the weapons cores were not authorised for deployment to the United Kingdom until April 1954.

could be targeted from information onboard the SSBN, or from information signalled to the SSBN during its patrol. In addition, the SSBN can be ordered to operate at higher readiness to match the crisis. The ability to shorten or extend the SSBN response times to match the strategic circumstances without such action escalating a crisis is one of the significant strengths of a continuous patrolling sea-based deterrent.

An SSBN operates passively from sailing until its return. Its greatest strength is its virtual undetectability; from this is drawn a significant element of its deterrence credibility – an easily detectable SSBN is a less assured deterrent. The safe and assured transit from berth, and undetected operation in its deep-water patrol area, draws also on the capabilities present in the Royal Navy, and the Royal Air Force, while the security and assurance of its many modes of land-based communications rests in crisis and war on elements of the British Army. All these capabilities, from the physical security while the SSBN is on surface passage, to the surety that its departure route is clear of mines and other interferences, to the knowledge of where potential hostile air and maritime forces are operating, are drawn from a tapestry woven from dedicated capabilities and units with other roles when not engaged in support of the SSBN.

At the height of the Cold War, the bulk of the Royal Navy's, and a significant slice of the Royal Air Force's, capabilities were tuned to anti-submarine warfare (ASW), largely in support of both the UK SSBN mission and the NATO transatlantic support convoys to Europe. Of all within this tapestry, the western SSBNs drew greatest confidence from the fixed detection systems in the Atlantic and the forces in support, in order of most effect: maritime patrol aircraft (MPA), nuclear-powered attack submarines (SSNs), ASW frigates and their helicopters. In the United Kingdom, the continual squeeze on conventional forces has seen a significant decline in the numbers and availability of forces in support in the northern Atlantic. Of all of these, undoubtedly the most significant was the decision in 2010 to withdraw the Nimrod MPA from service and cancel its replacement. While the subsequent announcement to buy a few P8 MPA from the United States has reduced the effect, there is no doubt that the absence of UK MPA from the support team has given the most pause for thought in Northwood HQ.

Each UK SSBN carries the Trident II D5 submarine-launched ballistic missile system. Following the decisions in the UK Strategic Defence and Security Reviews (SDSRs) of 2010 and 2015, the United Kingdom now deploys eight Trident missiles on each operational Vanguard-class submarine. The United Kingdom had initial title to 58 missile bodies within the US inventory, which are held in a communal pool at the Strategic Weapons Facility at the Kings Bay Submarine Base in Georgia, United States. Maintenance and in-service support of the missiles is undertaken at Kings Bay at periodic intervals.

Each Trident missile was originally designed to carry up to twelve nuclear warheads, but the 2010 SDSR imposed a limit of 40 warheads per operational submarine. The destructive power of each of the warheads is not made public but has been estimated at up to the equivalent of eight to ten Hiroshima weapons. All the UK's warheads are built and maintained at the Atomic Weapons Establishment in Aldermaston and nearby Burghfield in Berkshire, and transported when required by secure convoy to the armament depot at Coulport, adjacent to Faslane, for mating with the missiles aboard an operational SSBN. They remain mated with the missiles for the duration of the submarine's commission (around ten years per commission).

CASD – Why It Remains the UK Posture

The United Kingdom became a nuclear-armed state in a very different world from that which it faces today. The genesis of the UK program, beyond the scope of this chapter, was a complex combination of post-war security fear and fading world power angst. It became a recognised NWS with the NPT and has remained a NWS through greatly changing times. It has sustained its program because successive UK governments of all colours and backgrounds have studied and concluded that the medium to long-term risk to the United Kingdom, its allies, and vital interests from adversarial nuclear coercion and attack remain sufficient to sustain the capability, albeit at a lower level today than any time since the earliest days. That is not to say that the United Kingdom has had an unswerving and continuous position on its nuclear status throughout this period. It is the nuclear-armed state that most often, and most critically, examines its deterrent both existentially and in terms of the means through which it is delivered. It is helpful to understand the threads of this self-examination to understand better the maintenance of CASD.

Any credible analysis that seeks to make a case to abandon the UK deterrent unilaterally must answer six strategic and sequential questions in opposition to all these successive governments:

- Do nuclear threats still exist that the United Kingdom and its allies cannot discount and need to counter over the next 30–50 years?
- Can these nuclear threats be countered credibly with non-nuclear capabilities?
- Is the UK nuclear deterrent in the eyes of allies and adversaries alike a necessary and effective component of that need to counter?
- Do the costs and benefits of maintaining a nuclear deterrent outweigh the risks of abandoning it?
- Is the current SLBM-based system still the most efficient and credible means of delivering that deterrence for the United Kingdom, its allies, and vital interests?
- Should the United Kingdom maintain the posture of its SSBN force (CASD) or consider alternatives?

Successive recent studies from the 2006 Defence White Paper through to the 2010 SDSR, the 2013 Trident Alternatives Review (TAR), and the 2015 SDSR, confirmed the initial answers to the first five questions (Yes, No, Yes, Yes, Yes). Three out of the four (the outlier being the TAR[3] – unsurprisingly given its source) also answered unequivocally yes to the last one, as has every Parliamentary vote on the subject, including the one after the debate on the TAR.

While this chapter will not detail the arguments underlining the answers to the first five questions, it will examine the enduring rationale behind CASD. The overwhelming vote in Parliament on 18 July 2016 to maintain CASD gave the strongest political endorsement in a decade to the continuation of the deterrent in its current form through the construction of four successor SSBNs at a then cost of 20p for every £100 of government expenditure.

Those who advocate breaking CASD do so primarily for reasons of either resources (build fewer submarines) or disarmament (non-continuous patrolling is a "step down the ladder") or both – the arguments for each are equally flawed. The resource saving through building fewer than four SSBNs would be relatively marginal as all the infrastructure costs would remain, and the unit costs of the remaining submarines would rise to account for the smaller production run on all elements of the construction.

Similarly, there is no evidence that UK reductions in nuclear systems and warhead counts over the last 30 years have changed one iota the intent or posture of other nuclear-armed or nascent nuclear states. The premise that a UK decision to break CASD would galvanise similar responses from other nuclear states is utopian wishful thinking with potentially dangerous consequences, particularly given the alarming increase in nuclear salience by other nuclear-armed states in recent years. Neither of these reasons are enough to usher in all the attendant risks of breaking CASD.

CASD is the strongest indicator today to ally and potential adversary alike of the UK's commitment to a credible minimum deterrent. CASD reduces the risk to the United Kingdom in any nuclear crisis. Removing the ability to eliminate the UK's nuclear capability pre-emptively significantly reduces the likelihood of an adversary using weapons in coercion or in anger in the first place, and ensures that the UK's deterrent patrols do not in themselves exacerbate the crisis.

CASD via SSBNs allows the United Kingdom to continue to field its deterrence at the minimum level, the lowest level of the five NWS under the NPT because that capability is immune to interdiction, preventing deployment, or assured destruction by an adversary. CASD also maintains a continual focus on the excellence the nation demands in the safe and secure production, custody, transportation, and deployment of these weapons.

The United Kingdom has currently determined that CASD will remain its policy through the life of the next class of SSBN (Dreadnought-class), that is until at least the late 2050s.

Nuclear-Strategic Stability: Deterrence and Disarmament – the SSBN

The world faces three simultaneous and interlocking nuclear weapon challenges:

- Increasing risk of misunderstanding and misinterpretation, which could escalate into nuclear employment from a conventional conflict or from an initial nuclear miscalculation. This risk is exacerbated by a more challenging communications environment and the resurgence of dual-capable and less-than-strategic capabilities, which risk lowering thresholds and increasing likelihood of use.
- An incipient arms race in both these destabilising systems and in new types of nuclear weapons (including trans-oceanic underwater "cruise missiles," hypersonic weapons, and a nuclear-powered cruise missile).
- A lack of arms control agreements leading to a continuing erosion of trust and a regression to the worst days of the Cold War. This has been made more urgent and significant by the withdrawal of the United States and Russia from the Intermediate-Range Nuclear Forces (INF) Treaty in August 2019.

Each of these challenges threaten global strategic stability through their ability to affect the nuclear component of that stability. As the definition of global strategic stability has proved very difficult,[4] a more constrained definition of strategic nuclear stability would be useful,[5] such as:

[3] The TAR was a study managed and controlled by the Liberal Democrats within the UK Government Coalition agreement of 2010. Its two main guiding objectives were first to make a case for a non-SSBN deterrent solution and, if that wasn't possible, to make a case for a non-continuous SSBN posture. The summary conclusion of the report dated 16 July 2013 stated: "The analysis has shown that there are alternatives to Trident that would enable the UK to be capable of inflicting significant damage such that most potential adversaries around the world would be deterred. It also shows that there are alternative non-continuous postures (akin to how we operate conventional military assets) that could be adopted, including by SSBNs, which would aim to be at reduced readiness only when the UK assesses the threat of a no-notice pre-emptive attack to be low. None of these alternative systems and postures offers the same degree of resilience as the current posture of Continuous At Sea Deterrence, nor could they guarantee a prompt response in all circumstances."

[4] The last valiant attempt to quantify it being a series of papers edited by Elbridge Colby and Michael Gerson in 2013. See Elbridge A. Colby and Michael S. Gerson, *Strategic Stability: Contending Definitions* (Carlisle, PA: Strategic Studies Institute and US Army War College Press, 2013).

[5] These concepts were introduced by the author in "Improving Nuclear Strategic Stability through a Responsibility-Based Approach: A Platform for 21st Century Arms Control," *Council on Strategic Risks*, January 7, 2019, https://councilonstrategicrisk.files.wordpress.com/2019/01/improving-nuclear-strategic-stability-through-a-responsibility-based-approach_briefer-1_2019_01_7.pdf.

> Nuclear-Strategic Stability (NSS) is a metric of international relations and is high where the risk of any conflict being initiated using nuclear weapons or escalated to the nuclear level is as low as is achievable. Every posture, capability, or declaratory change should be assessed against this metric. Nuclear Armed States should always strive to improve NSS.

Fundamental to the adoption of NSS as the overriding metric is the understanding that it does not affect deterrent relationships nor individual state security. Indeed, the higher the NSS metric, the more effective strategic nuclear deterrence becomes.

Evidently, the highest NSS would be achieved once nuclear weapons were no longer fielded by any state (though this, without other compensating security actions, might make the world less stable in broader conventional conflict terms). Direct progress from today's state to "Global Zero," however, would not be a continuous improvement in NSS. Even with a carefully constructed pathway aimed at maintaining optimum NSS through an omnilaterally agreed plan will have spikes in instability, especially at low numbers.

It is important to seek agreement that adherence and progress to the Article VI commitments within the NPT while maintaining minimum credible strategic deterrence means a long duration pattern of international activity. This agreement would involve progressive activity towards nuclear-armed states reducing omnilaterally towards a single relatively survivable strategic system (for example, the SSBN) each, thence through reductions to zero. There is, however, currently little international agreement as to where on such a path we might be (even what such a path might look like).

Future arms control discussions and agreements would benefit from understanding their placement within such a schematic pathway designed to increase NSS to a position where overall strategic stability is at a place where the final implementation of the disarmament commitments in the NPT's Article VI could be undertaken. The pathway would pass through two gateways, the first of which would be achieved when the weapons "most susceptible to nuclear warfighting" were controlled and eliminated. Achievement of this would be akin to the stabilising effect of the post–Cold War US Presidential Nuclear Initiatives of 1991–1992 and the Russian responses.

The second gateway would mark the removal and decommissioning of all remaining weapons, primarily those remaining tactical and "delegated in conflict" weapons that did not meet the criteria of strategic, politically controlled weapons of deterrence. The period between these gateways would require adaptions in the pervading security situation to accommodate a final removal of nuclear weapons. It is likely that new formal conventional arms control agreements and treaties would be necessary to assure all nuclear-armed states (including those current non-signatories to the NPT) that their security would not be significantly diminished by their agreement to decommission their remaining weapons.

From the UK perspective, it has already passed through the first and second gateways. Its SSBN force is a strategic, politically controlled weapon solely of deterrence operated at a continuously scrutinised minimum level.

Relevance of the UK Experience to the Indo-Pacific

Given the history of the United Kingdom in the Indo-Pacific region, particularly in regard to the nuclear-armed states of India and Pakistan, it is always challenging to proffer UK experience as valuable. There remain, however, five key points from the UK experience that directly affect the development of submarine-launched nuclear weapons in this region.

Fielding an SSBN, while challenging enough, is not enough to declare a sea-based deterrent. Without robust and capable NC3 systems and sufficient ocean area and supporting forces to assure SSBN survivability, the credibility of its deterrence is significantly reduced.

The nuclear-armed states in the region make much of their policies, on the whole, of maintaining de-mated systems, with warheads in peacetime securely located separate from delivery systems. This is impractical for nuclear-armed submarines, particularly SSBNs. Implicit in fielding operational SSBNs, therefore, is that the submarines have missiles permanently mated to warheads.

SSBNs best operate in relatively sparsely navigated ocean spaces reached relatively swiftly, and particularly those spaces that are not areas of contested ownership. Neither the Bay of Bengal nor the Arabian Sea fit the first two criteria easily, and the South China Sea is the worst of the three, particularly in the last criterion. The realities of the sea areas open to SSBNs in the Indo-Pacific region, particularly when they field shorter-range SLBMs in the near-term, make operations challenging and the risk of interaction and inadvertent escalation high.

The maintenance of a force of nuclear submarines depends upon a strong industrial-technological base and a retained specialist cadre of competent crew to operate and maintain the submarines. None of the countries operating SSBNs has operated a small force of SSBNs alone. An accompanying force of SSNs has provided, as a by-product, a larger pool of expertise that can absorb the challenges of training failures, illness, and retention failures without undue pressure on the safe and effective delivery of the SSBN mission. Only France built SSBNs first, but on the back of a large conventional submarine force. This challenge will face all three nascent SSBN operators in the region.

India, in particular, is a state with a currently declared policy of no-first-use and an active SSBN program. Should India continue to develop its SSBNs such that its accompanying policy of "massive retaliation" becomes capable of being fielded in the SSBN, it would in theory, and if its declared posture matched reality, have no further use for other nuclear weapons systems, either air- or land-delivered. *See Chapters Ten and Eleven.*

The Enduring SSBN Advantage – Oceans Yet to Prove Transparent to Drone Swarms

There has been a renaissance in recent years of papers and articles seeking to portray the risks of novel technologies to the enduring advantages of the SSBN. This was triggered in a great part by the desire to influence the UK replacement SSBN procurement decision in 2016, by implicitly undermining their rationale. The main area of "novel" vulnerability predicted has been the imminent transparency of the oceans, brought about by the reportedly inexorable capability derived from swarms of underwater drones with novel detection capabilities.

The authors of these papers draw together several research activities, industrial product descriptions, and imagined scenarios to weave a story of future near certainty of SSBN detection. While the potential for unmanned underwater vehicles (UUVs) to add to the arsenal of those seeking either to find, or indeed hide, submarines cannot be dismissed, on analysis, the whole is considerably less than the sum of its parts. *See Part Three.*

In setting the context, it is worth examining the changing nature of both submarine and ASW operations over the past 40 years. A most challenging subset of this is SSBN and counter-SSBN operations, the nature of which has seen the greatest shift. In the early days where adversary SSBNs were noisy and had relatively short-range missiles, the emphasis was on detection, tracking and, if necessary, marking, in order to be able to neutralise their threat on the commencement of hostilities. As submarines quietened, and patrol areas widened, these activities became both more difficult and less strategically relevant, since it was increasingly uneconomic to develop capabilities that could be interpreted as escalatory. In addition, assets designed to prosecute SSBNs have seen their roles and utility across the spectrum of warfare – at sea and on the land – multiply. Thus, through a combination of stealth, challenge, and a gradual evolution in strategy, the emphasis has shifted from prosecution of the adversary SSBNs to a much wider range of roles, including protection of the patrol areas for one's own SSBNs. While never explicitly acknowledged, prosecution of SSBNs in peacetime has evolved from a core component of nuclear strategy to an activity that may now be unnecessarily escalatory, and may have been very risky even at the height of the Cold War, notwithstanding the then significant acoustic advantage that the Western allies held over the Soviet Union.

Apart from the reduction in the ability and strategic ambition to conduct peacetime anti-SSBN activity and the likely increased escalation risk of doing so in crisis, the calculable challenge of scale and environment will complicate the introduction of UUVs. The problems differ in the inshore, choke points, and open ocean, but the scale advantages of the first two are diminished by the even more hostile environment. First, consider the open ocean: while no one outside the program can know the exact areas UK SSBNs patrol, they are assuredly vast. Even if only the open ocean segments of just the North Atlantic and Norwegian Sea are considered, there is a search area of the top 500 metres in depth of around 4.5 million square nautical miles. With an optimistic detection and classification range against a modern allied SSBN, acoustically and through other fieldable sensors of two kilometres in all directions, this would demand nearly four million UUVs. That would pose a currently unimaginable command, control, and communications challenge for these UUVs, so the focus shifts to fewer sensors patrolling a smaller area, and further analysis demonstrates swiftly that the only feasible operating area for such hypothetical UUVs becomes identifiable choke points.

It is no secret but simply geography that SSBNs deploying from the United Kingdom must pass either north or south of Ireland to enter deep water. On the face of it, these offer attractive choke points at which to station sensors, including UUVs, to detect the passage of an SSBN. Indeed, during the majority of the Cold War, the Soviet Union placed intelligence ships upon the choke points and deployed submarines close to them to track deploying and returning UK and US SSBNs. That they were unsuccessful points not only to the relative stealth advantage of allied SSBNs, but also to the significant difficulty in conducting ASW in a noisy inshore environment. UUVs would face the same challenges, with the additional risk of being gathered and rendered inoperative by the many trawlers that criss-cross both areas. Submarines, while taking great care to avoid trawlers and their gear, usually consider them a challenge, not an ally. In the case of drifting or swarming UUVs, for once, the trawlers would be unknowing or even deliberate allies.

The choke points also do not fully remove the challenge of scale. Even a relatively small "barrier" search in the two choke points would require 100 UUVs, assuming a detection range of one kilometre (very optimistic inshore); a more realistic (but still optimistic) inshore detection range of 500 metres would require around 200 UUVs. The operation of large numbers of UUVs in these areas assumes that the ships, submarines, or aircraft deploying the UUVs do so undetected and are not interdicted within or close to the UK's territorial waters.

These UUVs would have a physical presence on or under the sea surface and a detectable data transfer system to processors capable of analysis and ultimate classification. In addition, to threaten the SSBN, there would need to be some sort of additional prosecution capability. All of these – the physical UUVs, the communications systems, and the prosecution capabilities – would have exploitable vulnerabilities that would vary depending on the chosen battlespace, but would be at their most vulnerable to interdiction or disruption in the inshore or choke point areas.

Proponents of the UUV swarm theory assert that the technology will take away the strategic advantage of the submarine. This has been an ambition of those who continue to work the ASW problem, yet if there has been one constant in the changing ASW battle over the last 40 years, it has been that each decade someone has confidently predicted that the submarine's advantage was to be short-lived and that in the next decade the oceans will become transparent.

There is no doubt that those in defence acquisition continue to strive to introduce UUVs into the underwater battlespace in as meaningful a way as unmanned aerial vehicles (UAVs) have proved over land. The fact that we are still years away from this after at least twenty years of ideas, promises, and trials speaks volumes for the challenges yet to be overcome, and for the immutable differences in the environments in which UAVs and UUVs operate. The choice to employ UUVs against SSBNs, particularly in the coastal or territorial waters of the SSBN owner state, is not simply a highly challenging technological one; it introduces political and strategic implications. In the open ocean, a realistic scale of effort is likely to be physically and economically unviable.

Conclusion

The scale and nature of the UK SSBN program has evolved as a result of competing and changing demands of deterrence, economy, and disarmament ambition. It has been underpinned from the start by close cooperation with the United States. In maintaining CASD, the United Kingdom fulfils its need to offer non-escalatory and scalable deterrence to NATO, while assuring the competence of its personnel and safety of the weapons in its charge. The United Kingdom has assessed that the continued benefits that SSBNs bring are not significantly threatened by novel technologies, and that fielding SSBNs as politically controlled strategic weapons of deterrence in only the most extreme circumstances best contributes to strategic stability and positions the United Kingdom at the vanguard of NWS contemplating their obligations under Article VI of the NPT.

For these reasons, and while it may not be the perfect model for current and future SSBN operators, the UK SSBN program may offer a series of metrics in all the areas covered above against which other nuclear-armed states operating SSBNs can be measured.

Chapter 17

Japan's Deterrence Posture and Approach to Anti-Submarine Warfare

Yoji Koda

Strategy of Japan and JMSDF: Japan–US Alliance

Since the founding of the Japan Self-Defense Forces (JSDF) in 1954, the defence strategy of Japan under the Pacifist Constitution (effective May 1947) has been based on the Japan–United States Alliance. This posture was first established in Japan's Basic Policy for National Defense (BPND) in 1957 by the Government of Japan.[1] In December 2013, the Japanese National Security Strategy (J-NSS) replaced the BPND, and firmly established a revised policy. With regard to the fundamentals of force build-up, seven National Defense Program Outlines/Guidelines (NDPOs/NDPGs) were approved, and the latest NDPG was issued in December 2018 (2019-NDPG).[2] These documents have clearly identified that Japan's security posture has been built upon the combined pillars of JSDF, and the Japan–United States Alliance.

Complementary Strategic Mission-Sharing

By fully complying with this concept, the defence strategy of Japan has been to build and maintain an effectively functioning JSDF, and to enhance combined operational capabilities with US forces. The strategic concept of JSDF with respect to US forces has been a complementary mission-sharing posture, in which US forces concentrate on strategic offensive operations against enemy nation(s), while JSDF maximises its capability for defensive operations. This mutually complementary posture between the two forces has been known as a "spear and shield" relationship.

Mission of JMSDF: Protection of Sea Lines of Communications in the Northwestern Pacific Ocean

As for maritime operations, ensuring the safety and security of the waters around Japan and its region has been the main mission of the Japan Maritime Self-Defense Force (JMSDF). In this concept, JMSDF ensures the safety of US reinforcements arriving from across the Pacific Ocean and guarantees the safety of US naval forces, such as US Carrier Strike Groups and Marine Expeditionary Strike Groups, operating in the Northwestern Pacific Ocean. The safety of Strategic Sealift Reinforcements from the United States has been another important element of the JMSDF's mission.

At the same time, for Japan, as a country of poor natural resources and limited domestic food production, as well as large industrial manufacturing, the safety of merchant shipping has been a matter of national survival too.

These two types of maritime operations are grouped under the heading of Protection of sea lines of communication (SLOCs). Bitter lessons from failed efforts to protect SLOCs by Imperial Japan during World War II strongly support and justify the strategic and operating concepts of JMSDF.

JMSDF's Tasks and Type of Operations in High-End Combat Scenarios during the Cold War Era: Anti-Submarine Warfare

In the Cold War period, JMSDF's major task was conducting anti-submarine warfare (ASW) operations against the robust submarine force of the Soviet Pacific Fleet, for example through:

- Intelligence operations.
- Wide-area ocean surveillance operations employing maritime patrol aircraft (MPA).
- Choke point control operations, employing ASW helicopters (HS), ASW destroyers (DD), submarines, and mines.
- Hunter-killer and direct escort operations of high-value units, employing DD, HS, and MPA.

JMSDF's Tasks and Type of Operations in High-End Combat Scenarios in the 21st Century: ASW and Choke Point Operations

After a decade-long period of uncertainty following the end of the Cold War, it became apparent that China would become a nation with overwhelming power to replace the Soviet Union, which had fallen apart in the late 1980s. During the first decade of the 21st century, predictions of China's rise became true.

In this new security environment, the worst scenario in global and regional security is a potential high-end military conflict between free nations, especially Japan and the United States (possibly joined by Australia), and an authoritarian nation like China. This fear remains the same as the one in the Cold War days; however, one significant difference from the Cold War period is today's vast expansion of the potential conflict area. This expanded area

[1] "Position of the Government of Japan on Defense of Japan," in *Boei Handbook of 2009* [*Handbook for Defense 2009*] (Tokyo: Asagumo Shinbunshya, 2009), 17.

[2] The NDPG was submitted on 18 December 2018; however, the NDPG is titled as "National Defense Program Guidelines for FY 2019 and Beyond." Because of this, 2019-NDPG is used in this article.

includes the Northwestern Pacific Ocean, the East and South China Seas, as well as the Indian Ocean.

Even so, the strategic task of Japan is still to ensure US presence in the Indo-Pacific region, to enable US forces to deter China's People's Liberation Army (PLA), and to victoriously fight against the PLA if necessary. For JMSDF, ASW is clearly the principal operation, because the People's Liberation Army Navy (PLAN) has been actively building a robust submarine force, expected to reach about 80 boats by 2030, which could pose a serious threat to Japan's SLOCs.

There is another element that will impact Japan's strategic planning. That is the "geographic reality" that will constrain and mitigate the PLAN's ambition to be a true blue-water navy outside of the East and South China Seas. For example, geographically, all PLAN bases are either in the East China Sea/Yellow Sea, or South China Sea. This means that those PLAN forces are contained in semi-closed waters, with only a few key egress/choke points located along the encompassing first island chain. In this respect, Choke Point Control Operations conducted by JMSDF against PLAN forces will become the most effective ones for deterrence.

Capability of JMSDF in the 21st Century

China Factor

Today, the capability of JMSDF in all areas of warfare, especially to fight modern high-end combat either unilaterally or bilaterally with US naval forces, is world class. One key factor that has strongly influenced Japan's security policy developments since the mid-1990s is the rise of China as a great power. Thus, the Government of Japan, without singling out China, puts highest priority on countering China's future military capabilities and strategies.

Japan's Force Build-Up

In response to the new security environment, the Government of Japan took China's military rise into full consideration in the two latest NDPGs (2014 and 2019). JSDF took both the aforementioned China factors and Japan's flat-developing economic situation at the time into account, and developed slightly adjusted strategies and force build-up programs for the next decade.

Three key strategic policies, listed below were developed in the two NDPGs:[3]

- Build and maintain a reasonably sized and capable JSDF, which would fully meet China's future security challenges, including those in new domains.
- Continue efforts to strengthen the Japan–United States Alliance.
- Develop new operational concepts to actively participate in international security operations.

Size and Capabilities of JMSDF Deterrence Force

For JMSDF, the following will be the basic composition of its deterrence force in 2025, which fully reflects the above-mentioned strategy and force build-up programs.[4]

Surface force:

- Four ASW flotillas, comprising a total of 32 ships, including one DDH (HS carrier), two Aegis guided missile destroyers (DDGs), and five DDs in each flotilla with eight to sixteen HSs. These units are the core forces for hunter-killer/direct escort operations in blue-water areas.
- Six ASW destroyer divisions, comprising three to four DDs per division for a total of 22. These units are used for choke point ASW operations.

Aviation:

- MPA (fixed wing): four wings/eight squadrons of 86 aircraft (P-1 and P-3). These units are responsible for wide area ocean surveillance.
- HS: two wings/five squadrons of 80 HS (SH-60J and SH-60K) to be deployed to surface forces. Some will conduct choke point ASW operations from land bases.

Submarine force:

- Twenty boats, to be increased to 22. These are the most suitable assets for choke point ASW operations and intelligence operations.

Mine force:

- One mine flotilla, consisting of two large tender-layers (mine warfare "mother ships"), as well as four divisions of Ocean Mine Sweeper/Hunters (MSO); a total of twelve MSOs.
- One MCM helicopter squadron; a total of ten MCH-101.

Others:

- In addition to JSDF's Ballistic Missile Defence program, JMSDF maintains certain types of operational and support forces other than for deterrence, including special operations, intelligence collection, logistic supply, transport, search and rescue, as well as training/development units.

[3] Government of Japan, *2019 Defence of Japan* (Tokyo, 2019), 8–18.

[4] Government of Japan, *National Defence Program Guidelines: For FY 2019 and Beyond* (Tokyo, 2019); *Sekai no Kansen, Ships of the World* (Tokyo: Kaijinsha, 2014).

Rise of the PLAN and its Impact on JMSDF Strategy

Two Closely Aligned Maritime Forces

As mentioned above, there have been few changes in JMSDF's strategy and operational posture in the 21st century. A key focus of JMSDF strategy is to maintain sufficient capability to meet the challenges of the PLAN. This focus will surely contribute to protect vital SLOCs, enable JMSDF to conduct support operations to US Navy (USN) forces, and contribute to JSDF's Island Defence Joint Operations.

At the same time, however, there should be additional considerations to cope with the PLAN under the new strategy. For example, there are several key elements in the PLAN's anti-access, area denial (A2AD) strategy, together with future maritime security challenges, against which the JMSDF should develop countermeasures towards, including:

- Anti-ship ballistic missiles.
- Territorial disputes and natural resource competition in the East and South China Seas.
- China's new naval base on Hainan Island and artificial islands in the South China Sea.
- The PLAN's naval build-up program, including aircraft carriers and naval strategic arms, such as SSBNs.
- Asymmetric warfare.

In order for the JMSDF to fully respond to the PLAN's new strategies, the most important thing is to develop and maintain sufficient operational capabilities against the PLAN. In this process, JMSDF should closely cooperate with the USN, because the main objective of China and PLAN strategy is directed at USN forces in the region. China strongly intends to create situations, favourable to itself, which will erode Washington's determination to intervene in Asian issues by deploying USN forces. So, there is a lot for JMSDF and the USN to do to deter China's strategic attempts.

One favourable factor is the current strength and capabilities of JMSDF, which is probably next-best to the USN among Western nations. So, it is critical for the USN that there is a robust JMSDF force, with non-strike but superb defensive ASW operational capabilities and which is able to fully support the US 7th Fleet. If the two great maritime powers coordinate and cooperate well, they will surely be able to deter the PLAN, responding to growing challenges in the region, effectively and wisely.

China's Achilles' Heel and a "God-Given Treasure" for Deterrence: Choke Points

All PLAN forces are contained in two semi-enclosed ocean areas, being the East and South China Seas. So, for PLAN forces to operate outside of China's immediate littoral zones, their units must pass through straits and channels, so-called "choke points," in order to enter and depart the outer, open-ocean waters.

This complicates PLAN's strategy. It is very difficult for the PLAN to operate freely in the outside "blue-water" ocean area. In particular, deployments of PLAN units in contingency and wartime scenarios could become extremely difficult and troublesome. In this context, for Japan and the United States, several choke points in the first island chain, which surround the PLAN's Areas of Operations in the East and South China Seas, is a principal deterrence factor, and will continue to be so in the future. For China, the choke points will become a real obstacle in its naval strategy. Additionally, the fact that all of these choke points belong to other nations, and China has no control over them, is a key disadvantage for China.

In this regard, the PLAN cannot count on the luxury of free transit by its operational units through the choke points in war time. Therefore, choke point operations of US allies could inflict substantial difficulties on China. For example, Japan can physically block choke points in its southwestern (Ryukyu) islands chain, thereby not allowing, for example, PLAN units' transit out to the open oceans to fight USN forces.

Additionally, JSDF is capable of controlling the Bashi Strait; and Australian forces, if the nation agrees, may block and control high-sea areas out of southern choke points in the Philippine and Indonesian archipelagos.

So, for China and the PLAN, the geographic characteristics of its home waters could be their most difficult obstacle to becoming a real blue-water navy to support its A2AD strategy. Of course, China has many options to solve or reduce this problem, but China will have to pay large costs for any solution. For Japan and the United States, choke points around China have been, and will be, "God-given treasures" to deter China and the PLAN. Of note, JSDF's new Island Defense posture is part of Japan's strategy of future deterrence.

Implications of New Technologies in ASW

In order for Japan and JMSDF to deter the PLAN's forces, especially its submarine forces, from conducting aggressive operations against Japan and the United States, the implications of new and innovative technologies to JMSDF's ASW operations will be vital for future success. JMSDF has several programs to improve its ASW capabilities, such as bi/multi-static sonar operations and new non-acoustic sensors. The below three areas are examples of new technologies and challenges.

Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR)

In all military operations, C4ISR capabilities are key for successful operations. In any C4ISR theatres or domains, new technologies, such as surveillance from space, intelligence collection by extremely long-endurance unmanned aircraft, sea-bed acoustic devices and deployable/expandable ASW sensors, which are supported by advanced data processing systems, will be game-changers for JMSDF's future ASW operations.

Unmanned Underwater Vehicles (UUVs)

Long endurance large UUVs like *Echo Voyager*, recently delivered to the USN for trials, have a huge potential to complement, but not to replace, conventional diesel-electric submarines in ASW operations. The deployment of low-cost/medium-performance UUVs, in large numbers, will largely make up for the inherent handicap of poor underwater manoeuvrability of conventional submarines. At the same time, the incorporation of artificial intelligence (AI) into the latest UUVs' autonomous capabilities will substantially improve their ability to function independently from controlling (mother) units.

AI Mines

AI and new sensors supported by latest data-processing technologies would be game-changers for mine operations, especially those conducted at choke points. These types of advanced mines will enable any navy to deploy a much smaller number of mines to establish its operational objectives than before. These AI mines will be most suitable for offensive mining at the mouth of enemy ports, and defensive mine operations at strategic choke points. These mines can attack the right target, at the right place, at the right time.

Conclusion

The PLAN has great potential to become a real blue-water navy and could challenge the USN and JMSDF. However, for China and the PLAN, there will be many obstacles to achieving this. Therefore, Japan and the United States will need to prepare themselves to counter China's strategy by precise, coordinated focus on the PLAN's most difficult challenge: the semi-enclosed nature of the East and South China Seas.

A key question for Tokyo and Washington is how to assure wartime control of these strategic choke points. In order for JSDF and US forces to maintain an advantageous position over the PLA, the two militaries have to retain the capability to keep the big "wild birds" (PLAN and the People's Liberation Army Air Force) in their naturally formed "God-given" cages of the first island chain surrounding the East and South China Seas. Both Japan and the United States need to develop an aligned strategy and mutual capability at the earliest opportunity to deter China's adventurism.

PART 3

Technology Trends

Chapter 18
Strategic Submarines and Strategic Stability: Looking Towards the 2030s

Norman Friedman

In theory, the basis of strategic stability – of averting World War III – is absolute confidence on the part of all parties that they cannot destroy their enemies' strategic weapons in a first strike. It is widely believed that the basis of current strategic stability is that nuclear-powered ballistic missile submarines (SSBNs) are inherently invulnerable. During much of the Cold War, however, that was obviously untrue.

Strategic submarines are part of a larger strategic defence system. How well that system can be expected to work depends on how all its elements work. The submarine is linked to a command system and a strategic warning or sensing system on which commands are based. Strategic defence is at one end of the chain and whether the submarine weapon reaches its target is at the other end.

Perhaps the key technology issue for submarine deterrents will not be some fantastic form of anti-submarine warfare (ASW) but rather some dramatic improvement in strategic defence technology that increases the minimum acceptable number of submarines or missiles to deal with a specific target. Current strategic submarine forces are substantially weaker numerically than those active during the Cold War, probably partly because it has been assumed that terminal defences would be ineffective at best. As terminal defences improve, the question will be how many targets must be held at risk to maintain deterrence. These calculations become more complicated if there is more than one rival superpower. The arms treaties negotiated during and immediately after the Cold War were bilateral; neither superpower took China into account. That seems less and less rational as China modernises and acquires substantial amounts of great power weaponry.

It is generally easy to attribute an attack by a land-based missile since space-based systems can determine its path. A similar determination of the path of a sea-based missile is no problem, but it leads back to a patch of sea. Unless all submarines are tracked and identified at all times – a most unlikely possibility – attacks by sea-based weapons are essentially anonymous. This reality raises the possibility of catalytic forms of warfare.

As many sensors are unlikely to be able to distinguish between strategic and non-strategic submarines, trends in global submarine forces should also affect the ability to detect and track strategic submarines. More countries seem to want submarines, seeing them as a vital prestige item. Some have bought submarines as a useful counter to growing Chinese sea power. The presence of these submarines in Chinese strategic submarine operating areas might make it more difficult for anyone hunting the Chinese submarines to be effective.

Really long submarine missile range, as in the current US and British Trident submarine-launched ballistic missile (SLBM), seems to have changed the strategic ASW situation significantly. It can place strategic submarines well within range of friendly naval forces, even when they are within range of their targets. Attaining that sort of range – the ability to hit a small target with an ICBM fired from a moving submarine – is by no means a trivial proposition. The submarine has to know where it is to a high degree of precision. Very long-range inertial guidance requires precision engineering. In the past it might reasonably have been suggested that the need for extreme precision – for example, in machining elements of a guidance system – would limit the number of countries that could develop very long-range submarine-based missiles. However, all countries now have access to the Global Positioning System (GPS) and equivalent navigational systems, and these systems are effective well above the earth. It seems likely that such technology will proliferate in the near future, as users are all aware that the operator of a GPS-like system has the option of suddenly switching it off or reducing its precision. That was the rationale for the European Galileo system, which went live in 2016, and also for the current Chinese system.

The Vulnerability of Strategic Weapons

Strategic submarines seem to be key to strategic stability. Since the 1960s they have provided a deterrent that is apparently immune to a first strike. It seems to follow that any effective and credible means of wiping out an enemy's strategic submarines would in itself upset strategic stability. The two scenarios usually posited for upsetting strategic stability by wiping out the "invulnerable" deterrent are bombardment by long-range nuclear missiles based on known positions and trailing by submarines that could be ordered (or scheduled) to attack.

The key to a disarming bombardment of strategic submarines would be some means of wide-area detection, which is typically described as "turning the sea transparent." In theory, if all or most of an enemy's strategic submarines at sea could be localised sufficiently and simultaneously, large nuclear weapons falling near them would disable or sink them. Since this sort of detection and localisation has to be done over a very wide area, the transparent sea threat is usually associated with space-based sensing.

Trailing is a different matter. It depends on whether individual submarines can be picked up by pursuers that would have to be nuclear attack submarines (otherwise they would have insufficient endurance). They would probably have to keep tracking over a lengthy period. It is also possible to imagine trailing by surface ships, although generally they have not been as effective as submarines in this role. It is also sometimes suggested that unmanned devices could be so multiplied that they could detect and track all submarines via some sort of network. The sheer sea space in which strategic submarines can operate seems to make that questionable, but the issue will be discussed below.

Submarines are by no means the only possible stable deterrent. The only candidates for obvious vulnerability to a first strike are fixed land-based missiles. The main argument in favour of land-based missiles is that they enjoy the best connectivity to command centres and are hence the most controllable strategic weapons.

One might posit a future force of stealthy long-range bombers to hit land-based missiles, either fixed or mobile. Their practicality depends on the future of stealth. Whilst stealth reduces signature, signal processing restores visibility. Looking out to 2039 means asking about the future of Moore's Law, the claim that signal processing power doubles every eighteen months, if not more quickly.

It seems to be widely assumed that although stealth can be effective against short-wave radars such as those used for targeting or defensive missile control, it is not particularly useful against longer-wave radars, including those looking beyond the horizon. If the bomber force was detected (and identified) as it penetrated another country's air space, it would inevitably trigger exactly the kind of strategic response no one wanted in the first place. For that matter, unless all the land-based strategic missiles were destroyed very nearly simultaneously, the attack would fail catastrophically. In theory, the new hypersonic missiles might solve the problem, but their approach would certainly be detectable from such a distance that they would trigger a mass missile launch.

Mobility applies not only to submarines but also to some land-based missiles (as used by both China and Russia) and to weapons onboard aircraft. Land-based mobile missiles can be hunted much more easily than submarines, but it seems unlikely that an attacker could be sure of wiping out all of them simultaneously. Space-based sensors can certainly see mobile missile launchers but their view is always periodic rather than continuous and they cannot somehow be detached to follow individual missiles. Sensors onboard a large unmanned aerial vehicle (UAV) could probably lock onto a mobile launcher, but an enemy's air defences would probably suffice to destroy the UAV. Mobile launchers are only slightly less well adapted to communication than are fixed launchers.

Strategic bombers can, in theory, be launched on warning of an enemy missile attack. This deterrent seems less credible than in the past, in the face of sophisticated air defences. However, bombers armed with medium-range ballistic missiles would seem to combine reasonable invulnerability with the ability to penetrate enemy defences. Missile-armed bombers are flexible and far easier to control than submarines. There would be ways of ensuring superpower strategic stability even if the problem of hunting nuclear strategic submarines was entirely solved. The rest of this paper is devoted to that problem – which does not seem on the verge of solution.

The question of submarine survivability as the key to strategic survivability seems to apply more to smaller nuclear powers that may rely entirely on submarines. During the Cold War, the Soviets came to operate their strategic submarines inside areas they felt they could defend, which were called (at least in the West) the bastions. In addition, they built submarine shelters within the bastions. Some years ago, the Chinese Navy built a heavily fortified submarine base on Hainan Island. It may follow that the Chinese see the South China Sea as a future strategic submarine bastion broadly equivalent to the one the Soviets tried to set up in the Barents Sea during the Cold War.

The South China Sea may be particularly attractive as a bastion because its hydrographic conditions are considered unusually difficult for ASW. Chinese reports of a "great underwater wall" and attempts to turn the South China Sea into a Chinese territorial sea are consistent with a bastion point of view. The "great underwater wall" is described publicly by its builder, the China State Shipbuilding Corporation (CSSC), as a surveillance system to be completed by 2020 using bottom-mounted upward-looking sensors.[1]

The effectiveness of a pure bastion strategy is dependent in part on the range of the missiles carried by the submarines nominally protected inside the bastion. Current Chinese naval ballistic missiles do not seem to have a range consistent with firing from a bastion in the South China Sea. It is, for example, about 11,600 kilometres from the fortified base at Hainan Island to San Francisco, and about 13,500 kilometres from that base to Washington. The JL-2 SLBM has a rated range of about 8,100 kilometres. The next-generation JL-3 is rated at greater than 5,600 nautical miles, which is about 10,200 kilometres. On 2 June 2019, China successfully tested the JL-3 SLBM from Bohai Bay (South China

[1] The Indian National Maritime Foundation posted a description of the project in December 2016. CSSC had announced it in December 2015 as a network of ship and undersea sensors that could detect and track all surface and subsurface traffic in the South China Sea. A sketch posted at the time showed a line of sensors linked to an underwater working station. The system would also include seismic sensors. The Indian description treated the system as a CSSC proposal, but since CSSC is a Chinese government entity, it would seem instead to meet a stated Chinese naval requirement (it also has disaster management elements not relevant here). The project is to be completed in 2020. According to the Indian foundation, the Chinese have already set up offshore detection systems to protect bases (such systems have been widely reported). The systems described in the Maritime Foundation paper employ a two-kilometre-long optical cable and three sets of sensors with three nodes. The distance mentioned suggests something close offshore, to deny the entrance of a base to enemy submarines or, more likely, special forces. Presumably these systems use upward-looking passive sonars, the optical cable indicating a fibre-optic rather than conventional wire connection. The small number of nodes and sensors suggests a narrow field of view.

Sea). The JL-3 may have a considerably greater range, particularly if its payload is reduced. Over a time span of several decades, it seems likely that the Chinese could produce a sea-based missile with sufficient range to reach anywhere in the United States from the South China Sea.

Chinese policy to take control of the South China Sea predates the development of long-range ballistic missiles and at present most of the countries around that sea are hostile to China (the Philippines may be the exception). Most of them also are building diesel submarine forces that are potential threats to Chinese strategic submarines operating freely in the area. However, it would be unwise to assume that over twenty years the current Chinese policy of seeking dominance of the area will fail. The Chinese may also see their growing carrier force as a means of maintaining the security of the area in the face of enemy ASW forces, such as maritime patrol aircraft.

Strategic Submarines in a Multipolar World

The Cold War world was at least nominally bipolar, which is why arms limitation treaties were negotiated between the United States and the Soviet Union. The end of the Cold War has made the world far more multipolar than before and the number of nuclear powers is likely to increase over the next twenty years. The nuclear submarine club is currently more exclusive than the nuclear weapon club; however, nuclear proliferation may change this because on a per-missile basis, submarines are far less expensive than sophisticated missile bombers or masses of land-mobile missiles.

Four countries that did not count in the Cold War balance now operate, or probably operate, strategic submarines: China, India, Israel, and North Korea. All but the Israelis carry ballistic missiles; the Israelis reportedly use cruise missiles. Of these countries, China and India have nuclear strategic submarines, both of which probably employ Russian-related technology, and therefore may have acoustic signatures something like those of current Russian strategic submarines.

Iran is probably close to having nuclear weapons, reportedly with extensive North Korean help. It seems likely that within a decade, and probably a good deal sooner, Japan will have nuclear weapons as a deterrent against North Korea and, to a lesser extent, China. South Korea will quite possibly develop weapons of its own to deter the North Koreans and possibly also to threaten Japan. We now know that during the 1970s Taiwan had a very active bomb program (which the US derailed) and it may well return. There are also other potential candidates. Saudi Arabia, for example, has long been a rival of Iran for primacy in the Islamic world. The Saudis once bought Chinese intermediate-range ballistic missiles (presumably as a threat to Iran), and for many years the Saudis underwrote the Pakistani military in return for a pledge of support in an emergency. The Turkish government has recently claimed its right to build a nuclear deterrent, although no such program has been reported.

Such nuclear proliferation has a twofold bearing on the submarine problem. First, some of these countries will deploy secure deterrents in the form of submarines. Imagine the impact of a much more numerous multinational submarine force on a "transparent ocean" system. The systems typically envisaged would operate from space and would be able to detect submarines but would have little or no ability to distinguish one submarine from another. The larger the number of submarines operating at sea, the better the chance that a space-based (or for that matter high altitude) ocean surveillance system would pick up non-targets. It would be embarrassing enough if the attack triggered by such a system failed to destroy some of its targets. It would be a lot worse if it targeted the wrong submarines.

Second, in the face of a multipolar nuclear world, the major powers may feel constrained to split their strategic submarine fleets to face multiple countries. That will be somewhat simplified if their submarines can fire very long-range missiles that can reach several countries from a single launch area. In either case, the prospective loss of a few submarines might have a much greater strategic impact than in the past.

This situation would be very different from that of the Cold War, when the last major studies of strategic ASW were published. At that time both the United States and the Soviet Union operated large numbers of strategic submarines. That considerably complicated any plan to gain a sudden strategic edge by destroying many of them. As missile performance and size improved – which gave the submarines far more flexibility in operating areas – submarines became substantially larger and more expensive and a lot less numerous. Thus, in the US Navy, 41 Polaris/Poseidon submarines were succeeded by eighteen Trident submarines, later reduced to fourteen under the final post–Cold War arms control agreements. The British and the French operate far less numerous fleets. It takes about three or four submarines to keep one SSBN continuously at sea, which would suggest that the United States has no more than three or four strategic submarines at sea at any one time (the United States probably does somewhat better than others in this respect). That is probably too few and there is current pressure to build more of the Columbia-class, which will succeed the Ohio-class.[2] Against the need for greater numbers of strategic submarines (or for that matter for strategic ASW) is the pressure of all the naval functions that must be fulfilled on a day-to-day basis. They include tactical ASW, which competes with strategic nuclear submarine forces for personnel and other resources.

[2] The Ohio-class was designed specifically for quick refits and hence for minimum time between patrols, and these submarines have alternating "blue" and "gold" crews (as do the British strategic submarines). A submarine is out of service once in its career, for refuelling. The Columbia-class are to have "one-shot" reactors and thus to avoid refuelling altogether. British submarines have similar reactor core technology. The French use short-life "caramel" fuel, which requires refuelling after about eight years.

In a bilateral world there is no real question of who had fired weapons against either side. Now, in a decidedly multilateral world, the single key fact of ballistic missile submarines is that, unlike land-based missiles, they do not automatically announce their nationality. If they are used, governments need some means of identifying their country of origin. The US government spends heavily on just this question, collecting signature information about missiles and bombs, even those tested deep underground. The knowledge that such information exists reinforces deterrence, since at least in theory it makes it possible to know who is responsible for a nuclear attack. The US strategic defence program includes measures to detect and observe missiles approaching from any direction (or, for that matter, fired at any other country) including measurement of their parameters as soon as they rise above the atmosphere. This capacity should in itself have a considerable deterrent effect, since this observation should provide identification. At the very least, unless details of the system become available to a potential attacker, the attacker cannot know whether their missile has been or can be identified.

India operates a Russian attack submarine and has built a nuclear strategic submarine; there will doubtless be more. When the North Koreans announced their own strategic submarine program, South Korean legislators said that a South Korean nuclear attack submarine program was warranted. There was no great outcry that this would be nearly impossible, but at the end of 2018 there was also no announced program. On 23 July 2019, North Korea revealed its latest indigenous submarine, a modified Romeo-class submarine reportedly able to launch ballistic missiles through its sail.

If Japan should ever adopt nuclear weapons they will also likely become interested in nuclear submarines. Brazil has a long-standing program to develop a single power reactor for both land use and for a submarine, and although it has not borne fruit in the past, twenty years ahead is a long time to assume it will go nowhere. Over two decades, other countries will probably also become interested. Canada, for example, has twice considered buying or building nuclear submarines in 1989 and 2011.

Submarine Sanctuaries and Economic Development

The future of submarine sanctuaries is likely to be impacted by increasing exploitation of the oceans. The UN Convention on the Law of the Seas (UNCLOS) provides each country with a sea coast with an Exclusive Economic Zone (EEZ). At present, maritime EEZs are little exploited, apart from fisheries and a few undersea oil and gas projects. It would seem fair to assume that over the next twenty years undersea industrial operations will expand enormously due to increased demand for raw materials sourced from the seabed. Countries are therefore likely to become more and more interested in monitoring their EEZs. Current Chinese attempts at monitoring and controlling the South China Sea may be read either as a naval exclusion measure or as an EEZ control measure, or as both.

In theory, nations with important seabed industry are likely to take measures to control access using naval or coast guard forces, but in practice it is virtually impossible to control a large sea area. As long as submarines do not actually destroy seabed operations, they will find refuge in seabed industrial areas with high noise levels due to that industry. The higher the noise levels, the more difficult it is likely to be to distinguish even noisy submarines at any distance.

During the Cold War, ships and submarines were very nearly the only sources of systematic sounds in the sea, so it was reasonable to use signal processing to reveal these. If commercial use of the oceans continues to increase, these sounds will compete for detection with whatever sounds submarines produce. At the same time, submarines are likely to continue to become quieter.

Increased commercial exploitation of the sea may well fuel the development of undersea sensors and networks currently not envisaged, which could monitor many submarine operations as a side effect. Such a network could be built right now but there is no economic basis for it. The economic basis would be very different in a world in which much mineral extraction had moved onto continental shelves.

There are already swimmer-detection sonars deployed at oil rigs in places like the Gulf. The only reason Saudi Arabia and the Gulf states have not (apparently) invested in more comprehensive submarine detection systems is that likely attackers have small or negligible submarine fleets. If submarine fleets grow over the next two decades, those depending on undersea resources offshore will provide a market for area submarine detection systems, hence pressure for development outside the usual government channels.

Increased use of the sea will probably fuel demand for much more comprehensive sensing of the global ocean environment, such as through inexpensive long-endurance unmanned devices such as “gliders.” This kind of sensing is unlikely to detect quiet submarines but it will provide sophisticated navies with a valuable guide to the most profitable paths to take to make long-range detection difficult.

It seems likely that the “big data” approach to oceanography will be a net plus for submarine operators able to take advantage of it. Right now that means the United States and its allies; in twenty years it will probably also mean China and possibly India and Russia.

Political Trends

The single greatest political question over the next twenty years is probably whether a new Cold War will break out between the United States and China. Without the impetus of a Cold War, defence spending is limited both by the demands of the civilian sector and by the need to limit taxation. It would probably take considerably worse relations between the United States and China to bring US military research and development spending back up to something like Cold War levels and really revolutionary technology to the fore.

The gap between possibility and affordable reality makes the political situation at least as important as the technological one. With the end of the Cold War, military research in the West was drastically cut. Civilian research spending, generally considerably less than military, has also been cut.

At the time of writing, the Chinese government seems to be ascendant, and US power in Asia may be declining. If these trends continue, the South China Sea may be a much friendlier environment for Chinese SSBNs in the 2030s. Another important political question for the next two decades is the future growth or shrinkage of world submarine forces. The more submarines pass through an area, the more confused the underwater picture will be. A non-strategic nuclear submarine may be particularly difficult to distinguish from a strategic one.

Current passive acoustic submarine detection is likely to rely mainly on broadband sound – on submarine indications that seem not to differentiate between submarines. Active detection systems are even worse adapted to distinguish between submarines. An SSBN may well be able to hide by operating in an area in which several countries are operating submarines. This consideration makes the possible future proliferation of strategic submarine forces a factor in SSBN survivability.

Different forms of ASW

Generally there are three different approaches to ASW. One focuses on the enemy submarines; it is often called offensive ASW. It includes the use of long-range sensors to cue attackers and the concentration of ASW forces at choke points. A second focuses on making concentrations of targets (convoys or battle groups) dangerous for submarines to attack, both deterring attacks and destroying submarines. A third focuses on protecting the targets rather than on destroying submarines. The third approach includes evasion (usually based on knowledge of submarine positions) and defensive measures such as anti-torpedo weapons.

Strategic ASW generally corresponds to the first approach: to finding and, if necessary, attacking submarines in the open ocean. There are three main variants. One is wide-area submarine detection and tracking, which is sometimes termed "making the ocean transparent." A second attacks submarines passing through choke points – which may not exist – between their bases and their patrol areas. A third is trailing; the trailer picks up the submarine target as it emerges from a harbour or base or passes through a choke point. Technology, strategy, and tactics determine which form of ASW is preferred.

Approaches to Strategic ASW

Anyone seeking to destroy an enemy's strategic submarine force using a wide-area detector has to sift the data to find strategic submarines. If the surveillance system cannot distinguish among submarines (or, worse, between the enemy's and neutrals) the scale of the problem grows enormously. The more countries operate strategic submarines, the more submarines there are that seem, from their behaviour, to be strategic and hence potential targets. Even in its heyday the sound surveillance system (SOSUS) would have found it difficult to distinguish between strategic and non-strategic submarines because it relied heavily on the characteristic sounds of noisy Soviet submarine machinery. The situation is further complicated if several countries' strategic submarines are at sea in roughly the same area. If the Russians decided that they no longer needed to keep their submarines in bastions, they would be operating in much the same areas that the British and the French probably use. If all of these submarines were quiet, detection would be by their broadband, mostly flow, noise. How would they be distinguished?

The ideal form of strategic ASW would employ long-range weapons that could, on demand, instantly destroy all of an enemy's strategic submarines. That would require a considerable measure of accuracy; the warheads would have to land fairly close to the target submarine, probably within a mile or two. This is far beyond what SOSUS ever promised.

To destroy an SSBN using SOSUS data it would be necessary for SOSUS to cue some platform, most likely either an aeroplane or a submarine, to close in on the target SSBN. That would take considerable time as an aeroplane would have to search the zone defined by SOSUS, which at best might be about 100 nautical miles on a side. It would do so by laying a field of long-range passive directional buoys, looking for a signature matching that found by SOSUS. The buoys would give an approximate fix, and the aeroplane would close in. It might do so using a few active directional buoys and then it would try to drop a weapon directly atop the submarine using magnetic anomaly detection (MAD). This would not be an instantaneous process and it is not at all clear how an attacker could be sure that the SSBN had actually been killed.

Moreover, once the aeroplane appeared, the submarine would probably be aware of what was happening. It would surely hear the splashes of the buoys as they entered the water. It might well be able to hear a low enough aeroplane. Modern submarines generally carry decoys and the splashes of the buoys and the sound of the aeroplane might make evasion possible. The noise of a nuclear explosion in the water, successful or not, would make post-attack evaluation impossible. The impossibility of post-attack evaluation makes the use of contact-fused torpedoes attractive: there is no explosion unless the target is hit (or produces a deceptive explosion of its own).

Similarly, a hunting submarine would have to close in using its long-range passive sonar. With sufficient range, the sonar might provide immediate location, but the submarine would still have to manoeuvre into an attack position, which might take considerable time.

To make a long-range missile strike possible an attacker would need something far more precise than a sound system. The usual candidate is a space-based non-acoustic device with so narrow a footprint that it would match the footprint of a nuclear weapon. It seems unlikely that a missile re-entry vehicle would have the requisite characteristics to penetrate the ocean surface at very high speed and then explode well underwater. If it had to explode at or well above the surface, its effect on a submerged submarine would be considerably reduced, so it would have to be placed quite precisely, say within a few hundred metres or less. That is about the accuracy normally reported for very precise missiles. A space-based non-acoustic device would pick the submarine up only intermittently and probably would be unable to estimate its course and speed. In that case, it would be necessary to fire a barrage of warheads and, even then, the attacker might find it difficult to be sure that the submarine had been sunk. Note, too, that the non-acoustic systems suggested generally cannot identify the submarine they detect.

To make matters more complicated, the missile would take time to get to the target. The target would be moving. A high-altitude UAV could orbit long enough to track the target and report its course and speed, so that the missile aimer could predict position when the missile burst. However, such a UAV would probably be sufficiently detectable that the submarine controller could know that an attack was being set up and could send an emergency evasion message to the submarine – say, dive deep and run.

The alternative is trailing by an attack submarine, which might pick up a strategic submarine as it exits a choke point of some sort. Again, the attack might fail as the trailed submarine could use decoys and manoeuvre and even shoot back.

Two message paths would be involved: one from the trailing submarine to its controller and another from the controller back to the trailer. The former is the worst problem. At anything more than extremely low frequency (ELF), radio signals do not penetrate sea water very deeply. Blue-green lasers do penetrate, but they have very narrow beams. A blue-green down-link can work, and the narrow beam can be scanned over the area in which a submarine is likely to be. Even then there are problems with low-lying clouds, which are very frequent over the ocean. During the Cold War the US Navy built an ELF radio transmitter specifically to send strategic submarines their action messages. It transmitted very simple messages very slowly (minutes for a few letters) and it was abandoned after the Cold War. The alternative means of getting out an emergency message was very low frequency (VLF) transmission by dedicated Take Charge and Move Out (TACAMO) aircraft.

Typically submarines have to bring a radio antenna near the surface to send out messages, or to receive complex ones. That might mean a recording in a buoy that would float to the surface, or coming to periscope depth to release a towed antenna, or putting a satellite dish above the surface. None of these techniques would be well-adapted to a strategic ASW attack. As the communication limits for ASW attacks seem to be physical, rather than consequences of current technology, it is difficult to see how they can be overcome.

In tactical situations a lot can be done; there are now effective underwater communication systems, and they might be used to connect a submarine with an underwater network of some kind (so could a vertical blue-green laser). However, it is difficult to imagine such a network covering the whole of an ocean basin, as it would have to do to ensure constant or near-constant long-range submarine communication.

All of this suggests that the main possible means of setting up an attack on an enemy's strategic submarines would be trailing from a choke point, assuming that one is applicable. If submarines are silenced so that they do not present signatures that can be used to support trailing, perhaps a trailable signature can be imposed on a strategic submarine before it gets very far out to sea. The obvious mechanism would be an unmanned underwater vehicle (UUV), which could attach itself to the victim submarine. The leech attaching itself to the victim would carry a transponder of some kind, so that a trailing submarine could be sure of where the victim was. Viability would depend on factors such as the energy supply to the leech and the ability of the victim submarine to detect it. The latter would seem to depend on how well a strategic submarine can monitor water flow along its hull. Since water flow is a key means of detecting a submarine, it may be that covert leeching is nearly impossible.

Another issue is energy supply, since the leech would have to be able to respond to an external signal over a period of months. Right now, no reasonable source of energy seems to be available. The best candidate is probably a nuclear battery or possibly to use the flow of sea water over the leech as a source of energy.

Future Technological Advancements

At present, the most powerful driving force in technology is Moore's Law – the assertion that the unit cost of computing will halve every eighteen months or, equivalently, that unit computer power will double every eighteen months. If that exponential growth continues, then by 2035 computer power should increase by a factor of about a thousand. However, no previous technology has improved exponentially over an unlimited length of time. Typically, technologies follow S-shaped (logistic) curves, which for a time appear to be simply exponential but eventually level out. Unfortunately, the mathematics are such that it is essentially impossible to say when the levelling out becomes noticeable. In the case of computers and particularly microchips, the most obvious limitation is the cost of new generations of chips compared to the demand for higher computing speed. Every few generations of chips require new production technology. The most likely way that Moore's Law will end, then, is that at some point the profit associated with significantly faster chips will cease to make the required heavy investment in new production facilities worthwhile.

Quantum computing is often cited as the way in which Moore's Law can continue beyond what silicon can support. It seems unlikely that quantum computers will ever appear in large quantities. The few that do appear may revolutionise communication by making encryption nearly worthless.

A few rudimentary quantum computers currently exist. The promise, if it actually exists, is that a few much more powerful quantum computers might become available over a decade or two from now. They would be extremely expensive, both to build and to maintain. Unless some form of high-temperature superconductivity appears, these computers are likely to be rare and impractical for anyone but a government or a huge corporation. Code-breaking would be one of the few functions that would justify their cost.

Cryptology as an ASW Sensor

Successful code-breaking can reveal where a strategic submarine is and where it is to go, to the point where interception or trailing becomes far more feasible. Looking ahead to a world of much more powerful computers, it seems vital to take the likely impact of signals intelligence into account. There is always a race between code-making and code-breaking, and, at present, it seems that code-making is winning.

More powerful computers promise to implement more and more complex keys, which can of course be changed frequently. It is not clear that quantum computing will make encryption impossible, but it does seem that – if it materialises as predicted – it can make it far more difficult and can probably defeat current commercial encryption systems.

It may still be possible to use a physical channel that would make eavesdropping difficult. That might be the case, for example, with a focused satellite down-link, or with a dedicated fibre-optic cable running under the earth. The main effect of really powerful decryption might be considerably increased effort to avoid interceptable links, such as nearly all forms of radio or an encrypted form of the Internet. From a communications point of view, the military world might look much more like that of, say, 1914.

If secret strategic radio communication really did become difficult or impossible, the relative advantages of different strategic forces might change dramatically to favour fixed land-based missiles enjoying land communication with control centres along physical paths difficult to intercept.

Even if coding becomes unsafe, it may still be possible to send messages covertly using some form of spread spectrum; that is, spreading the message over a very wide range of frequencies, so that an interceptor will find it difficult to recognise it as a message in the first place. Faster computers should make various forms of spread-spectrum more effective, as they can control more and more apparently random sequences of bits of signals. The higher the frequency, the broader the spectrum in which a message can hide. The issue then becomes the frequency at which signals are sent, and that depends on physical considerations, such as the transparency of the atmosphere.

Unmanned Underwater Vehicles (UUVs)

The new computing technology has made modern UUVs possible, with important applications to deep-water construction and other operations. UUVs seem to offer interesting possibilities as decoys to help large silenced submarines defeat surveillance systems. Recently the US Defense Advanced Research Projects Agency (DARPA) has developed some unmanned ASW vehicles, both surface and submerged. One is an unmanned surface ship DARPA calls the ASW Continuous Trail Unmanned Vessel or ACTUV *(Sea Hunter)* announced in 2016. It carries a short-range sonar and is capable of operating in Sea State 5 and surviving in Sea State 7.

There are very serious policy considerations as to the arming and attack capabilities of an entirely autonomous vehicle. If ACTUV is unarmed, a submarine aware that it is being trailed using an active sonar might find it easiest simply to counter-attack. Experience to date suggests that the seizure or destruction of an unmanned vehicle in a foreign or international area is generally acceptable in peacetime; unlike destruction of a manned ship, it is not regarded as an act of war.

There is a natural inclination to assume that an unmanned vehicle is inherently inexpensive; however, so much of a vehicle goes into its basic performance that the saving by making it unmanned is often quite limited.

Another DARPA unmanned vehicle is the Submarine Hold at Risk (SHARK) UUV, which would be cued by a bottom array of upward-looking sonars the agency calls Transformational Reliable Acoustic Path System (TRAPS). TRAPS is envisaged as a large persistent field of inexpensive upward-looking passive sensors connected by acoustic modems. This is not a particularly novel idea; the novelty would be in the size of the sensor field, its persistence (as compared to, say, sonobuoys) and in the use of acoustic modems to tie it together.[3] Even so, the sensor field would hardly be oceanic in extent and it is not clear how it could be deployed in a hostile area. Presumably DARPA's idea for SHARK is that the UUV would trail the submarine, constantly revealing its position, so that it could be attacked. Exactly how it would gain the necessary endurance at submarine speed is not clear.

There is also a current US Navy project for long-range UUVs, which are sometimes described as a means of patrolling off enemy ports, replacing submarines there. As with SHARK, such a UUV cannot enjoy the sustained long-range endurance of a nuclear submarine, although presumably it can achieve long underwater range by snorkelling. The UUV might be able to sound an alarm when a submarine under observation left port, but trailing would be far more difficult. In the past, the US Navy has also shown interest in a leech-like UUV that could attach itself to a submarine as it left port and attaching such devices may be the key role

[3] TRAPS and SHARK were described in a 2013 article in *Wired*. The article pointed out that DARPA had not announced solutions for the serious technical problems both presented – for example, power and endurance in the UUV. ACTUV in particular has received enormous publicity as a transformational device.

of the long-range UUV. If it worked as planned, it might have a deeply disruptive effect. The leech could embody a transponder that would both much increase the sonar signature of the target submarine and also identify it. In that case the energy issue would move from the patrolling UUV to the leech: how long could it retain sufficient power? To date there seems to have been no public discussion of a leech-like UUV.

SOSUS and a Transparent Ocean

Deep sea SOSUS arrays look out horizontally across ocean basins, their reach limited mainly by underwater geography. The barrier to expansive SOSUS systems is more economic than political. It is still unlikely that many countries have exploited it, if only because it would probably involve covert emplacement of the arrays, presumably using deep-diving submersibles or deep-diving UUVs. Much of the data processing could be done in or near the array and the ability to transmit this data back to a user would be much easier today than it was in the Cold War.

China currently operates deep acoustic arrays several hundred miles from Guam; some writers have speculated that their true role is not the claimed research, but rather to track US attack submarines operating from Guam. If that is the case, the Chinese arrays are presumably upward-looking, forming some sort of acoustic fence. The data are being fed back to China either directly by undersea cable or via satellite radio from a nearby ship monitoring the arrays.

Current submarine silencing seems to have defeated the sort of ocean-wide system the United States operated during the Cold War, but by 2039 much greater computing power might revive that capability in a different form. It is not clear from public sources to what extent China and India have benefited from Soviet silencing research, but India has been operating a leased Soviet-era attack submarine since 2011.[4]

SOSUS and Low Frequency Fixing and Ranging (LOFAR) were conceived when the only submarines in service were diesel-electric, running most of the time on relatively silent electric motors. They provided usable long-range passive signatures only when running on their diesel engines, but that was enough to give a fair idea of where they were operating. The advent of nuclear submarines in the 1950s dramatically changed the situation. Such submarines must operate their engines and associated equipment continuously. This machinery necessarily creates detectable sound. Worse, from a submarine point of view, rotating machinery works best if it rotates at a constant rate. SOSUS detected sounds by analysing their frequency content, so it worked best against anything producing sound at a fixed frequency. In the 1980s the fixed SOSUS arrays were supplemented by long Surveillance Towed Array Sensor Systems (SURTASS), which were broadly equivalent to fixed SOSUS arrays towed by special surveillance ships (T-AGOS).

In the 1980s, Soviet attempts to silence their submarine fleet resulted in them buying precision numerically controlled milling machines in Japan and Norway, which in turn allowed them to manufacture much quieter propellers. This development became public in 1985 when a furious US government attacked companies in the two Allied countries for materially reducing the performance of its long-range passive underwater sensors.

In light of these silencing efforts, SOSUS and other passive systems were becoming much less effective. The solution then and over the next few decades was to introduce active elements to the passive systems so that instead of relying on whatever sound the submarine produced, the detectors now listened for a ping off the submarine. There were various approaches. The United States was already deploying what amounted to mobile SOSUS arrays onboard T-AGOS. The new approach was to add an active element operating at very low frequency (for maximum range) – a sound source suspended under the hull. As active propagation power is limited by reverberation, range is in the hundreds rather than thousands of miles.

On the tactical level, active elements could be added to existing towed arrays. Both the Royal Navy and the US Navy became interested in inserting active elements into their passive sonobuoy systems, generally in the form of a noisemaker that would generate pings to be received by an array of passive buoys.

Acoustic signalling in the ocean is difficult due to fact that the speed of sound often varies so much with depth. Sound paths often bend, and multipath effects bedevil communication. The alternative to looking across an ocean basin, as SOSUS did, is to look upwards over a limited area exploiting the vertical or near-vertical reliable acoustic path (RAP).[5] It is reliable in the sense that it overcomes the refractive (bending) effect of layers in the ocean by looking vertically rather than horizontally. An upward-looking RAP device defines a cone or cup-shaped zone, which may be about twenty nautical miles wide near the surface.

[4] After China, India has been the chief recipient of Russian military and naval technology. According to *Flottes de Combat* 2018, p. 726, the Indian program was quite protracted, beginning with a 1976 project and assisted when the Soviets leased a Charlie-class (Project 670A) missile submarine to India in 1988–1991. There was also a design based on a shortened Yankee-class (Project 667) ballistic missile submarine. The pressurised-water reactor is derived from a land-based prototype that became operational in September 2006. The Russians may have helped with the reactor, but *Flottes* does not identify it with any Russian type. The submarine's reactor went critical on 10 August 2013, the submarine beginning sea trials on 13 December 2014; she did not enter service officially until 23 February 2016. The causes of the numerous delays are not clear. The Indians currently lease a Russian Akula-class submarine (with provision to buy it) and are negotiating a second lease. These arrangements are unique: no other country has transferred a nuclear submarine under any conditions.

[5] RAP generated considerable interest in the 1970s, when some proposed fast ASW craft were (notionally) provided with RAP sensors, which they would lower, ping, and raise. Targets detected by the ping would be reached by the sprinting craft. The problem was that the pinger had to be raised and lowered extremely quickly from a depth of hundreds of metres. Later the US Navy adopted a RAP sonobuoy, ERAPS.

A line of RAP sensors would constitute an acoustic fence. A submarine passing over the fence would register that it had passed and also where in the fence it had penetrated. Monitoring a second fence might indicate the submarine's course and speed, although the combination might find it difficult to be sure that the same body had registered on both fences. At the end of the Cold War, the United States was experimenting with a SOSUS successor called the Fixed Distributed System (FDS). There is a current US research program to develop a next-generation form of FDS called Deep Reliable Acoustic Path Exploitation System (DRAPES).

The other way to overcome silencing is to impose a signal on the submarine. Early in the Cold War the US Navy relied on simple sonobuoys to hear the raw sound of a moving submarine. Just as silencing threatened sonobuoys it also threatened big static systems such as SOSUS. The only possible solution was to insert a big pinger, the existing SOSUS arrays being used as receivers of the echoes of its pings. The US Navy deployed a pinger as the Low Frequency Adjunct (LFA) to its surveillance towed array sensor system (SURTASS). LFA is a vertical string of low-frequency sound sources. The LFA/SURTASS combination seems analogous to current fishery surveillance Ocean As Waveguide Sonars (OAWS). Like SOSUS, an OAWS looks across an ocean basin but its range is inherently shorter. Also like SOSUS, an OAWS is subject to limitation by land masses, which means that it probably cannot look effectively into a partly land-locked bastion.

In 1997, the US National Academy of Sciences summarised existing sonar technology and prospective developments.[6] It pointed out that VLF (under 100 or 200 hertz) were very promising, and that silencing at such frequencies is very difficult. Given massive computing and very large arrays, something like SOSUS coverage might be revived. It appears that really long-range acoustic detection, if it can be achieved, will be achieved by fixed sensors, which in turn have to be connected to massive computing resources ashore. Who, if anyone, can exploit future acoustics will therefore depend heavily on who has reliable access to the real estate involved.[7]

The ocean varies enormously both horizontally and vertically. Ocean currents act as walls reflecting most sonar signals. Masses of impurities, not to mention fish, have important effects on sonar scattering. Marine life produces sound that can bedevil a broadband sonar. There are current claims for long-range active sonars, either on the bottom in deep water (RAP sonars) or focused horizontally to use the ocean as a wave guide. Both approaches have been tried on a limited scale, and from time to time it is pointed out that a chain of such devices can cover a considerable area (e.g. the entire GIUK (Greenland–Iceland–United Kingdom) Gap). There is no reason, it seems, to imagine that sensors will be made in such astronomical quantities that they can detect and track everything in the broad oceans. Even if the broad oceans become transparent, the Russians and probably the Chinese can overcome long-range detection by operating their submarines inside bastions.

Non-Acoustics

Cold War ASW was based on acoustics because only acoustic energy seems to propagate through water over any great distance. However, sound propagation through water is a complex and frustrating phenomenon.

There has always been a hope that some alternative means of sensing might replace or at least supplement sound. Such non-acoustic concepts are particularly attractive for strategic ASW because they might be implemented from a fast aeroplane or a satellite that could cover wide areas very rapidly and thus contribute to a wide-area picture of underwater activity – to making the sea "transparent."

Attempts at non-acoustic submarine detection have a long but generally unsuccessful history. All of the methods described below have been analysed in unclassified literature, which suggests strongly that none of them have proven at all successful. A submerged submarine produces both surface (Kelvin) and internal wakes. Like a surface ship wake, a submarine's Kelvin wake is detectable by radar, but that becomes more and more difficult with increased depth and decreasing speed. It is very difficult to detect a submarine at a depth of more than 60 metres. There are also many oceanic phenomena other than ships and submarines that produce wakes. In addition there is a centreline turbulent wake from the propeller.

The internal wake is the wave in the water created by the submarine. In theory an internal wake can create a detectable effect at the surface but that seems not to be the case with submarines. As the submarine must push water aside, it creates a shallow Bernouilli hump and depression at the surface. They cover a considerable area and they fall off more slowly with submarine depth than the surface wake. Height depends on submarine depth – and it is quite small. For example, a submarine at a depth of 300 metres and a speed of twenty knots produces a hump rising only 0.18 centimetres above the mean ocean surface.

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[6] US National Academy of Sciences, *Technology for the US Navy and Marine Corps, 2000-2035, Becoming a 21st Century Force, Volume 7: Undersea Warfare* (Washington DC: National Academy Press, 1997).

[7] This real estate issue is the basis of Owen Cote's argument that no one but the United States can operate an oceanic-scale sensor system. There are two vital caveats. One is that anyone using long enough cable can locate arrays almost anywhere. The other is that towed systems, which already (in the oil drilling industry) may be quite long, can substitute for fixed ones. China currently operates several acoustic surveillance ships comparable in theory to the US T-AGOS fleet; it is not clear from published material whether they have low-frequency sonars like the US LFA. Most of the Chinese ships are smaller than their US counterparts. Cote argues that even if a hostile country could emplace arrays in areas under other countries' control, they would not be tolerated. That would be more the case in a future in which countries anxious to exploit their EEZs maintained surveillance over them and over contiguous continental shelves. That is not the case at present.

Submarines generally operate with positive buoyancy using their control surfaces to hold them down. Like wings on aircraft, the control surfaces shed vortices at their tips and these vortices rise to the surface. Unfortunately, the calculated speed of a vortex reaching the surface is much smaller than that of wind-driven surface currents. Their advantage for detection is that they are likely to persist. It might also be possible to use massive computing to recognise and compensate for wind-driven surface waves, perhaps measuring the modulation of those waves by surface vortices. This type of detection would be most likely to work in relatively calm shallow water, as in a littoral. There are also pancake eddies created aft of the wake.

The submarine may create a detectable thermal scar at the surface. Layers of the sea have different temperatures and the submarine herself is warmer than the sea. She therefore creates a temperature differential around herself. In theory, the heat difference causes water to rise to the surface, where its greater temperature may be detectable by infra-red. The thermal scar has been observed experimentally but it is apparently too weak to be useful for tracking.

A submarine disturbs the sea, including organisms living in it, and they react. In theory, their reactions can be detected. This bioluminescence may be detectable from above. It has long been a staple of non-acoustic investigation; however, it seems unlikely to be effective for a deeply submerged submarine, which would not produce enough surface disturbance to cause much light emission.

Another possibility is light detection and ranging (LIDAR). Blue-green light penetrates relatively deeply into the ocean. Normally, reflection off the surface would swamp anything from deeper, but a pulsed laser could be linked to a range-gated detector, which would ignore the surface reflection. This approach was used in a US system intended to detect shallow mines. It does not appear to have been particularly successful. LIDAR has, however, been used quite successfully for underwater surveys, albeit in shallow water. From time to time there are reports that submarines are being fitted with laser detectors, which would allow them to evade a laser radar. Probably the greatest drawback of a laser radar is the very small spot it creates, which makes any kind of search laborious and slow – and evadable. After the US Navy lost interest in LIDAR submarine detection it retained considerable interest in blue-green lasers for communication down to strategic submarines (the one-way path made for considerably less loss).

The submarine reactor emits neutrinos, which can be detected anywhere because they interact so weakly with matter. The problem is that the neutrinos travel in straight paths; the detector has to be on that path and it has to be huge to have any chance of detection at all.

The submarine also has an electrical signature. Beginning during World War II there has been interest in Underwater Electric Potential (UEP), which arises from the corrosion current between a propeller and a ship hull. It has both AC and DC components. UEP is a short-range phenomenon and it has been used as a mine sensor. In a narrow strait, UEP might be used in a fence detecting the passage of submarines.

Moving underwater objects apparently create other electromagnetic signatures, one being the Debye effect discovered in 1933, due to the relative movement of sodium and chlorine ions. At least in theory, the Debye effect ought to create a magnetic signature out of wake turbulence.

Twice in the past decade DARPA has announced non-acoustic projects, but they seem to have been directed more at submarines in littoral areas than in open ocean ballistic missile submarines. In evaluating these projects the reader should keep in mind that DARPA is chartered specifically to press exotic and risky technology. The first seems to have been a 2011 project called Shallow Water Agile Submarine Hunting (SWASH) for which proposals were invited. Three small contracts were awarded, all of which may have been for Debye effect wake sensors. Nothing has been heard since. DARPA generally trumpets its triumphs so the implication is probably that the project failed.

The only non-acoustic detector that is currently in service in the West is MAD. It is very reliable but also has short inherent range. Typically it is used in the final stage of an attack because it will activate when an aeroplane or helicopter is directly over a submarine. Current interest in the likelihood that non-acoustic sensors will soon make the oceans more transparent can be traced to a Chinese announcement in August 2017 of a breakthrough in MAD using a Superconducting Quantum Interference Device (SQUID) that would increase MAD sensitivity. The Chinese reportedly claimed that they could detect submarines at depths as great as 500 metres. SQUID is not a new idea but it has not been implemented because it requires extremely low temperatures in order to operate. A group at the Shanghai Institute of Microsystem and Information Technology claimed in 2017 that by using an array of SQUIDs they could overcome the noise usually associated with such devices, to give them a range of several kilometres. This presumably means random noise in the SQUID detectors but all forms of MAD must overcome external noise, most of it geomagnetic. The longer the range of detection, the larger the area on the earth that the detector sees and, consequently, the better the chance that the submarine signature will be superimposed on noise.

According to a 2017 article in the *New Scientist*, the Chinese SQUID offers a range as great as six kilometres, and with noise suppression it could do much better. To put such performance in perspective, six kilometres is about 3.3 nautical miles. A good direct-path sonar can detect a submarine at or beyond nine kilometres. The great virtue of a SQUID would be that it would equip a fast aeroplane, but in that case much of the range of the SQUID device would be taken up by the height of the aeroplane above the sea. Recently, DARPA has shown interest in biological phenomena such as bioluminescence, again apparently in the hope of detecting shallow-running submarines.[8]

It cannot be shown that over the next twenty or 30 years the ocean will not become transparent. However, given the very long ranges of current US and Russian naval ballistic missiles – 6,000 nautical miles in the case of Trident – the ocean areas in which strategic submarines can lurk are vast. Beijing is well within the range of a submarine operating in the Arctic. Yet to many the possibility of some seismic shift in submarine survivability due to non-acoustics remains attractive. There is apparently a current official Chinese government campaign promoting just that idea, beginning with the 2017 leak of the account of a breakthrough in SQUID technology and including claims of a prospective LIDAR satellite and also references to a satellite to detect small gravitational variations.

Making it Work

Nearly everything in this section has been about detecting a submarine, more or less precisely. Ultimately, the question is whether the submarine, once detected, can be destroyed. That is not a simple matter. Much depends on how precisely the submarine can be located, hence whether destroying it requires a further effort to fix its position more precisely. Much also depends on how well ASW weapons work in practice, as opposed to theory. Submarines already have defences such as decoys. Current work on anti-torpedo weapons to protect major surface ships may also produce effective submarine self-defence weapons. US aircraft carriers are currently armed with small anti-torpedo torpedoes. The larger the submarine, the smaller the cost (to its effectiveness) of effective self-defence. Self-defence is certainly a difficult problem in an underwater environment, but it is unlikely to be insurmountable.

Conclusions

On balance, it seems that strategic submarines will be less, not more, vulnerable in the future. Postulated means of detecting strategic submarines will almost certainly not include means of identification and, in a world of more powers operating such submarines, identification becomes much more important to any attacker. It would be extremely embarrassing to seek to upend the strategic balance only to find out that the attacker had hit the wrong targets. This is aside from the likelihood that growing industrial use of the sea will greatly complicate any type of detector. At least at present, the most-touted advanced form of ASW is not radical enough to justify any claim that submarines will be finding their lives much more difficult over the next two decades.

Currently, very few navies in the world are at all effective in ASW, even at close quarters. Such operations are very expensive. They require considerable training against realistic targets. Past experience, for example in World War II, suggests that peacetime attempts at such realism often fail. Moreover, an emphasis on undersea warfare of any kind detracts from investment in naval missions, which may be far more important, apart from during an all-out war, particularly in terms of presence and power projection. Usually the same ships and aircraft cannot do both these jobs and ASW very effectively. ASW is largely invisible and success is very difficult to judge in peacetime (an offensive against someone's strategic submarines would count as all-out war).

That means that even if some method of reliably tracking strategic submarines became available, exploiting it would be extremely expensive, possibly unaffordable. As noted above, there are serious practical difficulties to be overcome even if submarines can be located, for example, from space.

Moreover, as knowledge of the oceans improves, that improvement is likely to favour submarines seeking places in which they will be difficult to find and to track (which are not the same thing). That is aside from questions of weapon effectiveness. Very large strategic submarines may be able to accommodate decoy and deception devices on a much larger scale than small ones. Detailed intelligence of such devices will probably be difficult or impossible to obtain. In contrast to air weapons, undersea weapons are essentially invisible to satellites. During the Cold War, US and British submarines were apparently able to penetrate Soviet coastal waters at will, but even then could not reach inland waters such as the Caspian Sea, where many Soviet weapons and systems were tested. Without detailed knowledge of the weapons, decoying would not be effective

All of this suggests that in the future it will be far more profitable to attack elements of the strategic submarine system (such as communications and missile systems) rather than the submarine itself. These elements are the means of maintaining the submarines (the base structure), the communications system, and the missile once launched.

A full-length version of this chapter is available on the NSC website at: https://nsc.crawford.anu.edu.au/publication/15176/strategic-submarines-and-strategic-stability-looking-towards-2030s

[8] Researchers are developing new types of sensor systems that detect and record the behaviours of marine organisms and interpret them to identify and report on the presence of manned and UUVs under DARPA's Persistent Aquatic Living Sensors (PALS) program. PALS program contracts were reported in the 18 February 2019 issue of *Space Daily*. Northrop Grumman received a contract to study the acoustics of snapping shrimp and bioluminescence; the Naval Research Laboratory to integrate microbes into a sensing platform to detect and characterise biological signals from micro-organisms responding to changes in their magnetic environment; Florida Atlantic University to record and analyse noises from goliath groupers; Raytheon BBN to tag black sea bass with sensors to track the depth and acceleration behaviours of schools of fish perturbed by underwater vehicles; and the Naval Undersea Center to use a seafloor hydrophone system to monitor ambient biological sound, looking for changes that could indicate the movement of undersea craft over coral reefs. US Navy interest may well be due mainly to the problem of whether bioluminescent flashes on a submarine would create excessive interference with blue-green communication laser signals.

Chapter 19
Prospects for Game-Changers in Detection Technology

Sebastian Brixey-Williams

Anti-submarine warfare (ASW) has always been a game of hide and seek, with adversarial states looking to adopt and deploy emerging technologies in submarine stealth or detection to give them the strategic edge. The advantage has shifted back and forth, but on the whole, it has proved easier to hide a submarine than find one: the oceans are wide, deep, dark, noisy, irregular, and cluttered. Technological change can alter the balance of military power, however, and parallel technological trends facilitated by the "digital revolution" may gradually make submarine detection more reliable. Certain scientific or technical breakthroughs and investments may even prove to be "game-changers" for submarine detection, defined here as a combination of technologies that would significantly reduce or even upend a state's confidence in the assumption that its submarines can elude tracking and remain undetected most of the time, though these are by nature difficult to predict.

History cautions that there can be no jumping to conclusions, however, as truly "game-changing" ASW technologies have been awaited for decades. This was clearly expressed in Western deterrence and arms control literature in the 1970s and 1980s, which reflected fits of "transparent oceans anxiety": a persistent and partially unfalsifiable disquiet that a technological innovation could make the oceans "transparent" and undermine strategic stability by making US nuclear-powered ballistic missile submarines (SSBN) sitting ducks in a bolt-from-the-blue first strike attack.[1] Such fears were not wholly unreasonable. Recent analysis on declassified sources suggests the United States could track Soviet SSBNs on a day-by-day basis with "high confidence," by combining US signals intelligence and acoustic detection provided primarily by the sound surveillance system (SOSUS) network of seabed hydrophones, before the Soviet Navy undertook quieting efforts and protected its SSBNs better with a bastion strategy.[2] Nevertheless, the technologies available towards the end of the Cold War were insufficient to give seekers the advantage that some analysts predicted and, as Owen Cote notes, also contributed directly to the development of effective countermeasures that ensured the survivability of US SSBNs.[3] After the Cold War, the notion that submarines (above all, SSBNs) are "invisible" became politically unassailable.

Several articles and studies in recent years have revisited the survivability of SSBNs, for which "game-changers" would perhaps have the greatest consequences for international security.[4] As Norman Friedman noted earlier in the previous chapter, "strategic submarines seem to be key to strategic stability," providing what is generally believed to be the most survivable nuclear second-strike force.[5] In a 2017 article, Keir Lieber and Daryl Press argue that the world is entering an "age of unprecedented transparency" and offer a framework of five technological trends that they claim could make SSBNs vulnerable to counterforce attacks: "[the growing diversity of] sensor platforms … a widening array of signals for analysis using a growing list of techniques … [increasingly] persistent observation … steady improvement in sensor resolution … [and] the huge increase in data transmission speed."[6] In their letter of response, Ryan Snyder and Benoît Pelopidas point out that Lieber and Press provide little empirical evidence and depend heavily on a 2015 report by naval analyst Bryan Clark that discusses ASW operations against littoral submarine threats only, but their framework nevertheless identifies some of the principal technological trends relevant to strategic submarine detection that merit further investigation.[7]

This chapter marshals some of the limited evidence available in the public sphere relevant to each of these five trends, but is deliberately cautious about making such a bold and certain prediction. The technologies outlined here relate primarily to emerging ASW capabilities developed by the United States, which has higher levels of transparency about its SSBN capabilities and nuclear strategy, but it may be assumed that similar technologies will proliferate to other navies.

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[1] Sebastian Brixey-Williams, *Will the Atlantic Become Transparent?* (London: British Pugwash, 2016), 1.

[2] Austin Long and Brendan Rittenhouse Green, "Stalking the Secure Second Strike: Intelligence, Counterforce, and Nuclear Strategy," *Journal of Strategic Studies* 38, no. 1–2 (2015): 47.

[3] Owen R. Cote Jr, "Invisible Nuclear-Armed Submarines, or Transparent Oceans? Are Ballistic Missile Submarines Still the Best Deterrent for the United States?" *Bulletin of the Atomic Scientists* 75, no. 1 (2019): 30.

[4] James Clay Moltz, *Submarine and Autonomous Vessel Proliferation: Implications for Future Strategic Stability at Sea* (Monterey: Naval Postgraduate School, 2012); James R. Holmes, "Sea Changes: The Future of Nuclear Deterrence," *Bulletin of the Atomic Scientists* 72, no. 4 (2016): 228–233; Brixey-Williams, Transparent?, 2016.

[5] See Chapter Eighteen, 68.

[6] Keir Lieber and Daryl Press, "The New Era of Counterforce," *International Security* 41, no. 4 (Spring 2017): 33–34.

[7] Ryan Snyder and Benoît Pelopidas, "Letter to the Editor," *International Security* 43, no. 3 (Winter 2018/19): 190–191; Bryan Clark, *The Emerging Era in Undersea Warfare* (Washington DC: Center for Strategic and Budgetary Assessments, 2015).

Sensor Platforms

ASW traditionally relies on a limited number of costly manned platforms such as attack submarines (SSNs and SSKs), frigates, and maritime patrol aircraft fitted with a variety of sensors. Today, there is evidence of a move away from this model towards unmanned aerial vehicles (UAVs), unmanned surface vehicles (USVs), and unmanned underwater vehicles (UUVs) fitted with equivalent sensors, which are more expendable and are becoming cheaper to develop, produce, modify, and deploy at scale. Navies are indicating that this is the direction of travel; as Robert Brizzolara, a US Office of Naval Research program officer, states: "The US military has talked about the strategic importance of replacing 'king' and 'queen' pieces on the maritime chessboard with lots of 'pawns.'"[8]

A prime example is the US Navy's Medium Displacement Unmanned Surface Vessel (MDUSV), formerly designated the ASW Continuous Trail Unmanned Vessel (ACTUV).[9] The prototype launched in April 2016, *Sea Hunter*, was reported to have demonstrated autonomous SSK detection and tracking from the ocean surface from two miles away, requiring only sparse remote supervisory control for patrols of three months, using a combination of "advanced hydro-acoustics, pattern recognition and algorithms."[10] Since the range and resolution of acoustic sensors are highly variable according to oceanic conditions (such as depth, temperature, and salinity), the range may well go further in favourable conditions; a Chinese estimate puts it at eighteen kilometres.[11] Since SSKs using air-independent propulsion or running on batteries are virtually silent, MDUSVs should theoretically be capable of pursuing SSNs and SSBNs (whose nuclear reactors continuously emit noise) at greater distances, and there are reports that they will be armed.[12] Whereas the new US FFG(X) frigate costs a sizeable US$1 billion per ship, MDUSV platforms are reported to cost only US$20 million each and so could conceivably be produced at scale to autonomously or semi-autonomously seek and trail submarines.[13] Former US Deputy Secretary of Defense Robert Work has suggested as much: "these will be everywhere."[14]

Signal Processing

ASW relies on separating tiny submarine signals from background ocean noise, primarily by using active/passive acoustic sensing (sonar) and magnetic anomaly detection (MAD), and it looks likely that these will remain the most important signals in the near future. However, the range of signals may grow as sensor resolution, processing power, and machine autonomy reach the necessary thresholds to reliably separate other, "quieter" kinds of signal. As Clark notes, "while the physics behind most [non-acoustic detection] techniques has been known for decades, they have not been exploitable until very recently because computer processors were too slow to run the detailed models needed to see small changes in the environment caused by a quiet submarine." However, he adds there is now "the capability to run sophisticated oceanographic models in real time."[15]

No breakthroughs have been publicly disclosed, although an independent investigation by British Pugwash in 2016 identified light detection and ranging, or LIDAR, using blue-green lasers, anti-neutrino detection, and satellite wake detection as signal types that may merit further examination.[16] Higher processing power can also enable digital sensor fusion, whereby different kinds of signal are synthesised and analysed together, and better simulations of the baseline ocean environment, which would show up anomalies in greater contrast.

Persistent Observation

Tracking submarines across large areas of ocean remains a key challenge for ASW. Manned platforms have limited ranges, and while the SOSUS network is still in operation in parts, it is geographically bounded and requires substantial modernisation to detect today's quiet submarines. This gap has been partially filled by modern acoustic sensor arrays like the Fixed Reliable Acoustic Path, but in relative terms these cover very small areas of ocean.[17] Distributed remote sensing (DRS) networks, however, which link interoperable manned and unmanned sensor platforms

[8] "ACTUV 'Sea Hunter' Prototype Transitions to Office of Naval Research for Further Development," *DARPA*, January 30, 2018, https://www.darpa.mil/news-events/2018-01-30a.

[9] "ACTUV," *DARPA.*

[10] Rick Stella, "Ghost Ship: Stepping Aboard Sea Hunter, the Navy's Unmanned Drone Ship," *Digital Trends*, April 11, 2016, https://www.digitaltrends.com/cool-tech/darpa-officially-christens-the-actuv-in-portland/; Kris Osborn, "DARPA Advances Testing for Sub-Hunting Surface Drone," *Defense Systems*, November 17, 2017, https://defensesystems.com/articles/2016/11/17/darpa.aspx.

[11] Lyle J. Goldstein, "How China Sees the U.S. Navy's Sea Hunter Drone," *The National Interest*, January 31, 2017, https://nationalinterest.org/feature/how-china-sees-the-us-navys-sea-hunter-drone- 19264.

[12] Jamey Bergman, "Upgrade for Sea Hunter – The US Navy's 32ft Submarine-Hunting Drone Boat," *Yachting and Boating World*, January 18, 2017, https://www.ybw.com/videos/us-navy-launches-submarine-hunting-drone-boat-actuv-18247.

[13] Nick Childs, "Global Frigate Market: Getting More Complex?" *International Institute of Strategic Studies*, September 24, 2018, https://www.iiss.org/blogs/military-balance/2018/09/global-frigate-market.

[14] Amanda Macias, "The First Drone Warship Just Joined the Navy and Now Nearly Every Element of It Is Classified," *CNBC*, April 25, 2018, https://www.cnbc.com/2018/04/25/first-drone-warship-joins-us-navy-nearly-every-element-classified.html.

[15] Clark, *Undersea Warfare*, 8.

[16] Carol Naughton and Sebastian Brixey-Williams, *British Pugwash Workshop: Emerging Undersea Technologies* (London: British Pugwash, 2016), 9.

together as nodes in a larger system-of-systems, could be used to scale up persistent observation across wider areas.[18] DRS in development include the US Defense Advanced Research Projects Agency (DARPA) Distributed Agile Submarine Hunting program, which is developing "a scalable number of collaborative sensor platforms to detect and track submarines over large areas," and the Persistent Littoral Undersea Surveillance Network, which aims to create "a semi-autonomous controlled network of fixed bottom and mobile sensors, potentially mounted on intelligent [unmanned platforms]" in littoral zones.[19] Networks of this type could be greater than the sum of their parts, with nodes able to carry heterogenous sensors, cross-reference positive signals from multiple directions and domains, and move and respond to get a "better look" at signals using real-time swarming. A video of a 56-strong "shark swarm" of Chinese USVs conducting complex manoeuvres on the sea surface has demonstrated that USV swarming is already possible, and the size of swarms can be expected to grow considerably just as it has for UAVs.[20] It is easy to imagine fleets of MDUSVs being used in the same way, potentially much further apart. Some technical challenges remain, including improving underwater communication, autonomous decision-making, self-location, battery life, and scaling up to blue water, but none appear insurmountable and some of the physical limitations felt by a single vehicle can be mitigated by swarming.

Sensor Resolution

While it seems likely that the proliferation of DRS networks could decrease the importance of extending sensor range and resolution as the quantity of platforms goes up, the two principal ASW sensor types (sonar and MAD) have, or are hoped to enjoy, significant improvements in resolution on their Cold War antecedents.

Acoustic sensing in peacetime mostly relies on passive sonar, as active sonar "pings" of adversary submarines risk a hostile response and disrupt ocean fauna. Recent techniques under development at the Massachusetts Institute of Technology's Laboratory for Undersea Remote Sensing, which use particular features of the ocean as acoustic waveguides for efficient long-range propagation, offer the potential for significantly greater ranges to detect and classify submarines under certain conditions. The Passive Ocean Acoustic Waveguide Remote Sensing (POAWRS) system was able to "detect, localise and classify vocalising [marine mammals] from multiple species instantaneously" over a region of approximately 100,000 square kilometres, and detect quiet diesel-electric surface vessels "over areas spanning roughly 200 kilometres in diameter" (30,000 square kilometres).[21] The active variant OAWRS can localise man-made objects as short as ten metres over areas 100 kilometres in diameter (8,000 square kilometres) provided that the resonant frequencies scattered by the object are known.[22] Crucially, by using many frequencies transmitted at once – multi-frequency measurements – the system can distinguish fish or seafloor clutter from man-made targets.[23] POAWRS can also be mounted on unmanned vehicles and used to detect larger man-made objects like submarines, even if their signal is partially mitigated by acoustic cloaking.

Today's MAD magnetometers can detect a submarine's ferromagnetic hull at a maximum range of several hundred metres. The use of more sensitive magnetometers with a range around an order of magnitude higher, known as Superconducting Quantum Interference Devices (SQUIDs), has been limited by their oversensitivity to background noise and their need for super-cooling. However, in June 2017, an announcement by the Chinese Academy of Sciences, which was later taken down, claimed that a Chinese team had produced a "superconductive magnetic anomaly detection array," which technical experts indicated could have ASW applications and could contribute to a wider strategy to create a "Great Underwater Wall" to monitor underwater traffic in and out of the South China Sea.[24] One expert in magnets estimated that such an array could have a range of six kilometres or further.[25] If this technology can be proved to work and be mounted on unmanned platforms, it could have significant implications for shorter-range submarine detection, though these reports remain unverified in the public domain.

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[17] Cote Jr, "Invisible," 33.

[18] National Research Council of the National Academies, *Distributed Remote Sensing for Naval Undersea Warfare: Abbreviated Version* (Washington DC: The National Academies Press, 2007).

[19] "Distributed Agile Submarine Hunting (DASH) (Archived)," *DARPA*, n.d., https://www.darpa.mil/program/distributed-agile-submarine-hunting; Chris Lo, "Persistent Littoral Surveillance: Automated Coast Guards," *Naval Technology*, April 30, 2012, https://www.naval-technology.com/features/featurenavy-persistent-littoral-surveillance-auvs-uuvs/.

[20] Liu Xuanzun, "Unmanned 'Shark Swarm' to Be Used in Sea Battles, Military Patrols," *Global Times*, June 6, 2018, http://www.globaltimes.cn/content/1105736.shtml.

[21] Delin Wang et al., "Vast Assembly of Vocal Marine Mammals from Diverse Species on Fish Spawning Ground," *Nature* 531, no. 17 (March 2016): 366; Wei Huang et al., "Continental Shelf-Scale Passive Acoustic Detection and Characterisation of Diesel-Electric Ships Using a Coherent Hydrophone Array," *Remote Sensing* 9, no. 8 (July 2017): 1.

[22] Naughton and Brixey-Williams, *Technologies*, 2.

[23] Srinivasan Jagannathan et al., "Scattering from Extended Targets in Range-Dependent Fluctuating Ocean-Waveguides with Clutter from Theory and Experiments," *Journal of the Acoustical Society of America* 132, no. 2 (August 2012): 680.

[24] David Hambling, "China's Quantum Submarine Detector Could Seal South China Sea," *New Scientist*, August 22, 2017, https://www.newscientist.com/article/2144721-chinas-quantum-submarine-detector-could-seal-south-china-sea/.

[25] Ibid.

Data Transmission Speed

Most data can be transmitted "nearly real time" through air.[26] Undersea communications are more challenging, as radio waves are heavily absorbed by water. While acoustic signals can be used, this has remained an expensive technique involving significant processing power. As a workaround, the DARPA POSYDON program looks to relay data between UUVs via low-frequency acoustic messages to USVs, and from them by radio to satellites, which can make use of radio waves.[27] Meanwhile, a team at Newcastle University has developed ultra-low cost acoustic "nanomodems," which can send data via sound up to two kilometres, which could be used in short-range underwater networks.[28] Improving the "intelligence" of each node in the network so it can discriminate useful data and minimise data packets would also increase the speed of transmission.[29] Hurdles still remain, but it seems that low-cost workarounds can be found.

Conclusion

The introduction of autonomous, unmanned platforms mounted with improving and digitally fused sensors, integrated within co-operative systems, will enable wider surveillance of the ocean. One effect may be to elevate the reliability of submarine detection and, in some circumstances, these technologies could prove to be game-changers that tip the balance in the favour of ASW. Nevertheless, because the history of science and technology is littered with unforeseen obstacles and elusive breakthroughs, and because many of these technologies are classified at present, it is difficult to offer any kind of firm timeline for game-changers in ASW. According to Professor James Clay Moltz at the US Naval Postgraduate School, writing in 2012, some "emerging autonomous-tracking technologies … are likely to be widely available within the next twenty years … [raising] the prospects for successful ASW against US forces."[30] If this proves correct, in spite of the United States' world-leading stealth technologies, it would imply that nuclear-capable states in the Indo-Pacific deploying relatively noisy SSBNs might have even weaker prospects of survival by the early 2030s. This would have important implications for India's first-generation Arihant-class SSBN to Chinese detection efforts, and to China's Type 094 from US and Russian ASW forces, for example. As the technological picture becomes clearer, future work will need to continually evaluate the relative gains and losses in detection and survivability that these technologies could provide to each state, and provide tangible responses to reduce strategic nuclear risks both in the region and globally.

[26] Lieber and Press, "Counterforce," 34.

[27] Kris Osborn, "DARPA Discovers 'GPS-Like' Undersea Drone Connectivity," *Defense Systems*, February 14, 2017, https://defensesystems.com/articles/2017/02/14/darpauuv.aspx.

[28] "A Better Way to Transmit Messages Underwater," *The Economist*, May 12, 2018, https://www.economist.com/science-and-technology/2018/05/12/a-better-way-to-transmit-messages-underwater.

[29] Naughton and Brixey-Williams, *Technologies*, 6.

[30] Moltz, *Submarine*, 6.

Chapter 20
Strategic Non-Nuclear Weapons, SSBNs, and the New Search for Strategic Stability

Benjamin Zala

In recent years, scholars and analysts have tracked the increasing role of certain strategic non-nuclear weapons in the strategic postures of the nuclear-armed powers. These technologies such as ballistic missile defence, conventional precision strike missiles, anti-satellite, and anti-submarine weapons, as well as elements of cyber, artificial intelligence, and quantum technology can be used – including in combination – to compromise an adversary's nuclear capabilities, with serious implications for issues of deterrence and stability.

This chapter discusses the unique role of sea-based capabilities in this trend. This includes both the ways in which these technologies are placing increasing pressures on new nuclear states to deploy nuclear-powered ballistic missile submarines (SSBNs) in order to preserve a second-strike retaliatory capability, as well as the specific role of anti-submarine warfare (ASW) capabilities in this trend. The chapter outlines a number of unilateral and multilateral policy avenues that could be explored in order to improve strategic stability through SSBN deployments in light of these strategic non-nuclear challenges.

The Challenge to Traditional Nuclear Deterrence Relationships[1]

Like any aspect of a nuclear force structure, the decision to deploy SSBNs in the years to come will be a product of the major paradigms and concepts used to manage nuclear dangers more broadly. Recently, an emerging literature has pointed to a major change in the way that at least the major powers plan to mitigate nuclear threats to their homelands (and, to some extent, their forces abroad).[2] In essence, this shift in thinking can be summarised as involving a greater reliance on strategic non-nuclear weapons – weapons and enabling systems that can be used to compromise an adversary's nuclear forces using both kinetic and non-kinetic means, without using nuclear weapons – and a decreased commitment to mutual vulnerability as the basis of strategic stability between nuclear-armed adversaries. Rather than relying on secure second-strike capabilities to deter adversaries from attacking first, concepts such as "damage limitation" and "deterrence by denial" have found a new lease of life by advocates of thinking in terms of a "second nuclear age" in which the dangers posed by supposedly irrational leaders of "rogue states" outweigh the dangers of undermining stable deterrence between the major powers.[3]

The weakened commitment to mutual vulnerability[4] and the increased focus on strategic non-nuclear weapons has been primarily driven by the United States. From missile defence, to conventionally armed precision strike missiles (including but not limited to hypersonic missiles), Washington was the first mover across each of the weapons technologies. However, more recently, the other nuclear-armed major powers, particularly in Asia, have all begun developing their own capabilities. The United States, Russia, China, and India now all have substantial programs across each capability.

The result is that the future of deterrence and strategic stability at a global level is now in serious doubt. Traditional approaches to deterrence based on the threat of punishment now compete with policies based instead on deterrence by denial. Stability based on rational calculations under conditions of mutual vulnerability appears set to be even harder to maintain. The potential for conventional counterforce strikes makes future scenarios involving use-it-or-lose-it logic more likely for states that face adversaries armed with more sophisticated capabilities. The contradictions and ambiguity of "tailored" deterrence in a world of strategic non-nuclear weapons are perhaps best captured by the US 2019 *Missile Defense Review*. This document both names Russia and China as being part of the "threat environment" that US missile defence is aimed at defending against.[5] Yet the same document also claims that the United States continues to rely on deterrence

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[1] This section draws heavily on collaborative work on strategic non-nuclear weapons and nuclear stability with Andrew Futter. For recent work that elaborates on these ideas, see Andrew Futter and Benjamin Zala, "Emerging Non-Nuclear Technology and the Future of the Global Nuclear Order," in *Nuclear Disarmament: A Critical Assessment*, ed. Bård Nikolas Vik Steen and Olav Njølstad (Abingdon and New York: Routledge, 2019), 207–224.

[2] See Futter and Zala, "Emerging Non-Nuclear Technology"; Kier A. Lieber and Daryl G. Press, "The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence," *International Security* 41, no. 4 (2017): 9–49; Nina Tannenwald and James M. Acton, *Meeting the Challenges of the New Nuclear Age: Emerging Risks and Declining Norms in the Age of Technological Innovation and Changing Nuclear Doctrines* (Cambridge, MA: American Academy of Arts & Sciences); Charles L. Glaser and Steve Fetter, "Should the United States Reject MAD? Damage Limitation and U.S. Nuclear Strategy toward China," *International Security* 41, no. 1, (2016): 49–98; James Acton, "Russia and Strategic Conventional Weapons: Concerns and Response," *Nonproliferation Review* 22, no. 2 (2015): 141–154; Andrew Futter and Benjamin Zala, "Advanced U.S. Conventional Weapons and Nuclear Disarmament: Why the Obama Plan Won't Work," *Nonproliferation Review* 20, no. 1 (2013): 107–122.

[3] For prominent examples, see Matthew Kroenig, *The Logic of American Nuclear Strategy: Why Strategic Superiority Matters* (New York: Oxford University Press, 2018); Brad Roberts, *The Case for U.S. Nuclear Weapons in the 21st Century*, (Stanford: Stanford University Press, 2016); Paul Bracken, *The Second Nuclear Age: Strategy, Danger and the New Power Politics* (New York: Times Books, 2012).

to address Russian and Chinese missile threats, while defences are instead reserved for addressing threats from "rogue states."[6] This change in the way both analysts and policy makers think about deterrence – from the cornerstone of strategic stability based on mutual nuclear vulnerability to a more malleable concept involving both nuclear and non-nuclear capabilities and applied in some circumstances but not others – has led a number of commentators to warn of the dangers of the concept being cast aside without any comparable strategy to replace it.[7]

The strategic effect of strategic non-nuclear weapons is in the prospect of their use in combination. For example, the ability to compromise an adversary's SSBNs through the deployment of new ASW techniques is of limited utility if that adversary can rely on land-based missiles to provide a secure second-strike capability. Similarly, even today's most sophisticated missile defence systems are unable to reliably defend against a large-scale attack. However, a state that possesses sophisticated anti-satellite, cyber, precision strike, and ASW capabilities that can be employed for a counterforce first strike, backed by a large and well-integrated missile defence system to soak up a small retaliatory strike, would be a difficult adversary to deter during a crisis. This is the nightmare scenario that all nuclear-armed states now must contend with – especially those with a small and consolidated force structure.

The combinational logic of strategic non-nuclear weapons creates many of the problems associated with the use of deterrent threats in one domain that are aimed at achieving goals in another, what is referred to as "cross-domain deterrence."[8] The single most important element for a deterrence strategy is the ability to send clear signals in order to maximise the chances of having that signal read as intended.[9] Attempting to deter across different domains raises the complexity of the environment in which signals are sent and received. Balancing deterrence and stability – that which achieves the deterrer's objective without so threatening its target as to create the kind of classic security dilemma dynamic that ends in inadvertent escalation and a heightened possibility of deterrence failure – has always been a notoriously difficult task.[10] Improvements in strategic non-nuclear weapons technology and the associated political abandonment of deterrence based on mutual vulnerability has made this task more complex than it has been since the beginning of the nuclear age.

The Undersea Component: More SSBNs with Less Reliability

The current challenge to traditional nuclear deterrence relationships has a dual but paradoxical effect on the incentives to deploy sea-based nuclear weapons. On the one hand, advances in missile defence, anti-satellite weapons, and conventional precision-strike missiles are likely to increase nuclear weapon states' reliance on SSBNs. In general, as missile silos (and even, over time, mobile land-based missiles), air fields, satellites, and command, control, and communications (C3) stations become more vulnerable to counterforce attacks,[11] the incentives to diversify a state's nuclear force structure increase. In particular, SSBNs still remain the most secure form of second-strike capability, meaning that the further spread of strategic non-nuclear weapons is likely to result in ever more nuclear weapons being deployed at sea.

[4] The commitment to mutual vulnerability, particularly in the United States, was only ever partial (i.e. the commitment was stronger in political circles than it was in the military). It was also always a reluctant commitment. It did, however, exist. Stable deterrence between the United States and the Soviet Union was an explicit policy goal for decades, and Cold War deterrence theory was based on the assumption that the one and only path to stability was the maintenance of mutual vulnerability (often captured by the phrase "mutually assured destruction"). Perhaps the clearest evidence of the reluctant acceptance of mutual vulnerability by US decision-makers during the Cold War was the signing of the Anti-Ballistic Missile Treaty with the Soviet Union in 1972.

[5] Department of Defense, *2019 Missile Defense Review*, (Washington DC: Office of the Secretary of Defense), 6.

[6] Ibid., ix.

[7] See, for example, Andrew F. Krepinevich Jr, "The Eroding Balance of Terror: The Decline of Deterrence," *Foreign Affairs* 98, no. 1 (2019), 62–74; Benjamin Zala, "How the Next Nuclear Arms Race will be Different from the Last One," *Bulletin of the Atomic Scientists* 75, no. 1, (2019): 36–43; Lieber and Press, "The New Era of Counterforce."

[8] Erik Gartzke and Jon R. Lindsay, eds., *Cross-Domain Deterrence: Strategy in an Era of Complexity* (New York: Oxford University Press, 2019); King Mallory, "New Challenges in Cross-Domain Deterrence," *Perspectives*, PE-259-OSD (Santa Monica, CA: RAND Corporation, 2018).

[9] Thomas C. Schelling, "Signals & Feedback in the Arms Dialogue," *Bulletin of the Atomic Scientists* 21, no. 1, (1965): 5–10; Thomas C. Schelling, *Arms and Influence* (New Haven and London: Yale University Press, 1966), 141–151; Barry Nalebuff, "Rational Deterrence in an Imperfect World," *World Politics* 43, no. 3, (1991): 313–335.

[10] Barry R. Posen, *Inadvertent Escalation: Conventional War and Nuclear Risks* (Ithaca and London: Cornell University Press, 1991).

[11] Lieber and Press, "The New Era of Counterforce"; James M. Acton, "Escalation through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risks of an Inadvertent Nuclear War," *International Security* 43, no. 1 (2018): 56–99.

On the other hand, one of the key technologies that falls under the banner of strategic non-nuclear weapons are ASW capabilities themselves, and much analysis now is focusing on whether advances in this area may in fact undermine the perceived invulnerability of SSBNs.[12] Among other things, the threats to SSBNs from new forms of both kinetic and non-kinetic ASW capabilities include (but are not limited to) improvements in sensing, tracking, and signals processing; the potential for using swarm formations of unmanned aerial, underwater, and surface vehicles for persistent ASW missions; and the threat of cyber-attack against SSBNs themselves (e.g. malware introduced during construction, upgrades, or maintenance) as well as the C3 capabilities upon which they rely.[13]

It is important to note that growing concerns over the effects of new ASW capabilities on strategic stability are, at least in part, based on projections about the future. Little serious analysis or commentary predicts that the oceans are going to become effectively transparent overnight. However, advances in sensing and signal processing in particular make the prospect of the oceans being significantly more transparent than they are today a serious possibility.[14] And when it comes to nuclear force structure planning, serious possibilities are enough to keep decision-makers up at night.[15]

Given that the established nuclear powers are engaged in major nuclear modernisation worth many billions of dollars and spread out over decades-long timescales, plausible future projections are not easily dismissed. For those in charge of the development of new SSBN fleets, as well as those in charge of balancing an overall nuclear budget of which the sea-based component is only one part, the recent warnings of scholars such as Daniel Moran are impossible to ignore: "The sensitivity of astronomical radio telescopes has improved ten-thousand-fold in the last fifty years. There is no reason to think the ocean's depths will remain impenetrable forever."[16]

One logical response by states with SSBNs concerned about the seas becoming more transparent is simply to deploy more vessels. For SSBNs to play their traditional role as the ultimate chance at nuclear retaliation, the prospect of a single submarine being able to launch its missiles unhindered is enough to place doubt in the mind of a would-be attacker contemplating a first strike. Therefore, the more vessels at sea at any one time, the greater the chance of having at least one vessel survive a first strike involving ASW weapons. However, for any of the six states that currently deploy SSBNs, or any others who may do so in the future, this choice comes with what will often be a prohibitively

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[12] Kenneth Payne, "Artificial Intelligence: A Revolution in Strategic Affairs?," *Survival* 60, no. 5 (2018): 9; Jürgen Altmann and Frank Sauer, "Autonomous Weapon Systems and Strategic Stability," *Survival* 59, no. 5, (2017): 131; Stanislav Abaimov and Paul Ingram, *Hacking UK Trident: A Growing Threat* (London: BASIC, June 2017), https://www.basicint.org/wpcontent/uploads/2018/06/HACKING_UK_TRIDENT.pdf; James R. Holmes, "Sea Changes: The Future of Nuclear Deterrence," *Bulletin of the Atomic Scientists* 72, no. 4, (2016): 228–233; David Hambling, "The Inescapable Net: Unmanned Systems in Anti-Submarine Warfare," BASIC Parliamentary Briefings on Trident Renewal Briefing no. 1, (March 2016) http://www.basicint.org/publications/david-hambling/2016/inescapable-net-unmanned-systems-anti-submarine-warfare; Bryan Clark, "The Emerging Era in Undersea Warfare," Center for Strategic and Budgetary Assessments, Washington DC, January 2015, https://csbaonline.org/research/publications/undersea-warfare. Austin Long and Brendan Green argue that even historically SSBNs have probably never been quite as secure as many assume, and that due to a combination of acoustic detection, signals intelligence, and overhead imagery the US Navy "felt confident in their ability to target a substantial portion of the Soviet SSBN force" by the 1980s. Austin Long and Brendan Rittenhouse Green, "Stalking the Secure Second Strike: Intelligence, Counterforce, and Nuclear Strategy," *Journal of Strategic Studies* 38, no. 1–2, (2015): 51.

[13] On the latter, see Aleem Datoo and Paul Ingram, "A Primer on Trident's Cyber Vulnerabilities," BASIC Parliamentary Briefings on Trident Renewal Briefing no. 2, (March 2016), http://www.basicint.org/wp-content/uploads/2018/06/BASIC_cyber_vuln_mar2016.pdf; Andrew Futter, *Hacking the Bomb: Cyber Threats and Nuclear Weapons* (Washington DC: Georgetown University Press, 2018).

[14] "Some current declassified research and development programs that are of interest in this regard include the US DARPA project known as the Distributed Agile Submarine Hunting (DASH), focused on advanced standoff sensing from unmanned systems; and the Shanghai Institute of Microsystem and Information Technology's project to develop a magnetometer based on a superconducting quantum interference device (SQUID).

[15] This is evident in the fact that even officials from the state with the most advanced capabilities in both SSBNs and ASW technology (the United States) publicly express concern about their ability to maintain such advantages. As Admiral Philip S. Davidson, the Commander of US Indo-Pacific Command, recently testified to the US House Armed Services Committee: "The United States must maintain its advantage in undersea warfare—an asymmetric advantage that our adversaries are focused on eroding. There are four-hundred foreign submarines in the world, of which roughly 75% reside in the Indo-Pacific region. One hundred and sixty of these submarines belong to China, Russia, and North Korea. While these three countries increase their capacity, the United States retires attack submarines (SSNs) faster than they are replaced. USINDOPACOM must maintain its asymmetric advantage in undersea warfare capability, which includes not just attack submarines, but also munitions and other antisubmarine warfare systems such as the P-8 Poseidon and ship-borne anti-submarine systems. Potential adversary submarine activity has tripled from 2008 levels, which requires at least a corresponding increase on the part of the United States to maintain superiority." Admiral Philip S. Davidson, Statement before the House Committee on Armed Services, Washington DC, March 27, 2019, https://armedservices.house.gov/_cache/files/6/2/62797eeb-3fa2-425d-8e20-2d6d72a83862/E91F41F85A10CAAE700D353741B29979.cdrusindopacom-written-testimony---hasc---27-mar-2019.pdf.

[16] Daniel Moran, "Conclusion: Maritime Strategy and the Next World Order" in *Maritime Strategy and Global Order: Markets, Resources, Security*, ed. Daniel Moran and James A. Russell, (Washington DC: Georgetown University Press, 2016), 311.

large price tag. For example, the estimated cost per vessel of the Russian Borei-class submarine is US$713 million,[17] the Chinese Jin-class submarine is US$750 million[18] and the new US Columbia-class submarine (set to replace the Ohio-class vessels) is US$6.5 billion.[19] These costs are only for the initial build of the vessel and do not reflect the extra sums of money required for upgrades, maintenance, or missiles.

In the short term, the effects of advances in ASW alongside the deployment of other strategic non-nuclear weapons capabilities will be felt in a highly uneven manner. For example, throughout the 2020s, ASW capabilities are unlikely to pose serious challenges to US SSBNs. Even while the Ohio-class vessels remain on patrol in advance of their replacement by the quieter Columbia-class vessels, the United States will continue to enjoy both technological and geographic advantages that make finding its SSBNs extremely difficult. Russia too is unlikely to face a significantly more difficult operating environment for its SSBN fleet in the short term as more of the quieter Borei-A (II) class vessels are put out to sea. In contrast, China's much smaller fleet of SSBNs already faces challenges in leaving port and avoiding key choke points such as the Luzon Strait or the seas surrounding the Ryukyu Islands without being detected as they transit into the Western Pacific. *See Chapter Seventeen*.

In South Asia, in the short term, the most likely result of the proliferation of strategic conventional capabilities is to encourage both India and Pakistan to further invest in nuclear-armed submarines. The key driver for India is technological developments in China, including Chinese investment in hypersonic missiles and its indigenous missile defence system. Similarly, the key driver for Pakistan is India. In particular, Indian missile defence plays directly into the hands of the Pakistani navy as it provides the perfect rationale for developing an SSBN force. As Sadia Tasleem has argued, Pakistan already "rationalizes its heavy investment in diversifying its missile capabilities as a way to neutralize an Indian missile defense system if and when one is put into place."[20] The combination of Indian missile defence with other offensive capabilities may offer New Delhi a pathway to neutralising Pakistan's land-based nuclear forces in the future.[21] The imperative for Islamabad to field more nuclear weapons under the sea as soon as possible is therefore likely to be strong.

Over the medium term, into the 2030s, these pressures are likely to increase. For example, the prospect of US–India cooperation on ASW over this time period will mean that Pakistan will likely be forced to maintain a relatively large land-based force (as threats to its limited and noisy SSBN fleet will increase). Over this time period both China and India are planning to have substantial SSBN fleets patrolling the waters of the Indo-Pacific (and possibly beyond). For both the United Kingdom and France, especially the former with its sole reliance on what will be by then the Dreadnought-class replacements to the current Vanguard SSBNs, counter-measures to mitigate the effects of unmanned vehicle swarms will be a prime concern.

By the 2040s, the effects of the widespread deployment of strategic non-nuclear weapons are likely to be such that the entire landscape of both regional and global nuclear balances is radically different than it is today. This would amount to a third nuclear age. A third nuclear age would be one in which the possession of a range of strategic non-nuclear weapons by an adversary would be as, if not more, important than their nuclear capabilities in shaping state decision-making on nuclear force structure, doctrines, and deployments, as well as their policies on strategic arms control and non-proliferation. The precise role of both SSBNs and ASW over this period is difficult to predict, as it will depend greatly on both the state of countermeasures to new ASW techniques and strategies, as well as strategic non-nuclear weapons. One factor that may mark this period out from the preceding decades is that the effects of advances in ASW technologies are likely to be far more evenly distributed across all the states that deploy

[17] Igor Rozin, "Money Shot: Russia's Top 3 Most Expensive Weapons," *Russia Beyond*, July 2, 2017, https://www.rbth.com/science-and-tech/328655-money-shot-russias-top-3. This estimate (in state-owned media) is likely to be a conservative one. Others put this figure as high as US$890 million per vessel. See Thomas Gibbons-Neff, "Russia Readies Two of Its Most Advanced Submarines for Launch in 2017," *Washington Post*, December 29, 2016, https://www.washingtonpost.com/news/checkpoint/wp/2016/12/29/russia-readies-two-of-its-most-advanced-submarines-for-launch-in-2017/?utm_term=.0937f1c82eb1.

[18] Bob Nugent, "Naval Acquisition Trends in Asia," in *Naval Modernisation in South-East Asia: Nature, Causes and Consequences*, ed. Geoffrey Till and Jane Chan (London and New York: Routledge, 2014), 23. Nugent's estimate is based on the assumption that China is able to build submarines at a lower acquisition cost than comparable vessels in Europe or the United States.

[19] US Congressional Research Service, *Navy Columbia (SSBN-826) Class Ballistic Missile Submarine Program: Background and Issues for Congress* (Washington DC, 2019), https://fas.org/sgp/crs/weapons/R41129.pdf. It should be noted that the much higher cost of the US SSBN as compared with the Russian and Chinese vessels reflects the Columbia-class vessel's anticipated relative invulnerability to ASW methods, which means that the US is the least likely of the three to face pressures to deploy more than the current planned twelve vessels in the short to medium term. This is, however, premised on no major technological breakthroughs in ASW capabilities on the part of US adversaries over this time scale.

[20] Sadia Tasleem, "Regional Drivers of Pakistan's Nuclear Outlook," in *Perspectives on the Evolving Nuclear Order*, ed. Toby Dalton, Togzhan Kassenova and Lauryn Williams (Washington DC: Carnegie Endowment for International Peace, 2016), 103.

[21] Frank O'Donnell and Debalina Ghoshal, "Managing Indian Deterrence: Pressures on Credible Minimum Deterrence and Nuclear Policy Options," *Nonproliferation Review*, online first, February 2019, https://www.tandfonline.com/doi/full/10.1080/10736700.2019.1565187; Christopher Clary and Vipin Narang, "India's Counterforce Temptations: Strategic Dilemmas, Doctrine, and Capabilities," *International Security* 43, no. 3, (2018/19): 7–52.

SSBNs – the United States' relative invulnerability in particular may well not hold over this length of time.[22] As a recent Center for Strategic and Budgetary Assessment report has pointed out, "emerging technologies present a serious challenge in that they may empower development of rival undersea forces and erode the stealth of US submarines."[23] Other states such as China and India are currently positioning themselves to take advantage of developments in areas such as computer processing power and power storage that will underpin breakthroughs in sensing, communications and long-range unmanned underwater vehicles (UUVs) used for ASW missions.[24]

Rebuilding Stability in Undersea Nuclear Deployments

As the development of strategic non-nuclear weapons and the associated shift in thinking about stable deterrence based on mutual vulnerability continues, policy makers and analysts will need to give serious attention to what might become the new determinants of stability in the global nuclear order. As outlined above, SSBNs will play a unique role as the most secure form of second-strike capability. However, this status is being undermined by the strategic non-nuclear weapons trend as it relates to ASW capabilities. In the years ahead, attention should be given to both unilateral and multilateral efforts that might be made with the aim of preserving strategic stability through, and in relation to, undersea nuclear deployments. The discussion will now turn towards a number of early ideas worthy of consideration.

First, we should expect the development of countermeasures to play an important role in mitigating the destabilising effects of disruptive technological breakthroughs in the ASW arena. The role of countermeasures is already evident in other domains. For example, as a reaction to US missile defence, both China and Russia today are placing increasing emphasis on the development of hypersonic missiles due to the fact that such missiles, resulting from their combination of speed and manoeuvrability, are extraordinarily difficult to defend against.

ASW countermeasures need not rely on kinetic effects. Both the development of ever quieter SSBNs with smaller acoustic signatures, and the development of new techniques of deception (e.g. UUVs designed to produce tonals that match that of SSBNs that are thought to have been identified by an adversary) can increase a state's confidence that at least some of its SSBNs can remain undetected and uncompromised in a crisis. As Geoffrey Till has put it, deception has long been an important component of all naval strategy "since it allows the deceiver to make the best use of his resources and encourages the victim into strategic error."[25] In this sense, we should expect developments in ASW aimed at compromising SSBNs and developments in countermeasures aimed at mitigating these breakthroughs to take on a tit-for-tat dynamic in the years to come. This is not a new phenomenon, but as rapid increases in things such as sensing techniques and data processing allow for technological leaps in ASW capabilities, countermeasures should be expected to take on a new and much greater importance.

Defensive measures for SSBNs aimed at increasing their reliability in the face of ASW technological breakthroughs are unlikely to solely rely on new technologies themselves. For example, James Holmes has suggested that both bastion strategies for SSBNs (vessels constricted to a much smaller, actively defended area for patrols), or SSBNs being accompanied by convoys of "skirmisher"-type defensive units (adopting a similar principle to aircraft carrier battle groups), may be necessary to regain confidence in the survivability of SSBNs.[26]

Most importantly, stability needs to be seen as the most important goal that will require a degree of what has been termed "security dilemma sensibility" among the nuclear-armed powers. Leaders that develop security dilemma sensibility display an openness to the idea that "an adversary is acting out of fear and insecurity and not aggressive intent, as well as a recognition that one's own actions have contributed to that fear."[27] For example, while the Commander of US Strategic Command, General John Hyten, has spoken publicly about his concerns over China's pursuit of quantum computing and communications capabilities,[28] it is precisely such capabilities that may come to restore Chinese confidence in their ability to communicate with their SSBNs without being detected despite advances in US ASW capabilities.[29]

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[22] For this argument in relation to the Russian navy in particular, see Holmes, "Sea Changes," 230.

[23] Clark, "The Emerging Era in Undersea Warfare," 18.

[24] Tomoko Ashizuka, "Pentagon seeks to Triple AI Warfare Budget to meet China's Rise," *Nikkei Asian Review*, October 4, 2019, https://asia.nikkei.com/Business/Aerospace-Defense/Pentagon-seeks-to-triple-AI-warfare-budget-to-meet-China-s-rise. On the United States, rising powers and technological diffusion, see Andrew B. Kennedy, *The Conflicted Superpower: America's Collaboration with China and India in Global Innovation* (New York: Columbia University Press, 2018).

[25] Geoffrey Till, *Maritime Strategy and the Nuclear Age*, 2nd edn (New York: St. Martin's Press, 1984), 179.

[26] Holmes, "Sea Changes," 231.

[27] Nicholas J. Wheeler, *Trusting Enemies: Interpersonal Relationships in International Conflict* (Oxford: Oxford University Press, 2018), 291.

[28] General John E. Hyten, Statement before the House Committee on Armed Services, Washington DC, March 28, 2019, https://armedservices.house.gov/_cache/files/5/6/56a2cdeb-3f4d-4bc7-a6de-283d9adeb020/0998EA873B99FD38A37DE299BCD297F2.hmtg-116-as29-wstate-hytenj-20190328.pdf.

[29] Raymond Wang, "Quantum Communications and Chinese SSBN Strategy," *The Diplomat,* November 4, 2017, https://thediplomat.com/2017/11/quantum-communications-and-chinese-ssbn-strategy/.

This would be a positive development in the US–Sino strategic relationship. The more confidence Beijing has in the security of its second-strike capability, the less likely it is that a crisis between the United States and China will inadvertently escalate into a situation where leaders in Beijing consider themselves as being in a use-it-or-lose-it situation.

Over the longer-term it may be possible to negotiate, and design, limited multilateral efforts aimed at restoring stability between adversaries, including in relation to sea-based nuclear deployments. Undersea nuclear deployments have traditionally been notoriously difficult to address in strategic arms control terms.[30] Controlling or limiting ASW capabilities is unlikely to prove to be easier ground in terms of developing norms of mutual restraint. However, history also suggests that confidence-building measures can play as important a role (including in relation to sea-based capabilities in particular)[31] as formal arms control measures in reducing nuclear dangers, meaning that finding avenues for dialogue, even at a low-level, should now be a top priority.

Conclusions

It is impossible to fully appreciate the impact on strategic stability of ASW without considering the wider context of the deployment of a wider suite of strategic non-nuclear weapons and the abandonment of deterrence strategies based on mutual vulnerability. These broader developments are likely to continue to encourage states to deploy more SSBNs (as counterforce threats to land-based forces increase) while simultaneously intensifying the pressures to better protect SSBN fleets that are already deployed from technological breakthroughs in the ASW domain.

Therefore, restraint in the deployment of ASW capabilities may need to become a substitute for the more traditional tools used to instil stability in nuclear-armed relationships – restraint in defensive technology (e.g. missile defence) and negotiated limits on arms. Given the current crisis in confidence in arms control agreements, a multilateral approach to limits on ASW capabilities will be exceedingly difficult to orchestrate. Rather than prematurely attempting formal arms control talks on ASW, efforts should be made to instigate both Track II and eventually Track 1.5 talks on practical confidence-building measures in this area (aimed at clarifying intentions, exchanging perspectives on new technologies, identifying areas of mutual concern, etc.). *See Chapter Four.*

Past experience demonstrates that some degree of stability can be achieved based on the (always extremely challenging) development of security dilemma sensibility between nuclear-armed rivals. There is no reason to think that the undersea element of tomorrow's nuclear-armed rivalries will be immune from such breakthroughs. Crucially, whatever specific initiatives are attempted (whether at an official level or between academics and think tank analysts), discussions around ASW, SSBNs, and strategic stability should be held with a focus on all four of the major nuclear-armed powers in the Indo-Pacific: the United States, Russia, China, and India.

[30] Desmond Ball, "Nuclear War at Sea," *International Security* 10, no. 3 (1985–1986): 3–31.

[31] Sean M. Lynn-Jones, "A Quiet Success for Arms Control: Preventing Incidents at Sea," *International Security* 9, no. 4 (Spring, 1985): 154–184.

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Support for this publication was provided by a grant from Carnegie Corporation of New York.

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