Then What?

Assessing the Military Implications of Chinese Control of Taiwan

Brendan Rittenhouse Green and Caitlin Talmadge

Taiwan is the most intractable issue in U.S.-China relations and the one that could most plausibly embroil the two great powers in a high-stakes, high-intensity war.[1] For decades, observers have debated the likelihood of U.S.-China conflict over Taiwan, assessing China's willingness to attempt reunification through force, the credibility of the U.S. commitment to Taiwan, and Taiwan's resolve in maintaining its autonomy.[2] Numerous studies have examined the cross-strait military balance—whether it might deter or enable a potential Chinese military campaign to retake Taiwan, for example, as well as whether Taiwan could effectively defend itself with or without the help of the United States.[3]

Brendan Rittenhouse Green is Associate Professor at the University of Cincinnati. Caitlin Talmadge is Associate Professor at Georgetown University.

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1. Robert D. Blackwill and Philip Zelikow, "The United States, China, and Taiwan: A Strategy to Prevent War" (N.Y.: Council on Foreign Relations, February 2021), https://www.cfr.org/report/united-states-china-and-taiwan-strategy-prevent-war; and Charles L. Glaser, "Washington Is Avoiding the Tough Questions on Taiwan and China," *Foreign Affairs*, April 28, 2021.
2. For representative examples, see Robert S. Ross, "Navigating the Taiwan Strait: Deterrence, Escalation Dominance, and U.S.-China Relations," *International Security*, Vol. 27, No. 2 (Fall 2002), pp. 48–85, http://dx.doi.org/10.1162/016228802760987824; David A. Shlapak et al., *A Question of Balance: Political Context and Military Aspects of the China-Taiwan Dispute* (Santa Monica, Calif.: RAND, 2009), https://www.rand.org/pubs/monographs/MG888.html; and Scott L. Kastner, "Is the Taiwan Strait Still a Flash Point? Rethinking the Prospects for Armed Conflict between China and Taiwan," *International Security*, Vol. 40, No. 3 (Winter 2015/16), pp. 54–92, https://doi.org/10.1162/ISEC_a_00227.
3. For a recent sample, see Stephen Biddle and Ivan Oelrich, "Future Warfare in the Western Pacific: Chinese Antiaccess/Area Denial, U.S. AirSea Battle, and Command of the Commons in East Asia," *International Security*, Vol. 41, No. 1 (Summer 2016), pp. 7–48, https://doi.org/10.1162/ISEC_a_00249; Eric Heginbotham et. al, "The U.S.-China Military Scorecard: Forces, Geography, and the Evolving Balance of Power, 1996–2017" (Santa Monica, Calif.: RAND, 2015); Michael Beckley, "The Emerging Military Balance in East Asia: How China's Neighbors Can Check Chinese Naval Expansion," *International Security*, Vol. 42, No. 2 (Fall 2017), pp. 78–119, https://doi.org/10.1162/ISEC_a_00294; James Steinberg and Michael E. O'Hanlon, *Strategic Reassurance*

International Security, Vol. 47, No. 1 (Summer 2022), pp. 7–45, https://doi.org/10.1162/isec_a_00437

Compared with this robust literature on the military balance, however, discussion over Taiwan's potential military value, and its implications for U.S. grand strategy, remains surprisingly underdeveloped and vague. Many advocates of maintaining or strengthening the U.S. commitment to Taiwan focus on the island's political importance, emphasizing that the U.S. commitment is vital to maintaining the credibility of other U.S. alliances and to democracy more broadly.[4] Failing to defend Taiwan would be disastrous, in this view, but largely because of the broader diplomatic implications, not because of any direct effect on the regional military balance.[5] Meanwhile, those who advocate the opposite position—ending or lessening the U.S. commitment to Taiwan—also frame the problem in largely political terms, arguing that the United States could sever its support of the island without significant military consequences as part of a bilateral grand bargain.[6] In contrast, the idea that control of the island itself could affect the military balance has not yet received a systematic, rigorous assessment, though a growing number of analysts mention it.[7]

Would Chinese control of Taiwan merely amount to a nationalist credential for the Chinese Communist Party (CCP), or could the territory changing hands

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and Resolve: U.S.-China Relations in the Twenty-First Century (Princeton, N.J.: Princeton University Press, 2014), pp. 120–149, http://dx.doi.org/10.1515/9781400873715; Ian Easton, "Why the US Defends Taiwan," *Taipei Times*, September 16, 2019, https://www.taipeitimes.com/News/editorials/archives/2019/09/16/2003722357; and Jim Thomas, Iskander Rehman, and John Stillion, "Hard ROC 2.0: Taiwan and Deterrence through Protraction" (Washington, D.C.: Center for Strategic and Budgetary Assessments, 2014), https://csbaonline.org/research/publications/hard-roc-2-0-taiwan-and-deterrence-through-protraction.

4. For example, Nancy Bernkopf Tucker and Bonnie Glaser, "Should the United States Abandon Taiwan?" *Washington Quarterly*, Vol. 34, No. 4 (2011), pp. 32–33, https://doi.org/10.1080/0163660X.2011.609128; Richard C. Bush, "The United States Security Partnership with Taiwan," *Asian Alliances Working Paper Series*, No. 7 (Washington, D.C.: Brookings Institution Press, July 2016); and Shelley Rigger, *Why Taiwan Matters: Small Island, Global Powerhouse* (Lanham, Md.: Rowman and Littlefield, 2011), pp. 187–198.

5. Tsai Ing-wen, "Taiwan and the Fight for Democracy," *Foreign Affairs*, Vol. 100, No. 6 (November/December 2021).

6. See Charles L. Glaser, "A U.S.-China Grand Bargain? The Hard Choice between Military Competition and Accommodation," *International Security*, Vol. 39, No. 4 (Spring 2015), pp. 49–90, https://doi.org/10.1162/ISEC_a_00199.

7. See, for example, Richard Haass and David Sacks, "American Support for Taiwan Must Be Unambiguous," *Foreign Affairs*, September 2, 2020, https://www.foreignaffairs.com/articles/united-states/american-support-taiwan-must-be-unambiguous; Hal Brands, "Does the U.S. Need to Fear That China Might Invade Taiwan?" *Bloomberg*, August 20, 2020, https://www.bloomberg.com/opinion/articles/2020-08-20/does-the-u-s-need-to-fear-that-china-might-invade-taiwan; Elbridge Colby and Jim Mitre, "Why the Pentagon Should Focus on Taiwan," *War on the Rocks*, October 7, 2020, http://warontherocks.com/2020/10/why-the-pentagon-should-focus-on-taiwan/; and Gerald C. Brown, "The Geostrategic Criticality of Taiwan," *9DASHLINE*, February 5, 2021, https://www.9dashline.com/article/the-geostrategic-criticality-of-taiwan.

significantly alter the broader military balance in the region? Does a friendly Taiwan endow the United States with military advantages that it would lose if the regime in Taiwan were aligned with China? Would China then be in a better position to pursue other military missions in the region? Or, contrary to General Douglas MacArthur's famous characterization of the island as "an unsinkable aircraft carrier and submarine tender," is control of Taiwan largely irrelevant to the broader military balance?[8]

The answers to these questions are central to the grand strategic debate. The more militarily valuable the island is, the more difficult it would be for the United States to strike a grand bargain or otherwise distance itself from Taiwan compared to present U.S. policy.[9] It is notoriously difficult for states to reach even tacit deals when the results may affect future bargaining strength, as is often the case with strategic military territory.[10] Moreover, the costs of accommodation over a militarily valuable Taiwan will rise rapidly if Chinese regional ambitions extend beyond reunification, making such a policy riskier for U.S. policymakers. Conversely, the less valuable Taiwan is in military terms, the more challenging present U.S. grand strategy will become relative to alternatives. The United States will have a harder time convincing China, Taiwan, or its Asian allies that its commitments are credible if it is widely believed that the United States sees little military interest in the island. A clear-eyed assessment of the island's potential military importance is thus warranted—even though it is just one input into U.S. decision-making, and ultimately the United States' policy toward Taiwan should and will take into account a broader range of considerations.

This article develops a framework for assessing the military value of Taiwan, which we use to show why Chinese control of Taiwan would likely improve the military balance in China's favor. Although there are multiple mechanisms by which Chinese control of Taiwan could affect the post-reunification military balance, we highlight the changes that would occur if China were to deploy assets on the island for undersea warfare and ocean surveillance. We focus, in particular, on submarines and hydrophone arrays,

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8. Memorandum of Conversation, by the Ambassador at Large (Jessup), June 25, 1950, *Foreign Relations of the United States (FRUS) 1950*, Vol. 7: *Korea* (Washington, D.C.: Government Printing Office, 1976), doc. 86, https://history.state.gov/historicaldocuments/frus1950v07/d86.
9. Current U.S. policy is deliberately ambiguous about whether the United States would defend Taiwan if it came under military attack by China. The United States does not have a defense treaty with Taiwan, and it has no legal obligation to respond.
10. James D. Fearon, "Rationalist Explanations for War," *International Organization*, Vol. 49, No. 3 (Summer 1995), pp. 408–409, https://doi.org/10.1017/S0020818300033324.

along with the associated coastal and air defense assets necessary to assist with their missions. Such deployments would impede the future ability of the United States to operate naval and air forces in the Philippine Sea. Although this is not the only theater in which the United States and China might engage in post-reunification competition and conflict, it will remain a vital one for U.S. treaty allies because of its relevance to defending them from coercion or attack.

Specifically, we find that basing existing Chinese submarine warfare assets in Taiwan's eastern deep-water ports would render U.S. surface forces more vulnerable to attack during a crisis, reduce the attrition rate of Chinese submarines during a war, and likely increase the number of attack opportunities against U.S. surface combatants. We also find that placing hydrophone arrays off Taiwan's east coast would forge a critical missing link in China's kill chain for long-range attacks against U.S. surface forces. The resulting Chinese targeting capabilities might then force the United States either to escalate to antisatellite warfare that it can presently avoid, or to channel its surface naval operations into a much smaller part of the Philippine Sea. Furthermore, over the longer term, if China develops a large fleet of truly quiet nuclear attack submarines (SSNs) and ballistic missile submarines (SSBNs), basing them on Taiwan would enable China to threaten the sea lanes of communication (SLOCs) and to strengthen its sea-based nuclear deterrent in ways that it is unlikely to otherwise be able to do.

Our article proceeds in six parts. First, we review the debate on Taiwan, noting the paucity of rigorous analysis regarding the island's military significance. Second, we describe our assumptions and methodology, developing a framework for analyzing the military value of Taiwan. The framework asks how Chinese control of Taiwan would affect the ability of U.S. naval forces to operate in the Philippine Sea given China's present day force structure and technology. The third and fourth sections use this framework to analyze post-reunification Chinese deployments of submarines and hydrophones on Taiwan. The fifth section then relaxes the assumption that China has only its current force structure and technology, assessing the longer-term military implications of control of the island if China were to develop a robust force of truly quiet nuclear submarines that might threaten northeast Asian SLOCs and alter the nuclear balance. The sixth section concludes with a discussion of the implications for U.S. grand strategy, showing that an understanding of the military value of the island is an important input to U.S. decision-making even though it does not by itself generate a definitive answer as to what U.S. policy toward Taiwan should be.

Strait Talk: Geostrategy in the Debate over Taiwan

Mainstream discussion of Taiwan's potential military importance is surprisingly rare. Advocates of strengthening the ambiguous U.S. commitment to Taiwan usually frame their arguments in nonmilitary terms, emphasizing Taiwan's status as a democracy and a trading partner.[11] They also cite the negative impact that abandoning Taiwan would have on the credibility of other U.S. commitments.[12]

To the extent that scholars and policymakers discuss the military aspects of Taiwan, the cross-strait balance is usually the focus. For example, analysts have extensively studied whether China can effectively coerce or invade Taiwan, how Taiwan would and should defend itself, and which weapons the United States should or should not sell to Taiwan.[13] But the follow-on question of what happens to the military balance after China actually gains control of Taiwan has received much less attention. Instead, the literature has addressed Taiwan's military value in three principal ways: in brief remarks suggesting Taiwan's military importance, without much elaboration; as a window into China's grand strategy and intentions; and from a historical perspective.

First, some analysts do affirm Taiwan's military value, but only in passing. Michael Beckley, for example, argues that "in Taiwanese hands, the island is a defensive barrier against Chinese expansionism; in Chinese hands, Taiwan could become a launching pad for Chinese aggression."[14] Aaron Friedberg, who is considerably less sanguine about U.S. fortunes versus China than Beckley, nevertheless makes a similar observation that "if the mainland ever succeeds in absorbing Taiwan and can base sensors, aircraft, missiles, and sub-

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11. Haass and Sacks, "American Support for Taiwan Must Be Unambiguous"; Bonnie S. Glaser et al., "Dire Straits," *Foreign Affairs*, September 24, 2020, https://www.foreignaffairs.com/articles/united-states/2020-09-24/dire-straits; and Gary J. Schmitt and Michael Mazza, "The End of 'Strategic Ambiguity' regarding Taiwan," *Dispatch*, American Enterprise Institute, September 17, 2020, https://www.aei.org/op-eds/the-end-of-strategic-ambiguity-regarding-taiwan/.
12. In addition to the previous note, see Hearing on Why Taiwan Matters, before the House of Representatives Foreign Affairs Committee, 112th Cong., 1st sess., June 16, 2011 (testimony from Ileana Ros-Lehtinen, June Teufel Dreyer, Nancy Bernkopf Tucker, Rupert Hammond-Chambers, and Randall Schriver), Serial No. 112-42, https://www.govinfo.gov/content/pkg/CHRG-112hhrg66902/html/CHRG-112hhrg66902.htm; and Easton, "Why the US Defends Taiwan."
13. Ross, "Navigating the Taiwan Strait"; Shlapak et al., *A Question of Balance*; Kastner, "Is the Taiwan Strait Still a Flash Point?"; Biddle and Oelrich, "Future Warfare in the Western Pacific"; Heginbotham et. al, "The U.S.-China Military Scorecard"; Beckley, "The Emerging Military Balance in East Asia"; Steinberg and O'Hanlon, *Strategic Reassurance and Resolve*; Easton, "Why the US Defends Taiwan"; and Thomas, Rehman, and Stillion, "Hard ROC 2.0."
14. Beckley, "The Emerging Military Balance in East Asia," p. 83.

marines there, it will be able to extend its reach even farther to the east and north. With the island in its possession, China would be well positioned to impose a blockade of its own on Japan or South Korea."[15] The former Assistant Secretary of Defense for Indo-Pacific Security Affairs Randall Schriver testified in 2011 that "mainland control of Taiwan would . . . significantly extend the reach of the [People's Liberation Army] PLA in the Asia-Pacific."[16] John Mearsheimer likewise contends that "Taiwan is effectively a giant aircraft carrier sitting off China's coast; acquiring that aircraft carrier would enhance China's ability to project military power."[17]

Other prominent analysts who are less convinced of Taiwan's geostrategic significance still note the same issues. For example, James Steinberg and Michael O'Hanlon write, "Possessing bases on Taiwan would extend the PLA's starting point for projecting force one hundred to two hundred miles farther east than is the case today. That would complicate regional dynamics, but it would not be a radical shift."[18] Similarly, Barry Posen acknowledges that "Taiwan is a link in the palisade that contains Chinese naval power, and the loss of that link would require some expensive adaptation," before declaring Taiwan to be "simultaneously the most perilous and the least strategically necessary commitment that the United States has today."[19]

A second part of the literature addresses Taiwan's military value through the lens of Chinese grand strategy and intentions. Charles Glaser, who has proposed ending the U.S. commitment to Taiwan as part of a grand bargain with China, writes that "available analyses provide little reason to worry that possession of Taiwan would significantly increase China's military reach or its ability to project power."[20] Glaser notes, however, that more research on Taiwan's military importance is needed because "little sustained analysis of this issue is publicly available."[21]

By contrast, regional experts such as Andrew Erickson and Joel Wuthnow argue that Chinese writings display an enduring and underappreciated em-

15. Aaron Friedberg, *A Contest for Supremacy: China, America, and the Struggle for Mastery in Asia* (New York: W. W. Norton, 2011), p. 231.
16. Hearing on Why Taiwan Matters, June 16, 2011, testimony; and Easton, "Why the US Defends Taiwan."
17. John J. Mearsheimer, "Taiwan's Dire Straits," *National Interest*, No. 130 (April 2014), p. 33.
18. Steinberg and O'Hanlon, *Strategic Reassurance and Resolve*, pp. 242–243.
19. Barry R. Posen, *Restraint: A New Foundation for U.S. Grand Strategy* (Ithaca, N.Y.: Cornell University Press, 2014), p. 102.
20. Glaser, "A U.S.-China Grand Bargain?" pp. 76–77.
21. Ibid., p. 74.

phasis on the geostrategic significance of Taiwan.[22] As Toshi Yoshihara and James Holmes document, "The notion that [Taiwan] is imbued with strategic and military value is uncontroversial on the mainland."[23] They note that Chinese "commentators speculate that retaking the island would grant China a commanding position over the near seas while guaranteeing direct military access to the Pacific Ocean."[24] In this view, Taiwan is a stepping-stone for Chinese regional hegemony.[25]

Finally, in his analysis of Chinese writings, including many predating the ascension of the CCP, Alan Wachman provides a historical perspective on the mainland's views of Taiwan's military value. "Taiwan matters not only because of what it is, but because of where it is," he argues.[26] Although there is no consensus within China, Wachman reports that for many, "Taiwan is seen as the westward edge of an insular cordon . . . putting the PRC's [People's Republic of China] maritime ambitions at risk. As part of the PRC's domain, though, Taiwan . . . can puncture the belt of strategically located islands that the United States, as the maritime hegemon, is perceived to be using to check the expansion of PRC power."[27] Again, the implication is that retaking Taiwan is about much more than Chinese nationalism; it is intimately bound up with the expansion of China's military power.

To sum up, much of the discussion of Taiwan focuses on the island's political value (or lack thereof) rather than its military value. When analysts have evaluated military issues, they have mostly assessed whether Taiwan is militarily defensible rather than whether controlling it could affect the broader military balance. A handful of analysts have flagged the potential military value of Taiwan in passing or as a window into Chinese strategic intentions, but no one has addressed the subject directly and comprehensively. Overall, analysts who strenuously disagree about U.S. policy and its foundations nonetheless raise the same general issues about Taiwan's military significance.

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22. Andrew S. Erickson and Joel Wuthnow, "Barriers, Springboards, and Benchmarks: China Conceptualizes the Pacific 'Island Chains,'" *China Quarterly*, Vol. 225 (March 2016), p. 9, https://doi.org/10.1017/S0305741016000011.
23. Toshi Yoshihara and James R. Holmes, *Red Star over the Pacific: China's Rise and the Challenge to U.S. Maritime Strategy*, 2nd ed. (Annapolis, Md.: Naval Institute Press, 2018), p. 83.
24. Ibid., p. 85.
25. Ibid., p. 296. See also June Teufel Dreyer, "Why Taiwan Matters," *Foreign Policy Research Institute E-Notes*, July 3, 2011, https://www.fpri.org/article/2011/07/why-taiwan-matters/.
26. Alan M. Wachman, *Why Taiwan? Geostrategic Rationales for China's Territorial Integrity* (Stanford, Calif.: Stanford University Press, 2007), p. 32.
27. Ibid., p. 23.

Agreement remains elusive because a systematic analysis of this specific question is lacking.

A Framework for Assessing Taiwan's Military Value

Assessing Taiwan's military value requires analyzing the effect that control of the island would have on the post-reunification U.S.-China military balance. By the military balance, we mean the relative capabilities on each side relevant to achieving particular military goals. As this notion implies, however, it is almost meaningless to speak of one single "military balance" between two countries, because the balance always requires context to define. There are, in fact, multiple military balances in any relationship that can be defined with reference to different parameters. Three of the most important parameters are the geography of a conflict scenario, the military missions to be performed, and the timing of the scenario in terms of force structure and technology. In this article, we examine the ways in which control of Taiwan would affect the U.S.-China military balance as it relates to Chinese sea denial missions in the Philippine Sea, in both the near and more distant future.

We focus on this geography because the ability of U.S. naval forces to operate in the Philippine Sea would be relevant to many, though certainly not all, potential scenarios for post-reunification conflict between the United States and China. The most obvious such scenarios pertain to U.S. defense of treaty allies along the first island chain against Chinese conquest or coercion. For example, the ability of U.S. naval forces to operate in the Philippine Sea would be central to protecting Japan against threats in either the East China Sea or at the southern end of the Ryukyu Islands. It would be relevant to most scenarios for defending the Philippines as well, and for any scenario that might lead to U.S. strikes on the Chinese mainland, such as a major conflagration on the Korean peninsula. Moreover, U.S. naval operations in the Philippine Sea are especially important given the increasing vulnerability of land-based aircraft and their associated regional bases, which will make carrier-launched aviation and missiles fired from ships increasingly relevant to the outcomes of air and sea battles around allies' territory and to striking targets on Chinese territory.

In terms of mission area, we focus our analysis on the military implications of Taiwan for Chinese submarine warfare and ocean surveillance capabilities. These are not, of course, the only military capabilities that might improve due

to Chinese control of the island. For example, China could station missiles, aircraft, unmanned aerial vehicles, or various other weapons systems on Taiwan. Yet the military impact of placing these assets on the island is fairly straightforward: Their range perimeter would shift east by the length of the Taiwan Strait. By contrast, as we explain below, the undersea and surveillance implications of Chinese control of the island are likely to be more extensive and consequential than a simple shift of the range perimeter eastward. Again, this does not mean that control of Taiwan is irrelevant to other military missions, only that submarine warfare and ocean surveillance appear to merit priority with limited space. We encourage others to extend the analysis to areas that we have omitted.

In terms of timing, our analysis mainly compares the post-reunification U.S.-China military balance to where it stands today. In other words, we ask: What do Chinese sea denial capabilities look like in a in a world where Taiwan is friendly to the United States, and how does the answer to this question change if China controls Taiwan? In asking this question, we treat the island as though it instantaneously materializes in China's hands as a base for military operations using China's current force structure and technology. We recognize that this is an unrealistic assumption because it could take China years to build the infrastructure required to effectively base assets on the island. Nevertheless, this assumption is analytically useful because it enables a straightforward, controlled comparison of the effect that ownership of the island might have on the future military balance that we examine. Because we focus on the impact of Chinese control of this real estate, our approach deliberately holds constant other variables—such as technology and force posture—that could also affect the post-reunification military balance. That being said, we conclude each of the next two sections by highlighting other variables that could alter our conclusions, and in the article's penultimate section we relax our near-term assumptions, examining how major, longer-term changes in the force structure and technology of the Chinese submarine force might affect our findings.

We bound our analysis in several other ways as well. First, we perform a capabilities analysis, not an intentions analysis. If China is quiescent after reunification, with no further territorial ambitions and posing no further regional threat, then we acknowledge that the question of the post-reunification military balance is largely moot. Yet we do not take a position on the likelihood or specific causes of U.S.-China conflict post-reunification, which

would depend on many other factors. We simply assess what reunification would mean for the ability of U.S. naval forces to operate in the Philippine Sea, if such conflict were to occur.

Second, we conduct a military rather than a political analysis. In other words, we assess key military implications of the island changing hands. But there could be large political effects as well, including political effects that then have other military effects. For example, depending on how it occurred, reunification could trigger stronger balancing against China, or, conversely, it could trigger the disintegration of the U.S. alliance system. To keep the analysis tractable, we focus on the military consequences of reunification even while being aware that these are not the only type of consequences that reunification could produce.

Third, we do not consider any effects that the reunification process itself might have on the military balance.[28] For example, were China to take Taiwan easily and swiftly, then China might redirect some of its military assets toward pursuing other Chinese military objectives. China might also be able to assimilate Taiwan's own strategic resources, such as its military equipment, personnel, or semiconductor industry.[29] By contrast, if China were to become mired in a prolonged effort to conquer and occupy Taiwan, reunification might destroy many Chinese and Taiwanese military assets. Predicting which of these contingencies would arise is beyond the scope of this article.

Using this framework, the next two sections demonstrate that control of Taiwan opens the door to new capabilities in undersea warfare and ocean surveillance that China does not currently possess. We first provide a brief primer on warfare in each mission area—undersea warfare and ocean surveillance, respectively—and identify the variables that control of Taiwan would affect in each domain. We then compare China's present capabilities to those that the emplacement of submarines and underwater sensors on or near Taiwan would enable, demonstrating how Chinese control of the island would affect the military balance in each area. We conclude each section by highlighting areas of uncertainty that have the potential to change our conclusions.

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28. See, for example, Roger Cliff and David A. Shlapak, *U.S.-China Relations after Resolution of Taiwan's Status* (Santa Monica, Calif.: RAND, 2007), https://www.rand.org/pubs/monographs/MG567.html.

29. Yen Nee Lee, "2 Charts Show How Much the World Depends on Taiwan for Semiconductors," *CNBC*, March 15, 2021, https://www.cnbc.com/2021/03/16/2-charts-show-how-much-the-world-depends-on-taiwan-for-semiconductors.html.

Submarine Warfare

Taiwan's impact on Chinese submarine and anti-submarine warfare (ASW) capabilities would figure prominently during future U.S. operations in the Philippine Sea. We argue that the United States is currently well positioned to wage an ASW campaign against Chinese submarines: It can deploy two different types of hydrophone barriers along the first and second island chains, allowing the United States to trail Chinese submarines in peacetime or a crisis, and causing substantial attrition during a war. But following reunification, China would be able to base submarines and air defenses on Taiwan. This would allow China to outflank U.S. hydrophone barriers and deny the United States the use of its most powerful ASW forces, making U.S. forces more vulnerable during a crisis and cutting the wartime Chinese submarine attrition rate. Basing on Taiwan would also increase the number of Chinese submarines on station and, as we argue in the next section, facilitate their attacks against U.S. surface forces, significantly raising the effectiveness of a Chinese submarine campaign in the Philippine Sea.

BACKGROUND ON UNDERSEA WARFARE

ASW is, at its heart, a search problem; it is about detecting the signatures of adversary submarines in order to identify, locate, track, and potentially attack them. All things being equal, finding an enemy submarine is much more difficult than sinking it. Submarines are relatively vulnerable to conventional naval power once found, yet they may have vast oceans in which to hide. The search task is greatly facilitated by the creation of ASW barriers: bodies of water where a confluence of geography and passive sonar arrays narrow the area that ASW forces must search.

Two types of barriers are especially relevant for this study. The first type uses hydrophones to passively monitor the deep sound channel, a hydroacoustic phenomenon in which low frequency sounds emitted at the correct angle can propagate for thousands of miles. If mounted at the axis of the deep sound channel—on average about 1,000 meters deep, where the speed of sound in water is at its lowest—acoustic sensors can use signal processing to detect the low frequency "tonals" emitted by submarines, which are sounds that occur at specific, narrow frequency bands.[30] Deep sound channel hydro-

30. On the depth of the sound channel, see Tom Stefanick, *Strategic Antisubmarine Warfare and Naval Strategy* (Lexington, Mass.: Lexington, 1987), p. 232.

phones can therefore continuously track contacts at very long distances, as well as imprecisely localize them into probability areas. Weapons platforms with more accurate, shorter-range sensors can then be directed into these areas, greatly improving the efficiency of a search.

The United States made ample use of such barriers during the Cold War, when most Soviet submarines had to traverse the Greenland-Iceland-United Kingdom (GIUK) gap if they wanted to reach their targets. The U.S. Navy mounted hydrophones on the underwater ridge connecting these islands, placing them at the axis of the deep sound channel. This Sound Surveillance System (SOSUS) enabled the United States to detect, track, and trail several generations of Soviet submarines across thousands of miles of ocean basin. As Owen Cote explains, SOSUS provided "an ocean-wide surveillance capability . . . during the Cold War. . . . If and when [the United States] wanted to prosecute or hold at continuous risk those contacts it could commit scarce tactical assets. . . , but it did not need to commit those assets to maintain the basic track."[31]

Deep sound channel barriers have two important limitations, however. First, they are available only in deep waters, as reflections off the surface and the bottom of the ocean greatly attenuate the propagation of sound in shallow water. Second, as enemy submarines become quieter, their acoustic signatures become much more difficult to distinguish from background noise across thousands of miles of ocean in the deep sound channel.

Addressing these challenges requires the second type of barrier, which uses the Reliable Acoustic Path (RAP) to detect contacts, rather than the deep sound channel. RAP sensor barriers network thousands of bottom-mounted, upward-looking hydrophones using underwater fiber-optic cables that come ashore for data processing. RAP sensors can detect even very quiet submarines because there is very little background noise in these small vertical areas, as opposed to the enormous horizontal search areas covered by deep sound channel systems. If placed at critical chokepoints through which an adversary's submarines must pass, RAP sensors can be used to cue the platforms that prosecute contacts. But precisely because the volume of ocean within range of these sensors is small, RAP barriers cannot continuously track contacts beyond the short period that they are in range. Thus, RAP sensors'

31. Owen R. Cote Jr., "Assessing the Undersea Balance between the U.S. and China," Security Studies Program [SSP] Working Paper (Cambridge: Massachusetts Institute of Technology SSP, February 2011), pp. 13–14.

detection capability is fleeting compared with the persistent ocean-wide surveillance of hydrophone sensors in the deep sound channel.[32]

It is difficult to overstate how important geography is for the effectiveness of ASW barriers. Without controlling the real estate adjacent to the waters that sonar arrays are to surveil, cables must run back long distances to onshore data processing facilities and are highly vulnerable to attack. As Tom Stefanick observes, "There is an obvious logistical problem in attempting to protect large sonar arrays on the ocean floor, with cables running up to shore-based facilities, off the coast of a country whose . . . forces are threatened by those arrays."[33]

BEFORE REUNIFICATION

In the status quo, China's challenging maritime geography allows the United States to deploy both deep sound channel and RAP sensor barriers against Chinese submarines. China's major direct routes to the Philippine Sea require passing by Taiwan—either to the north, between Taiwan and the Ryukyu Islands, or to the south, between Taiwan and the Philippines, through the Luzon Strait. Moreover, Chinese submarines passing through the chokepoints around Taiwan must travel from shallow coastal waters directly into the deep ocean basin because Taiwan is perched on the edge of the continental shelf that extends from mainland China.

Given these geographic circumstances, the United States likely deploys multiple ASW barriers against Chinese submarines. Because Japan, Taiwan, and the Philippines are friendly (though the Philippines less reliably than in the past), the United States likely deploys RAP sensors across these chokepoints, stretching down from the Ryukyu Islands toward Taiwan and up from the Philippines.[34] The United States also has plenty of choices for where to bring ashore the fiber-optic cables for data processing.[35] Furthermore, U.S. control of Guam, plus friendly control of other islands in the second island chain, likely enables the United States to use deep sound channel sensors to surveil the whole Philippine Sea basin. Deploying redundant arrays in this manner makes it very likely that the United States would not only detect any Chinese subma-

32. Ibid., pp. 7–8.
33. Stefanick, *Strategic Antisubmarine Warfare and Naval Strategy*, p. 38.
34. Desmond Ball and Richard Tanter, *The Tools of Owatatsumi: Japan's Ocean Surveillance and Coastal Defence Capabilities* (Canberra: Australian National University Press, 2015), pp. 51–54, https://doi.org/10.22459/TO.01.2015.
35. Cote, "Assessing the Undersea Balance between the U.S. and China," p. 12.

rines attempting to reach the open ocean, but also be able to track these nuclear submarines while on station in the Philippine Sea—at least until such vessels grow significantly quieter.[36] The United States could also use its own SSNs for covert peacetime trails of China's submarines as they cross the RAP barriers.

More importantly, a Chinese submarine campaign against U.S. surface forces would face important challenges in crisis or war. During a crisis, policymakers would retain the option of maintaining overt, active trails from standoff range of any submarines that crossed the RAP barriers, using maritime patrol aircraft and ships equipped with ASW helicopters. Such trails would prevent Chinese submarines from getting a free shot at U.S. surface forces during the transition from crisis to war, when U.S. forward-deployed naval assets would be at their most vulnerable.[37] In wartime, any RAP barriers would exact considerable attrition, and deep sound channel hydrophones on the second island chain would be able to do the same against current Chinese nuclear attack boats and diesel submarines that must snorkel on patrol.

To understand how barriers affect submarine warfare outcomes, consider an illustrative example. If a hypothetical Chinese submarine force had to cross five ASW barriers (RAP barriers coming and going from their patrol area, one attack cued by deep sound channel hydrophones, and an ASW screen coming and going from attacks on U.S. surface forces) in the Philippine Sea, and each barrier imposed Cold War levels of attrition, it could lose up to two-thirds of its end strength by the conclusion of its first patrol.[38] In reality, this calculation understates the effectiveness of ASW barriers against the Chinese fleet, which are mostly diesel submarines. Many diesel boats that are not sunk at a barrier would likely exhaust their battery reserves during a high-speed escape. Such an escape would force them to either leave the operating area, or snorkel and attract further ASW attacks, or both, increasing the mission failure or attrition rate.

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36. Ibid.; and 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*, Vol. 75, No. 1 (2019), pp. 33–34, https://doi.org/10.1080/00963402.2019.1555998.
37. Cote, "Assessing the Undersea Balance between the U.S. and China," p. 19.
38. We assume a barrier p(K) of 0.2, which means $0.8^5 = 0.33$, or 33 percent of the initial submarine force survives all five barriers; this number is illustrative rather than definitive and follows Alain C. Enthoven and K. Wayne Smith, *How Much Is Enough? Shaping the Defense Program, 1961–1969* (New York: Harper and Row, 1971), p. 226. We also assume that, in order to reach their patrol areas expeditiously, China's diesel electric boats will have to snorkel once in their patrol area, making them vulnerable to a deep sound channel detection.

AFTER REUNIFICATION

Gaining control of Taiwan would enable China to base its submarines in the ports on Taiwan's eastern coast, such as Keelung, Su'ao, Hualian, and Taitung.[39] In this scenario, at least three ASW barriers, and perhaps all five, would disappear, reducing attrition of the Chinese submarine force and increasing its attack opportunities against U.S. surface forces.

Instead of having to pass through RAP barrier chokepoints going to and from their patrol areas, Chinese submarines would be able to slip from their Taiwanese pens directly into the Philippine Sea, making them more difficult to detect and trail with U.S. submarines. Chinese air and costal defenses on Taiwan would prevent the United States and its allies from operating maritime patrol aircraft or ASW ships near Taiwan, limiting their capability to trail contacts and conduct open ocean searches. Overall, crisis ASW against Chinese submarines would become significantly more difficult, increasing the vulnerability of U.S. surface forces at the beginning of a war.

In addition, the distance from Chinese submarine bases to their patrol areas would shrink from an average of 1,240 kilometers to zero. Chinese diesel submarines would therefore have less need to snorkel in their patrol areas; only China's small number of nuclear submarines would be vulnerable to deep sound channel cueing, effectively erasing another barrier. Moreover, by eliminating the long journey to the Philippine Sea, China would be able to keep many more of its submarines on station. If China divided its large diesel submarine force into two groups with thirty-day patrols and staggered their departures by fifteen days, it could average more than 60 percent of its diesel force on station, up from 38 percent now. By itself, this would increase Chinese attack opportunities by roughly 50 percent.[40]

Finally, we argue in the next section that with ownership of Taiwan, China could likely use hydrophone and satellite ocean surveillance to provide cues to its forces targeting U.S. naval assets. Such cueing could reduce to zero the number of ASW barriers that Chinese submarines would have to face by allowing them to circumvent the ASW screens of U.S. surface forces through

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39. Peter Howarth, *China's Rising Sea Power: The PLA Navy's Submarine Challenge* (London: Routledge, 2006), p. 38.

40. In this scenario, over a sixty-day period, 50 percent of Chinese diesel submarines would be on station 75 percent of the time, and 100 percent would be on station for 25 percent of the time, for a total on station rate of 62.5 percent. We calculate the current on station rate of 38.5 percent from Eric Heginbotham's assessment that it takes 2.59 diesel submarines in inventory to keep one on station. See Heginbotham et. al, "The U.S.-China Military Scorecard," pp. 195, figure 7.8, 196, table 7.11, 181, table 7.6.

cruise missile attacks from standoff range. Even if Chinese submarines had to pass through such screens before attacking in order to acquire their targets using onboard sonars, the absence of the three hydrophone barriers would cut attrition roughly in half.[41] Furthermore, cueing would dramatically increase the search efficiency of the Chinese submarine force: Eric Heginbotham et al. estimate that even a single cue every twenty-four hours increases the number of attack opportunities eightfold.[42]

THE FUTURE OF CHINESE SUBMARINE WARFARE

There are several uncertainties that might alter our analysis above. If China can already destroy U.S. RAP barriers in the early stages of a war, for example, then the advantages of new bases on Taiwan that outflank them would disappear, diminishing the value of the island. Likewise, if limited U.S. and allied ASW platform numbers allow Chinese submarine forces to surge over the RAP barriers in large numbers before a war, this would increase the initial effectiveness of a submarine campaign irrespective of basing on Taiwan. Conversely, if the United States and its allies can either replicate RAP barriers using rapidly deployable hydrophone systems during a war or replace them in peacetime with a new barrier that extends from the southern Ryukyu Islands to Luzon, then U.S. ASW advantages might persist even if Taiwan were to change hands. We consider these possibilities unlikely or of modest relevance at present.[43] However, there are real uncertainties here, especially concerning the outcome of a "battle for the barriers," that are worth keeping in mind.

Ocean Surveillance for Maritime Targeting

Assessing Taiwan's military value also requires understanding how the island might contribute to China's over-the-horizon targeting complex. We argue that, at least for the near future, all of China's extant sensor platforms for finding U.S. naval assets have liabilities: They are poorly suited for wide-area surveillance, or they can be defeated with non-kinetic means, or they are likely to be destroyed during a war. But if China were to control Taiwan, it would gain the ability to place and defend deep sound channel hydrophones off

41. In this case $0.8^2 = 0.64$, or 64 percent of the initial submarine force survives both barriers.
42. The search efficiency increases from 0.58 attack opportunities to 4.68 attack opportunities per carrier per week. See Heginbotham et. al, "The U.S.-China Military Scorecard," p. 196, table 7.12.
43. See the online appendix, p. 1.

Taiwan's coast. Such sensors would provide an excellent surveillance capability for detecting and roughly tracking U.S. surface forces, forging a critical missing link in China's over-the-horizon kill chain. The resulting Chinese targeting capabilities might then force the United States to escalate to anti-satellite warfare, which it can presently avoid, or to channel its surface naval operations into a much smaller part of the Philippine Sea. But future developments in Chinese force structure or technology could potentially change this assessment, as we explain further below.

BACKGROUND ON OCEAN SURVEILLANCE

China's over-the-horizon targeting complex consists of sensors mounted on aircraft and surface ships, land-based over-the-horizon (OTH) radar, signals intelligence (SIGINT) satellites that collect the electronic emissions of warships from space, and imaging satellites using either synthetic aperture radar or electro-optical sensors.[44] Assessing the capabilities of these Chinese assets requires evaluating them along at least three dimensions.

First, long-range attacks against U.S. assets in the Philippine Sea are dependent upon sensors for two tasks: surveillance and reconnaissance.[45] Surveillance sensors typically observe large ocean areas, monitoring them systematically with moderate fidelity to detect, roughly track, and perhaps identify target signatures. The surveillance picture is then used to cue more accurate reconnaissance platforms that precisely locate and identify targets, usually moving into position to do so. Once a target's location, identity, and general course of movement are obtained, this targeting data is handed off to tactical forces that plan attacks, engage targets, and assess results.

The effectiveness of an over-the-horizon targeting complex is critically dependent on its surveillance sensors given the difficulties involved in randomly searching large ocean areas. The surface area of the Philippine Sea is roughly 5 million square kilometers. We estimate that the portion of the Philippine Sea where an aircraft carrier could usefully contribute to a post-reunification fight—based on the unrefueled combat radius of the F-35C, the U.S. Navy's

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44. See Thomas R. McCabe, "Chinese Intelligence, Surveillance, and Reconnaissance Systems," *Journal of Indo-Pacific Affairs*, Vol. 4, No. 2 (Spring 2021), https://media.defense.gov/2021/Mar/07/2002595026/-1/-1/1/25%20MCCABE.PDF. Having addressed submarines in the previous section, we omit them here.

45. Surveillance and reconnaissance definitions are from Jonathan Solomon, "Defending the Fleet from China's Anti-Ship Ballistic Missile: Naval Deception's Roles in Sea-Based Missile Defense," M.A. thesis, Georgetown University, 2011, p. 3, n. 8, http://hdl.handle.net/10822/553587.

premier fighter aircraft—is still about 2 million square kilometers.[46] In short, without a cue from surveillance sensors telling them where and when to look, reconnaissance sensors become dramatically less effective at providing targeting intelligence.

Second, the effectiveness of any sensor is also dependent on its ability to defeat non-kinetic countermeasures. Though there is little publicly available information on the state of most measure-countermeasure battles, past history and open-source assessments can be used to assess certain parts of the Chinese targeting complex, which we explain in the next section.

Third, the vulnerability of each sensor to kinetic attack, and the escalation risks that would stem from such attacks, are also relevant to assessing China's long-range targeting capabilities. The transition from crisis to war is likely to make the first Chinese salvo more effective than subsequent efforts, as U.S. rules of engagement are more likely to dictate refraining from kinetic attacks on the Chinese targeting complex before rather than after a war has begun.[47] The vulnerability of Chinese sensors during wartime and the U.S. willingness to bear any resulting escalatory risks are therefore critical to evaluating the wartime viability of the Chinese targeting system.

Before Reunification

Currently, all potential Chinese surveillance platforms have liabilities that likely would prevent China from operating an effective over-the-horizon targeting complex during a war. Below, we survey these challenges for each platform: aircraft, ships, SIGINT satellites, OTH radar, and imaging satellites. We conclude that for the near future, Washington can probably defeat long-range Chinese attacks on its surface forces without escalating to anti-satellite warfare, so long as U.S. forces can effectively practice emissions control (EMCON) and policymakers are willing to attack Chinese OTH radars.

Aircraft. To be effective surveillance platforms, aircraft either require giant search radars, or they must knit together the radar returns of many randomly searching aircraft over an extended period. Alternatively, several randomly searching aircraft or unmanned aerial vehicles (UAVs), especially if they are small and stealthy, might rely on passive sensors that collect visible or infrared light and electronic signatures to put together a surveillance picture.

46. See the online appendix, pp. 2–3.
47. Solomon, "Defending the Fleet from China's Anti-Ship Ballistic Missile," p. 76.

But using passive sensors will greatly reduce the area covered by searching aircraft, making them inefficient random searchers.

During wartime, the challenge facing airborne platforms is that active emitters looking for U.S. surface forces far from defended airspace will not be long for this world.[48] The escalation risk of destroying Chinese aircraft over the Philippine Sea once a major war has already begun is basically nil; we should expect U.S. surface forces to attempt to destroy Chinese aircraft over the Philippine Sea as soon as their rules of engagement permit.

Stealthy aircraft might survive longer, but stealth cannot protect passively sensing aircraft forever.[49] As Jonathan Solomon puts it, "No amount of stealth can prevent a scout or strike aircraft from eventually being discovered the longer it loiters in a given area without air defense suppression support."[50] For instance, Stephen Biddle and Ivan Oelrich report that the powerful Aegis search radar on U.S. surface ships ought to be able to detect an aircraft two and a half times as stealthy as the F-117 at 136 kilometers, which would greatly facilitate attacks by fleet air defenses. Moreover, small, stealthy UAVs designed for passive observation are unlikely to be able to carry the weapons needed to defend themselves.[51] These factors give rise to Biddle and Oelrich's judgment that "it is far from clear that passive drones could survive in such a high-threat environment long enough to extend China's [surveillance] reach significantly beyond what airborne radar could do."[52]

SHIPS. Chinese warships and auxiliary intelligence gathering (AGI) ships are also not especially effective as surveillance platforms given their much lower search speeds and coverage areas. But a large number of randomly searching hulls distributed throughout the Philippine Sea might provide a reasonable surveillance picture. This has led some analysts to suggest that China could mobilize its large fishing fleet and maritime militias as a giant surveillance net.[53]

However, Chinese ships of whatever kind are not likely to be effective war-

48. On the vulnerability of airborne radars operating more than 400–600 kilometers beyond a friendly coastline—for example, over the Philippine Sea—see Biddle and Oelrich, "Future Warfare in the Western Pacific," pp. 22–29.
49. Ibid., pp. 35–37.
50. Solomon, "Defending the Fleet from China's Anti-Ship Ballistic Missile," p. 26, n. 59.
51. Biddle and Oelrich, "Future Warfare in the Western Pacific," pp. 37, 39.
52. Ibid., p. 30.
53. Solomon, "Defending the Fleet from China's Anti-Ship Ballistic Missile," p. 18; and James M. Landreth, "The Strategic Significance of the Chinese Fishing Fleet," *Military Review*, Vol. 101, No. 3 (May/June 2021), p. 35.

time searchers. China's warships and AGI ships are valuable and vulnerable enough that they are unlikely to remain forward deployed outside the cover of land-based air defenses after a war starts.[54] Chinese warships and AGI ships might trail U.S. surface forces during peacetime—just as Soviet "tattletale" warships and AGI ships did during the Cold War—meaning they could be potentially useful during the first salvo. But this role is a suicide mission; the Soviets did not expect the tattletales to survive past the opening shots of a war, and China would have little reason to either.[55]

Fishing boats and other small craft will face all the same problems, while also having to cope with shorter ranges, slower top speeds, less powerful sensors, and limited defenses. If they turn on their automatic identification system beacons and radars like normal fishing ships, U.S. surface forces will easily track and avoid them. If these ships go dark, they will still be vulnerable to space systems such as those operated by HawkEye 360, a geospatial analytics company that uses radio frequencies to track communications, as well as to the outer screens of U.S. battle forces.[56]

Furthermore, in a high-threat environment, the U.S. Navy is unlikely to hold back from sinking Chinese hulls of whatever size. During World War II, the U.S. Navy attacked commercial ships weighing as little as 25 tons, including sampans, schooners, fishing trawlers, and junks. One military rationale given for these attacks was the possibility that these boats were serving as radio-linked scouts.[57] In 2019, Chief of Naval Operations Admiral John Richardson warned his Chinese counterpart that the U.S. Navy would respond to aggressive actions by small fishing boats as if they were part of the Chinese armed forces.[58]

SIGINT SATELLITES. China operates two constellations of Yaogan SIGINT satellites in low-Earth orbit (LEO), but only its medium-altitude constellation of

54. Andrew S. Erickson et al., "Correspondence: How Good Are China's Antiaccess/Area-Denial Capabilities?" *International Security*, Vol. 41, No. 4 (Spring 2017), p. 212, https://doi.org/10.1162/ISEC_c_00278; and Solomon, "Defending the Fleet from China's Anti-Ship Ballistic Missile," p. 18.
55. Solomon, "Defending the Fleet from China's Anti-Ship Ballistic Missile," p. 46.
56. On the effectiveness of U.S. screening forces against uncued ships during the Cold War, see ibid., pp. 42–43. On HawkEye 360, see "HawkEye 360," *Wikipedia*, last modified March 24, 2022, https://en.wikipedia.org/wiki/HawkEye_360.
57. Michael Sturma, "Atrocities, Conscience, and Unrestricted Warfare: US Submarines during the Second World War," *War in History*, Vol. 16, No. 4 (November 2009), pp. 461, 454, respectively, https://doi.org/10.1177/0968344509341686.
58. James Kraska, "China's Maritime Militia Vessels May Be Military Objectives during Armed Conflict," *Diplomat*, July 7, 2020, https://thediplomat.com/2020/07/chinas-maritime-militia-vessels-may-be-military-objectives-during-armed-conflict/.

triplet satellites is configured for effective ocean surveillance.[59] During wartime, U.S. surface forces should be able to defeat either of these SIGINT constellations using non-kinetic means. SIGINT collectors rely on a cooperative adversary that is generating signals, but the U.S. Navy can operate under strict emissions control (EMCON) procedures that will produce nothing for satellite ears to detect. The United States can also deceive SIGINT satellites using decoys to simulate the communications and radar signals of aircraft carriers and other high-value units.

During the Cold War, the U.S. Navy used EMCON and deception during peacetime to defeat the Soviet Ocean Surveillance System (including SIGINT satellites), though the task required learning and discipline.[60] U.S. naval exercises achieved communications EMCON with high-frequency radio silence by using highly directional communications that can be intercepted only by inserting a listening asset directly inside their narrow beam, by using aircraft as line-of-sight relays, and by conducting preplanned or highly delegated battle force command and control.[61] EMCON of radars required turning them off when satellites were overhead; this meant delegating all air traffic control duties to airborne early warning platforms such as the E-2 Hawkeye, or even shutting off all radars in a battle group.[62] The United States also created decoy groups of frigates and other lower-value warships that deceptively emulated the communications and radar signatures of higher-value warships as the latter silently maneuvered in a different direction.[63] Success in these operations was usually evident from the behavior of Soviet scouting platforms, which were observed making laborious random searches or pursuing the wrong targets, depending upon how they had been misled.[64]

Chandrashekar and Ramani report that in simulations of the Chinese SIGINT ocean surveillance constellation, a target near Taiwan was visible about 32 percent of the time. Though these results should be treated with caution, they probably indicate the general scale of Chinese SIGINT coverage over

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59. See the online appendix, pp. 3–4.
60. For an example of the training requirements and difficulty of EMCON, see Robert G. Angevine, "Hiding in Plain Sight—The U.S. Navy and Dispersed Operations under EMCON, 1956–1972," *Naval War College Review*, Vol. 64, No. 2 (2011), pp. 81–83, https://digital-commons.usnwc.edu/nwc-review/vol64/iss2/6.
61. Norman Friedman, *Network-Centric Warfare: How Navies Learned to Fight Smarter through Three World Wars* (Annapolis, Md.: Naval Institute Press, 2009), pp. 233–234, 237–238, 343–344, n. 6; and Solomon, "Defending the Fleet from China's Anti-Ship Ballistic Missile," p. 51, nn. 109, 110.
62. Friedman, *Network-Centric Warfare*, pp. 235, 237–238.
63. Ibid., pp. 234–235.
64. Ibid., p. 235.

the Philippine Sea.[65] Even if U.S. surface forces were forced to completely turn off their air defense radars a third of the time to evade detection, they could probably do so with tolerable risks to survival deep in the Philippine Sea.

OTH RADAR. Although China's Skywave OTH radars are well suited for surveillance duties, they face two major difficulties during wartime. First, like all radars, OTH systems require a high degree of operational and technical sophistication to win the ferocious measure-countermeasure duel between jamming and counter-jamming that they will be subject to in any major war. It is unclear whether the Chinese would be able to win this competition; Cote calls such an assumption "heroically conservative."[66]

Second, even if Chinese forces can win the jamming battle, OTH radars are large, soft targets with fixed locations, which makes them vulnerable to long-range kinetic attacks. The cost-exchange ratio for cruise missile salvos against such targets is attractive: It is much cheaper and easier for the United States to destroy them than for China to replace them.[67] Moreover, OTH radar's persistent surveillance capabilities give it a unique role in contesting U.S. surface forces in the Philippine Sea. As Cote notes, in a U.S.-China war "there would be tremendous pressure on American political leaders to strike Chinese OTH radars so as to deny cueing to Chinese" forces.[68]

Would the United States blanch at crossing the escalation threshold needed to destroy OTH radars—that is, of conducting direct attacks on mainland China? Although it is possible that policymakers might hesitate, it seems unlikely. China would probably directly attack U.S. airbases in South Korea and Japan in the early phases of a war, and the United States would likely retaliate against Chinese air bases, both of which would be crucial to the outcome of early air battles. The United States is building weapons designed for mainland attacks, such as the B-21 stealth bomber and the JASSM-ER cruise missile. Thus, the geographic expansion of the war is likely in any case; adding an additional target to the U.S. list would not change much.

IMAGING SATELLITES. China's synthetic aperture radar and electro-optical imaging satellites, the most important of which are found in the Yaogan con-

65. S. Chandrashekar and N. Ramani, "China's Space Power and Military Strategy—The Role of the Yaogan Satellites" (Bangalore: International Strategic and Security Studies Programme, National Institute of Advanced Studies, July 2018), p. 14, http://isssp.in/chinas-space-power-military-strategy-the-role-of-the-yaogan-satellites/.
66. Cote, "Assessing the Undersea Balance between the U.S. and China," p. 16, n. 16.
67. See the online appendix, pp. 4–5.
68. Cote, "Assessing the Undersea Balance between the U.S. and China," p. 17.

stellation, are not especially well suited for surveillance. They can monitor the Philippine Sea only when the timing of their orbits and the revolution of the earth take them over it, two or perhaps three times a day. This means that China would need numerous imaging satellites to generate the passes that would allow them to function as a surveillance system. Yet China's Yaogan imaging constellation continues to be modestly sized: China has kept between nine and twelve operational imaging satellites in orbit during the past decade. Heginbotham et al. estimate that this constellation would randomly image a surface target only once every 2.9 days.[69]

Although there is no consensus in the public literature about how effective non-kinetic attacks against satellites might be, they are likely to be less than 100 percent effective.[70] Conversely, kinetic attacks on satellites in LEO are highly likely to succeed: There is little time for such satellites to maneuver out of their predictable orbits, while the energy needed to attack a satellite is much less than that needed to put it in orbit, giving large structural advantages to attackers over attempts to improve satellite maneuverability and other defenses.[71]

Will U.S. leaders tolerate the escalatory risks inherent in anti-satellite warfare?[72] An anti-satellite war that got out of hand would not only degrade the military capabilities of both sides but also risk permanent damage to commercial and civilian uses of space. A kinetic anti-satellite conflict would cause space debris to proliferate throughout LEO, increasing the odds that a "Kessler syndrome" of cascading collisions would occur. Such a scenario could make space junk the primary determinant of satellite lifespan, and it might even render large portions of LEO useless.[73] Moreover, there are few obvious,

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69. Heginbotham et. al, "The U.S.-China Military Scorecard," p. 163, chart.
70. For a survey of non-kinetic methods of attack, see Todd Harrison et al., "Space Threat Assessment 2020" (Washington, D.C.: Center for Strategic and International Studies [CSIS], March 2020), pp. 2–7.
71. Biddle and Oelrich, "Future Warfare in the Western Pacific," p. 25.
72. We assume that command and control of satellites from difficult-to-target mobile ground stations would eventually drive anti-satellite warfare into space. For Chinese developments in this area, see Ian Easton and Mark Stokes, "China's Electronic Intelligence (ELINT) Satellite Developments: Implications for U.S. Air and Naval Operations" (Arlington, Va.: Project 2049 Institute, February 2011), p. 10, https://project2049.net/2011/02/23/chinas-electronic-intelligence-elint-satellite-developments-implications-for-u-s-air-and-naval-operations/.
73. Charles Powell, "Saving Space from 'Star Wars'-Style Misperceptions," *War on the Rocks*, July 14, 2020, http://warontherocks.com/2020/07/saving-space-from-star-wars-style-misperceptions/; and National Research Council, "Hazards to Space Operations from Debris," in *Orbital Debris: A Technical Assessment* (Washington, D.C.: National Academies Press, 1995), pp. 79–100, https://doi.org/10.17226/4765.

salient thresholds that could be used to limit an anti-satellite engagement in LEO. Unlike the geographic expansion of the war, which might plausibly be limited to military targets, it is hard to find a natural break point in numbers of satellites that both sides would recognize.

U.S. policymakers might nevertheless decide to escalate to anti-satellite warfare because the United States could benefit militarily, on net, from such an escalation.[74] But the costs and risks of doing so would be significant enough to give policymakers pause. Importantly, U.S. leaders will be more likely to hold back from anti-satellite attacks the less threatening those satellites are to U.S. forces. Absent a Chinese means of persistent surveillance to cue satellite reconnaissance missions, U.S. leaders may find Chinese satellite passes more tolerable than the escalatory risks of kinetic anti-satellite attacks.

SUMMARY. The extant Chinese over-the-horizon targeting complex has an important flaw. During a crisis, China may be able to exploit the rules of engagement of forward-deployed U.S. surface forces in order to target them in a first strike that opens the war. But once a war begins, China's best surveillance asset, OTH radar, is likely to be quickly destroyed, along with any platforms in the vicinity of U.S. surface forces. Meanwhile, Chinese satellites are unlikely to be effective surveillance platforms: SIGINT satellites can likely be evaded with EMCON procedures that the United States honed during the Cold War, and Chinese imaging satellites are inefficient random searchers. Under these conditions, U.S. surface forces operating in the Philippine Sea will face real but tolerable dangers from long-range attacks, and U.S. leaders will retain the option of avoiding kinetic anti-satellite warfare should non-kinetic measures lack high effectiveness.

AFTER REUNIFICATION

Controlling Taiwan would enable China to utilize deep sound channel sonar arrays for surveillance of the Philippine Sea, solving the flaw in China's current over-the-horizon targeting complex. Such arrays could be mounted off the eastern shore of Taiwan, where the continental shelf rapidly falls away.

Using simple calculations and known facts about hydrophones, we estimate that a system of deep sound channel hydrophone arrays placed off the coast of Taiwan would cover 77 percent of the Philippine Sea area where aircraft carriers could operate. We also calculate that even in a worst-case scenario for China, a U.S. surface ship in this zone could be located within a 14,000 square

74. Cote, "Assessing the Undersea Balance between the U.S. and China," pp. 23–26.

kilometer area of uncertainty, which any Chinese imaging satellite could search in a single pass.[75] Outside this zone, Chinese satellites would still be forced into random searches, but of a much smaller area.

The idea of using hydrophones to target surface ships may strike some analysts as novel, so it is worth discussing the concept in some detail. As noted above, the United States employed SOSUS hydrophones during the Cold War to detect and track Soviet submarines. Contemporary U.S. submarines are too quiet to be detected by any deep sound channel hydrophones that China might install off the coast of Taiwan. But the same physical principles that allow deep sound channel hydrophones to detect submarines also let them detect surface ships; indeed, the major task of hydrophone signal processing is to detect a submarine amid all the noise generated by surface ships.[76] U.S. surface forces operating in much of the Philippine Sea would thus be imminently detectable.

During the Cold War, SOSUS detected and tracked surface targets. In 1968, for example, a Soviet nuclear submarine operating well off the coast of Oregon attempted to intercept the U.S. carrier *Enterprise* on its journey from San Francisco to Hawaii. Bruce Rule, the lead acoustic analyst for the U.S. Office of Naval Intelligence (and thus the SOSUS system) for much of the Cold War, reports that SOSUS arrays in the Pacific tracked the entire 37.4-hour event, comparing speeds of both the Soviet submarine and the U.S. carrier; the resulting data were used for command and control of the *Enterprise*.[77] Along the same lines, a key challenge SOSUS faced early on was "the similarity of the signature of certain surface vessels, principally fishing boats, to submarine signatures."[78] This difficulty initially led to false alarms, "meaning that ASW assets often spent considerable time 'prosecuting' merchant ships." Later, after

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75. See the online appendix, pp. 5–8.

76. See Stefanick, *Strategic Antisubmarine Warfare and Naval Strategy*, pp. 293–306. For example, in 1968, Atlantic SOSUS nets detected 467,677 contacts, of which only 4,755 were submarines. "Sea-Based Airborne Antisubmarine Warfare, 1940–1977: Volume 2, 1960–1977" (Arlington, Va.: U.S. Department of the Navy and R.F. Cross, February 17, 1978), p. 78, https://www.hsdl.org/?view&did=853428 (hereafter, "Cross Report: Vol. 2").

77. Declassified excerpts of a report on this incident, which strongly imply that both ships were tracked by the SOSUS, can be found in the 1977 "Cross Report" on sea-based airborne anti-submarine warfare (ASW). "Cross Report: Volume 2," pp. 70–72 . For Bruce Rule's commentary, see Bruce Rule, "The SOSUS System: A Personal Perspective of the Early Years," *Integrated Undersea Surveillance System CAESAR Alumni Association (IUSSCAA)*, June 17, 2015, www.iusscaa.org/articles/brucerule/the_sosus_system_a_personal_perspective_of_the_early_years.htm.

78. "Sea-Based Airborne Antisubmarine Warfare, 1940–1977: Volume 1, 1940–1960" (Arlington, Va.: U.S. Department of the Navy and R.F. Cross, February 17, 1978), p. 156, https://www.hsdl.org/?view&did=853419 (hereafter, "Cross Report: Vol. 1").

the U.S. Navy had developed an extensive library of ship and submarine signatures, ASW forces would often "train against diesel trawlers, which had signatures similar to a snorkeling submarine."[79]

Importantly, SOSUS detections could occur at very long ranges against noisy targets because of the fidelity with which the deep sound channel preserves low frequency sound. Even as an experimental system in 1954, SOSUS operators had contact ranges out to nearly 1,000 kilometers.[80] Rule reports that on July 6, 1962, SOSUS arrays off the coast of Barbados detected a Soviet submarine nearly 6,000 kilometers away in the GIUK gap.[81] Similarly, the geometry of the *Enterprise* incident implies that Pacific SOSUS arrays had detection and tracking ranges of at least 1,900 kilometers.[82]

It is likely that Chinese hydrophones placed off the coast of Taiwan would be able to make long-range detections of surface forces like SOSUS did during the Cold War. Two principal factors will regulate such detections: the sound profile of U.S. surface forces, and ambient noise levels in the Philippine Sea.[83]

First, U.S. surface ships radiate the same types of low frequency, narrowband tonals as submarines do, except ships' tonals are much louder. As with submarines, these tonals originate from vibrating machinery and blade rate modulations of cavitating propellers.[84] But U.S. warships have multiple screws with much larger propellers than submarines, as well more numerous machine parts that are not separated from the hull as they are on contemporary submarines. At normal operating speeds, loud signals from propeller cavitation of

79. Owen R. Cote Jr., *The Third Battle: Innovation in the U.S. Navy's Silent Cold War Struggle with Soviet Submarines*, Newport Papers No. 16 (Newport, R.I.: Naval War College Press, 2003), pp. 27, 46.
80. "Cross Report: Volume 1," p. 154.
81. See Bruce Rule, "Faulty Intelligence Nearly 'Sank' SOSUS during the Cuban Missile Crisis," *IUSSCAA*, 2012, n. 4, www.iusscaa.org/articles/brucerule/brucerule_cable_2012.htm.
82. We obtain this figure by conservatively but unrealistically assuming a series of SOSUS arrays at San Francisco and Honolulu that each tracked the *Enterprise* for half of the straight-line distance between the two cities. Realistic array geometry means that the actual detection range was almost certainly larger.
83. Two other important factors—the detection threshold and array gain of the hydrophones—should be similar to the Cold War SOSUS experience. Comparative data on a fifth factor, transmission loss curves, is unavailable, but likely favors detections in the deeper Philippine Sea. For the full sonar range equation, see Stefanick, *Strategic Antisubmarine Warfare and Naval Strategy*, p. 305.
84. Cavitation occurs when water vaporizes into air pockets behind a propeller blade because of local fluid pressure dynamics. These bubbles swell and pop, creating "a steady, general roar" behind fast-moving propeller blades. This broadband noise is modulated by the passage of propeller blades through the asymmetric wake of a ship, creating a series of distinctive narrowband tonals at low frequencies. Ibid., p. 269. Unlike surface forces, submarines generally operate at speeds below the onset of cavitation.

U.S. surface forces are assured, and aircraft carriers generate additional acoustic impulses from the takeoffs and landings of their aircraft, as well as from the operation of steam catapults.[85] Although the acoustic characteristics of U.S. warships are classified, a conservative comparison is the sound from a bulk carrying merchant ship designed for a cruising speed of 16 knots, for which John Heine estimates blade rate tonals of 170 decibels.[86] Such a narrowband signature is 1000 to 5000 times louder (because the decibel scale is logarithmic) than that of the notoriously loud (135–140 decibels) Soviet Yankee-class SSBN operating at low, non-cavitating speeds.[87]

Second, low-frequency ambient noise levels in the Philippine Sea are similar to those that SOSUS faced during the Cold War. Compared to the Norwegian Sea, for example, where SOSUS had many of its Cold War contacts, the Philippine Sea has similar distant shipping noise and wind speeds, the two primary determinants of ambient noise.[88] Even under worst-case conditions, which included heavy rain, Stefanick estimates that during the Cold War a

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85. However, steam catapults are being phased out, and short takeoff and vertical landing aircraft have reduced signatures. William Howard, "Future of the Aircraft Carrier" (Washington, D.C.: Defense Science Board, October 2002), p. 57, https://apps.dtic.mil/sti/citations/ADA408129. U.S. destroyers and cruisers might try to operate below cavitating speed, but they would still produce blade rate tonals not associated with cavitation that were picked up by sonar during the Cold War, albeit at quieter source levels. Stefanick, *Strategic Antisubmarine Warfare and Naval Strategy*, p. 271.

86. Note that this ship is probably quieter than a U.S. warship. The sound level from propeller cavitation (and thus the blade rate modulation thereof) is a function of several variables, including the number of propeller blades, the rotation frequency of the shaft (speed), and the volume of water that vaporizes (related to propeller size). A U.S. warship would have multiple screws with larger blades and would typically operate at higher speeds than a bulk carrier. John C. Heine, "Acoustic Source Characteristics of Merchant Ships," in *Underwater Ambient Noise: Proceedings of a Conference Held at SACLANTCEN on 11–14 May 1982*, Vol. 2: Unclassified Papers, Part 1 (San Bartolomeo, Italy: NATO SACLANT ASW Research Center, 1982), pp. 2–4, 2–5, 2–7, and 2–13 through 2–14, figures 3–6, https://openlibrary.cmre.nato.int/handle/20.500.12489/69.

87. Table A2, appendix 1, in Eugene Miasnikov, "The Future of Russia's Strategic Nuclear Forces: Discussions and Arguments" (Dolgoprudny, Russia: Center for Arms Control, Energy, and Environmental Studies, Moscow Institute of Physics and Technology, 1995), https://spp.fas.org/eprint/snf0322.htm.

88. Measurements across four decades at two sites in the Philippine Sea give omnidirectional noise owing to distant shipping as 75 decibels. See R. D. Gaul et al., "Ambient Noise Analysis of Acoustic Data from the Philippine Sea" (Arlington, Va.: Office of Naval Research, February 26, 2009), p. 1. Stefanick gives best- and worst-case estimates for shipping noise in the Norwegian Sea as 70–85 decibels. Stefanick, *Strategic Antisubmarine Warfare and Naval Strategy*, pp. 352; 285, table A6–1, and 352, respectively. Young estimates that mean monthly wind speeds, depending on the season, range from 2.5 meters per second (5 knots) to 10 meters per second (19 knots) for the Philippine Sea, and from 7.5 meters per second (15 knots) to 15 meters per second (29 knots) for the Norwegian Sea. I. R. Young, "Seasonal Variability of the Global Ocean Wind and Wave Climate," *International Journal of Climatology*, Vol. 19, No. 9 (1999), p. 937, figure 1(b), https://doi.org/10.1002/(SICI)1097-0088(199907)19:9<931::AID-JOC412>3.0.CO;2-O. This would produce wind noise levels of 53 to 65 decibels in the Philippine Sea, and 60 to 73 decibels in the Norwegian Sea.

160-decibel source could have been detected more than 1,100 kilometers away in the Norwegian Sea. Given that ambient noise conditions are somewhat better in the Philippine Sea, and U.S. warships are much louder, detection ranges might be closer to Stefanick's best-case estimate for deep-water transmission: 3,500 to 4,600 kilometers.[89]

Hydrophones placed off the east coast of Taiwan would thus enable China to classify the signatures from U.S. surface forces, using the same techniques that SOSUS exploited. During the Cold War, the United States assembled a library of Soviet acoustic signatures, collected most notably by U.S. attack submarines engaged in intelligence missions. These signatures allowed acoustic systems to discriminate among Soviet submarine contacts by class and even "identify by hull number" individual Soviet subs.[90] U.S. surface forces likely produce similarly unique signatures. For instance, Heine notes that machinery-induced tonals are unpredictable across merchant ships and highly dependent "on the details of operation of a given machine and on the structure on which a given machine is fastened," implying high variance in such tonals. Likewise, propeller blade rate tonals are determined by the number of propeller blades, their diameter, and the blade rotation rate, which should allow ships to be classified by propeller type.[91] Reports of Chinese submarines following U.S. naval formations at sea suggest China's ability to collect such intelligence.[92]

Deep sound channel hydrophones would be difficult to defeat nonkinetically. For instance, a 2002 U.S. Department of Defense's Defense Science Board study on the future of the aircraft carrier concluded that "inherently, little can be done to quiet a CVN [aircraft carrier]." Even modern propeller designs cannot stop cavitation, while "the propulsion and power generating machinery of a CVN is hard-mounted to the underlying platforms on which

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Stefanick, *Strategic Antisubmarine Warfare and Naval Strategy*, p. 286, table A6-2. All noise estimates are for low frequency sounds of 50 hertz.

89. Stefanick, *Strategic Antisubmarine Warfare and Naval Strategy*, pp. 354–355, table A8-22.

90. Christopher Ford and David Rosenberg, *The Admirals' Advantage: U.S. Navy Operational Intelligence in World War II and the Cold War* (Annapolis, Md.: Naval Institute Press, 2005), pp. 103, 105. For several examples of how such identifying signatures were collected, see Sherry Sontag and Christopher Drew, *Blind Man's Bluff: The Untold Story of American Submarine Espionage* (New York: Public Affairs, 1998), pp. 173–179.

91. Heine, "Acoustic Source Characteristics of Merchant Ships," pp. 2–4, 2–7.

92. Franz-Stefan Gady, "Closest Encounter since 2006: Chinese Submarine Tailed US Aircraft Carrier," *Diplomat*, November 4, 2015, https://thediplomat.com/2015/11/closest-encounter-since-2006-chinese-submarine-tailed-us-aircraft-carrier/; and Dugald McConnell and Brian Todd, "Chinese Submarine Tracked U.S. Aircraft Carrier off Japan," *CNN*, November 5, 2015, https://www.cnn.com/2015/11/04/politics/chinese-submarine-u-s-aircraft-carrier-japan/index.html.

they sit," which makes reducing machinery tonals complicated and expensive.[93] U.S. forces may be able to successfully deceive Chinese sonar operators with decoys and other acoustic devices, but doing so would be technically and operationally demanding. During the U.S. Navy's UPTIDE acoustic deception exercises from 1969 to 1972, U.S. forces could delay acoustic acquisition of the carrier but not prevent it, and they could usually achieve the delay only by operating the carrier at speeds below those needed for flight operations.[94]

Deep sound channel hydrophones would also be difficult to destroy with kinetic attacks. Because the deep sound channel exceeds the crush depths of most pressure hulls, only highly specialized submarines or unmanned underwater vehicles (UUVs) can cut the array cables outside the small areas where they come ashore. Moreover, China would have a number of options for defending its sonar arrays. China could surround the approaches to the arrays with mines that are capable of distinguishing Chinese ships and submarines from other acoustic signatures.[95] It could also use active sonar—the emission of a sound pulse that reflects off the target—to cue its deep sound channel arrays to the approach of submarines or UUVs, which could then transmit the data to locally based Chinese ASW forces to rapidly prosecute the contact. Even if the United States did manage to damage China's hydrophone cables, Chinese repair ships would be able to operate under the cover of the dense air defenses that China could deploy on the island.[96] Repairing cables is neither easy nor cheap, but relative to the task of replacing large OTH radar facilities, making such repairs close to Chinese-controlled territory would be feasible.[97]

The best hope of interfering with deep sound channel surveillance is to attack the vulnerable processing stations where the data come ashore. But these stations could be very hard to find without human intelligence. Submarine cables can be buried both on land and at sea, and the buildings where data processing occurs are indistinguishable from other similar, nondescript military buildings. The potential target set could include multiple well-defended military locations across Taiwan and might encompass many hundreds of separate aim points.

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93. Howard, "Future of the Aircraft Carrier," p. 57.
94. "Cross Report: Volume 2," pp. 149–151; and Angevine, "Hiding in Plain Sight," pp. 87–88.
95. On China's mine warfare investments, see Andrew S. Erickson, Lyle J. Goldstein, and William S. Murray, *Chinese Mine Warfare: A PLA Navy "Assassin's Mace" Capability*, No. 3 (Newport, R.I.: China Maritime Studies Institute, U.S. Naval War College, 2009).
96. Thomas, Rehman, and Stillion, "Hard ROC 2.0," pp. 45–55; and Shlapak et al., *A Question of Balance*, pp. 60–61.
97. Bryan Clark, "Undersea Cables and the Future of Submarine Competition," *Bulletin of the Atomic Scientists*, Vol. 72, No. 4 (2016), p. 235, https://doi.org/10.1080/00963402.2016.1195636.

In sum, after reunification, China would have the opportunity to substantially improve its ocean surveillance capabilities by mounting deep sound channel hydrophone arrays on Taiwan's rapidly descending continental shelf. The U.S. experience with using SOSUS for long-range surveillance of Soviet submarines makes it highly plausible that China could create an analogous system to listen for U.S. surface ships. After all, surface vessels were routinely detected during the Cold War, U.S. surface forces have loud and distinctive signatures, and surface vessels would be located in waters with acoustic conditions that are as good or better than those surveilled during the Cold War. Furthermore, it would be difficult for the United States to defeat these deep sound channel hydrophone arrays, with or without kinetic attacks. As a result, if China were to deploy such hydrophones, U.S. policymakers seeking to disrupt China's long-range targeting complex could be forced to either escalate to anti-satellite attacks that they would prefer to avoid or to channel surface naval operations into a much smaller part of the Philippine Sea.

The Future of Chinese Ocean Surveillance

At least three developments in Chinese technology or force structure could alter our conclusions. First, if China cannot effectively transmit, process, and exploit its sensor data; use it to plan, coordinate, and execute missile attacks; or engineer its missiles to defeat the passive and active defenses of U.S. surface forces, then long-range attack would remain highly difficult, irrespective of China's surveillance capabilities, which would reduce the value of controlling Taiwan. Conversely, if China deploys many new, large imaging satellites, or if small satellites become so ubiquitous that attacks on them are cost ineffective, then it may become relatively easy to target U.S. surface forces, making additional hydrophone surveillance from Taiwan less valuable. Finally, if China blankets the sky with SIGINT triplet satellites, it might force U.S. surface vessels into "EMCON suicide": having to keep their radars off for so long that they become vulnerable to large air raids. Such an eventuality might force the United States into anti-satellite warfare regardless of who owned Taiwan. We consider these possibilities relatively unlikely in the near term.[98] But there are important uncertainties here, and space technology in particular bears watching.

98. See the online appendix, pp. 8–9.

The Longer-Term Military Implications of Chinese Control of Taiwan

Our analysis to this point has deliberately focused on what China could do with its existing force structure and technology if it were to gain control of Taiwan. In this section, we relax that assumption and briefly analyze some potential longer-term military implications of Chinese control of Taiwan if China were also to pursue major new capabilities. Specifically, we consider outcomes if China were to successfully transform its present fleet of largely diesel-electric submarines and a few noisy nuclear submarines into an equivalent fleet of much more quiet, advanced SSNs and SSBNs. We argue that these advancements in force structure and technology, when combined with access to Taiwan's eastern deep-water ports, would strengthen both China's ability to threaten the SLOCs and China's nuclear deterrent in ways that developing these capabilities in the absence of reunification would not. Although this analysis is necessarily more speculative, it demonstrates that over the long term reunification could offer China additional military advantages beyond those already discussed.

QUIET SSNS ON TAIWAN AND CHINA'S THREAT TO THE SLOCS

A large fleet of truly quiet SSNs deployed off the east coast of Taiwan would strengthen China's ability to threaten the SLOCs on which Korea, Japan, and other nations depend for seaborne oil supplies, as well as maritime trade more generally.[99]

Currently, China's fleet of Shang-class SSNs is relatively noisy, regardless of where they are based. According to the U.S. Office of Naval Intelligence, they are even noisier than the Soviet Victor III SSNs, which U.S. SOSUS-style arrays could detect during the Cold War.[100] Even if China bases these submarines on Taiwan, where they will become much more difficult to trail, the United States will retain at least a potential long-range detection capability against them by using deep sound channel hydrophones along the second island chain. If Chinese submarines grow quieter, however, then deep sound channel hydro-

99. Bonnie S. Glaser, Richard C. Bush, and Michael J. Green, "Toward a Stronger U.S.-Taiwan Relationship" (Washington, D.C.: CSIS, October 2020), p. 4.
100. "The People's Liberation Army Navy: A Modern Navy with Chinese Characteristics," (Washington, D.C.: Office of Naval Intelligence, November 2009); and Office of the Secretary of Defense, "Military and Security Developments Involving the People's Republic of China" (Washington, D.C.: U.S. Department of Defense, 2021), p. 49.

phones will lose their ability to perform this role, and China's quiet nuclear submarines will eventually become invulnerable to long-range detection.

This post-reunification outcome stands in contrast to what would happen if China acquired very quiet nuclear submarines but still had to base them inside the first island chain. Absent Chinese control of Taiwan, any submarines seeking to reach the open ocean to interdict maritime trade would still have to pass over RAP arrays nestled at the exits to the first island chain. This brief detection, which as discussed previously is possible even with very quiet nuclear submarines, would provide important cues to other U.S. ASW assets, such as maritime patrol aircraft and ships with ASW helicopters. If China were to control Taiwan, however, its submarines would never have to pass over these RAP arrays in order to threaten the SLOCs because they would be able to directly access the deep waters of the Philippine Sea, where they would also be too quiet to be detected by SOSUS arrays. Furthermore, the United States' most powerful ASW assets would be unable to search for them near Taiwan once the island is populated with hostile radars, aircraft, and missiles. In short, were China able to develop truly quiet nuclear submarines post-reunification, the United States would be unable to detect them using either RAP or deep sound channel arrays.

This invulnerability would be a boon to any Chinese efforts to engage in attacks against maritime traffic in the SLOCs. Nuclear submarines are a vital platform for such attacks because they can operate at essentially unlimited ranges for long periods of time. Traditionally, global shipping has proven resilient in the face of threats to the SLOCs because of the ability to reroute traffic outside the range of hostile forces. For example, even the closure of the Suez Canal from 1967 to 1975 had only a minimal impact on global trade because shipments went around the Cape of Good Hope instead, albeit with some increase in cost.[101] If China were to acquire a quiet force of SSNs, however, then it could threaten maritime traffic as it approached northeast Asian ports. This would represent a significant change from the status quo, or even from a world in which China developed quiet nuclear submarines but had to base them inside the first island chain.

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101. Euan Graham, *Japan's Sea Lane Security: A Matter of Life and Death?* (New York: Routledge, 2005), pp. 24, 30, 49; Eugene Gholz and Daryl G. Press, "Protecting 'The Prize': Oil and the U.S. National Interest," *Security Studies*, Vol. 19, No. 3 (2010), p. 462, https://doi.org/10.1080/09636412.2010.505865; Michael Levi, "The Enduring Vulnerabilities of Oil Markets," *Security Studies*, Vol. 22, No. 1 (2013), pp. 132–138, https://doi.org/10.1080/09636412.2013.757171; and John H. Noer, "Southeast Asian Chokepoints: Keeping Sea Lines of Communication Open," No. 98 (Washington, D.C.: National Defense University Strategic Forum, December 1996), pp. 2–3, https://apps.dtic.mil/dtic/tr/fulltext/u2/a394162.pdf.

Whether China would actually seek to make such an investment in a large fleet of modern SSNs is hard to surmise. Doing so would be a costly and difficult project, and the potential benefits of an anti-SLOC campaign are not so clear-cut as to make this choice an obvious one. On the one hand, air and surface convoying ultimately defeated German anti-SLOC campaigns in the two battles of the Atlantic during the world wars. On the other hand, the victorious states were able to win only by means of a wildly disproportionate effort; and where such efforts could not be made, as in the case of World War II Japan, the result was economic and strategic strangulation. Moreover, the victors in the second battle of the Atlantic were in some sense "saved by the bell" from pro-submarine innovations coming online as the war ended.[102] Some past revisionist naval powers, such as Nazi Germany and the Soviet Union, made large investments in building a modern submarine force, but others, such as Wilhelmine Germany and imperial Japan, arguably underinvested in submarines in order to build capital fleets.[103]

The utility and probability of China building a large fleet of quiet SSNs is therefore an open question. Not in question is that control of Taiwan would open up a new military option for China, one that several previous great powers thought very useful, with a much greater potential payoff than if Taiwan were to remain independent.

Quiet SSBNs on Taiwan and the U.S.-China Nuclear Balance

A fleet of quiet SSBNs deployed off the east coast of Taiwan would render the sea leg of China's nuclear deterrent more survivable, enabling China to pose a more credible threat of sea-launched nuclear attack on the continental United States.

Currently, China's SSBN force is highly constrained in the threat it can pose to the United States due to its basing inside Chinese coastal waters. The JL-2, China's submarine-launched ballistic missile carried aboard its six Type 094 SSBNs, has a reported range of only 7,200 kilometers.[104] As a result, the Yellow Sea is the only part of China's coastal waters from which this missile can reach

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102. Cote, *The Third Battle*, pp. 2, 7, 12–15.
103. On these cases, see Robert S. Ross, "China's Naval Nationalism: Sources, Prospects, and the U.S. Response," *International Security*, Vol. 34, No. 2 (Fall 2009), pp. 49–52, https://doi.org/10.1162/isec.2009.34.2.46. On Japan, see David C. Evans and Mark R. Peattie, *Kaigun: Strategy, Tactics, and Technology in the Imperial Japanese Navy, 1887–1941* (Annapolis, Md.: Naval Institute Press, 2015), pp. 492, 496.
104. Hans M. Kristensen and Matt Korda, "Nuclear Notebook: Chinese Nuclear Forces, 2021," *Bulletin of the Atomic Scientists*, November 15, 2021, https://thebulletin.org/premium/2021-11/nuclear-notebook-chinese-nuclear-forces-2021/.

the United States, and even then probably just Guam, Hawaii, Alaska, and possibly Seattle.[105] But the Yellow Sea is shallow and crowded with dense maritime traffic, making it a poor operating environment for SSBNs. Other parts of China's coastal waters are more suited for SSBN operations—for example, the northern and central portions of the South China Sea—but the JL-2 cannot reach the continental United States from these areas.[106]

In order to reach Washington, therefore, Chinese SSBNs need to either carry missiles of significantly longer range, or launch them from well outside China's coastal waters, or, ideally, both.[107] China is already working on the first solution, developing a longer-range JL-3 missile to carry aboard its next-generation Type 096 SSBN, and China may pursue a bastion strategy in the South China Sea or Bohai Gulf once this missile is operational.[108] But the range of even the JL-3 is believed to be only 10,000 kilometers, meaning that it would still need to launch from well outside China's coastal waters in order to target more than the northwestern edge of the United States.[109] Range aside, it is also far from clear that a bastion strategy is optimal for the survivability of China's SSBN force, given the likely balance of ASW capabilities between the two countries inside China's coastal waters.[110] These limitations point to why pursuing the second solution—being able to launch from deep in the Pacific, closer to the United States—remains important.[111]

Currently, the noisiness of China's SSBNs makes it very unlikely that they would survive the journey from China's inner seas to any launch positions in the western Pacific without being detected, trailed, and if necessary targeted by U.S. ASW forces. Open sources estimate that China's Jin-class SSBNs are "two orders of magnitude louder than the top Russian or American SSBNs," which is likely why China is already working on the Type 096 boats.[112] But as long as they are based in China's coastal waters, even the Type 096s or a more quiet future SSBN would likely be detected on a journey out of the first island

105. Ibid.; and Cote, "Invisible Nuclear-Armed Submarines, or Transparent Oceans?" p. 34.
106. Tong Zhao, *Tides of Change: China's Nuclear Ballistic Missile Submarines and Strategic Stability* (Washington, D.C.: Carnegie Endowment for International Peace, 2018), pp. 31–32.
107. Ibid., pp. 25–33.
108. "Military and Security Developments Involving the People's Republic of China," 2021, p. 91.
109. Kristensen and Korda, "Nuclear Notebook: Chinese Nuclear Forces, 2021."
110. Eleanor Freund, "Blind Man's Bluff? Strategic Anti-Submarine Warfare and U.S.-China Nuclear Stability," draft paper (Cambridge: Massachusetts Institute of Technology, May 21, 2020).
111. Ankit Panda, "China Conducts First Test of New JL-3 Submarine-Launched Ballistic Missile," *Diplomat*, December 20, 2018, https://thediplomat.com/2018/12/china-conducts-first-test-of-new-jl-3-submarine-launched-ballistic-missile/.
112. Kristensen and Korda, "Nuclear Notebook: Chinese Nuclear Forces, 2021."

chain because of their vulnerability to RAP arrays that could hear them at the exits.

As with quiet SSNs, basing a quiet SSBN force on Taiwan would solve this problem. It would obviate the need to pass over the RAP arrays, and the boats would be too quiet to be detected by deep sound channel arrays. China's quiet SSBNs would thus become essentially invisible to U.S. ASW forces as they traveled from Taiwan to launch locations from which they could then comfortably reach the entire United States.

Evaluating the broader impact of this improvement in China's nuclear capabilities would require an assessment of the survivability of the rest of China's nuclear forces. For example, if one believes that China's land-based nuclear forces already, or will soon, provide China with a robust second-strike capability, then strengthening the sea-based leg would not necessarily represent a significant change from the status quo.[113] If, on the other hand, one views China's current SSBN force as highly vulnerable, and China's land-based forces as vulnerable to U.S. counterforce attacks, then China's ability to land SLBMs on Chicago and Washington could meaningfully reshape the nuclear balance.[114]

Ultimately, the degree to which survivable Chinese SSBNs matter depends on whether or to what extent the United States actually derives benefits from being able to hold Chinese nuclear forces at risk. Certainly, the United States has long behaved as though it values damage limitation, consistently making force posture and declaratory choices that seek to avoid a state of mutual nuclear vulnerability with China.[115] Although some experts point out the difficulty of meaningfully limiting damage in an all-out nuclear war with China, and the dangers of attempting to do so, others argue that such a capability is both feasible and valuable, deterring China in peacetime and conferring coercive leverage in a crisis or war.[116] For those in the former camp, a more capable

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113. Charles L. Glaser and Steve Fetter, "Should the United States Reject MAD? Damage Limitation and U.S. Nuclear Strategy toward China," *International Security*, Vol. 41, No. 1 (Summer 2016), pp. 49–98, https://doi.org/10.1162/ISEC_a_00248.

114. Wu Riqiang, "Living with Uncertainty: Modeling China's Nuclear Survivability," *International Security*, Vol. 44, No. 4 (Spring 2020), pp. 84–118, https://doi.org/10.1162/isec_a_00376; and Keir A. Lieber and Daryl G. Press, "The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence," *International Security*, Vol. 41, No. 4 (Spring 2017), pp. 9–49, https://doi.org/10.1162/ISEC_a_00273.

115. Brad Roberts, *The Case for U.S. Nuclear Weapons in the 21st Century* (Stanford, Calif.: Stanford University Press, 2015), p. 153; and Brendan Rittenhouse Green, *The Revolution That Failed: Nuclear Competition, Arms Control, and the Cold War* (New York: Cambridge University Press, 2020).

116. Glaser and Fetter, "Should the United States Reject MAD?"; Brendan Rittenhouse Green et al.,

Chinese SSBN force would be a neutral or even stabilizing development. For those in the latter camp, however, a more robust Chinese SSBN force would portend negative political and strategic costs for the United States. In particular, experts from this latter camp worry that entering a condition of deep nuclear stalemate with China could make U.S. allies much more concerned about the United States' willingness to defend them if it exposed the U.S. homeland to greater risk of nuclear attack.[117] Our analysis cannot resolve this debate but merely points out that control of Taiwan is a potential input to the long-term nuclear balance.

Finally, it seems plausible, but is by no means guaranteed, that China will actually pursue the steps needed to maximize the opportunities for SSBN deployment afforded by control of Taiwan. China would need to master much more advanced quieting technology and devolve nuclear launch capability to submarine commanders in a manner antithetical to China's tradition of highly centralized party control of nuclear weapons.[118] Yet the fact that China is already investing in an SSBN force despite its present geographic constraints suggests that the country might be willing to make the needed investments if those constraints were loosened.[119] Certainly, the Soviet Union made comparable choices, investing heavily in SSBNs even though it possessed an enormous land-based nuclear arsenal.[120]

Conclusion

This article has argued that Chinese control of Taiwan would significantly hinder the ability of U.S. naval forces to operate in the Philippine Sea compared with the status quo. In particular, we argue that Chinese capabilities for submarine warfare and ocean surveillance would improve post-reunification.

"The Limits of Damage Limitation," *International Security*, Vol. 42, No. 1 (Summer 2017), pp. 193–199, https://doi.org/10.1162/ISEC_c_00279; and Austin Long, "U.S. Nuclear Strategy toward China: Damage Limitation and Extended Deterrence," in Caroline Dorminey and Eric Gomez, eds., *America's Nuclear Crossroads: A Forward-Looking Anthology* (Washington, D.C.: Cato Institute, 2019), pp. 47–55.

117. Austin Long, "U.S. Nuclear Strategy toward China." For criticism, see Glaser and Fetter, "Should the United States Reject MAD?"

118. Tong Zhao, *Tides of Change*; and Caitlin Talmadge, "The U.S.-China Nuclear Relationship: Why Competition Is Likely to Intensify" (Washington, D.C.: Brookings Institution Press, September 2019), p. 4, https://www.brookings.edu/research/china-and-nuclear-weapons/.

119. On the history of China's investments, see Andrew Erickson et al., eds., *China's Future Nuclear Submarine Force* (Annapolis, MD: Naval Institute Press, 2007), pp. 59–113.

120. On Soviet investments, see Brendan Rittenhouse Green and Austin Long, "Conceal or Reveal? Managing Clandestine Military Capabilities in Peacetime Competition," *International Security*, Vol. 44, No. 3 (Winter 2019/20), pp. 71–73, https://doi.org/10.1162/isec_a_00367.

Furthermore, if over the longer term China were to develop a large fleet of truly quiet SSNs and SSBNs, basing them on Taiwan would enable China to threaten the SLOCs and to strengthen its sea-based nuclear deterrent in ways that it is unlikely to otherwise be able to do.

Our analysis is military rather than political, yet understanding the military value of Taiwan naturally raises questions of policy: Specifically, what do our findings mean for the question of whether the United States should defend Taiwan? Clearly, our findings about the island's military value are a possible argument in favor of keeping the island in friendly hands. Yet how decisive that argument is depends on a number of other variables. Some of these we highlighted in our analysis, such as long-term developments in Chinese technology and force structure that would make the military value of the island higher or lower. Some of these we did not analyze but have referenced because they are already part of the public debate, such as the island's status as a democratic ally. And some depend on one's preferred grand strategy: whether one is committed to the current approach of containing any expansion of Chinese power through political commitments to the entire suite of U.S. regional allies and partners, including Taiwan, and significant forward military presence; or prefers a China policy with a more circumscribed security perimeter that excludes Taiwan and retains commitments only to core treaty allies, while reducing forward-deployed forces; or seeks to loosen all such political and military commitments as part of a more restrained approach.

Our findings highlight that whichever of these three grand strategies one prefers, each will carry important and often unrecognized costs given Taiwan's military value. For those committed to defending Taiwan and keeping current U.S. alliances, the findings demonstrate just how costly this proposition is likely to be. The military value of Taiwan adds to the list of potential Chinese motives for reunification beyond the purely nationalist impulses that are most commonly referenced. Overcoming the asymmetry of stakes and deterring China could therefore require abandoning strategic ambiguity and making a crystal clear commitment to the island's defense.[121] But ending strategic ambiguity could provoke the crisis that it is trying to prevent. It almost certainly would heighten pressures for both the United States and China to arms race in anticipation of conflict, with all the attendant dangers of an intensified competition.[122] Similarly, even if a policy of strategic clarity could deter a Chinese at-

121. Haass and Sacks, "American Support for Taiwan Must Be Unambiguous."
122. See Bonnie Glaser in "Three Experts on U.S. Role and Response Options in Taiwan-China Conflict," *PBS NewsHour*, video, starting at 3:52, December 15, 2021, transcript at

tempt to take the island, it would likely spur Chinese efforts to compensate for some of the military disadvantages of not controlling Taiwan, further raising peacetime tensions.

Alternatively, if one prefers a more circumscribed security perimeter that excludes Taiwan but retains treaty allies and some forward-deployed military forces, our analysis shows that pursuing this approach will carry real military costs. It would become much more dangerous for U.S. surface forces to conduct their missions if Chinese submarines and hydrophones were deployed off the coast of Taiwan. The United States might need to pursue decoys to spoof these hydrophones, or prepare operational concepts for its surface forces that would work in areas outside the likely hydrophone detection zone, or devise ways to cut Chinese hydrophone cables in any future war. More realistically, U.S. officials would want to double down on their efforts to find non-kinetic ways to disrupt the Chinese satellites that would rely on the hydrophone data to cue their searches.

Diplomatically, it would become much more arduous for the United States to reassure its allies during peacetime. Precisely because ownership of Taiwan would endow China with military advantages, Korea, the Philippines, and Japan would likely demand strong and renewed demonstrations of U.S. commitment if the United States severed its relationship with Taiwan. Japan, in particular, would almost certainly be concerned that a reduced U.S. ability to operate in the Philippine Sea would improve China's coercion or attack capability, especially given the proximity of Japan's southernmost islands to Taiwan.

Over the longer term, our analysis suggests that regional allies would also likely fear a growing Chinese threat to the SLOCs, even if China were never to actually mount such a campaign, and that they would worry that a stronger sea-based leg of China's nuclear deterrent would reduce the credibility of U.S. extended deterrent commitments, even if the crisis or war in which such a commitment would be tested never arrived. Allies' anticipation of these dangers would almost certainly drive them to seek greater reassurance from the United States in the form of tighter defense pacts, greater military aid, and more visible forward-deployed U.S. forces in the region, including nuclear forces stationed on or near allied territory, and perhaps nuclear sharing. East Asia could come to resemble late Cold War Europe, with U.S. allies demanding

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https://www.pbs.org/newshour/show/three-experts-on-u-s-role-and-response-options-in-taiwan-china-conflict.

demonstrations of their patron's commitment in the face of doubts about the military balance.[123] If the Cold War is any guide, such steps could themselves heighten risks of nuclear escalation in a crisis or war.

Finally, our findings also highlight the costs of the third grand strategic approach mentioned previously: loosening all U.S. political and military commitments in the region, both to Taiwan and to treaty allies.[124] The military value of Taiwan provides a persuasive rationale for why Japan might fight to defend it, even if the United States were to forsake a commitment to do so. Consequently, the United States might be drawn into a major power war in Asia, willingly or not. Either way, such a war would be devastating. Yet upsetting the status quo's delicate equilibrium by ceding this militarily valuable piece of territory could make such a war more likely. Overall, this dilemma points back to the core argument in favor of present U.S. grand strategy: that U.S. alliance commitments and forward military presence exert a deterring and constraining effect on conflict in the region.[125]

Ultimately, our findings do not decisively identify which of these three grand strategies is best because that judgment depends on factors outside the scope of our analysis. Nevertheless, the military value of Taiwan is an important input to U.S. policy toward the island, and a full appreciation of it highlights the distinct but substantial costs that the United States would pay with various grand strategic approaches to the region. Which costs are worth paying is in the end a political question, but it is one that can only be evaluated with a firm understanding of the military realities that we have assessed in this article.

123. Ivo H. Daalder, *The Nature and Practice of Flexible Response: NATO Strategy and Theater Nuclear Forces since 1967* (New York: Columbia University Press, 1991); and Brendan Rittenhouse Green and Caitlin Talmadge, "When the Strong Suffer What They Must: Asymmetric Alliances and Nuclear Escalation Risk," draft paper (2020).
124. Posen, *Restraint*, pp. 69–134.
125. Stephen G. Brooks, G. John Ikenberry, and William C. Wohlforth, "Don't Come Home, America: The Case against Retrenchment," *International Security*, Vol. 37, No. 3 (Winter 2012/13), pp. 33–40, https://doi.org/10.1162/ISEC_a_00107.