Center for Strategic and Budgetary Assessments

CHINA'S CHOICES

A NEW TOOL FOR ASSESSING THE PLA'S MODERNIZATION

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Cover: Xi Jinping attends the launch of China's first indigenously-produced aircraft carrier, the *Shandong*, at a ceremony in Sanya, Hainan Province, on December 17, 2019. Credit: Li Gang/ Xinhua/Alamy

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Executive Summary

All militaries confront resource tradeoffs. Policymakers must meet competing demands over limited resources, including longer-term investments in future capabilities and shorter-term spending on readiness. The recent debates within the U.S. defense establishment about the proper balance between readiness, force structure, and modernization demonstrate that these tradeoffs can be quite painful and contentious.

As China and the United States enter a period of intensifying military competition, understanding the defense tradeoffs that the two sides must entertain and evaluating their likely consequences will become ever more important. Yet, there has been a stark asymmetry in perceptions about the resourcing challenges on both sides of the Pacific. The U.S. defense community is all too aware of its own constraints. Few in the community, however, have engaged in the deep study of Beijing's tradeoffs in military modernization. Without a better sense of China's own resourcing constraints and the associated vulnerabilities, policymakers lack the critical insights to holistically assess the state of the competition and develop effective strategies.

CSBA's China Strategic Choices Tool: Assessing Beijing's Tradeoffs

To advance the policy community's understanding of China's budgetary choices, relative tradeoffs, and constraints on military modernization, the Center for Strategic and Budgetary Assessments (CSBA) has created a one-of-a-kind model for exploring Beijing's defense portfolio. The China Strategic Choices Tool (SCT) is a user-friendly, web-based application that allows participants to step into the shoes of Chinese statesmen and defense planners to make high-level resourcing and force structure decisions regarding the future of the People's Liberation Army (PLA).

The China SCT simulates investments in and divestments from a broad portfolio of PLA capabilities, ranging from strategic nuclear weapons to major surface combatants to tactical fighter aircraft. Similar to a production possibilities curve in economics, the tool allows users to generate alternative force structures within a budgetary constraint, requiring users to offset their investments by equivalent divestments. These tradeoffs represent the kinds of difficult resourcing choices that Chinese decision makers must confront as they plan the PLA's modernization.

The China SCT is designed to contribute to ongoing analysis and debates about China's military modernization and the Sino-American military rivalry.

First, the tool offers a model for users to consider China's resourcing calculus and the feasible range of China's future force structures. Users are given the opportunity to play the role of Chinese leaders. In that role, users make decisions that rebalance the PLA, bending its future trajectories in different directions. Through such Red team exercises, participants can gain valuable insights about China's potential choices and trade-offs. The tool also links the users' resourcing decisions to alternative PLA force structures over a coming ten-year period. The China SCT thus encourages participants to think about Chinese strategy and investments in terms of a long-term competition.

Second, by using the China SCT, along with CSBA's existing U.S. Strategic Choices Tool, policy-relevant insights can be generated regarding the competitive dynamics and potential interactions between the United States and China. The U.S. and China tools allow reallocations in defense spending over a ten-year period, broken into two five-year periods (e.g., 2022–2026 and 2027–2031), which opens the door to interactive exercises and wargames. Within a workshop, competing U.S. and China teams can assess each other after the first five-year move and then react to their opponent's actions in the second five-year move.

Third, this tool can advance the development of U.S. and allied competitive strategies against China. Through iterative exercises and wargames using the new China tool, either alone or in conjunction with the U.S. tool, hypotheses can be developed and refined regarding how the United States can capitalize on China's cost constraints and defend against China's attempts to take advantage of U.S. limitations.

Importantly, alternative force structures produced using the China SCT are not predictions of the future. Rather, the outputs are meant to facilitate analysis and debate about the PLA's trajectory and the linkages between China's defense strategy, operational concepts, force structure, and resources. The China SCT functions as a hypothesis-generating tool: experts and generalists alike can select a range of force structure choices that serve as points of departure for further discourse.

Relative Costs, Not Absolute Costs

Central to CSBA's methodology for constructing the China SCT is the concept of relative cost. Specifically, this report details how *relative* cost estimates—as opposed to *absolute* cost estimates—can be used to evaluate China's defense modernization tradeoffs and provide insight into the PLA's potential modernization trajectories.

The term *relative cost* refers to the ratio of resource expenditure required by two different platforms or units. In other words, the ratio shows how much one platform costs in terms of a different platform. For instance, based on CSBA's costing methodology—described in detail in this report—the procurement cost of one J-20 fighter aircraft equals approximately one-seventh the procurement cost of one Type 052D destroyer. Conversely, the procurement cost of one Type 052D is roughly equal to the procurement cost of seven J-20s. Although it is necessary to price each platform and unit in terms of a common unit of measurement (this study uses 2018 U.S. dollars), the unit of measurement is not the analytical focus of this methodology and is simply a means to establish relative cost tradeoffs.

Our analytic approach—using relative cost relationships to analyze PLA budgetary tradeoffs and alternative modernization trajectories—does not attempt to resolve all of the challenges posed by Beijing's budgetary opacity. The goals of this project do not include estimating the absolute size of the Chinese defense budget, estimating the affordability of Chinese defense spending as a percentage of gross domestic product (GDP), or estimating the absolute cost of any particular PLA platform. Given the lack of Chinese defense budget data and the inevitable disagreement that would emerge around such estimates, we have intentionally avoided using our cost estimates for those purposes.

Insights on the Affordability of PLA Modernization

The PLA's modernization goals appear affordable, at least over the next decade.

- We developed a cost-informed 2021–2031 PLA force structure projection (see Appendix) as a starting point for China SCT users. Although the exact platform-level numbers in this projection will almost assuredly be off by some degree once the future comes to pass, the projection overall indicates that the PLA has the resources necessary to continue its modernization over the 2020s. The PLA can maintain, expand, and improve its regional defense forces, including short-range fighter aircraft, land-based ballistic and cruise missiles, frigates, missile boats, and diesel-electric submarines. At the same time, the PLA can continue building a range of large power projection platforms for global operations, including aircraft carriers, cruisers, destroyers, blue water logistics vessels, strategic bombers, and strategic transport and refueling aircraft.

- The PLA, particularly the Navy, will face increasing strain from operations and maintenance (O&M) costs over the next decade due to its rapid procurement of large surface combatants and aircraft carriers. Yet O&M costs do not appear to pose a major obstacle to the PLA's continued modernization over the 2020s.

- The force structure projection relies on our platform and unit-level cost estimates, which include research and development, procurement, O&M, and personnel costs tied to force structure. The projected annual budget real growth rate varies by PLA service, based on our assessment of Beijing's defense strategy and force structure requirements, though force structure-related spending in the tool generally increases over 2021–2031 at approximately a three percent real annual growth rate.

- Although our analysis indicates that this force structure projection is plausible, small changes in certain factors, such as the PLA's annual budget growth rate and the inflation rate, can substantially expand or constrain the PLA's resources for modernization, especially in the out years. CSBA's force structure forecast is therefore simply a starting point, rather than a prediction, for assessing Chinese defense modernization. The China SCT also has the flexibility to incorporate differing budgetary assumptions.

Preliminary Insights and Trends on the PLA's Future Modernization

CSBA organized three exercises in which a total of six teams, composed predominantly of American national security experts, used beta versions of the tool to assess China's plausible defense modernization trajectories. Although these exercises were organized primarily to test the tool's features and assumptions, several preliminary themes on the PLA's modernization emerged from the decisions of the various teams. The suppositions below are the consensus expectations of the players.

- **Consolidating Power Regionally, Then Expanding Globally**: The sequencing of China's force structure investments may indicate the prioritization of China's strategic objectives. Rising powers generally consolidate power regionally and then seek to expand globally. Similarly, in our exercises, teams prioritized the further development of near seas capabilities first, followed by overseas power projection capabilities and posture. This sequencing would emphasize that regional goals, especially Taiwan, continue to have precedence over China's global ambitions. The PLA's balance between regional and global force structure investments thus serves as an indicator of Beijing's strategic priorities.
- **Trading Away PLA Army Force Structure for Platforms in Other Domains**: All teams in CSBA's exercises chose to pay for investments in their priority categories through cuts to the PLA Army, usually including cuts to modernization spending, reductions in Army force structure, and decreases in Army personnel levels. Participants generally concluded that, despite large reductions to PLA Army personnel and units over the last several decades, further reductions were needed to free up funds sufficient to realize China's strategic goals in the maritime direction. Teams thus accepted greater risk along China's continental fronts. The exercises indicate that further PLA Army force structure reductions could be an important indicator of the pace and direction of future PLA modernization.
- **Retiring Legacy Air Capacity to Invest in Modern Air Capabilities**: In general, teams sacrificed legacy air capacity to free up the funds necessary to field more modern, though smaller, air forces that could project power farther from China's borders. Team choices resulted in a PLA Air Force that, while still fighter-heavy, reflected a more diverse

composition by 2031. Similarly, the PLA Naval Aviation fleet was generally reduced in terms of aircraft inventory but boasted greater capabilities by the end of the 2031 planning period. Whether and how quickly the PLA Air Force and PLA Naval Aviation proceed in this direction is an important indicator of China's military modernization goals, the PLA's operational concepts, and Beijing's potential timelines for engaging in future conflicts.

Assessing American Expectations of the PLA's Modernization

Since the People's Republic of China was founded, American experts have repeatedly been surprised by Beijing's strategic decisions, the capabilities of the Chinese defense industrial base, and the PLA's ability to undertake new types of operations. Given that the beta exercises predominantly consisted of players from the United States, the exercise results necessarily reflect the expectations, preconceptions, and assumptions among American experts about likely developments in Beijing's defense strategy, operational concepts, and force planning over the coming decade. These exercises therefore provided a means to clearly define certain American expectations and subject those assumptions to inquiry.

- **Underestimating Beijing's Incentives to Develop and Expand Nuclear Forces**: In our exercises, most participants were hesitant to invest in Chinese nuclear forces. Only three of six teams invested in any existing or prospective Chinese nuclear capabilities, and none of the teams chose to invest in silo-based nuclear forces, with two teams retiring some silo-based missiles. In what was an unintended experiment, these exercises occurred prior to June 2021 news reports about the expansion of Chinese nuclear missile silos. The teams' decisions may reflect projections based on the momentum of longstanding historical trends, namely the limited aims of China's nuclear strategy and the modest size of its nuclear arsenal. Yet, in the case of Chinese nuclear modernization, linear extrapolations of past trends could lead to grave strategic misjudgments. Theater-level nuclear weapons are relatively cheap but powerful tools that could be rapidly expanded to undermine U.S. extended deterrence and credibility.

- **Undervaluing Conflicting Force Structure Requirements in the Near and Far Seas**: Rather than needing small surface combatants that can hide and survive throughout the near seas, several participants believed that the PLA Navy could use general-purpose large surface combatants in both near and far seas conflicts. These teams also believed that large surface combatants could accomplish lower-end missions, even though they may not fulfill those missions as efficiently as smaller vessels. Moreover, large surface combatants in littoral areas and enclosed seas face formidable operational constraints and risks. Depending on U.S. and allied posture and capabilities in the Western Pacific, the PLA could be compelled to stretch its resources by procuring and operating separate near seas and far seas capabilities.

- **Assuming Additional PLA Army Force Reductions Over the 2020s**: All teams made considerable cuts to PLA Army force structure, modernization funding, and personnel—sometimes cutting well over 100,000 Army personnel—to generate funds for investment priorities in other domains. Yet PLA Army reductions may prove difficult to implement due to the extent of previous reductions, China's external and internal security requirements, and the persistent bureaucratic strength of the Army. Just as with assessments of China's future nuclear forces, analysts should be careful in carrying past trends on Army force structure reductions into the future without factoring in changes in context and driving forces.

Implications of the Exercises for Allied Strategy

- **The allies should prepare to face a China that poses both a regional and, increasingly, a global military threat.** Beijing seems likely to have sufficient resources to maintain a large continental army and a substantial regional force structure composed of air, sea, and land-based missile capabilities, while simultaneously expanding and modernizing its air, sea, and amphibious capabilities for global power projection. The PLA can also place bets on a variety of platforms and technologies, increasing the complexity and uncertainty that allied planners face in assessing future operational scenarios involving Chinese forces.

- **For Washington and its allies, pursuing cost imposing strategies against China will become increasingly important**, especially as the U.S. defense budget likely faces relatively flat real growth in the years ahead. Given China's resources, any one cost imposition strategy will not bankrupt the PLA. But, over time, the cumulative effects of multiple cost imposition strategies that stress the PLA in various areas and directions could prevent the PLA from mustering sufficient resources to accomplish its major objectives.

- **If the United States seeks to limit the PLA's ability to fight and win conflicts in the Western Pacific, it would behoove allied policymakers to reduce Beijing's desire and ability to further downsize the PLA Army**. Allied policymakers should thus seek to raise China's perceived continental threats. Aiding the Indian and South Korean militaries in their modernization efforts, particularly in the ground domain, could induce PLA leaders to maintain large ground forces. The Allies could also consider opportunistic ways to increase the relative bureaucratic strength of the PLA Army, through means such as publicizing corruption within or encouraging defections from the other PLA services.

- **The Allies have strong incentives to limit China's technological advancements in both defense-related areas and a wide range of dual-use categories**. The PLA's modernization depends in part on the Chinese defense industrial base's ability to develop and manufacture advanced capabilities. The Allies have considerable agency in shaping Chinese technological developments, and policymakers should consider a range of means to limit China's absorption of Western technology and know-how.

- **More broadly, the Sino-U.S. security competition extends beyond the military domain to other areas critical to China's overall security strategy, including technology, trade, finance, and politics.** U.S. and allied policymakers must consider a variety of military and non-military means to impose costs on China's military modernization and uphold the existing U.S.-led international order.

Future Applications of the China Strategic Choices Tool

The preliminary insights above highlight the analytical promise of future China SCT exercises and wargames structured around focused research questions. The China SCT could be applied in many ways to advance the study of the PLA's modernization and of U.S. and allied competitive strategies toward China.

- Exercises could be organized in which Red teams rebalance PLA force structure, potentially given certain strategic guidance or timelines. Other exercises could feature competing Blue and Red teams, using CSBA's U.S. SCT and China SCT, respectively, in order to study the strategic interaction between the two sides. Separately, the U.S. and China SCTs can be integrated into wargames to assess how various force structures may perform in plausible future conflicts.
- Several other novel types of SCT exercises exist. Future Green–Red exercises would enrich the perspective of how the PLA may develop in the future, in part by balancing out potential biases among U.S. players. Blue–Green–Red exercises, potentially with integrated wargames, could examine ways of complicating PLA planning and stretching PLA force structure requirements. Finally, exercises could be organized to examine the effects of tectonic geopolitical shifts resulting from major conflicts, such as a successful Chinese conquest of Taiwan.

We expect the China SCT to generate analytically rich debates about the specific tradeoffs Beijing policymakers face and the potential alternative trajectories of PLA modernization. Moreover, through various exercises, workshops, and wargames that feature the China SCT, CSBA anticipates developing new networks between communities that are too often isolated from each other, including PLA experts, cost analysts, economists, defense planners, intelligence analysts, senior military officers, defense industry experts, and defense policymakers. The substantive lessons and professional connections developed at these events will be critical in helping the entire U.S. national security community prepare for the greatest strategic challenge of our era for years to come.

Introduction

All militaries confront resource tradeoffs. Policymakers must meet competing demands with limited resources, including longer-term investments in future capabilities and shorter-term spending on readiness. The recent debates within the U.S. defense establishment about the proper balance between readiness, force structure, and modernization demonstrate that these tradeoffs can be quite painful and contentious.

As China and the United States enter a period of intensifying military competition, understanding the defense tradeoffs that the two sides must entertain and evaluating their likely consequences will become ever more important. Yet, there has been a stark asymmetry in perceptions about the resourcing challenges on both sides of the Pacific. The U.S. defense community is all too aware of its own dilemmas. Few in the community, however, have engaged in the deep study of Beijing's tradeoffs in military modernization. Without a better understanding of China's own resourcing constraints and the associated vulnerabilities, policymakers lack the critical insights to holistically assess the state of the competition and develop effective strategies.

To address this gap, the Center for Strategic and Budgetary Assessments (CSBA) has created a one-of-a-kind model for exploring the tensions and tradeoffs within Beijing's defense portfolio. The China Strategic Choices Tool (SCT) is a user-friendly, web-based application that allows participants to step into the shoes of Chinese statesmen and defense planners to make high-level resourcing and force structure decisions regarding the future of the People's Liberation Army (PLA).

The China SCT simulates investments in and divestments from a broad portfolio of PLA capabilities, ranging from strategic nuclear weapons to major surface combatants to tactical fighter aircraft. Similar to a production possibilities curve in economics, the tool allows users to generate alternative force structures within a budgetary constraint, requiring users to offset their investments by equivalent divestments. These tradeoffs represent the kinds of difficult resourcing choices that Chinese decision makers must confront as they plan the PLA's modernization.

In addition to introducing the tool and the rigorous methodology that informs its functions, this report's purpose is to illustrate how policymakers and analysts can better understand and assess Beijing's budgetary choices, relative tradeoffs, and constraints on defense modernization. Specifically, this report details how *relative* cost estimates—as opposed to *absolute* cost estimates—can be used to evaluate China's defense modernization tradeoffs and provide insight into the PLA's potential modernization trajectories. The term *relative cost* refers to the ratio of resource expenditure between two different platforms or units. In other words, the ratio shows how much one platform costs in terms of a different platform. For instance, based on CSBA's costing methodology—described in detail in this report—the procurement cost of one J-20 fighter aircraft equals approximately one-seventh the procurement cost of one Type 052D destroyer. Conversely, the procurement cost of one Type 052D is roughly equal to the procurement cost of seven J-20s. Although it is necessary to price each platform and unit in terms of a common unit of measurement (this study uses 2018 U.S. dollars), the unit of measurement is not the analytical focus of this methodology and is simply a means to establish relative cost tradeoffs.

The tool and this report are the product of a multi-year research effort into better understanding Beijing's defense costs and tradeoffs. To pierce the opacity surrounding China's defense budget and its larger calculations about military investments, we employed a variety of classic and novel methods—including expert opinion and applied statistics—to estimate the relative costs of PLA platforms and units, and to forecast fiscally plausible alternative force structures. CSBA hosted two workshops with cost analysts, PLA experts, defense industry analysts, financial experts, and economists to present the team's preliminary findings and receive feedback. Members of the research team presented analysis at multiple external workshops and conferences and published preliminary research and analysis.[1] These events, presentations, and written products generated constructive feedback that improved CSBA's ability to capture the relative costs of PLA force structure, acquisitions, and other initiatives and to present that information in a manner salient for strategic decisions. Once the China SCT was created, CSBA then hosted three exercises in which leading scholars and practitioners used the tool. These experts evaluated the China SCT's ability to capture the kinds of decisions Beijing may be weighing in future force planning, and they provided input that aided CSBA in refining the tool's methodological integrity and policy utility.

The China SCT is designed to contribute to ongoing analysis and debates about China's military modernization and the Sino-American military rivalry (Figure 1).

1 Harrison Schramm, Lukas Autenried, and Jack Bianchi, "Strategic Cost Estimation," *ORMS Today*, October 7, 2019, available at https://pubsonline.informs.org/do/10.1287/orms.2019.05.06/full/; Jack Bianchi, "Strategic Cost Estimation: Understanding Resource Tradeoffs in China's Defense Modernization Efforts," paper presented at the Naval Postgraduate School Acquisition Research Symposium, April 20, 2020, available at https://calhoun.nps.edu/bitstream/handle/10945/64785/SYM-AM-20-080.pdf. Members of the research team also presented research findings at the International Cost Estimating and Analysis Association annual workshop and Military Operations Research Society workshops.

FIGURE 1: PROJECT SCOPE

Goals	Not Goals
✓ Assess Chinese military's potential resourcing tradeoffs and range of future force structures	✗ Estimate total Chinese defense spending in absolute terms
✓ Generate policy-relevant insights about U.S.-China peacetime competitive dynamics	✗ Determine China's defense spending as a percentage of GDP
✓ Advance development of U.S. competitive strategies against China	✗ Estimate the absolute cost of individual PLA weapons platforms or military units
✓ Create a methodology for examining potential force structure tradeoffs that can be broadly applied to other countries	✗ Generate a single prediction of China's future force structure

First, the tool offers a model for users to consider China's resourcing calculus and the feasible range of China's future force structures. Participants are given the opportunity to play the role of Chinese leaders. In that role, users make decisions that rebalance the PLA, bending its future trajectories in different directions. Through such Red team exercises, users can gain valuable insights about China's potential choices and trade-offs. The tool also links the participants' resourcing decisions to alternative PLA force structures over a coming ten-year period. The China SCT thus encourages users to think about Chinese strategy and investments in terms of a long-term competition.

Second, by using the China SCT, along with CSBA's existing U.S. Strategic Choices Tool, policy-relevant insights will be generated regarding the competitive dynamics and potential interactions between the United States and China. The U.S. and China tools allow reallocations in defense spending over a ten-year period, broken into two five-year periods (e.g., 2022–2026 and 2027–2031), which will enable interactive exercises and wargames. Within a workshop, competing U.S. and China teams will assess each other after the first five-year move and then react to their opponent's actions in the second five-year move.

Third, this tool can advance the development of U.S. and allied competitive strategies against China. Through iterative exercises and wargames using the new China tool, either alone or in conjunction with the U.S. tool, hypotheses can be developed and refined regarding how the United States can capitalize on China's cost constraints and defend against China's attempts to take advantage of U.S. limitations.

Importantly, our analytic approach—using relative cost relationships to analyze PLA budgetary tradeoffs and alternative modernization trajectories—does not attempt to resolve all of the challenges posed by Beijing's budgetary opacity. The goals of this project do not include estimating the absolute size of the Chinese defense budget, estimating the affordability of Chinese defense spending as a percentage of gross domestic product (GDP), or estimating the absolute cost of any particular PLA platform. Given the lack of Chinese defense budget data and the inevitable disagreement that would emerge around such estimates, we have intentionally avoided using our cost estimates for those purposes.

Chapter 1 addresses U.S. and allied policymaker requirements for defense planning and the need for a tool that offers more insights into the PLA's modernization trajectories over the medium-to-long term. This chapter argues that establishing *relative* cost relationships between PLA platforms and units—as opposed to *absolute* cost relationships—is a promising method for advancing analysis of the PLA's modernization tradeoffs and constraints. This methodology bypasses the lack of program-level budgetary data in China, overcoming an obstacle that has long hindered Western analysis of the PLA.

Chapter 2 is a technical review of the cost and force structure estimation methodologies that CSBA employed to create the China SCT. This chapter is intended to provide transparency for anyone seeking details on the assumptions, inputs, and models that informed the tool. CSBA's research objective was not to get such estimates precisely right, but rather to provide a policy-relevant framework for strategically meaningful evaluation and choices. The framework is designed to accommodate future updates as additional information on Beijing's costs becomes available.

Chapter 3 provides some preliminary policy-relevant insights generated from the China SCT and its early employment in structured exercises. Our findings indicate that the PLA's force structure modernization ambitions appear affordable over the next decade. Although these early exercises were intended primarily to refine the tool and its estimation methods, they have already identified trends and insights on PLA modernization that merit further study and that demonstrate the analytical promise of the tool.

Finally, Chapter 4 addresses ways in which the China SCT could be applied in future exercises, wargaming, and research to aid study of the force structure tradeoff decisions Beijing faces as well as U.S. and allied options for developing and implementing competitive strategies toward China.

CHAPTER 1

Planning for a Dynamic China

Policymaker Requirements for Defense Planning

Forecasting the future threat environment is a perilous business. Information on future, let alone current, adversary capabilities and intentions is often limited, and future events are subject to uncertainty, chance, chaos, and human choice.[2] Nonetheless, the success of the U.S. military in future conflicts will depend on the bets political and military leaders make today. Policymakers and planners are routinely presented with a range of potential strategy, concept, and budgetary options, but given scarce resources, these leaders are forced to select a limited set of choices based on their best assessment of the severity and scale of future threats.

The gravity of these decisions is underscored by their long-term consequences. Due to lengthy research and development timelines and the long average service life of U.S. military platforms and weapon systems, for example, the effects of today's defense acquisition decisions will be felt for decades to come. Beyond procuring hard capabilities, areas such as doctrine, organization, training, and personnel require years—even decades—to adjust to developments in strategies, concepts, and capabilities. Force planning decisions should be based on an assessment of the security environment over a 10- to 20-year period, but policymakers are often asked to make decisions given narrow or piecemeal analysis of future threats. Personal experience, bias, or intuition, along with bureaucratic inertia and political and industrial interests, therefore become the basis for many research and development or investment decisions. History is replete with cases where political and military leaders planned for threats that either never fully materialized or evolved unexpectedly.

To better plan for a variety of plausible future security challenges, defense planners would benefit from tools that encourage deeper thinking and stimulate debate on the varying ways

2 Nicholas Rescher, *Predicting the Future: An Introduction to the Theory of Forecasting* (Albany, NY: State University of New York Press, 1998), pp. 133–156.

a given threat may develop over time. Although anticipating the particular context and characteristics of a future contingency is nearly impossible, such methods would help ensure that policymakers are at least closer in their understanding of future threats and that they make force planning and posture decisions today that are sufficiently flexible to meet a range of plausible contingencies.[3]

In no case are such tools more necessary than for the threat posed by China's modernizing military. As the beneficiary of decades of double-digit budget growth, with continued growth expected in the decade ahead, the PLA is rapidly acquiring military capabilities sufficient to overturn existing military balances and challenge the U.S.-led security architecture in the Indo-Pacific and beyond.[4] Beijing possesses the means to make a variety of big bets on how it can deter and win future wars. These developments may have massive and potentially tragic consequences for the post-Cold War strategic balance, regionally and globally.

Yet China is undoubtedly subject to resource constraints. Despite its remarkable economic growth since 1978, policymakers in Beijing must grapple with allocating finite resources. China's resource constraints may become even sharper over the coming decade as Beijing confronts slowing economic growth rates, the higher recurring costs incurred in fielding and sustaining a larger modern military force, rising social demands from Chinese citizens for a range of cradle-to-grave benefits, and major structural problems, including large private debt, pollution, and a rapidly aging population.

American and allied policymakers would benefit from a deeper and more nuanced understanding of the bets China is making and the opportunity costs of those strategic choices. American analysts—indeed, most defense analysts—tend to focus on their own weaknesses and their adversaries' strengths, but identifying the force structure tradeoffs facing Chinese civilian and military leaders is of particular importance. Beijing's subsequent choices will serve as leading indicators of the direction of the PLA's modernization and the strategic goals that the Chinese Communist Party (CCP) has prioritized in the near and long term. Understanding how China's resource constraints impact PLA force structure can also help to bound the range of future PLA developments and therefore provide a more realistic basis for assessing the PLA's future and conducting U.S. and allied defense planning. Moreover, examining the underlying dynamics that drive certain PLA force structure decisions may

3 As Colin Gray argues, it is impossible for today's defense planners to meet future requirements because future events have not occurred yet. Defense planners should instead aim to be "right enough" in their major decisions and implement planning processes and postures that are adaptable as events unfold. Gray realistically concludes, "The motto for a Ministry of Defence ought to be 'minimum (avoidable) regrets'." Colin S. Gray, "Strategic Thoughts for Defense Planners," *Survival* 52, no. 3, pp. 159–178.

4 Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China, 2021* (Arlington, VA: Office of the Secretary of Defense, 2021); Toshi Yoshihara, *Dragon Against the Sun: Chinese Views of Japanese Seapower* (Washington, DC: Center for Strategic and Budgetary Assessments, 2020), available at https://csbaonline.org/research/publications/dragon-against-the-sun-chinese-views-of-japanese-seapower; and Toshi Yoshihara and Jack Bianchi, *Seizing on Weakness: Allied Strategy for Competing with China's Globalizing Military* (Washington, DC: Center for Strategic and Budgetary Assessments, 2021), available at https://csbaonline.org/research/publications/seizing-on-weakness-allied-strategy-for-competing-with-chinas-globalizing-military.

identify avenues for U.S. and allied policymakers to favorably influence and shift Chinese force structure decisions.

Difficulties in Forecasting Future Trends and Events

Despite substantial interest and research, humans are still quite poor at predicting the future.[5] Predictions are typically based on "pattern fitting," in which the future is expected to conform in some way to data from past events.[6] Yet, even if complete and perfect information on a given variable in the past and present were attainable—which usually is not the case, especially in the social sciences and certainly in the case of Chinese military studies—the direction of future events is impacted by uncertainty, chance, chaos, and human choice in ways that are unpredictable.[7] Recent research efforts intended to advance mankind's predictive abilities still show that predictions of specific events more than five years ahead are usually no better than chance.[8]

Fortunately, predicting an adversary's future force structure ten to fifteen years in the future is more feasible than simply predicting whether an event will happen. Traditional military platforms have long service lives, typically measured in decades. The U.S. military's average fighter aircraft age is over 25 years old, for instance.[9] Forecasting force structure is similar to forecasting demographic changes in a given population; both are slow-moving processes that require decades to change and are therefore amenable to a certain level of estimation.[10]

Yet predictions of an adversary's future force structure that do not account for variability are potentially misleading and may lead to dangerous outcomes when used in analysis and decision making. Defense policymakers and planners must consider alternative future force structures that an adversary could realistically field with a given pool of resources. In military studies and defense planning, future adversary capabilities are usually predicted as

5 This section primarily focuses on prediction in the social sciences. In the natural sciences, accurate predictions can sometimes be made looking decades or more ahead, such as in calculating astronomical movements and tidal flows. For an overview of predictive methods, see Jack Bianchi, "Why Predicting, and Planning for, a Single Future for China is Unwise," in Ross Babbage, ed., *Which Way the Dragon? Sharpening Allied Perceptions of China's Strategic Trajectory* (Washington, DC: Center for Strategic and Budgetary Assessments, 2020), pp. 55–65.

6 Rescher, p. 86. Predictions based on past observations carry with them the implicit assumption that future events will be governed by the same underlying processes that produced the previous observations. A data-based predictive model is limited by a number of factors, such as variables not observed and chance. It is sometimes the case that the predictive 'signal' is overwhelmed by the 'noise' of randomness.

7 Rescher, pp. 133–156.

8 Philip E. Tetlock, *Expert Political Judgment: How Good Is It? How Can We Know?* 2nd ed. (Princeton, NJ: Princeton University Press, 2017), pp. 67–86.

9 Mark Gunzinger, Carl Rehberg, Lukas Autenried, *Five Priorities for the Air Force's Future Combat Air Force* (Washington, DC: Center for Strategic and Budgetary Assessments, 2020), pp. ii.

10 Unanticipated exogenous shocks, such as war, pandemic, or famine, could still impact demographic or force structure estimates, and therefore remain a limitation in forecasting.

single-point estimates. Popular and academic writings are full of these types of estimates.[11] In the United States, the wargames routinely conducted by the Department of Defense, defense industry, and defense-related research institutes also frequently assume a static adversary force list provided by the designers of a given game. These wargames are often set ten to thirty years in the future and are critical for developing assessments of the future operational environment and for informing today's defense investments.

Point estimates of future Chinese or other adversary capabilities can serve important purposes, such as highlighting a need to prepare for one potential direction of the future threat. Furthermore, wargame design varies based on a given research objective, and it is not feasible or desirable for all, or even most, wargames to feature multiple or dynamic adversary force lists.

Nevertheless, when viewed as a portfolio, future wargame and planning efforts must consider an adversary's ability to readjust its strategy and reallocate resources across a variety of programs and forces. Wargames and other exercises that allow for a dynamic adversary and include various adversary force structures will encourage U.S. decision makers to consider strategies and plans that are robust and flexible in the face of uncertainty. Moreover, games and exercises that account for a thinking adversary and recognize the move-countermove cycle between two adversaries in force planning can help policymakers better understand how one's actions could intentionally and unintentionally affect an adversary.[12]

China's Strategic Ambitions and Military Modernization

China's expanding strategic ambitions and rapidly modernizing military indicate Beijing has the will and, increasingly, the capability to challenge and potentially overturn by force the U.S.-led security order in the Western Pacific and globally. Although Western analysts have become increasingly alarmed about China's ability to deter and potentially win future conflicts, there remain stark disagreements about the particular direction of China's future

11 Office of Naval Intelligence, Farragut Technical Analysis Center Naval Platforms Department, *China: Naval Construction Trends vis-à-vis U.S. Navy Shipbuilding Plans, 2020–2030* (Washington, DC: Department of Defense, Office of Naval Intelligence, February 6, 2020), available at https://fas.org/irp/agency/oni/plan-trends.pdf; James Fanell, "China's Global Navy Today—Today's Challenge for the United States and the U.S. Navy," *Naval War College Review* 73, no. 4, Autumn 2020, p. 25; Rick Joe, "Predicting the Chinese Navy of 2030," *The Diplomat*, February 15, 2019, available at https://thediplomat.com/2019/02/predicting-the-chinese-navy-of-2030/; and Christopher P. Carlson, "PLAN Force Structure Projection Conception, A Methodology for Looking Down Range," *China Maritime Studies Institute, Naval War College*, no. 10, November 2020, available at https://digital-commons.usnwc.edu/cgi/viewcontent.cgi?article=1009&context=cmsi-maritime-reports.

12 Action-reaction dynamics only partially explain force structure developments between two competitors. Other factors, such as strategic culture, bureaucratic inertia, inter-service rivalries, and domestic political incentives and constraints, also certainly come into play. For example, see Thomas G. Mahnken, Gillian Evans, Toshi Yoshihara, Eric Edelman, and Jack Bianchi, *Understanding Strategic Interaction in the Second Nuclear Age* (Washington, DC: Center for Strategic and Budgetary Assessments, 2019), pp. 5–10.

military modernization efforts.[13] Charting Beijing's alternative future force structures is critical for U.S. policymakers, who must assess how the Chinese military may evolve in the coming years and make choices today on how to meet that range of potential threats.

Xi Jinping has laid out China's strategic goals in addressing his self-proclaimed "Chinese Dream." While the Chinese Dream is ambiguous, likely intentionally so, some of its major components are still evident through Xi's speeches and writings. Xi's Dream at least includes:

1. Maintaining and strengthening the political monopoly of the Chinese Communist Party;
2. Realizing the two centenary goals, namely the creation of a "moderately prosperous" society by 2021 and the achievement of "a great modern socialist country that is prosperous, strong, democratic, culturally advanced, harmonious, and beautiful" by 2049; and
3. Unification with Taiwan.

Beyond Taiwan, although perhaps not explicitly part of the Chinese Dream, Beijing has long intended to defend what it views as its valid territorial claims, from maritime claims in the East and South China Seas to claims along the Himalayan border.

In addition to domestic and regional concerns, China's ambitions are increasingly global. China's growing economy has become dependent on international trade and resource imports, and Beijing now has an interest in protecting sea lines of communication between China and overseas markets. Chinese state-owned and private companies are investing large sums abroad, starting with the "Going Out" campaign to promote overseas investment in the late 1990s and, more recently, through Xi's Belt and Road Initiative. Chinese nationals are increasingly found in far-flung locations abroad due to these growing trade and investment ties, and Beijing feels compelled to ensure their safety in the event of crisis or conflict. Chinese policymakers also view their country's growth as tied to developing the global commons, including fisheries and hydrocarbon deposits.

To advance the Chinese Dream and protect China's growing global interests, Xi has announced a complementary "Strong Military Dream." In his 2017 speech to the National People's Congress, Xi explained that "building people's forces that obey the Party's command, can fight and win, and maintain excellent conduct is strategically important to achieving the two centenary goals and national rejuvenation."[14] Xi has set future markers for the PLA's development, decreeing that the PLA's modernization be "basically completed"

13 For an overview of the institutional and bureaucratic dynamics within the U.S. defense community that contribute to conflicting perspectives of and diagnoses for the threat posed by the PLA, see Christopher Dougherty, "Gradually and then Suddenly: Explaining the Navy's Strategic Bankruptcy," *War on the Rocks*, June 30, 2021, https://warontherocks.com/2021/06/gradually-and-then-suddenly-explaining-the-navys-strategic-bankruptcy/.

14 "Full Text of Xi Jinping's Report at the 19th CPC National Congress," *China Military*, November 5, 2017, available at http://english.chinamil.com.cn/view/2017-11/05/content_7812833.htm.

by 2035 and that the PLA field "world-class forces" by 2050.[15] Like the Chinese Dream, the precise form that this military dream will take is unclear, but Xi's pronouncements indicate that he intends for the PLA to become a fully modern military that is on par with the United States by midcentury.

Even before Xi, the PLA has benefited from sustained real budget increases since the mid-1990s. Beijing's largesse has funded a decades-long modernization process, which has included the development and procurement of advanced weapons platforms and systems. Compared to the Cold War-era, when the PLA's conventional forces were largely confined to the Asian continent and focused on preparing for large-scale ground warfare with the Soviet Union, the PLA is now increasingly capable of engaging in complex military operations beyond China's borders in all warfighting domains.

The PLA's ongoing modernization is seriously concerning to the United States and its allies and partners. China's rising military power casts doubt on the ability of the United States to defend regional partners and allies, including Taiwan, Japan, the Republic of Korea, and the Philippines, which have been subjected to growing Chinese military threats in recent years. China's modernizing forces will also strain the ability of the United States, which faces persistent defense budget constraints and competing global security demands, to maintain the overall stable post-1945 balance of power in the Indo-Pacific.[16] If regional states perceive Washington as a weak or unreliable security partner, they could choose to accommodate Chinese power or pursue destabilizing options, such as the development of nuclear weapons. Given these potentially grave consequences, U.S. and allied defense policymakers need to refocus their strategies, plans, and investments to counter the PLA's growing capabilities and to ensure that Beijing does not further erode the existing military balance.

Despite the PLA's recent advancements and Xi's stated modernization aims, the exact magnitude and character of the future threat posed by the PLA remain uncertain. Modern military equipment is expensive to procure and to operate and maintain. As pressure on China's defense budget likely increases over the coming decade, Beijing will confront difficult choices concerning the type of force structure the PLA should field. The military capabilities required for potential conflicts along China's immediate periphery in the near seas, for example, are quite different from those needed to project power globally.[17] Consequently, China's leaders will also need to prioritize among their country's expanding security goals, which now range from ensuring the Chinese Communist Party's survival to unifying with Taiwan to protecting Chinese investments and nationals overseas. In the coming years,

15 Ibid.

16 For a recent overview of U.S. defense budget tradeoffs being considered within the U.S. national security community, see: *America's Strategic Choices: Defense Spending in a Post-COVID-19 World* (Washington, DC: Center for Strategic and Budgetary Assessments and the Ronald Reagan Institute, 2021), https://csbaonline.org/research/publications/americas-strategic-choices-defense-spending-in-a-post-covid-19-world.

17 Toshi Yoshihara and Jack Bianchi, *Seizing on Weakness: Allied Strategy for Competing with China's Globalizing Military* (Washington, DC: Center for Strategic and Budgetary Assessments, 2021), pp. 51–65.

Beijing's leaders will likely face growing tensions between their expanding commitments and their constrained resources. These tensions will have a significant influence on the PLA's modernization.

The Limitations of Chinese Defense Budget Data and Analysis

Analyzing the clear quantitative indicators contained in a country's defense budget can complement qualitative threat assessments and provide greater strategic clarity on the character and direction of a particular threat. But, in the case of China, Beijing's reticence to release detailed defense expenditure data has long hindered Western analysis of the PLA's budget and, more broadly, China's strategic intentions, military strategy, and force planning.

A country's defense budget, particularly over a period of years, can provide a wealth of strategic insights. First, information on changes in budgetary spending levels, even if only at the topline level, can offer clues on changes in a country's strategic intentions or threat perceptions. More detailed budget data at the program level, including the types of capabilities being procured and the levels of spending on particular capabilities, can furnish even clearer indications on the direction and aims of a country's strategy (e.g., continental or maritime; regional or global; defensive or offensive). Second, spending at the platform and unit level can enable assessments of the current and future threats posed by an adversary's forces. Budgetary decisions and trends allow one to infer the future trajectory of a country's force structure. Analysts can then evaluate the various ways those forces may be used together as a system to accomplish operational objectives in potential conflicts. Third, budget data offers a means to assess the degree of alignment between a country's stated strategy and its actual investments. Mismatches could indicate that a country is perhaps strategically overplaying its hand or understating its true ambitions. Finally, the defense budget can indicate the short- and long-term affordability of a nation's defense spending as a percentage of GDP, which can be useful for forecasting the change in magnitude of a given threat over time and preparing one's forces accordingly.[18]

For China, these types of budget-derived insights have been elusive. The primary official figures available to foreign analysts are the annual PLA topline budget and, for a limited set of years, a breakdown of the PLA budget into three defense-wide categories: equipment, training and operations, and personnel (Figure 2).[19] Few other data points are

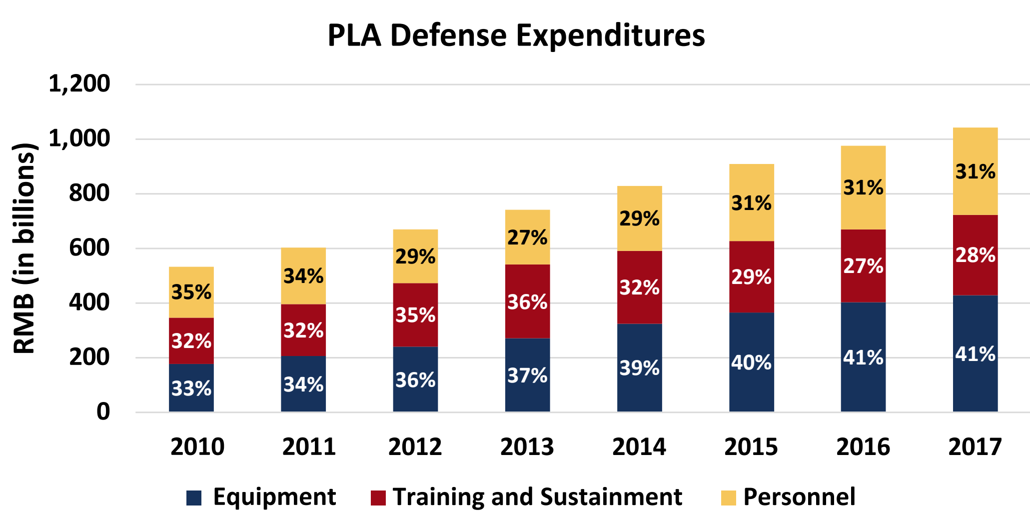
18 This list is informed by Richard A. Bitzinger, "Analyzing Chinese Military Expenditures" in *The People's Liberation Army and China in Transition*, Stephen J. Flanagan and Michael E. Marti, ed. (Washington, DC: National Defense University Press, 2003), p. 179; and Office of Research and Reports, *The Role of ORR in Economic Intelligence* (Langley, VA: Central Intelligence Agency, 1951), pp. 1–3.

19 The most recent breakdown by equipment, training and operations, and personnel is available in State Council Information Office of the People's Republic of China, *China's National Defense in the New Era* (Beijing: Foreign Language Press, 2019). Definitions of these categories can be found in Dennis Blasko, Chas W. Freeman, Stanley A. Horowitz, Evan S. Medeiros, and James C. Mulvenon, *Defense-Related Spending in China: A Preliminary Analysis and Comparison With American Equivalents* (Washington, DC: The U.S.–China Policy Foundation, 2007), pp. 10–11.

available. Beijing does not release figures on spending by service, unit, or platform/system. Information on Chinese arms exports is available through media reports and other open sources, yet only a total sale amount is available for most transactions, impeding an analyst's ability to calculate an average unit cost for each of the various items or services included in each arms deal.[20]

Given data limitations, Western research on China's defense budget to date primarily focuses on overall spending levels and addresses topics such as: categories of spending included in or excluded from the official budget; defense budgeting processes; and estimates of the difference between official and actual defense spending.[21] One analyst has even developed a military purchasing power parity index to compare what China's defense budget can purchase relative to other countries' defense budgets.[22]

FIGURE 2: OFFICIAL PLA EXPENDITURES BY CATEGORY, 2010-2017[23]



20 SIPRI Arms Transfers Database, Stockholm International Peace Research Institute, available at https://www.sipri.org/databases/armstransfers.

21 Nan Tian and Fei Su, *A New Estimate of China's Military Expenditure* (Solna, Sweden: Stockholm International Peace Research Institute, 2021); Adam P. Liff and Andrew S. Erickson, "Demystifying China's Defence Spending: Less Mysterious in the Aggregate," *The China Quarterly*, 216, December 2013, pp. 805–830; Blasko et al., *Defense-Related Spending in China*; Keith Crane, Roger Cliff, Evan S. Medeiros, James C. Mulvenon, William H. Overholt, *Modernizing China's Military: Opportunities and Constraints* (Santa Monica, CA: RAND, 2005); Shaoguang Wang, "Estimating China's Defence Expenditure: Some Evidence From Chinese Sources," *The China Quarterly*, 147, 1996, pp. 889–911.

22 "Nominal Spending Figures Understate China's Military Might," *The Economist*, May 1, 2021, available at https://www.economist.com/graphic-detail/2021/05/01/nominal-spending-figures-understate-chinas-military-might.

23 State Council Information Office of the People's Republic of China, *China's National Defense in the New Era* (Beijing: Foreign Language Press, 2019).

Chinese defense budget estimates at more detailed levels are rare, though a select number of analysts have ventured to advance our understanding of China's defense spending. These analysts tend to develop approximate, yet defensible, spending estimates at more granular levels based on qualitative information about PLA strategy, modernization programs, technological capabilities, and other factors. Examples of these types of estimates include PLA spending estimates by service[24] and platform-level cost estimates.[25] Other forward-looking analysis has examined the affordability of certain modernization programs given rough estimates of future defense spending and platform-level procurement costs.[26] One analyst estimated future PLA procurement across multiple domains given historical spending trends, estimated platform costs, and other qualitative information.[27] One group even generated bottom-up estimates of Chinese defense spending by service from 2000 to 2019 in categories including procurement, operations and maintenance, and personnel through a combination of methods.[28]

Despite the efforts of these teams and individuals, public discussion and analysis of China's defense budget have remained stymied, unable to move much beyond the topline. Budget allocations reflect the hard choices being made by a nation's leaders and, in China's case, the lack of public budgetary data at the platform level, let alone by service, has masked these tradeoff decisions and debates. At least in the public domain, the U.S. defense community has lacked comprehensive medium- to long-term forecasts of PLA procurement, operations and maintenance, and personnel spending at a platform level that would enable the analysis of plausible tradeoffs and alternative future force structures. Portfolio analysis of how Beijing's program-level budget decisions connect to individual service strategies or to the implementation of Xi's Strong Military Dream has remained challenging.

Charting a New Path: Assessing Relative Budgetary Tradeoffs and Alternative Trajectories in Chinese Force Structure Planning

Analysis of China's defense budget can be advanced by focusing on the *relative* costs between different types of PLA platforms and units, rather than the *absolute* size of China's

24 Craig Caffrey, "China Defence Budget," Janes, 2018.

25 Gabe Collins, "How Much Do China's Warships Actually Cost?" *The Diplomat*, June 18, 2015, available at https://thediplomat.com/2015/06/how-much-do-chinas-warships-actually-cost/.

26 Richard Bitzinger and Chong-Pin Lin, *The Defense Budget of the People's Republic of China* (Washington, DC: Center for Strategic and Budgetary Assessments, 1994); Richard Bitzinger, "Analyzing Chinese Military Expenditures," in Stephen J. Flanagan and Michael E. Marti (Eds.), *The People's Liberation Army and China in Transition* (Washington, DC: National Defense University Press, 2003) pp. 177–193.

27 Roger Cliff, *China's Military Power: Assessing Current and Future Capabilities* (Cambridge, England: Cambridge University Press, 2015).

28 Jacqueline Deal, "China Could Soon Outgun the U.S.," *Politico*, May 27, 2021, https://www.politico.com/newsletters/politico-china-watcher/2021/05/27/china-could-soon-outgun-the-us-493014. Within this research, these historical bottom-up spending estimates were then projected forward at the topline level using 2000–2019 compound annual growth rates.

military budget or the absolute cost of a given PLA platform. Such analysis can deepen discussions of PLA force planning tradeoffs and the budget's connection to Chinese military strategy, operational concepts, and capabilities.

The term *relative cost* refers to the ratio of resource expenditure between two different platforms or units. In other words, the ratio shows how much one platform costs in terms of a different platform. For instance, based on CSBA's costing methodology—described in detail below—the procurement cost of one J-20 fighter aircraft equals approximately one-seventh the procurement cost of one Type 052D destroyer. Conversely, the procurement cost of one Type 052D is roughly equal to the procurement cost of seven J-20s. Although it is necessary to price each platform and unit in terms of a common unit of measurement (this study uses 2018 U.S. dollars), the unit of measurement is not the analytical focus of this methodology and is simply a means to establish relative cost tradeoffs.

This type of cost-informed analysis can build off the lessons learned from previous U.S. government efforts to estimate the defense spending of the Soviet Union.

Historical U.S. Government Analysis of Soviet Force Structure Tradeoffs

Over the course of the Cold War, the U.S. government dedicated substantial effort to estimating the Soviet Union's defense expenditures. This labor started within the Central Intelligence Agency (CIA) in the early 1950s and gradually encompassed other government organizations, especially the Defense Intelligence Agency (DIA), until the work ended in the early 1990s. The techniques applied in this research continue to be relevant today in assessing the PLA's alternative futures.

The goals of the Soviet-focused analytic effort were ambitious and expansive. The U.S. government sought to estimate total Soviet defense spending, calculate defense spending as a percentage of Soviet GDP, and forecast the Soviet Union's future force structure based on estimates of Soviet cost constraints. This effort included two distinct types of Soviet defense budget estimates: 1) an estimate denominated in Soviet rubles, to assess defense costs and spending tradeoffs from the perspective of Soviet policymakers; and 2) an estimate denominated in U.S. dollars, to convey what the cost of the Soviet effort would be if the United States attempted to replicate it.[29] The latter estimate was more nuanced than many understood it to be. The dollar values were not the simple result of converting rubles to dollars at a set exchange rate. Rather, they were intended to express the cost the U.S. government would incur if it copied the Soviet defense program (i.e., procured and maintained the same type and number of Soviet tanks, fighters, ships, etc.) using U.S. wage and material costs. The dollar estimate of Soviet defense spending was intended to provide a methodologically sound

29 Noel E. Firth and James H. Noren, *Soviet Defense Spending: A History of CIA Estimates, 1950–1990* (College Station, TX: Texas A&M University Press, 1998), pp. 9–33.

common basis for an American audience—conversant in U.S. dollars instead of rubles—to comprehend and compare the scale of respective Soviet and American defense efforts.

From the outset of this work in the 1950s, due to doubts about the veracity of official Soviet statistics, CIA analysts committed to a labor-intensive process of developing cost estimates at the platform level in order to create a bottom-up estimate of overall Soviet defense spending. In the 1950s, due to the lack of detailed Soviet budget figures, the CIA developed estimates of Soviet defense procurement, operations and maintenance, and military construction that were primarily based on U.S. data, usually with some modification for the characteristics of individual pieces of Soviet equipment.[30] By the late 1970s and 1980s, many of the cost estimates had been tailored to Soviet production efficiencies and operating practices through rigorous and detailed multidisciplinary studies of various aspects of Soviet defense spending.[31]

Today, collective memory of this U.S. government effort overly focuses on the absolute estimates of total Soviet defense spending (in rubles and U.S. dollars) and the controversy and politicization that emerged within the U.S. policy community about the accuracy of these absolute numbers.[32] The government's estimates of total Soviet defense spending drew intense criticism starting in the mid-1970s, as the absolute ruble and dollar estimates underwent major updates. In particular, because of changes in Soviet price levels, updated Soviet cost data, and changes in cost estimation methodologies, the absolute numbers sometimes changed drastically, undercutting confidence in the estimates, even if the revisions increased the accuracy of the estimate.[33] Critics also pointed to various other methodological challenges, particularly the "index number problem."[34] In general terms, this problem results from distortions that arise from selecting a common price base for international (or intertemporal) economic comparisons due to differences in relative costs (e.g., the capital to labor cost ratio) between the two countries (or time periods). In short, when U.S. prices were used

30 Firth and Noren, pp. 18–20.

31 For examples of standout multidisciplinary studies that combined expertise in Russian military studies, cost analysis, defense manufacturing, and operations and maintenance, see Office of Strategic Research, *The Economics of Soviet Military Aircraft Maintenance* (Langley, VA: Central Intelligence Agency, 1979) and Office of Strategic Research, *Cost Implications of Soviet Ship Design and Construction Practices* (Langley, VA: Central Intelligence Agency, 1981). Many studies were contracted out to U.S. defense industry given their expertise in manufacturing and maintaining defense platforms. Firth and Noren, pp. 66–68.

32 Works that address these estimates and the related controversies, as well as provide a reassessment of the CIA's estimates include Firth and Noren, pp. 140–191; Marc Trachtenberg, "Assessing Soviet Economic Performance During the Cold War: A Failure of Intelligence?," *Texas National Security Review* 1, no. 2, 2018, pp. 76–101; Franklyn D. Holzman, "Soviet Military Spending: Assessing the Numbers Game," *International Security* 6, no. 4, 1982, pp. 78–101.

33 Firth and Noren, pp. 51–65, 87–93.

34 On the index number problem, see Holzman, "Soviet Military Spending," pp. 78–101; and Firth and Noren, pp. 223–226. Other critiques, both internal and external, focused on various methodological issues, including: the limited availability of actual Soviet defense budget data; uncertainty over estimates of the quantities of Soviet platforms and systems; limited data on Soviet operations and maintenance practices and on Soviet research and development programs; definitional issues on what constitutes defense spending; and the usefulness of a U.S. dollar-equivalent estimate of Soviet defense spending. Firth and Noren, pp. 140–191, 223–226.

to calculate Soviet military expenditures, the resulting U.S. dollar estimate of Soviet expenditures was artificially high, whereas a ruble estimate of U.S. expenditures would have been artificially low.[35]

The estimates also inadvertently led to overly simplified, or even inaccurate, discussion of the Soviet military threat and appropriate U.S. and allied responses. Policymakers understandably search for easily comprehensible metrics to publicly advocate for their political agendas with non-expert audiences and constituents. Government estimates of an adversary's absolute defense spending are too easy a metric for policymakers to pass up, and both Democratic and Republican policymakers used the Soviet defense budget estimates to support their respective policy positions.[36] For example, in his speeches in the 1980s, President Ronald Reagan often cited the absolute U.S. dollar estimates of Soviet total defense spending, which were higher than the U.S. defense budget, in order to justify large increases in U.S. defense spending necessary to close the perceived gap.[37] As the Cold War wore on and policymakers used the Soviet spending estimates with increasing frequency, the estimates also succumbed to a degree of politicization. Even though the estimates were generated primarily by the CIA, a staunchly independent agency, some began to believe that the figures were being distorted or misrepresented for political purposes, which undercut nonpartisan analysis that used these estimates to inform policymakers.[38]

35 The U.S. government's U.S. dollar cost estimates of Soviet spending attempted to show the cost of replicating the Soviet defense effort in the United States using U.S. prices. But relative price levels were different in the two countries, which would distort any comparison in a common currency. For example, labor was relatively cheap compared to capital in the Soviet Union but, in the United States, labor was relatively more expensive compared to capital. In other words, Soviet defense policymakers in part chose to field large standing armies because it was relatively cheap to enlist more manpower rather than to procure additional equipment. Yet, when U.S. labor rates were used to estimate Soviet defense expenditures, the resulting personnel expenditure estimates were disproportionately high compared with other cost categories. Moreover, due to the Soviet military's large standing force, the net impact of using U.S. labor rates resulted in an artificially high U.S. dollar estimate of the Soviet defense budget. Firth and Noren, pp. 148–150.

36 Jimmy Carter, "State of the Union Address," January 16, 1981, available at https://www.jimmycarterlibrary.gov/assets/documents/speeches/su81jec.phtml.

37 In one televised 1982 speech, President Reagan even used several graphs comparing U.S. and Soviet defense spending in order to convince his audience of the need to raise the U.S. defense budget to levels equaling Soviet spending. Ronald Reagan, "Address to the Nation on Strategic Arms Reduction and Nuclear Deterrence," November 22, 1982, available at https://www.reaganlibrary.gov/archives/speech/address-nation-strategic-arms-reduction-and-nuclear-deterrence. This top-down approach—that is, they spend X so we must also spend at least X—contrasts with, and even contradicts, an address by President Reagan just a few months later. In arguing for his proposed defense budget, President Reagan stated that the defense budget is the bottom-up result of a chosen strategy and the necessary capabilities to implement that strategy against potential threats. Given the latter statement, one could argue that it is simply too tempting for even well-informed politicians to pass up an opportunity to use, or misuse, adversary budget estimates in ways that corroborate their policy proposals. Ronald Reagan, "Address to the Nation on Defense and National Security," March 23, 1983, available at https://www.reaganlibrary.gov/archives/speech/address-nation-defense-and-national-security.

38 Firth and Noren, pp. 87–88. See also Robert Gates, *From the Shadows: The Ultimate Insider's Story of Five Presidents and How They Won the Cold War* (New York: Touchstone, 1996), pp. 318–319. Gates maintains that the Soviet defense expenditure estimates were never changed in response to political criticism.

More broadly, the current perception of the CIA's Soviet military-economic analysis has been strongly affected by vigorous debate, both during the late Cold War and after, on the CIA's estimates of the absolute size of the Soviet economy.[39] In the wake of the Soviet Union's collapse, some policymakers and other experts charged that the CIA's estimates of the Soviet economy had drastically overstated Soviet economic performance and had misled intelligence consumers as to the critical weakness and impending collapse of the Soviet Union. Multiple studies have since shown these charges to largely be incorrect, yet they have persisted nonetheless.[40]

What has been lost in collective memory of the CIA and broader U.S. government program to calculate Soviet defense expenditures is the useful analysis that was enabled by establishing cost relationships between Soviet platforms and units. These platform and unit-level estimates were important in determining relative priorities in Soviet force planning across differing capability areas and in creating cost-informed medium- to long-term projections of Soviet platforms and systems. Starting as early as 1962, a CIA–DIA Joint Analysis Group used the CIA's platform-level cost estimates to provide Secretary of Defense Robert McNamara and other defense planners with fiscally-realistic alternative future force structures that the Soviets could field ten years in the future.[41] Alternative Soviet force structure forecasts were wrapped into the National Intelligence Estimate process in the mid-1960s.[42] These estimates were generated in response to direct requests from U.S. defense planners, who needed to tailor U.S. force structure investments to the Soviet forces the U.S. military could confront in a future conflict.[43]

Although these force structure estimates were born out of the bottom-up effort to estimate the absolute Soviet defense budget, the *absolute* cost estimates did not need to be correct for

39 On the various challenges and debates related to estimating the size of the Soviet economy and the Soviet defense burden, see Charles Wolf, Jr., *Defense and the Macroeconomy in the Soviet Union* (Santa Monica, CA: RAND, 1990); Dmitri Steinberg, "Trends in Soviet Military Expenditure," *Soviet Studies* 42, no. 4, pp. 675–699; "Panel One: Revisiting the Estimates and Analyses of the Soviet Era," in *U.S. Assessments of the Soviet and Post-Soviet Russian Economy: Lessons Learned and Not Learned* (Washington, DC: Woodrow Wilson International Center for Scholars, 2002), pp. 10–45, available at https://www.wilsoncenter.org/sites/default/files/media/documents/publication/op283_us_assessments_soviet_post_russian_economy_conference_2002.pdf.

40 Starting in the 1960s, the CIA had provided numerous assessments that the Soviet economy was slowing and, continuing into the 1970s and 1980s, these intelligence judgements noted with increasing severity that structural problems posed a serious threat to the economy. See Trachtenberg, pp. 76–101; Gates, pp. 184–185, 317–319. Nevertheless, even as Firth and Noren note, despite gloomy estimates of Soviet economic growth by the CIA over the 1970s and 1980s, the intelligence community predominantly believed that Soviet defense spending would not be severely constrained by the slowing performance of the overall economy. Firth and Noren, pp. 93–96. Moreover, despite analysis calling attention to increasingly severe Soviet economic problems, the CIA's Soviet economic growth statistics, even in the 1980s, suggested that the Soviet economy was not in a dire position. Andrew W. Marshall and Abram N. Shulsky, "Assessing Sustainability of Command Economies and Totalitarian Regimes: The Soviet Case," *Orbis* 62, no. 2, pp. 220–243.

41 Firth and Noren, pp. 34–37.

42 Firth and Noren, 36.

43 Wallace E. Seidel, "Intelligence for Defense Planning," *Studies in Intelligence*, Spring 1964.

these alternative force structure forecasts to be useful. Instead, the forecasts depended on the accuracy of the *relative* cost relationships. Estimating that a destroyer could be traded for twenty fighter aircraft, for instance, rather than calculating with certainty the absolute cost of the destroyer and the fighter, was all that was necessary. This nuance may not have been argued explicitly at the time, since CIA analysts openly strove to calculate absolute Soviet defense spending, but it is clearer in hindsight.

Moreover, even as the CIA's cost estimation sources and methodologies were updated over time, which resulted in changes in the absolute costs of individual platforms and the total Soviet defense budget, the relative budgetary trends across different mission areas remained unchanged.[44] This point is crucial, as this strategic-level military-economic analysis aims not to predict the absolute cost of a tank or a fighter jet but rather to inform defense policymakers and planners about major trends, opportunities, and limitations in an adversary's defense program. This finding indicates that even the initial relative cost estimating relationships derived from U.S. data in the 1950s were still useful in understanding strategic-level Soviet defense resource tradeoffs.

Most importantly, when confronted by an adversary's opaque defense budget, there may be just as much, if not more, analytical promise and practical relevance for defense policymakers and planners in estimating adversary force structure tradeoffs and developing cost-informed projections of adversary forces, rather than in simply estimating total absolute expenditures. Using relative cost tradeoffs to create cost-informed adversary force structure estimates will focus analysis more concretely on the forces an adversary can plausibly field and the strategic priorities implied by those forces. Alternative fiscally-realistic force structures could then feed follow-on analysis and wargaming on the operational effectiveness of those forces in various potential operational scenarios against U.S. and allied forces. This analysis would yield valuable insights for allied policymakers and planners on today's consequential force planning decisions.

Applying Relative Cost Estimation to the PLA

As the U.S. national security community reorients itself to long-term competition with China, it is at risk of repeating some of the same mistakes that it committed during the Cold War. Already, attention-grabbing headlines, articles, and quotes are generating debate about how to estimate and compare absolute American and Chinese defense spending and

44 Firth and Noren, pp. 164–167.

derive related policy implications.[45] The methodologies for creating comparisons of absolute spending in a common currency are fraught with assumptions and deficiencies, as explained in the Soviet case above.[46] Audiences are left unclear and skeptical of any topline number, especially when a study's costing methodologies are not transparent. One's position on an absolute estimate of the Chinese defense budget risks simply devolving into a basic litmus test for one's overall stance on the security threat posed by China and the necessary level of U.S. defense spending.

Informed by the analysis and debates of previous generations, our analysis focuses on estimating relative cost tradeoffs between PLA platforms, rather than estimating the absolute size of the Chinese defense budget (either in U.S. dollars or Chinese yuan). Our practical aim is to advance understanding of the PLA's potential force structure tradeoffs over the medium- to long-term in order to support the development of U.S. plans and competitive strategies toward China. This project has taken shape in a PLA force structure and modernization tradeoff tool, called the China Strategic Choices Tool (hereafter, China SCT), the development of which will be detailed in Chapter 2.

We aim to fulfill four major goals through this effort. First, our project seeks to advance understanding at the strategic level of the feasible range of China's potential future force structures. Similar to a production possibilities curve in economics, this tradeoff tool will enable users to generate plausible alternative force structures given differing allocations of a defined set of resources. The China SCT contains CSBA's cost-informed projection of China's force structure over the 2022–2031 time period. The projection is essentially an unofficial estimate of the PLA's program of record force structure. Using the China SCT, participants can then adjust this default projection by choosing from among nearly 1,000 individual investment and divestment options to generate alternative PLA force structures given budget and industrial base constraints. By focusing on relative cost tradeoffs, this tool sidesteps potentially counterproductive debate on absolute Chinese defense spending and enables participants to engage in deeper discussion of the PLA's alternative modernization trajectories under a range of strategic conditions and assumptions.

45 For example, see Carla Babb, "China, Russia Military Budgets Combined Exceed US Spending, Top General Says," *VOA News*, June 10, 2021, available at https://www.voanews.com/a/usa_us-politics_china-russia-military-budgets-combined-exceed-us-spending-top-general-says/6206876.html; Jacqueline Deal, "China Could Soon Outgun the U.S.," *Politico*, May 27, 2021, https://www.politico.com/newsletters/politico-china-watcher/2021/05/27/china-could-soon-outgun-the-us-493014; "Nominal Spending Figures Understate China's Military Might," *The Economist*, May 1, 2021, available at https://www.economist.com/graphic-detail/2021/05/01/nominal-spending-figures-understate-chinas-military-might; Bill Greenwalt, "China Already Outspends the U.S. Military? Discuss," *Breaking Defense*, May 26, 2021, available at https://breakingdefense.com/2021/05/china-already-outspends-us-military-discuss/; Lawrence Korb, "China Is Not Outspending US On Defense; '22 Budget Is Enough," *Breaking Defense*, June 7, 2021, available at https://breakingdefense.com/2021/06/china-is-not-outspending-us-on-defense-22-budget-is-enough/.

46 Echoing the past Cold War effort to estimate Soviet defense spending, Congress has even required the Department of Defense to fund a study that includes an estimate of the Chinese defense budget and creates a methodology for comparing the Chinese and American defense budgets. *William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021*, 116th Congress, H.R. 6395, p. 623–625, available at https://www.congress.gov/bill/116th-congress/house-bill/6395/text.

The China SCT is not intended to simulate or predict the exact quantities of platforms and systems that China will field over the next ten years; instead, the tool aids users in identifying the possible range of strategic choices, constraints, and opportunities that Chinese decision makers will likely confront. This tool can serve to expand analysis of PLA force structure from largely a capabilities-based discussion to one that more explicitly includes economic and industrial base constraints. As CIA analysts Noel Firth and James Noren point out, military analysts often focus on new and advanced platforms that are under development and will not be a large part of a military's force structure for some time. Lost is most of the existing force structure, where the majority of a military's funds and efforts are dedicated in the short-to-medium term.[47] Since the China SCT estimates the costs of China's military at the platform and unit level, the tool conveys the substantial effort dedicated to existing force structure and the tradeoffs and limitations embedded in PLA modernization.

Second, by pairing the novel China SCT with CSBA's existing U.S. SCT, policy-relevant insights can be generated regarding the competitive dynamics and potential interactions between the United States and China. The U.S. and China tools allow changes in defense spending over a ten-year period, broken into two five-year periods (e.g., 2022–2026 and 2027–2031), which could enable interactive exercises and wargames. Competing U.S. and China teams can assess each other after the first five-year move and then react to their opponent's actions in the second five-year move. CSBA has also developed Strategic Choices Tool datasets for a variety of U.S. allies and partners that would even enable exercises that incorporate allied and partner teams and explore how alliance partners can jointly respond to the PLA's modernization.

Third, this project endeavors to further the development of U.S. competitive strategies against China. Through an iterative series of exercises and wargames using the new China tool, either alone or in conjunction with the U.S. tool, insights and conclusions can be developed regarding how the United States can both capitalize on China's cost constraints and defend against China's attempts to take advantage of U.S. constraints. In other words, the China tool can serve as a foil in U.S. strategic planning.

Finally, we seek to create a common methodology for creating a force structure tradeoff tool that can be applied to other countries, such as Russia and Iran, that have opaque defense budgets.

Underpinning all of these objectives is the tactile nature of the China Strategic Choices Tool and its novel use in exercises by teams of experts who can pool their collective knowledge in discussions and debates about the potential trajectory of Chinese force structure developments. While forecasting force structure developments is normally a challenging analytical task that a given analyst independently tackles piecemeal—for example, estimating the force structure of a particular PLA service, rather than the entire PLA—this hands-on tool is

47 Firth and Noren, pp. 3–4.

accessible to individuals of all skill levels, knowledge bases, and backgrounds and enables rapid, portfolio-wide assessments of strategic tradeoffs. In other words, participants need not be China or PLA experts to draw insights from the tool. The tool forces participants to make choices regarding what forces and capabilities best meet strategic ends, which prompts deeper, more substantive debate about potential tradeoffs than is normally generated by conference papers and other articles by individual analysts.

Importantly, our analytic approach—using relative cost relationships to analyze PLA budgetary tradeoffs and alternative modernization trajectories—does not attempt to resolve all of the challenges posed by Beijing's budgetary opacity. The goals of this project do not include estimating the absolute size of the Chinese defense budget, estimating the affordability of Chinese defense spending as a percentage of GDP, or estimating the absolute cost of any particular PLA platform. Given the lack of Chinese defense budget data and the inevitable disagreement that would emerge around such estimates, we have intentionally avoided using our cost estimates for those purposes.

Compared with the U.S. government's Cold War-era efforts, the cost estimation goals of this project are humbler and more achievable, yet still of great practical analytical value for U.S. policymakers and planners who must anticipate and respond to an evolving PLA threat over the long-term.

CHAPTER 2

Modeling China's Force Structure Tradeoffs

To assess the prospective force structure tradeoffs that Chinese defense planners face, CSBA created an interactive PLA force structure tradeoff tool. This tool is based on CSBA's existing U.S. Strategic Choices Tool, which has been used by defense policymakers, planners, and analysts for nearly a decade in assessing potential trajectories in U.S. military modernization. This technical chapter first provides a brief overview of the SCT's uses and functions. The chapter then delves into the methodologies that were used to create relative cost relationships between PLA platforms and units and project the PLA's force structure over the next ten years. Readers who prefer to focus on the strategic-level insights from this research may skim this chapter or proceed directly to Chapter 3.

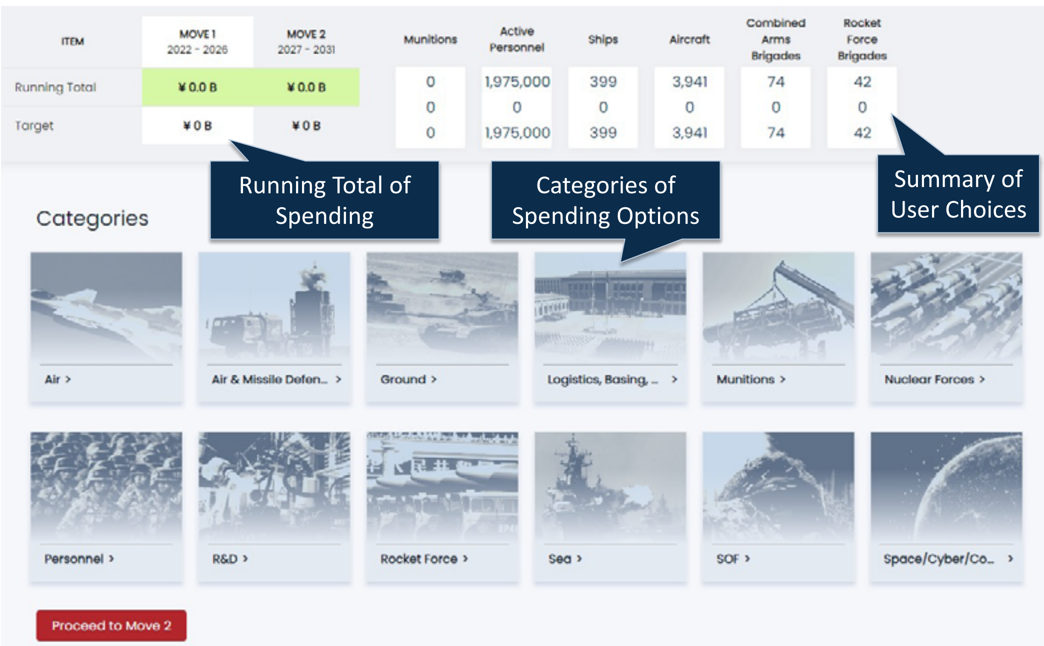
The Form and Functions of CSBA's Strategic Choices Tool

CSBA's Strategic Choices Tool (Figure 3) is a web-based program that enables the evaluation of tradeoffs in a given country's defense modernization and force structure spending over a coming ten-year period within a given budget constraint.

CSBA originally developed the Strategic Choices Tool in 2012, following the passage of the Budget Control Act in Congress, to evaluate alternative approaches to enacting the required U.S. defense spending reductions while still advancing U.S. strategic objectives. The tool has since become an integral part the CSBA's research program, including its many workshops and wargames. In a given wargame, for example, U.S. ("Blue") teams can be tasked with accomplishing specific objectives in an operational scenario set ten years in the future (e.g., 2031) given projected U.S. forces. After completing the scenarios, teams can then use the SCT in a Strategic Choices Exercise (SCE) to realign projected U.S. defense spending and generate a new, alternative future force structure that may be more successful in the scenarios compared to the current projected, or baseline, U.S. force structure. Finally, teams can re-fight the original scenarios using their alternative U.S. force structure and evaluate whether their rebalancing choices may lead to a more successful operational outcome. These integrated SCE-tabletop wargames serve as an ideal first stage of analysis, offering a robust, yet convenient and rapid, strategic-level view of how future competitions and conflicts may evolve. Outputs of the events, such as insights on critical future operational competitions, concepts, technologies, are subjects for more time-consuming and rigorous follow-on stages of analysis using operations research or other methodologies.

The existing U.S. version of the Strategic Choices Tool contains over one thousand pre-costed options, covering research and development, procurement, operations and maintenance, personnel, and military construction. For this strategic-level tool to function properly, only rough order of magnitude cost estimates are needed. In fact, since this tool analyzes tradeoffs within a projected baseline defense portfolio, accurate *relative* cost relationships between all of the options are more important than the precise *absolute* cost of each option. For the U.S. SCT, the cost data is primarily derived from publicly available U.S. Department of Defense budget documents, which provide a level of fidelity far beyond the SCT's basic requirements.

FIGURE 3: THE CHINA STRATEGIC CHOICES TOOL HOMEPAGE



The tool primarily evaluates force structure tradeoffs; it is not a budget-building tool and does not cover the entire defense budget. The tool contains a projected ten-year (e.g. 2022-2031) force structure, which serves as a baseline, or starting point, from which users can diverge. Users can invest in or divest from capabilities and platforms using the tool's add and cut options to readjust that baseline force structure under a defined budget constraint. For the United States, the ten-year baseline force structure is a current projection based on publicly available information from the Future Years Defense Program, budget documents, service-level strategy and planning documents, and other sources.

This approach stands in stark contrast to an attempt at estimating the absolute cost of the entire defense budget from the bottom up. In such an approach, one would calculate the defense budget by identifying every line item in the budget, estimating the expenditure for each item, and then adding together all of the individual expenditures.

Importantly, the SCT itself does not evaluate the battlefield effectiveness of any given force structure. The tool instead allows reallocation of defense spending over a ten-year period to produce a new force structure, with expert judgment required to evaluate that force structure's operational merits. These forces can serve as an input for wargames, exercises, workshops, and other analytical methods that can assess the effectiveness of military capabilities.

The SCT is primarily a platform- and unit-centric analytical framework. As the character of warfare evolves, systems warfare is becoming more important than the combat power of individual platforms and units. The tool contains various options for space, network, and electronic forces and systems, but networks and algorithms are more difficult to capture as discrete choices in the SCT. The tool thus faces limitations in incorporating some of the leading information-centric capabilities that will prove critical in future conflicts. Nonetheless, for the foreseeable future, great powers, including China, will continue to dedicate vast resources to developing, procuring, and maintaining traditional military force structure. By pairing wargames and other analytical methods with the SCT outputs, analysts can attempt to assess how certain force structures may be used as an operational system in a potential conflict.

Overcoming Challenges in Estimating PLA Platform and Unit Costs

To create a China version of the Strategic Choices Tool, CSBA developed rough order of magnitude cost estimates of PLA procurement, operations and maintenance, and personnel costs at the platform and unit level. Given the lack of public data on PLA expenditures, the challenges to developing these estimates are numerous and considerable. Nevertheless, given that the tool is a strategic-level, medium- to long-term planning tool that evaluates relative tradeoffs, these challenges can be overcome given existing data sources and estimation methods.

First, and most importantly, the basic lack of platform-specific budget data is a tremendous knowledge gap since cost estimates are usually drawn from historical data. Even Chinese cost analysts face a deficiency of accurate historical cost data on Chinese platforms.[48] Chinese media and blogs occasionally include the procurement cost of a given platform, but the veracity of these sources is questionable and the specific type of cost provided is often unclear. For instance, the "cost" of a platform could be its average procurement unit cost, which is the program procurement cost divided by the number of platforms procured. Or the "cost" could be the program acquisition unit cost, which is the sum of research and development, procurement, military construction, and other expenditures, divided by the quantity of test and production units. Or the "cost" could be the flyaway cost, which is the marginal procurement cost for an additional unit.[49] Beyond procurement, looking to Chinese media reports for program-level research and development or operations and maintenance figures is an even murkier endeavor. Establishing relative tradeoffs with cost data from media reports and blogs thus poses problems in data consistency and standardization.

Estimating average unit costs from Chinese arms export deals is similarly difficult. Many of these agreements include only a total cost figure that is not broken down by platform type. This is particularly troublesome when multiple platforms are sold under one deal. Moreover, these deals could include unspecified numbers of spare parts and maintenance agreements that inflate the transaction's overall cost, and thereby inflate any unit cost that an analyst attempts to generate from the total cost.[50] This challenge also frequently occurs when trying to evaluate costs and capabilities included within U.S. Foreign Military Sales cases.

Second, estimating research and development costs is inherently difficult due to numerous uncertainties in the research and development phase. Research and development program costs depend in part on the novelty of the technologies involved and the state of research previously performed.[51] Unless tailored to a particular program, generic rough order of magnitude cost estimates for research and development (R&D) are suited more for indicating approximate level of effort than for predicting cost with accuracy.

48 Anecdotally, Chinese cost analysts even purchase Western cost analysis software to support their cost estimation work. Author interview with U.S. cost analyst, May 2019. Chinese language journal articles on defense platform cost analysis typically do not provide cost data for specific PLA military platforms; instead, these authors often make use of U.S. cost data or other generic public datasets. For an example of the use of U.S. cost estimation software and U.S. military cost data by Chinese cost analysts, see 周舟 郭基联 周义蛟 沈安慰 [Zhou Zhou, Guo Jilian, Zhou Yijiao, and Shen Anwei], "PLS-SEM在装备成本估算核心参数中的应用 [Application of PLS-SEM in Core Parameter of Armament Cost Estimation]," 航空学报 [*Acta Aeronautica et Astronautica Sinica*] 39, no. 3, 2018. For an older, though still relevant, English-language article in which Chinese cost analysts openly lament the lack of cost data for PLA platforms, see J.-Y. Zhu, X.-B. Zhang, H.-X. Zhang, and B. Ren, "Estimating Military Aircraft Cost Using Least Squared Support Vector Machines," *International Journal of Plant Engineering and Management*, no. 2, 2004, pp. 97–102.

49 For definitions of these terms and various other terms related to cost analysis, see Cost Assessment and Program Evaluation, *DoD Cost Estimating Guide* (Arlington, VA: Office of the Secretary of Defense, 2020), pp. 74–75; "DAU Glossary," *Defense Acquisition University*, available at https://www.dau.edu/glossary/Pages/Glossary.aspx.

50 Various nonmarket forces could also conceivably affect the value of individual export transactions.

51 For example, research and development and production of the B-1B benefited significantly from work previously conducted under the canceled B-1A program. Had the B-1A program never existed, the R&D and production costs for the B-1B would have been higher. Daniel P. Raymer, *Aircraft Design: A Conceptual Approach* (Washington, DC: American Institute of Aeronautics and Astronautics, 1992), p. 501.

Third, the production processes and efficiencies of Chinese defense conglomerates are obfuscated due to a lack of public data. For instance, organizational structure can have a substantial impact on product cost; flat organizations generally have lower indirect costs compared with hierarchical organizations with multiple management layers.[52] Substantial Chinese-language research and technical subject matter expertise could potentially use open-source data to develop cost estimating relationships based on unique factors of the Chinese defense industrial base, though this would entail years of access and research similar to what the CIA conducted in the 1970s and 1980s to improve their cost estimates of Soviet defense equipment.

Fourth, learning curve effects and the synchronization of production schedules can impact procurement costs over time.[53] As production increases, average unit costs generally decrease. A consistent production schedule, as opposed to an erratic, infrequent one, serves to streamline production and reduce costs.[54] The pace and scale of a particular PLA platform's production could vary substantially year-to-year, in which case year-to-year cost differences could be substantial.

Fifth, PLA operations and sustainment (O&S) practices could differ considerably from U.S. or Western practices.[55] Many observers assume that O&S costs for an equivalent platform are cheaper in China than in the United States, but this is not necessarily true. For example, Chinese aerospace companies have struggled to indigenously produce high-quality, modern, and reliable jet engines. An inferior Chinese engine, even if produced at a cheaper procurement unit cost than an equivalent Western engine, is likely more expensive to operate and sustain over its lifetime due to worse fuel efficiency and the need for frequent maintenance, rebuilds, and replacement.[56]

During the Cold War, CIA analysts found that Soviet aircraft operations and maintenance practices were particularly expensive due to the Soviet military's preventative maintenance practices. The Soviet military could not trust their insufficiently skilled maintenance

52 Our thanks to Christian Smart for this insight.

53 Ronald O'Rourke, personal communication, January 29, 2019.

54 United States Government Accountability Office, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs* (Washington, DC: Government Accountability Office, 2020), pp. 380–383, available at https://www.gao.gov/assets/gao-20-195g.pdf.

55 On terminology, operations and sustainment (O&S) is a platform life cycle cost category while operations and maintenance (O&M) is a budget appropriation category. O&S costs are spread across the appropriation categories of procurement, operations and maintenance, and military personnel, see Cost Assessment and Program Evaluation, *Operating and Support Cost-estimating Guide* (Arlington, VA: Office of the Secretary of Defense, 2020), pp. 81–83, available at https://www.cape.osd.mil/files/OS_Guide_Sept_2020.pdf.

56 John Pomfret, "Military Strength Is Eluding China," *The Washington Post*, December 25, 2010. Operators of Chinese-manufactured civilian aircraft likely face a similar issue. Although the procurement cost of Comac's ARJ21 regional jet or C919 narrowbody aircraft may be cheaper than a Western equivalent, the operations and maintenance costs of these Chinese aircraft will be higher than their Western counterparts, making these Chinese jets uneconomical options for commercial airlines. See Keith Crane et. al, *The Effectiveness of China's Industrial Policies in Commercial Aviation Manufacturing* (Santa Monica, CA: RAND Corporation, 2014), pp. 66–70.

personnel to exercise discretion on maintenance issues, so they instituted an expensive preventative maintenance model that included frequent servicing and the replacement of functioning parts before they broke.[57] The bottom line is that, for a given platform, ratios of procurement to O&S costs can vary widely by country.

Next, PLA platform quality is difficult to assess in quantitative terms since open-source data on the exact capabilities and cost at a sub-component level are lacking. A platform's cost can be reduced when quality and reliability are compromised, such as by using inferior components, failing to build in redundancy, or limiting platform testing.[58] The paucity of granular data on PLA platforms limits the extent to which cost estimating relationships (CERs) can be developed to estimate Chinese costs.

Finally, fluctuations in market exchange rates could result in dramatic changes to any cost estimates developed in currencies other than the Chinese Yuan. For instance, suppose that the cost of a J-16 aircraft was determined to be U.S. $60 million, which at a 1-to-7 market exchange rate would equal 420 million Chinese Yuan. If the prevailing U.S. Dollar—Chinese Yuan market exchange rate changed from 1-to-7 to 1-to-6 over a given year, then that would decrease the J-16 cost estimate from 420 million Chinese Yuan to 360 million Chinese Yuan. Yet, within China, these foreign exchange rate changes would have little impact on the price that the PLA actually pays a Chinese manufacturer. Determining the absolute cost of a given PLA platform or the PLA budget based on U.S. cost data can therefore be problematic if this methodological issue is not considered.

Despite these challenges, it is still feasible to develop rough order of magnitude cost estimates for PLA platforms to support strategic level analysis of PLA resource tradeoffs and modernization trends. First, although PLA-specific cost data is not publicly available, there are inherent, universal relationships between platform characteristics and cost that no country or economy can escape.[59] Moreover, a platform's typical life cycle costs include four main cost categories: research and development, procurement, operations and sustainment, and disposal costs (Figure 4).[60] Generally, operations and sustainment incur the greatest cost over a platform's life, followed in order by procurement, R&D, and disposal costs.[61]

57 Office of Strategic Research, *The Economics of Soviet Military Aircraft Maintenance*.

58 The authors thank Christian Smart for this point.

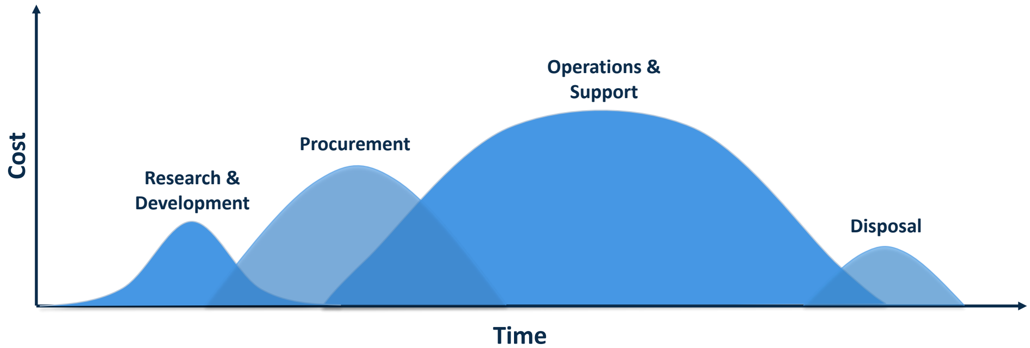
59 This statement reflects an overarching principle that platform characteristics generally correlate with platform cost. The absolute cost of producing a given platform may still vary substantially between countries for many of the reasons addressed further above.

60 In Washington, it has become popular to joke that China is realizing substantial savings on R&D costs due to intellectual property theft from the United States. While this is a serious threat that has already resulted in benefits to PLA platforms, the realized savings from this theft is likely overstated. While the Chinese government actively seeks Western intellectual property to advance Beijing's economic, technological, and military goals, the central government and the defense industry still fund vast R&D bureaucracies that consume substantial resources.

61 There are exceptions to this order, such as with space systems, for which procurement and R&D are typically the two largest cost categories, followed by operations and sustainment. For a visual breakdown of life cycle cost by platform type, see Cost Assessment and Program Evaluation, *Operating and Support Cost-estimating Guide*, p. 5.

While every state's economic circumstances, including China's, are unique, countries generally cannot escape these inherent costs and their rough proportions.[62]

FIGURE 4: NOTIONAL PLATFORM LIFE CYCLE COST



Second, to develop rough order of magnitude cost estimates for many types of platforms, only a few key variables often prove sufficient. For example, tonnage and power density consistently remain the two primary variables correlated with cost in modern naval shipbuilding, even though costly information technology systems are increasingly integrated into these platforms. A ship's power density—the amount of power generated per ton—essentially serves as a proxy for the expensive, energy-hungry information technology systems found on modern ships.[63] Similarly, weight and speed, along with a few other variables, are strongly correlated with the cost of military aircraft.[64] Thankfully, for many PLA platforms, these overall platform characteristics are observable or can be estimated with a degree of confidence. Although more granular information on the particular sub-components and materials of PLA platforms would allow more refined cost estimates, the high-level characteristics above are more than sufficient for the rough order of magnitude cost estimates needed for strategic-level tradeoff analysis.

Third, analysis of force structure tradeoffs only requires accurate *relative* cost relationships between platforms and units, rather than precise *absolute* costs. Precise absolute costs of PLA platforms would certainly be helpful for fully understanding the magnitude of China's defense modernization effort, but they are of secondary importance for this type of analysis.

62 State subsidies, preferential financing, and other government economic intervention in China can lower the costs of a particular Chinese defense company in producing a given platform or system. Nevertheless, our effort focuses on the cumulative cost that actors within China must bear to produce a given platform or system. The forms of economic intervention above still involve resources that Beijing can choose to shift to other defense modernization priorities.

63 Mark V. Arena, Irv Blickstein, Obaid Younossi, and Clifford A. Grammich, *Why Has the Cost of Navy Ships Risen?* (Santa Monica, CA: RAND, 2006).

64 Mark V. Arena, Obaid Younossi, Kevin Brancato, Irv Blickstein, and Clifford A. Grammich, *Why Has the Cost of Fixed-Wing Aircraft Risen? A Macroscopic Examination of the Trends in U.S. Military Aircraft Costs over the Past Several Decades* (Santa Monica, CA: RAND, 2008).

The primary function of the SCT is to allow users to make resource tradeoffs within a fixed pool of assets (or, in other words, a budgetary constraint). What is most important is that the relative cost ratios between different platforms and units are roughly accurate. The tool does not need to predict the absolute cost of the J-20 fifth-generation fighter; instead, it only needs to estimate, for example, how many J-20 fighters equals a modern Type 052D Destroyer or, alternatively, a Heavy Combined Arms Brigade. In other words, an investment must be offset by a proportionate divestment, akin to balancing a checkbook.

Within the SCT, CSBA sets the budgetary constraint by establishing an estimate of the force structure for the base year (e.g., 2021) and by projecting the growth of that force structure over a ten-year period (e.g., 2022–2031). In short, the tool defaults to CSBA's ten-year PLA force structure forecast (see Appendix), which estimates approximately three percent annual real growth over 2022–2031.[65] The participants then make tradeoffs within the force structure's preset growth trajectory. For example, the tool currently defaults to the procurement of three aircraft carriers over the coming ten-year period, and participants can choose to add a fourth flattop within that same timespan. To offset the cost of the additional carrier, the participants must divest an equal amount in relative cost from other categories of assets, such as aircraft and Army units.[66]

Fourth, while reliable platform-level Chinese cost data is unavailable, initial relative cost relationships between platform types can be estimated using U.S. platform-level cost data. The U.S. Department of Defense provides abundant sources on platform and system cost data, and through collecting and analyzing that data, U.S.-based CERs can be generated. Aware of the hazards of mirror imaging, U.S.-based CERs are still useful in providing a consistent and explainable way to assess relative tradeoffs between different PLA platform types at the strategic level. Within CSBA's China SCT, these relationships are not used to predict the absolute cost of procuring, operating, and manning a given Chinese platform per se; rather, they are used more generically to estimate the relative costs between a single-engine fourth-generation fighter aircraft and a twin-engine fifth-generation fighter aircraft, or between a single-engine fourth-generation fighter aircraft and a 7,500-ton naval destroyer, for example. In other words, in our framework, the U.S. dollar only acts as a common unit of measurement, and the estimated U.S. dollar costs of various PLA platforms and units are used to establish relative cost relationships both within and across domains.

65 The three percent real growth rate is a starting point, rather than a prediction, for assessing Chinese defense modernization in the tool. As noted in Chapter 4, various budget targets—either above or below the default growth rate—can be set in the tool to examine how Beijing may adjust Chinese defense modernization in response to differing budget constraints.

66 The authors recognize that, by setting a budgetary constraint, the SCT does impose a form of absolute pricing, even if the prices listed in the tool are meant to only establish relative trades between platforms and units. Once the budgetary constraint is created, the SCT users then have a finite amount of resources available to them; the users are making absolute trades within this finite pool of resources, even if the prices are not in terms of an absolute cash unit.

Challenges that would be unavoidable in determining absolute platform costs, such as the impact of the USD-RMB currency exchange rates on U.S.-derived cost estimates, become unimportant when the goal is only to evaluate relative tradeoffs. Within this tool, exchange rate fluctuations are essentially changes in a constant factor and would not impact relative cost relationships derived from U.S. data.

The use of U.S. data to establish PLA cost estimates is analogous to the CIA's initial estimates of Soviet defense costs in the 1950s. As in the 1950s, the United States finds itself in the early days of a prospective long-term great power competition.[67] When facing an adversary's unwillingness to provide cost data, researching and developing cost models based on the defense industry production efficiencies and military operating practices of an adversary is a painstaking, decades-long process. Similar to the CIA's Cold War-era models, initial PLA cost estimates derived from U.S. data can be refined over time through additional research on Chinese defense industry production efficiencies and PLA operating practices. Indeed, we have created this tool in part to provoke more substantive debate on PLA modernization and to prompt more intensive research of these understudied areas in Chinese defense economics.

Finally, several of the other cost estimation challenges outlined above become less meaningful when evaluating defense spending over multi-year time periods. The SCT evaluates defense spending over a ten-year period, broken into two five-year increments. Although slight changes in certain variables can lead to significant cost differences over individual years, these year-to-year peaks and troughs become less pronounced when averaged over a five or ten-year timespan. For example, due to the effect of learning curves, the initial units of a platform's production run can be considerably higher than the average procurement cost over the entire production run. When assessing platform procurement over a five or ten-year period, however, the strategic significance of the learning curve quickly decreases.

More broadly, regardless of country, defense budget analysts are often forced to make simplifying assumptions and estimates in their assessments. Even for the United States, despite reams of publicly released DoD data, defense budget analysts frequently need to overcome either a lack of data on existing platform or unit-level costs or uncertainty surrounding cost estimates of prospective programs. For instance, CSBA's existing U.S. Strategic Choices Tool, which has been productively applied in workshops, wargames, and exercises for almost a decade to generate strategic-level insights, adopts many of the same simplifying assumptions used in the China Strategic Choices Tool. Learning curves, for instance, are not applied due to the long ten-year timeframe of the tool; instead, estimates of average procurement unit cost (APUC) are used to reflect average unit costs over multi-year

67 In Washington, although widespread recognition of a long-term Sino–U.S. strategic competition did not occur until the mid- to late-2010s, the competition arguably started decades earlier, particularly from Beijing's perspective. Elsa Kania, "Not a 'New Era'—Historical Memory and Continuities in U.S.-China Rivalry," *The Strategy Bridge*, May 7, 2019, available at https://thestrategybridge.org/the-bridge/2019/5/7/not-a-new-erahistorical-memory-and-continuities-in-us-china-rivalry.

production runs.[68] Similarly, personnel costs are calculated through a simple per-person cost rather than a more granular, complex cost model that estimates cost per person by rank, grade, or other criteria. Other reputable organizations that study the U.S. defense budget similarly rely on rough order of magnitude cost estimates and simplifying assumptions, such as for estimating unit-level operations and maintenance costs.[69] For strategic-level analysis, these types of simplifying assumptions are both necessary and expedient and do not detract from or negate the strategic insights generated.

Toward a China Strategic Choices Tool

CSBA's development of the China SCT included three lines of effort (Figure 5):

1. Cost estimates for research and development, procurement, operations and maintenance, and personnel at the platform or unit level;[70]
2. A ten-year force structure estimate, including estimates for: the base year (e.g., 2021), five years in the future (e.g., 2026), and ten years in the future (e.g., 2031); and,
3. PLA budget estimates.

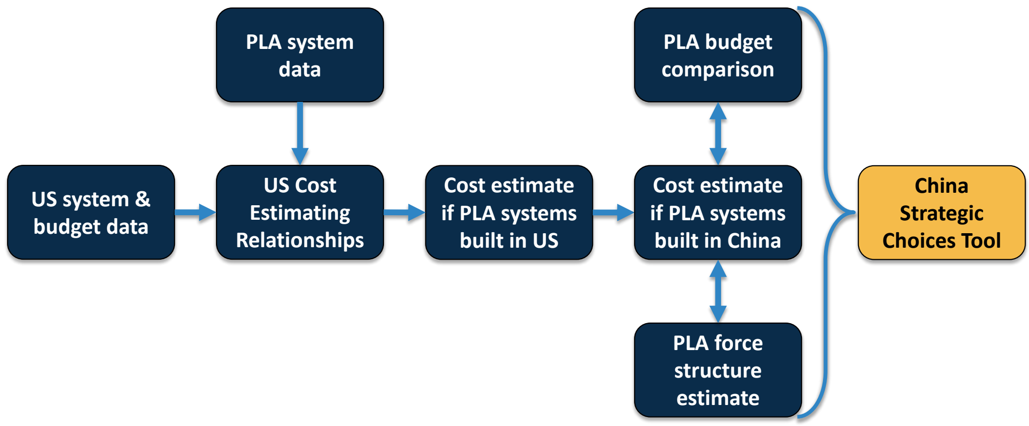
These three mutually reinforcing tasks collectively fed into the China Strategic Choices Tool. The cost estimates for individual platforms and force structure units supported the development of a cost-informed force structure estimate, using realistic defense spending growth rates. The force structure estimate in aggregate was then compared against PLA budget estimates to determine whether the cumulative amount of spending seemed reasonable.

68 Learning can have a significant impact on unit cost in year-to-year terms, particularly as production rates of a given platform begin to increase substantially. But, since the SCT focuses on strategic-level long-term force planning over a ten-year time period, the cost estimates used in the tool reflect average unit costs over long production runs.

69 *The U.S. Military's Force Structure: A Primer, 2021 Update* (Washington, DC: Congressional Budget Office, 2021). In particular, see pages 12–13.

70 Within the SCT, we display O&M costs, rather than O&S costs, because we estimate and display personnel costs separately within CSBA's SCT. As a separate note, just like for CSBA's U.S. SCT, disposal costs are not included in the China SCT. Disposal costs are a relatively small portion of a platform's life cycle cost and are not necessary for strategic-level tradeoff analysis.

FIGURE 5: METHODOLOGY FOR DEVELOPING THE CHINA STRATEGIC CHOICES TOOL



Developing Cost Estimates for PLA Platforms, Systems, and Units

Procurement and Operations and Maintenance Cost Estimates

Our development of procurement and operations and maintenance cost estimates follows similar methodologies. First, U.S. platform and system characteristic and budget data were used to create U.S.-based CERs for procurement and operations and maintenance. CSBA conducted a substantial time-intensive effort to collect historical cost and characteristic data on modern U.S. platforms and systems, dating back approximately to the 1970s in most domains. Using the cost and characteristic data, we then used a variety of methods to develop cost estimating relationships for platforms, systems, munitions, and other equipment across domains.

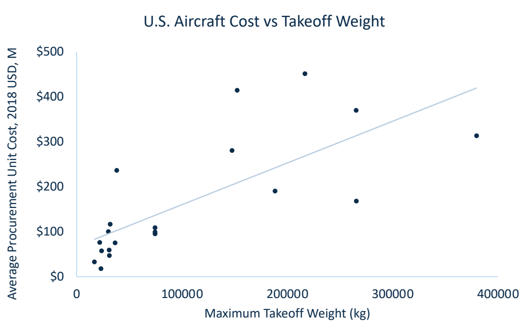
Estimating the cost of a PLA platform is more art than science. For manned fixed-wing aircraft procurement, for instance, we employed several complementary techniques, including linear regression, support vector machines, neural networks, and analogies.[71] In aggregate, we treated the outputs of these models as competing expert opinions, though we favored linear regression since that method produces outputs that are more explainable than advanced machine learning methods.[72] A regression model's R-squared value, which ranges between zero and one, provides an accessible measure of a model's predictive power and the underlying variability of the data. In other words, R-squared, and the closely-related R-squared (adjusted), contain a statement about both the model's goodness of fit

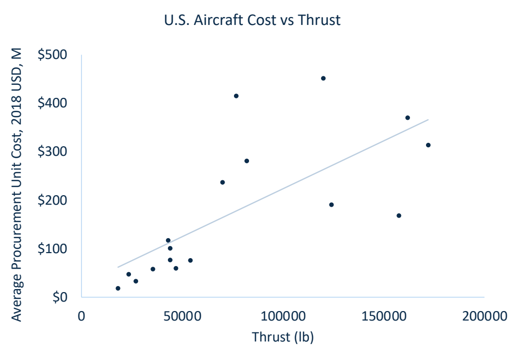
71 For a comprehensive overview of modern statistical methods and data science, we recommend the following technical yet accessible work: Bradley Efron and Trevor Hastie, *Computer Age Statistical Inference: Algorithms, Evidence, and Data Science* (Stanford, CA: Stanford University Press, 2016), available at https://web.stanford.edu/~hastie/CASI_files/PDF/casi.pdf.

72 For the same reasons, linear regression was the favored cost estimation method for most platform types, where possible. Although linear regression was the preferred cost estimating method, the final cost estimates used in the SCT reflect the authors' holistic assessment of the outputs of the various cost estimating methods.

and the underlying variability of the dependent variable.[73] For manned, fixed-wing aircraft, we were able to explain 92 percent (R-squared adjusted=.92) of the variation in aircraft cost through our linear regression model. For independent variables, this model focused on easily-observed numerical variables, such as maximum takeoff weight and thrust, and observable factor variables, such as whether an aircraft was a carrier variant, an electronic variant, a bomber, or a stealth aircraft (Figure 6). Our choice of variables is similar to, and informed by, contemporary research.[74] The outputs from neural networks and support vector machines were also useful in determining the final cost that we input into the China SCT, but we gave less weight to these models since the implied complex, nonlinear relationships between data hinder straightforward explanation.

FIGURE 6: FIXED-WING AIRCRAFT PROCUREMENT COST CORRELATED WITH THRUST AND WEIGHT[75]





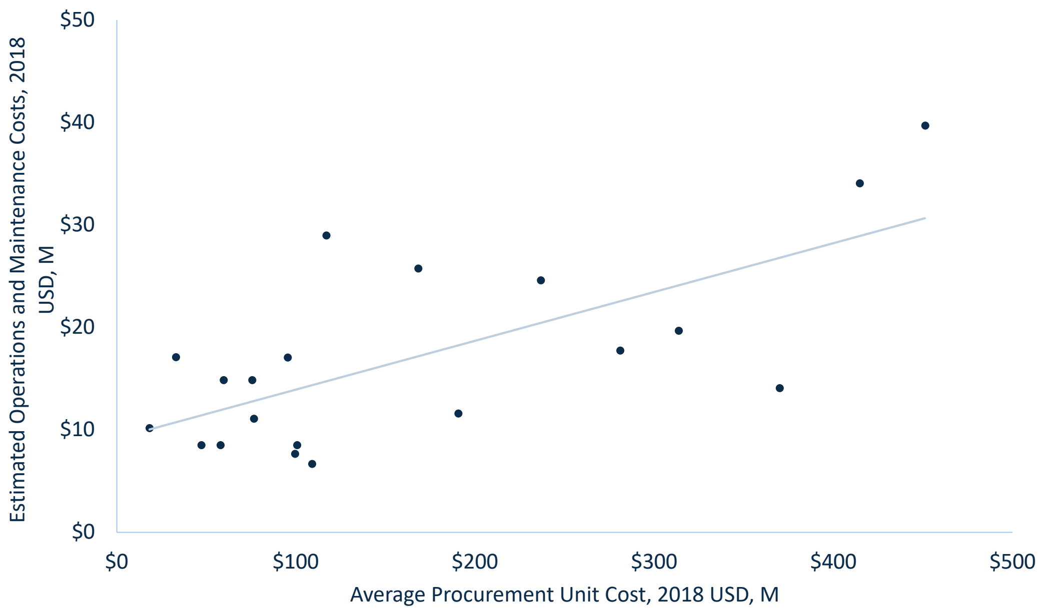
73 As technical readers will be aware, it is possible to have a good model with a low R-squared, or a bad model with a high R-squared. Practitioners need to remain aware of the hazards of overfitting and the possibility of producing a model with a high R-squared value that is actually poor at predicting the behavior of the dependent variable. As Douglas C. Montgomery, Elizabeth A. Peck, and G. Geoffrey Vining note: "The statistic R-square should be used with caution, since it is always possible to make [it] large by adding enough terms to the model. For example, if there are no repeat points, a polynomial of degree (n-1) will give a 'perfect' fit…Although R-square cannot decrease if we add a regressor variable to the model, this does not necessarily mean the new model is superior to the old one. Unless the error sum of squares in the new model is reduced by an amount equal to the original error mean square, the new model will have a larger error mean square than the old one because of the loss of one degree of freedom for error. Thus, the new model will actually be worse than the old one. The magnitude of R-square also depends on the range of variability in the regressor variable. Generally, R-square will increase as the spread of the [regressors] increases and decrease as the spread of the [regressors] decreases provided the assumed model form is correct." Douglas C. Montgomery, Elizabeth A. Peck, and G. Geoffrey Vining, *Introduction to Linear Regression Analysis* (Hoboken, NJ: John Wiley & Sons, Inc., 2001), p. 40. To penalize extraneous predictor variables, we chose to use R-squared (adjusted), which is a modified R-squared value. When an additional independent variable is added to a model, R-squared (adjusted) increases or decreases to reflect whether the additional variable improves or worsens the model's predictive power.

74 Arena et al., 2008.

75 Dozens of data sources—too numerous to note in detail—informed this graphic. The historical cost data was collected from decades of DoD reporting, including DoD Annual Reports, individual service Justification Books, the Program Acquisition Costs by Weapon System Factbook, the Selected Acquisition Reports (SARs), and the Total Quantities and Unit Procurement Cost Tables published by the Congressional Budget Office (CBO). For platform characteristics, CSBA mainly consulted Air Force and Navy Fact Sheets for each platform, found at "Fact Sheets," *U.S. Air Force*, https://www.af.mil/About-Us/Fact-Sheets/; and "Fact Files," *U.S. Navy*, https://www.navy.mil/Resources/Fact-Files/. Where the fact sheets were unable to fill gaps in certain platform characteristics, CSBA turned to other reputable data sources, including Janes.

Similarly, for fixed-wing aircraft operations and maintenance, we developed a linear regression cost model that predicts aircraft O&M as a function of the estimated procurement cost, which in turn was based on the weight, thrust, and other variables above (Figure 7). This model explained 72 percent of the cost variance. Given the data available, alternative techniques were not appropriate for estimating O&M costs.[76] Basing the O&M cost on the procurement cost was therefore the most explainable and feasible method available.

FIGURE 7: FIXED-WING AIRCRAFT OPERATIONS & MAINTENANCE CORRELATED WITH PROCUREMENT COST[77]



For a limited set of capabilities, linear regression and machine learning cost models were not suitable, given U.S. and Chinese data limitations, so various methods of analogy costing were typically applied in these cases.[78] For example, although U.S. and Chinese ground vehicles are numerous, they are varied and specialized. The number of ground vehicles of a particular class can be relatively small, limiting the available sample size. Moreover, U.S.

76 Chinese operations and maintenance cost models—compared with models for procurement, R&D, personnel, and disposal costs—are the ones most deserving of future research since O&M costs comprise the majority of a platform's life cycle cost. The PLA's O&M practices—to include flying hours, days at sea, deployment tempo, etc.—differ substantially from those of the U.S. military, but limited quantitative data is publicly available on those practices.

77 Historical O&M cost data for weapons platforms was collected primarily from DoD Selected Acquisition Reports and CBO's underlying appendix tables from *The U.S. Military's Force Structure: A Primer,* Congressional Budget Office, July 29, 2016, https://www.cbo.gov/publication/51535.

78 For the China SCT in general, in cases where analogy costing was applied, qualitative adjustment factors (e.g. weight or power) were typically used to adjust U.S. cost data for Chinese platforms and units. Separately, beyond the ground vehicle, air defense system, and nuclear warhead examples in the text, other areas where analogy costing was used include rotary-wing aircraft, submarines, unmanned aerial vehicles, and space systems.

and Chinese platforms can exhibit significant differences in platform characteristics within a given class. U.S. main battle tanks, for instance, are generally much heavier than Chinese main battle tanks.[79] To estimate PLA ground vehicle procurement cost, we applied k-means clustering to measure groups with similar characteristics according to gross weight, horsepower, and primary armament size. These clusters were used to choose the 'best' U.S. analog. Next, a costing analogy was created for each pairing in which the cost of the U.S. platform was adjusted by the ratio of the vehicle weights. Separately, for air defense systems, statistical cost estimating relationships are elusive given the small number of existing systems and their complexity. We primarily relied on costing analogies using data from U.S. government documents and press reports on foreign arms sales. In certain cases, factors based on system size and complexity were also applied.

For nuclear warhead development and production, we also relied on analogy costing. Nuclear warhead production is a high fixed-cost, low variable-cost endeavor. Although establishing the infrastructure necessary to support a country's nuclear weapons development and production carries substantial upfront and fixed costs, the variable cost of developing, producing, and maintaining new types of nuclear warheads is relatively low.[80] Similar to the United States, given the large scale of China's existing nuclear program, additional investment in developing new nuclear capabilities is likely relatively cheap, particularly when compared with the PLA's other major acquisition programs. To develop analogies for Chinese nuclear warhead development and production costs, CSBA primarily relied on public U.S. government documents for program cost data and on independent estimates of the United States' warhead inventory.[81]

Linear regression was mainly used to estimate the annual O&M cost of individual platforms, with ground unit operations and maintenance costs being the primary exception. For ease of use in the tool, ground options are presented in terms of units, rather than individual

79 The main battle tank of the U.S. Army—the M1 Abrams and its variants—ranges from 60 to 74 tons, whereas the ZTZ-96, the PLA's primary main battle tank, is approximately only 45 to 50 tons. "Abrams Tank Upgrade," *United States Army Acquisition Support Center*, available at https://asc.army.mil/web/portfolio-item/gcs-m1-abrams-main-battle-tank; Janes, "Land Warfare Platforms: Armoured Fighting Vehicles - Type 80; Type 85; Type 96," March 22, 2021.

80 Author interview with analysts in the National Nuclear Security Administration's Office of Programming, Analysis, and Evaluation (PA&E), April 2020. The authors are grateful to these analysts for their input on sources and methodologies for developing rough order of magnitude cost estimates for nuclear warheads.

81 For cost data, see National Nuclear Security Administration, *Fiscal Year 2021 Stockpile Stewardship and Management Plan-Biennial Plan Summary: Report to Congress* (Washington, DC: National Nuclear Security Administration, 2020), available at https://www.energy.gov/sites/default/files/2020/12/f82/FY2021_SSMP.pdf; U.S. Government Accountability Office, *Nuclear Weapons: NNSA Should Further Develop Cost, Schedule, and Risk Information for the W87-1 Warhead Program* (Washington, DC: U.S. Government Accountability Office, 2020), available at https://www.gao.gov/assets/gao-20-703.pdf. For inventory estimates, see Hans M. Kristensen and Matt Korda, "United States Nuclear Weapons, 2021," *Bulletin of the Atomic Scientists*, no. 1, 2021, pp. 43–63; and Hans M. Kristensen and Matt Korda, "China Nuclear Forces, 2020," *Bulletin of the Atomic Scientists*, no. 6, 2020, pp. 443–457.

platforms.[82] Determining the operations and maintenance of a given ground unit is problematic even for the U.S. military. Publicly-released data on U.S. Army operations and maintenance is not calculated at the unit level.[83] Any unit-level estimate involves identifying a subset of overall U.S. Army operations and maintenance funding that is tied to force structure units, then distributing that portion of funds across the U.S. Army's ground units. Rather than disperse those funds equally across all unit types, a weighted factor is necessary to allocate funds appropriately based on the relative size and complexity of particular units. For example, operations and maintenance costs for armored units are higher than for infantry units, due to the operations and maintenance requirements of heavy armored vehicles. For the PLA, we followed an operations and maintenance estimation methodology similar to the one we already use in our U.S. SCT. We estimated a portion of PLA funding tied to ground units from both the equipment budget (for equipment maintenance) and from the training and sustainment budget.[84] We then dispersed that amount of funding across PLA ground units using a weighted factor. The weighted factor was informed by O&M data that CSBA collected on U.S. units, as well as non-public datasets that CSBA had access to based on previous research efforts on foreign militaries.

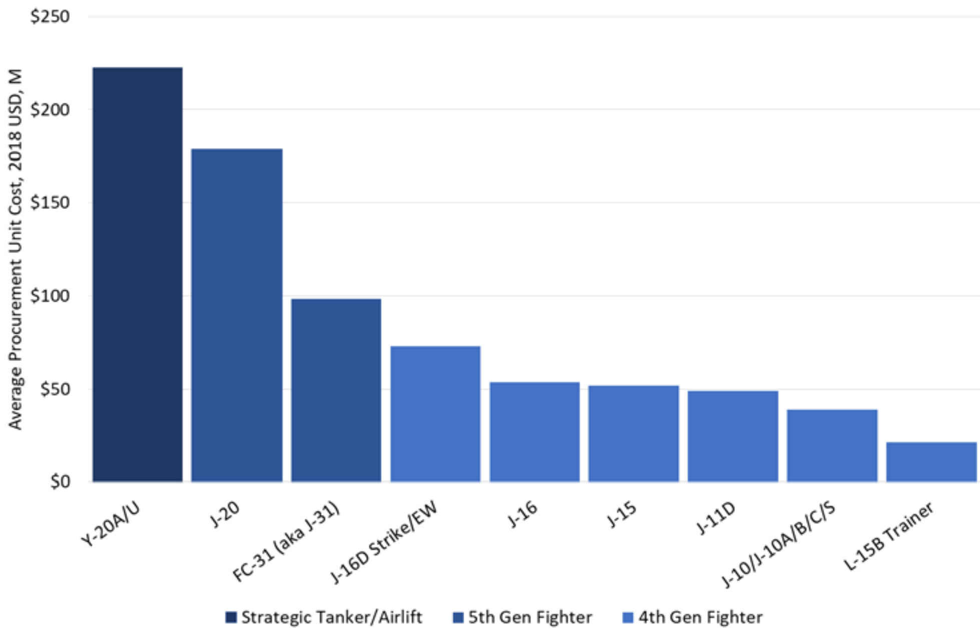
After developing CERs for various U.S. platforms and systems, we then input PLA platform and system characteristic data into these CERs to generate the procurement and operations and maintenance costs of PLA platforms and systems as if they were built and operated in the United States (Figure 8).

82 SCT users can select to increase/decrease the quantity of a type of ground unit (e.g., a heavy combined arms brigade) or accelerate/decelerate the pace of modernization for a given type of unit. Since ground equipment is so varied and specialized, it's easier for an SCT user to make selections at the unit level rather than to individually select all of the individual types of vehicles, in the appropriate quantities, necessary for a given ground unit.

83 For example, see Office of the Undersecretary of Defense (Comptroller), *Department of Defense Budget Fiscal Year 2022: Operations and Maintenance Programs (O-1) Revolving and Management Funds* (Arlington, VA: Department of Defense, 2021), pp. 3–9, https://comptroller.defense.gov/Portals/45/Documents/defbudget/FY2022/FY2022_o1.pdf.

84 The equipment budget includes funds used for equipment maintenance. Blasko et al., *Defense-Related Spending in China*, pp. 10–11.

FIGURE 8: ESTIMATED COSTS OF SELECT FIXED-WING PLA AIRCRAFT AS IF PROCURED IN THE UNITED STATES



Importantly, these CERs set the relative cost relationships between different types of platforms and units. Macroeconomic factors that could be applied to these cost models to adjust U.S. costs for Chinese costs would simply change the absolute numbers; the relative relationships would be unchanged.

Finally, we cross-checked our procurement cost estimates with a select number of Chinese-language sources. As noted above, in developing our cost estimating relationships, we did not use cost estimates of PLA platforms scattered piecemeal across Chinese press reports and blogs due to significant concerns regarding accuracy and data consistency. Nevertheless, we did compare our estimates to certain Chinese-language sources, particularly when the source seemed credible and provided a means to compare relative cost estimates between platforms.[85]

85 For example, see the following report from AVIC Securities, a subsidiary of the Chinese aerospace defense conglomerate Aviation Industry Corporation of China (AVIC). The report, while not citing privileged Chinese sources, provides rough cost estimates by platform type, which were compared with the relative cost relationships derived from CSBA's cost estimating relationships. The report also provides estimates of the PLA's aircraft procurement from 2016-2030, which served as a cross-check with CSBA's PLA force structure forecast. 李欣 魏永（Li Xin and Wei Yong), 军用飞机产业链深度报告：作战类飞机加速列装，支援类飞机补偿发展（*Military Aircraft Industry Value Chain In-depth Report: Accelerating Series Production of Combat Aircraft, Compensating for Development of Support Aircraft*) (Shenzhen, Guangdong: AVIC Securities, June 2017), available at http://pdf.dfcfw.com/pdf/H3_AP201706230664458513_01.pdf. Our thanks to Shanshan Mei for sharing this source.

Personnel Cost Estimates

Personnel costs were calculated more simply by using official data on PLA personnel spending and an estimate of the number of PLA personnel.[86] Dividing the personnel budget by the total number of PLA personnel yields a cost per PLA service member. The total annual personnel cost tied to a platform or force structure unit is determined by multiplying the individual service member cost by the approximate number of personnel per platform or force structure unit, a number that comprises the personnel directly associated with the platform or unit (e.g., the platform crew and directly supporting personnel or units).[87] The number of personnel tied to a platform or unit was determined through published research and conversations with experts on Chinese military personnel levels.[88] This approach to personnel costs is the same as that used for the existing U.S. SCT.

Research & Development Cost Estimates

Research and development costs at a program level are particularly difficult to estimate, even in the United States. Given the paucity of data, CSBA's rough order of magnitude estimates primarily follow general rule-of-thumb relationships regarding the proportion of research and development spending within a program's total life cycle cost. These estimates are further informed by R&D research costs from historical programs in the U.S. military and other militaries. The primary purpose of the R&D category in the SCT is for users to be

86 PLA personnel spending trends through 2031 were extrapolated based on official personnel expenditure data for 2010-2017. *China's National Defense in the New Era*, 2019. For PLA personnel level estimates, see International Institute for Strategic Studies (IISS), *The Military Balance* (Oxfordshire, UK: IISS, 2021), p. 249.

87 The use of U.S. data to determine procurement and operations and maintenance costs and the use of Chinese data to calculate military personnel costs could theoretically result in relative cost relationships in which personnel costs are undervalued in relative terms. Nevertheless, we are comfortable with this decision for multiple reasons. First, the military personnel costs directly tied to most force structure platforms and units are relatively small, except for ground force structure units, which are comprised of large numbers of personnel. If the labor costs are relatively undervalued in the SCT, then ground force structure may be relatively cheap compared with other technologically-dependent platforms and units, such as in the sea and air domains. In our test exercises thus far, participants have frequently reduced ground force structure units to free up funds for other domains. If Chinese ground units in our tool are relatively cheap, this would act as a built-in brake on the amount of funding that could realistically be freed up with large ground force structure reductions. Second, in China, the labor cost per person, including the cost per servicemember, is indeed much cheaper than in the United States, and the capital to labor ratio is lower in China than in the United States. Compared with the United States, using cost ratios for the PLA in which personnel-heavy ground units are cheaper in relative terms compared to technology-centric platforms likely reflects reality more than not. Finally, CSBA compared it's top-down per-servicemember personnel cost estimate to bottom-up PLA personnel cost estimates conducted by another Chinese military analyst. CSBA found its per servicemember personnel cost estimate to be relatively close to the bottom-up estimates. Thus, despite concerns about official data on PLA expenditures, the official personnel expenditure data appears sufficiently reasonable for use in strategic-level tradeoff analysis. For additional detail, see: "Nominal Spending Figures Understate China's Military Might," *The Economist*; Eswar Prasad, "Column: Is China's Economy a House of Cards?," *PBS News Hour*, January 13, 2017, available at https://www.pbs.org/newshour/economy/column-chinas-economy-house-cards; and Marcus Clay, *Understanding the "People" of the People's Liberation Army: A Study of Marriage, Family, Housing, and Benefits* (Montgomery, AL: China Aerospace Studies Institute, 2018), pp. 45–52.

88 In particular, the authors are grateful to Dennis Blasko and Ken Allen for their input on unit- and platform-level personnel levels.

able to identify critical technology areas or capabilities that would be of high value in future military operations. Within a given exercise, the cancelation or selection of certain R&D programs is therefore instructive in evaluating the potential trajectories of the PLA in the long term and gauging the PLA's possible reactions to various external stimuli.

Since the SCT is a tradeoff analysis tool rather than a bottom-up budget building tool, the tool fortunately does not require an estimate of all Chinese research and development spending. Compared to the total amount of spending in the tool, the R&D options in total comprise a relatively small portion of spending, equal to approximately 1-2% of the PLA annual budget.[89] Because the SCT focuses on a ten-year time period, most research and development program options would result in only a limited number of platforms produced within that time frame.[90]

Remaining Focused on Relative Tradeoffs Instead of Absolute Costs

We considered the more ambitious goal of generating absolute cost estimates for Chinese defense platforms but, due to the shortcomings of available methodologies for such estimates, we decided to concentrate on relative tradeoffs. To adjust the U.S.-based absolute cost estimates for China's economic conditions, we could apply certain macroeconomic indicators that reflect differences in U.S. and Chinese factor prices and productivity. A metric often used to adjust prices of goods and services across borders is the purchasing power parity (PPP) exchange rate. Yet, while PPP rates may be helpful in reflecting differing price levels in broad baskets of goods, such as agricultural and textile products, that are commonly found across countries, we found PPP unsuitable in this specific case because it tends to underestimate China's costs to produce complex, technologically advanced military equipment.[91]

89 An added uncertainty in calculating R&D costs is that R&D costs are highly based on labor costs and, compared to the United States, labor costs are cheaper in China. Fortunately, since the R&D costs included in the SCT account for only one to two percent of total expenditures in the SCT, further refinement of the R&D estimates based on labor cost would have little impact on the strategic level insights from a given exercise.

90 The tool primarily contains major research and development efforts that either are, or could potentially be, underway. Such programs include: nuclear aircraft carrier development; H-20 strategic bomber development; JH-XX fighter-bomber development; rail gun development; hypersonics development; unmanned surface vehicle development; new nuclear warheads and nuclear delivery vehicles; etc.

91 For a basic overview on the challenges of using PPP exchange rates for cross-border price adjustments, see James Mackintosh, "China, the US, and PPP: A Pretty Poor Parallel," *Financial Times*, May 2, 2014, available at https://www.ft.com/content/d05038f3-4232-3020-861d-f0a795d61a54.

We considered other novel methods to make cross-border price adjustments, but ultimately rejected these approaches due to concerns over methodology and accuracy.[92] The application of such adjustments often held diminishing marginal returns and implied a methodological precision beyond what was necessary to yield strategic insights. For the purposes of this strategic tradeoff tool, absolute cost adjustments are of limited utility since any macroeconomic factors applied would serve as constants that adjust the absolute numbers without changing the underlying cost ratio between different forces and capabilities. Although estimating China's absolute costs for defense platforms could advance broader analysis of the magnitude of the PLA's defense spending, only relative cost relationships are necessary to explore the PLA's alternative modernization trajectories.

Developing a Future Force Structure Estimate

As explained above, the SCT requires a projected, or baseline, force structure estimate for the coming ten-year period, so that users of the SCT can then readjust defense spending over that time period by selecting add and cut options. Since the SCT functions in two five-year increments, force structure estimates are needed for the base year (e.g., 2021), the end of the first five-year increment (e.g., 2026), and the end of the second five-year increment (e.g., 2031). Overall, through the methodology described below, CSBA used its platform and unit-level cost estimates to estimate historic PLA force structure expenditures and then forecast PLA force structure growth over the coming ten years, given approximately three percent annual real growth. This force structure estimate essentially acts as the China SCT's default budget constraint; that is, the fixed pool of resources that China SCT users can reallocate to create alternative future PLA force structures.

Future force structure estimates for the PLA confront several methodological challenges. First, analysts often disagree about what comprises the PLA's force structure today, let alone in five or ten years. In addition to differences in the absolute number of platforms or units, sources vary in the level of granularity provided on the number of each type of platform variant.

92 For instance, for procurement costs, one could assume that the capital to labor ratios in defense manufacturing in the United States and China are roughly equal, and that capital costs are approximately equal between the United States and China since materials are traded internationally at market exchange rates. Therefore, only the labor portion of the procurement cost would require adjustment. To adjust U.S. labor costs for China, two factors could be applied. First, to reflect lower Chinese wages, a ratio of Chinese wages to U.S. wages could be used. Next, to reflect lower Chinese productivity per worker, a ratio of U.S. productivity to Chinese productivity could be employed. At the macro level, the lower wages but lower productivity would largely cancel each other out, resulting in a marginal overall adjustment for Chinese labor. Despite the possibility of applying this method, we declined to do so since the application of such these factors would involve a number of less than certain assumptions. This uncertainty would be compounded when attempting to develop factors to adjust U.S. R&D and O&M costs for China, not just for procurement. Moreover, the factors would only reflect current cost differences and, for the purposes of CSBA's ten-year force planning tool, forecasting how these factors would adjust over the next ten years would add unnecessary complexity. Therefore, such factors may not make the relative tradeoff analysis in the SCT any more accurate than it already is, and would perhaps introduce greater uncertainty and inaccuracy in the estimates. As research on cross-border price adjustments progresses in coming years, the application of various factors can be revisited and our models can be updated.

Second, when looking toward the future, there is inherent uncertainty about the PLA's force structure plans. This uncertainty results from the PLA's lack of transparency about its current plans and the fact that, in the future, the PLA could diverge from an earlier plan due to any number of factors, such as changes in the security environment, shifts in military strategy, technological developments or challenges, changes in political or military leadership, and the outcomes of other inter-service or bureaucratic battles.

Third, defense industrial base constraints limit the possible quantity produced of a particular platform. These constraints usually become less stringent over the medium-to-long term, since prioritization of the production of any particular platform type could result in major changes in defense industrial base capacity. Yet there are certain areas where defense industrial base constraints are difficult to shift even in a five- or ten-year period, such as in submarine production.

Fourth, defense industrial base constraints and domestic production limitations, more broadly, can be overcome through foreign military sales. China has engaged in these sales over the last several decades, particularly with Russia, though they have become rarer in recent years as the quality of China's defense industrial base has improved dramatically and the PLA can increasingly rely on indigenous production of defense platforms.

Fifth, annual historical data on the PLA's force structure inventory is usually uneven, complicating calculations of force structure trends. Due to the lack of accurate and timely data on the PLA's procurement or retirement of particular platforms, foreign assessments of the PLA's historical force structure inventory often show year-to-year changes that are too great in magnitude to have occurred in only one year.

Finally, data is unavailable on platform attrition rates, expected service life, service life extension programs, and other factors that would provide clarity on future force structure changes.

CSBA's approach to overcome these challenges and estimate PLA force structure follows existing unclassified best practices and, notably, also uses cost constraints to inform projected changes in force structure. First, CSBA collected historical PLA force structure data for the last 10 to 20 years for major platform, system, and force structure unit types from multiple sources. This data was used to assess, among other factors, trends in production, retirement, and force composition, which enabled the development of working assumptions about future changes in force structure. Due to significant year-to-year fluctuations in the data, some of the historical numbers were smoothed out to reflect more realistic changes over time and to produce recognizable trends that can be applied to estimate future growth.[93]

93 Roger Cliff, personal communication, August 10, 2018.

To develop future force structure projections, these growth rates, trends, and working assumptions were then applied forward, combined with assessments of defense industrial base capacity for new platforms. Qualitative assessments based on China's national security goals, PLA strategy and modernization plans, and internal and external drivers and trends related to force structure were also factored into the estimates.[94] CSBA aimed for PLA force structure spending annual real growth rates of approximately three percent, though this rate varies by service.[95] Given the various inputs for estimating the PLA's future force structure, the resulting force structure estimates are cost-informed, rather than pure budgetary-based forecasts.

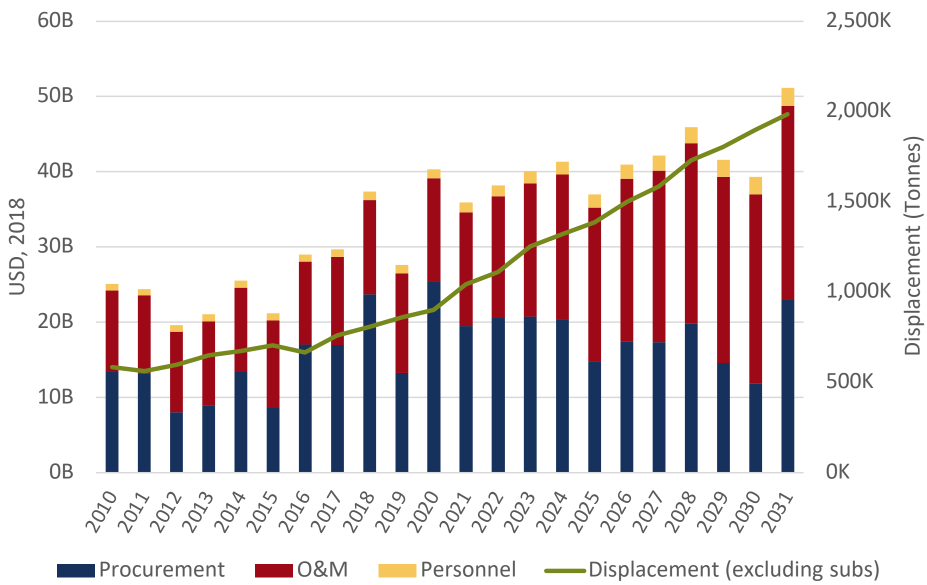
Figures 9 and 10, depicting PLA Navy (PLAN) force structure costs and inventory, respectively, are examples of the above methodology. CSBA used historical trends from 2000-2021, qualitative information about the PLA's modernization and force structure plans, and CSBA's cost estimates for PLA platforms and systems to generate a baseline projection of PLA Navy force structure from 2022-2031. Given the platform-level cost estimates that we developed,

94 Factors in the qualitative assessment included, for instance: Xi Jinping's goal that the PLA's modernization will be "basically completed" by 2035 and the PLA will become "world-class forces" by 2050; a PLA main strategic direction in the maritime, rather than the continental, direction; a PLA strategic guideline of "winning informationized local wars"; and the PLA's main operational form of "integrated joint operations." At the service-level, key trends influencing the force structure projection included: the PLA Army modernizing capabilities to conduct combined arms and joint operations; the PLA Navy implementing a "near seas defense, far seas operations" strategy; the PLA Marine Corps developing forces and capabilities for expeditionary operations; the PLA Air Force becoming a "strategic air force" that can independently conduct operations; the Rocket Force focusing on expanding theater-range precision-strike capabilities; and the Strategic Support Force aiming to integrate space, computer network, and EMS capabilities to achieve information dominance and support joint operations. For background on these trends and goals, see "Full Text of Xi Jinping's Report at the 19th CPC National Congress," *China Military*, November 5, 2017, available at http://english.chinamil.com.cn/view/2017-11/05/content_7812833.htm; M. Taylor Fravel, *Active Defense: China's Military Strategy since 1949* (Princeton: Princeton University Press, 2019), pp. 230–235; Dennis J. Blasko, "The Biggest Loser in Chinese Military Reforms: The PLA Army," in Phillip C. Saunders, Arthur S. Ding, Andrew Scobell, Andrew N.D. Yang, and Joel Wuthnow, ed., *Chairman Xi Remakes the PLA* (Washington, DC: National Defense University Press, 2019), pp. 345–392; Christopher Carlson and Jack Bianchi, "Warfare Drivers: Mission Needs and the Impact on Ship Design," in Andrew Erickson, ed., *Chinese Naval Shipbuilding: An Ambitious and Uncertain Course* (Annapolis, MD: Naval Institute Press, 2016), pp. 19–40; Ken Allen and Cristina Garafola, *70 Years of the PLA Air Force* (Montgomery, AL: China Aerospace Studies Institute, 2021), pp. 67–101; Conor Kennedy, *China Maritime Report No. 15: The New Chinese Marine Corps: A "Strategic Dagger" in a Cross-Strait Invasion* (Newport, RI: U.S. Naval War College China Maritime Studies Institute, 2021), pp. 1–11; and Elsa Kania and John Costello, "Seizing the Commanding Heights: The PLA Strategic Support Force in Chinese Military Power," *Journal of Strategic Studies* 44, no. 2, 2021, pp. 218–264.

95 CSBA's projected budget annual real growth rate varied by service due to CSBA's assessment of Beijing's force structure requirements and various strategic level trends, particularly the PLA's increasing emphasis on the PLAN, PLAAF, PLARF, and PLASSF, at the expense of the PLA Army. By service, in CSBA's baseline estimate in the China SCT, the PLA Army real growth rate is close to flat, the PLAN and PLAAF real growth rates are approximately 3-4 percent per year, and the PLARF real growth rate is approximately 5 percent per year. The space, network, and electronic options in the tool, although costed based on real-world data, serve more as notional options; an overall force structure spending growth rate for the PLASSF was therefore not calculated. Even though PLA Army annual real budget growth will likely be higher than flat over the 2020s, CSBA is comfortable with relatively flat real growth because users in our initial exercises frequently traded away PLA Army forces in order to increase spending in the other services. A relatively constrained PLA Army growth estimate therefore provides additional realism in the exercise; users are prevented from cutting unrealistic levels of PLA Army spending in order to procure improbable amounts of platforms and systems in the other services.

the 2010-2021 force structure data resulted in a historical PLAN force structure spending real growth rate of 5.8 percent and an annual displacement growth rate of 5.6 percent. The annual spending real growth rate of 5.8 percent appears sensible given the PLA budget's annual real growth rate of approximately 8 to 10 percent over that time period. Over 2021-2031, the force structure projection yielded a 4.2 percent annual real growth rate in naval expenditures and a projected annual tonnage growth rate of 6.7 percent. While slightly lower than the historical average, the forecast annual budget growth rate is logical given that the PLA budget will probably face headwinds as China's GDP growth rate likely decreases over the 2020s.

FIGURE 9: PLA NAVY PROCUREMENT, OPERATIONS & MAINTENANCE, AND PERSONNEL COSTS FOR SURFACE AND SUBSURFACE PLATFORMS[96]



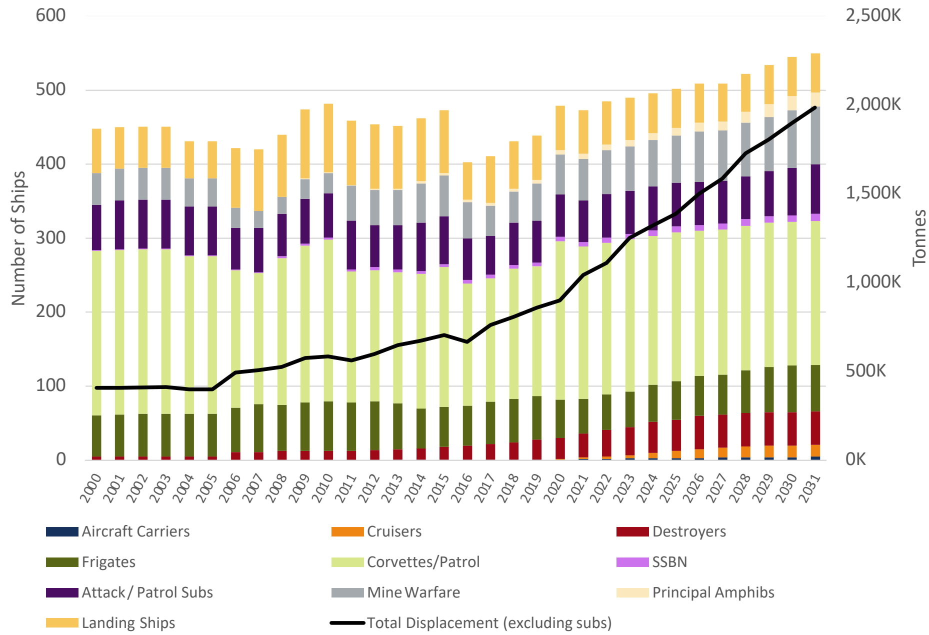
More important than the specific number of any individual platform or unit type in the estimate is the cumulative amount of spending in the future force structure estimate.[97] In the SCT, the future force structure estimate essentially serves as a projected budget baseline or, in other words, a default budget constraint. Users have the freedom to disagree with any of the preset force structure projections and can select various add and cut options in the tool to generate their preferred alternative future force structures, provided they stay within

96 CSBA collected historical PLA inventory data from numerous sources. For naval force structure, CSBA primarily relied on International Institute for Strategic Studies, *The Military Balance*, (Oxfordshire, UK: IISS) (multiple years) and Janes, *World Navies Equipment in Service Inventory*, (multiple years), available at www.janes.com. CSBA assessed and adjudicated differences between sources.

97 Roger Cliff used a similar methodology to examine PLA procurement tradeoffs. Cliff, 2015, pp. 88–103.

the available fixed pool of resources.[98] In other words, the force structure forecast sets the basket of resources available to SCT users, and users can then reallocate those resources, provided that their investments and divestments offset each other.

FIGURE 10: PROJECTED COST-INFORMED PLA NAVY FORCE STRUCTURE[99]



PLA Budget as a Top-Down Check

Complementing the bottom-up cost estimates and force structure estimates, the overall PLA budget serves as a top-down check to confirm whether the bottom-up estimates appear reasonable in absolute terms. As stated above, this project explicitly does not attempt to estimate either the absolute Chinese defense budget or the absolute costs of individual platforms. Yet comparing the PLA budget—both the official figures and unofficial third-party estimates—to the cumulative PLA spending levels yielded by our bottom-up estimates serves as a simple check on the magnitude of our spending estimates. Were the cumulative cost

98 Although CSBA's default force structure forecast estimates approximately three percent real annual growth in PLA spending, users of the China SCT can also explore PLA modernization under other budgetary environments. As noted in Chapter 4, the tool also allows various budget constraints to be set for a given exercise. For instance, a budget constraint can be set above or below the projected budget baseline to force teams to assess how Beijing may modernize the PLA given more or fewer resources.

99 As explained in the footnote for Figure 9, CSBA collected historical PLA inventory data from a variety of sources. The ship displacement estimates are from reputable open sources, such as Janes. The force structure categories in this graph generally reflect the U.S. military's classification of PLA platforms. For example, the Type 055 Renhai-class ships are regarded here as cruisers even though the PLA defines them as destroyers.

estimates in our tool found to be orders of magnitude higher than the PLA budget, then doubt could arise about the appropriateness and accuracy of our methodologies. We find that our cumulative spending estimates comprise a stable and reasonable proportion of the official budget and unofficial budget estimates, both historically and over the coming ten years.

The official Chinese defense budget, which was 1.35 trillion yuan (U.S. $212 billion) in 2021, has historically been criticized as undercounting China's actual defense spending. This criticism has eased in recent years, as many PLA experts believe that China's defense budget now includes several categories of spending previously omitted and that other categories of spending that still remain outside of the defense budget have been drastically reduced or become inconsequential (Figure 11).[100] In the 2000s, for instance, the U.S. Department of Defense claimed that the PLA's budget was two to three times greater than officially stated.[101] In contrast, in the last couple of years, prominent expert estimates—such as from the Stockholm International Peace Research Institute (SIPRI) and Janes—on average state that the PLA budget is roughly only 15 to 40 percent higher than the official topline.[102] In terms of Beijing's undercounting of defense spending, Western experts in recent years have focused more on including categories of spending that are excluded from the official budget—such as veterans payments and most research and development spending—rather than on arguing that China is intentionally underreporting expenditures in categories that are already included in the official budget.[103]

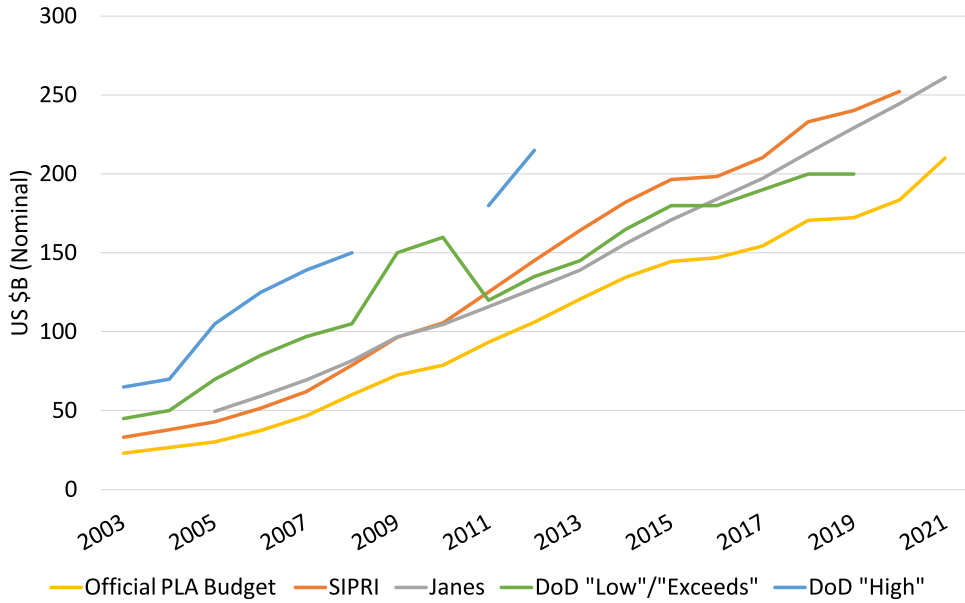
100 For example, in a recent study, SIPRI updated its methodology for estimating China's overall defense budget. SIPRI no longer includes foreign military imports, claiming these have become infrequent and are likely now included in the defense budget. SIPRI also no longer includes subsidies to the defense industry, since it believes these subsidies have been reduced to inconsequential levels as the defense industrial base has reformed and become profitable. Tian and Su, *A New Estimate of China's Military Expenditure*. See also Craig Caffrey, "China Defence Budget," Janes, 2018.

101 Office of the Secretary of Defense, *Annual Report on the Military Power of the People's Republic of China* (Arlington, VA: Department of Defense, 2004), available at https://permanent.fdlp.gov/lps24358/2004/2004_report.pdf.

102 In 2020, the Department of Defense stated that China's official 2019 defense budget of US $174 billion "could be more than $200 billion." At US $200 billion, the difference would be 15 percent. SIPRI estimates that China's 2019 defense budget was US $240 billion, which is 38 percent higher than the official budget. Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China* (Arlington, VA: Department of Defense, 2020), p. 140; Tian and Su, *A New Estimate of China's Military Expenditure*, pp. 22–23.

103 This is partly a definitional issue as to what constitutes "defense" spending. For more background on this issue, see Dennis Blasko et. al, *Defense-related spending in China*, pp. 5–10; Tian and Su, pp. 2–3.

FIGURE 11: OFFICIAL PLA BUDGET AND UNOFFICIAL THIRD-PARTY ESTIMATES[104]



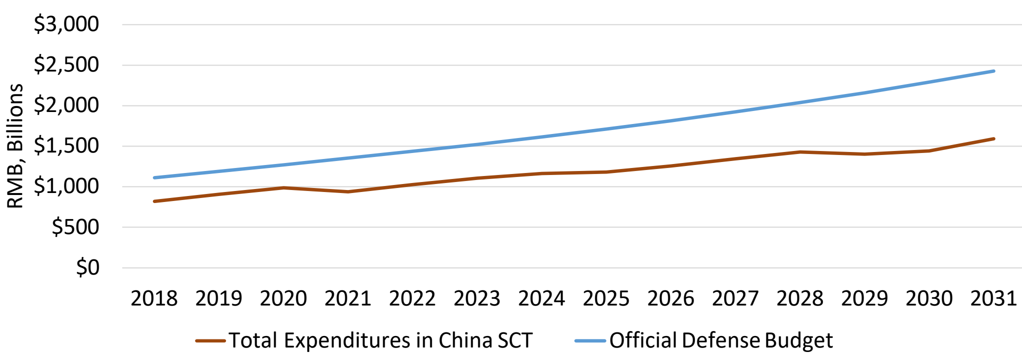
Our expenditure estimates are tied to PLA force structure only and should therefore represent a proportion of total PLA spending. From 2018 to 2031, CSBA's bottom-up cost estimates for all domains total approximately 64 to 79 percent of China's official annual

104 "Official China": National Bureau of Statistics of China, *China Statistical Yearbook*, (Beijing: China, China Statistics Press, 2005-2019). RMB data was collected here for years 2003–2018 using the 2005 through 2019 yearbooks. Data for the year 2019 was gathered from the Ministry of Finance, "Budgeted Expenditure in the 2020 Central General Public Budget," June 17, 2020, available at http://www.mof.gov.cn/en/data/202011/t20201126_3630686.htm. Data for years 2020 and 2021 was collected from the Ministry of Finance, *Report on the Execution of the Central and Local Budgets for 2020 and on the Draft Central and Local Budgets for 2021*, (Beijing, China: Ministry of Finance, March 2021), available at http://www.xinhuanet.com/english/download/20210313budget.pdf, p. 4, 38. The final USD values are based on the average annual RMB-USD spot exchange rate using data provided from FRED Economic Data, "Chinese Yuan Renminbi to U.S. Dollar Spot Exchange Rate," available at https://fred.stlouisfed.org/series/AEXCHUS#0. The USD value generated for 2021 is based on the average annual RMB-USD spot exchange rate using data provided by the International Monetary Fund, "Exchange Rate Archives by Month," available at https://www.imf.org/external/np/fin/data/param_rms_mth.aspx. "SIPRI": Stockholm International Peace Research Institute, "SIPRI Military Expenditure Database," *Data for all countries 1949–2020*, available at https://www.sipri.org/databases/milex. The SIPRI estimates reflect their most recent budget estimation methodology, found in Nan Tian and Fei Su, *A New Estimate of Chinese Military Expenditure*, (Stockholm, Sweden: Stockholm International Peace Research Institute, 2021). "DoD 'High'" and "DoD 'Low'": Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China, 2003–2021* (Arlington, VA: Office of the Secretary of Defense, 2003-2021). Annual Reports. This annual DoD report has framed estimates on China's defense budget in various ways over the years. For certain years, the DoD provides a "high" and a "low" estimate, though the Department's particular wording and formulation of these estimates has changed over time. For other years, the DoD may provide only a single estimate of China's defense spending. These single estimates have also been framed in numerous ways, usually in terms that China's actual defense spending exceeds a particular figure. Janes, "Defence Budgets Spreadsheet-Defence Budget," *Janes Defence Budgets*, November 16, 2021.

defense budget, assuming a three percent real annual budget increase from 2022 onward (Figure 12).[105] We believe this result is acceptable since it is relatively consistent over time and appears to be well within an order of magnitude of whatever actual PLA force structure spending is.[106]

Compared with the external PLA budget estimates, all of which estimate higher levels of actual spending than the official PLA budget, our force structure-based spending estimates also appear reasonable. Assuming the same real three percent annual defense budget increase over the next decade, we projected forward two recent external estimates of the Chinese defense budget.[107] Our cost estimates comprise roughly 46 to 58 percent of the unofficial spending estimates over the 2022–2031 time period.

FIGURE 12: CHINA SCT EXPENDITURES AS A PORTION OF BUDGET TOPLINE



105 From 2022 to 2031, our estimates assume a nominal Chinese defense budget increase of six percent annually and an annual inflation rate of three percent.

106 This comparison provides further confirmation that our estimates are sufficiently accurate to support strategic-level tradeoff analysis, though we do not claim that the PLA's force structure spending is exactly 64 to 79 percent of the PLA's official budget. Separately, we are comfortable with the annual variation being within a range of 15 percentage points. The year-to-year variation in our model largely results from procurement spending estimates. Accountants in Beijing can likely smooth out procurement funding for platforms across multiple years whereas our methodology assumes the full procurement cost of any platform, even an aircraft carrier, is paid in one given year, which can lead to some unevenness in year-to-year spending levels. Relatively small variation in year-to-year spending levels does not pose a challenge to our methodology. These estimates are used to support strategic-level analysis of trends over the medium- to long-term, rather than to precisely estimate the budget in a given year. Finally, the proportion of total expenditures in the China SCT compared to the official defense budget declines slightly over the 2022–2031 timespan. This is largely due to the assumption of relatively flat growth in PLA Army expenditure over 2022–2031, the impact of which is noticeable in the outyears. Although the growth rate in PLA Army spending will likely be higher than flat, we intentionally were conservative in our PLA Army expenditure estimates since our beta test exercises indicated that teams frequently trade away PLA Army force structure to free up funds for investments in other areas. To improve the realism of the exercises, we constrained opportunities to dramatically reduce Army spending in the SCT.

107 Andrew MacDonald, "China - Defence Budget," *Janes*, June 24, 2021; Tian and Su, *A New Estimate of China's Military Expenditure*, p. 22–23.

These comparisons to the total PLA budget provide an additional measure of confidence in our estimates. The limited conclusions that we draw from these results are that: 1) our expenditure estimates are roughly stable over time given projected defense spending levels; 2) our cumulative force structure expenditure estimates are reasonable given overall PLA spending levels; and 3) the cost and force structure estimates in the tool are accurate enough to simulate feasible relative tradeoffs in PLA force structure.

These basic trends and insights are more important than the exact percentages above, as these figures can be highly sensitive to changes in certain model inputs and assumptions, including the annual defense budget growth rate, the inflation rate, and the forecast program of record.[108] To be clear, given our methodological focus on establishing relative cost relationships, rather than estimating absolute costs, we do not claim to have recreated 64 to 79 percent of the PLA budget.[109] Nevertheless, these defense budget comparisons seem to indicate that estimating and projecting China's defense budget in absolute terms through bottom-up cost estimates of Chinese platforms and units may not be an entirely unrealistic objective in future research.

The China SCT Realized: Some Example Tradeoffs

Once inputted into the China Strategic Choices Tool, the platform and unit-level cost estimates and force structure forecasts enable a powerful and accessible means of examining potential PLA modernization trajectories. China SCT users can contemplate investments and divestments across the PLA's entire defense portfolio, simulating some of the same debates on strategy, concepts, and investments that policymakers in Beijing are assuredly engaged in.

Figure 13 below contains some notional tradeoffs, which are roughly budget-neutral, that users could select within the SCT. Users aren't required to connect a specific add, such as procuring six J-20 fighter aircraft, with a specific cut, such as retiring a heavy combined arms brigade, though the adds and cuts cumulatively must meet the user's budget target.

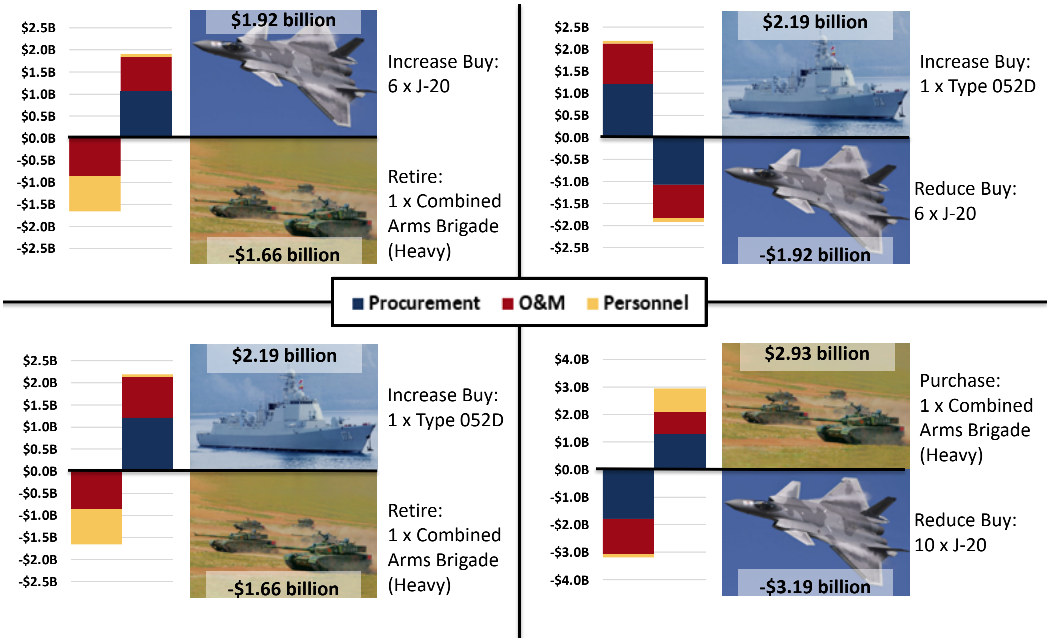
The tradeoffs in Figure 13 indicate the cross-domain portfolio-wide trades that users can consider in the tool. These trades are likely analogous to the ones that political and military leaders in Beijing are considering as they shape the future of the PLA. The tool enables

108 For instance, we could have adjusted various inputs and assumptions so that our cumulative expenditure estimates resulted in a fixed percentage (e.g., 70 percent), of every annual PLA budget from 2022-2031. We refrained from doing so as that could create an illusion that our estimates are more accurate than they are. Although choosing a fixed percentage of the PLA budget could make our model's budgetary constraint assumptions more explicit, various inputs beyond cost should be factored into a future force structure estimate, as explained above. Additionally, under our methodology, which assumes the full procurement cost for a platform is paid in the year it is produced, there is inherent year-to-year variation in total spending levels, as detailed in the separate note above. Overall, the tool's design is intended to support strategic-level tradeoff analysis, rather than to build an absolute PLA budget estimate from the ground up.

109 Relatedly, these comparisons should not be used to generate any analytic assessment of what total PLA spending is in absolute terms.

Western policymakers and analysts to step into the shoes of Chinese decision makers to examine the trade-offs and make difficult resourcing choices. In structured exercises, the tool encourages participants to debate potential PLA modernization pathways and discuss how the United States and its allies could potentially shape China's peacetime force structure investments.

FIGURE 13: POTENTIAL TRADEOFFS IN PLA FORCE STRUCTURE (FIVE-YEAR MOVE)



CHAPTER 3

PLA Tradeoffs and Strategic Implications: Preliminary Insights from Research & Beta Exercises

China's growing strategic ambitions and unavoidable resource constraints will sharpen the PLA's force structure tradeoffs over the coming decade. Some of these tradeoffs are evident in our expenditures estimates alone, such as rising operations and maintenance costs facing the PLA over the 2020s. Additional PLA tradeoffs became evident through three exercises that CSBA conducted over 2020-2021 using beta versions of the China Strategic Choices Tool.[110] Although these events were primarily intended to test the functions, options, and estimates within the tool, these exercises yielded preliminary trends and insights, particularly on likely tradeoffs and Beijing's intentions and sense of timing.[111] The exercises also revealed perceptions and assumptions within the U.S. policy community that could influence and even skew estimates of China's future modernization.

110 These exercises were held in March 2020, April 2021, and May 2021 at CSBA's offices in Washington, DC and included a mix of physical and virtual participants to both mitigate COVID-19 risks and account for the geographic dispersal of various experts. The exercise participants consisted of a broad range of national security professionals including think tank experts, current and former U.S. government civilian employees, military officers, and defense industry analysts.

111 The beta version of the tool used in these exercises included all of production features of the final tool, though the individual investment and divestment options were expanded and refined over time. For the first exercise, the beta version of the tool contained hundreds of investment and divestment options, primarily for air and sea platforms, ground units, munitions, and personnel. Additional sets of options were added for each subsequent exercise. The cost estimates, forecast production rates, industrial base limitations, and other assumptions for various platforms and units were also refined over time given user feedback at these events.

The tool was in varying stages of completion during these events, so the analytical takeaways below offer only an initial preview of the future applications of the tool. Looking ahead, now that the tool has been completed, its analytic usefulness will become clearer through future exercise series designed to answer focused research questions, as addressed in Chapter 4.[112]

The Affordability of the PLA's Ambitions

The most apparent takeaway from CSBA's cost-informed force structure (see Appendix) is that the PLA's modernization goals appear affordable, at least over the next decade, based on our budget growth assumptions.[113] The PLA can continue to maintain, expand, and improve its regional defense forces, including short-range fighter aircraft, land-based ballistic and cruise missiles, frigates, missile boats, and diesel-electric submarines. At the same time, the PLA can continue building a range of large power projection platforms for global operations, including aircraft carriers, cruisers, destroyers, blue water logistics vessels, strategic bombers, and strategic transport and refueling aircraft. By 2031, for instance, the PLA may have sufficient resources to boast five aircraft carriers and over 60 cruisers and destroyers, the vast majority of which will be considered modern, based on our cost-informed projection.[114]

The PLA, particularly the Navy, will face increasing strain from operations and maintenance costs over the next decade, yet this may not pose a major obstacle to the PLA's continued modernization over the mid-term under our growth assumptions. CSBA's expenditure calculations focused on force structure-related spending, including procurement, operations and maintenance, and personnel costs, along with some research and development expenses. Over the next ten years, operations and maintenance spending will increase as a proportion of overall force structure spending, driven by the PLA's rapid procurement of large power projection platforms and the maintenance of a large legacy force structure (Figure 14). For example, within our estimates on naval spending tied to force structure, naval O&M increases from an average of 44 percent of expenditures over 2010–2021 to 52 percent over 2022–2031. These percentages are not meant to be definitive, rather they are intended to convey a likely strategic-level trend in future PLA budgets. Given the substantial

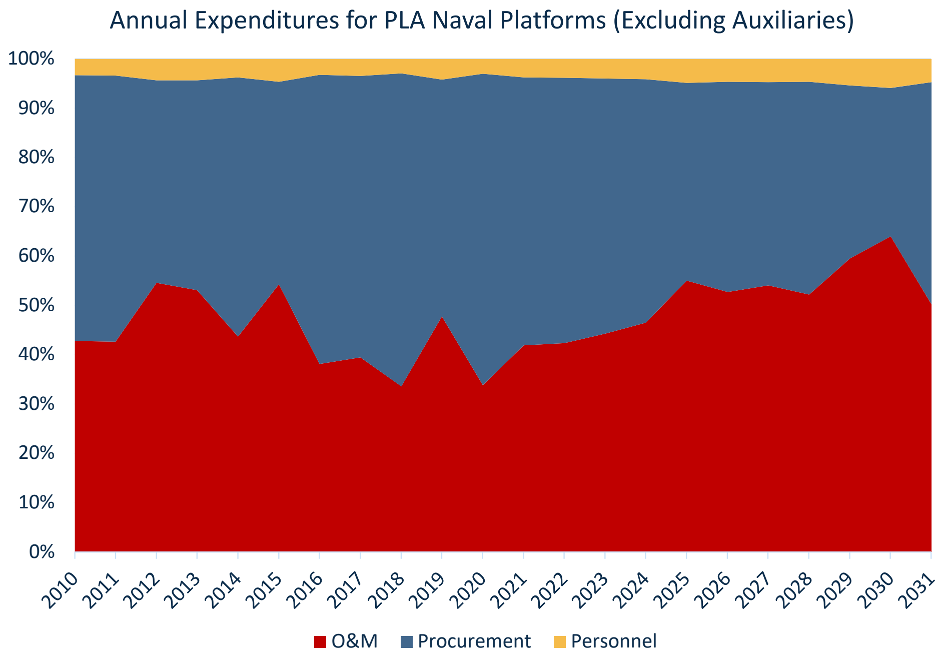
112 For an example of analysis from one such series conducted in mid-2021, see Jack Bianchi and Madison Creery (Center for Strategic and Budgetary Assessments), *China as a Dynamic Strategic Competitor: Assessing Potential Trajectories of China's Military Modernization* (Fort Belvoir, VA: Defense Threat Reduction Agency Strategic Trends Division, August 2021). This report, sponsored by the DTRA Strategic Trends Division, is the first analytic report CSBA has authored based on exercises using the completed China SCT.

113 As stated in Chapter 2, the projected real annual budget growth rate varies by PLA service, based on our assessment of Beijing's defense strategy and force structure goals. Generally, the tool assumes that force structure-related spending increases over 2021–2031 at approximately a three percent real annual growth rate.

114 As with CSBA's force structure estimate overall, the specific naval vessel estimates here are not a prediction of the exact composition of the future fleet, but rather are meant to convey one feasible outcome given the PLA's plausible level of resources over the next decade.

procurement quantities included in our projection, this O&M pressure appears manageable as the PLA reaches toward its global power projection ambitions.[115]

FIGURE 14: O&M PRESSURES SET TO INCREASE OVER 2021–2031



Although our analysis indicates that this PLA force structure forecast is plausible within a realistic fiscal constraint, small changes in certain factors, such as the PLA's annual budget growth rate and the inflation rate, can substantially expand or constrain the PLA's projected resources for modernization, especially in the out years. Moreover, as Chapter 1 cautions, forecasting future events in the social sciences, including economic growth rates, is subject to considerable uncertainty. China's economic growth rates have been moderating in recent years due to various structural factors, and its economy will continue to face substantial headwinds through the 2020s, in part due to high Chinese private debt levels and the world's slow recovery from the COVID-19 pandemic. Unforeseen exogenous shocks, such

115 The affordability of the PLA's transition to a large power projection force has been questioned previously. For example, Christopher Carlson casts doubt on the PLA Navy's ability to afford its O&M requirements, which will increase over the 2020s due to the procurement of large surface combatants and the maintenance of a large fleet. Similar to his analysis, our estimates also indicate that the Navy's O&M pressures will rise in the years ahead. Whether the PLA Navy can withstand these increasing O&M costs will depend on larger assumptions about the budget growth of the PLA Navy and the PLA overall over the next decade. As detailed in Chapter 2, CSBA's force structure projections are based on approximately a three percent real annual growth rate in force structure-related spending over 2022–2031, with service-specific growth rates varying based on CSBA's assessment of China's strategic goals and force structure requirements, among other factors. Christopher Carlson, *China Maritime Report No. 10: PLAN Force Structure Projection Concept, A Methodology for Looking Down Range* (Newport, RI: U.S. Naval War College China Maritime Studies Institute, 2020).

as war, natural disasters, and weather events, could also limit Beijing's available resources for defense.

CSBA's force structure forecast, including its growth rate assumptions, is therefore simply a starting point, rather than a prediction, for assessing Chinese defense modernization. The framework detailed in this study has the flexibility to incorporate differing budgetary environments. Within the China SCT, various budget targets—either above or below the default growth rate—can be set to force teams to examine how Beijing may adjust PLA modernization in response to differing budget constraints. For example, the budget target can be set to simulate a period of austerity owing to an economic shock, allowing users to consider China's choices in retrenchment.

Beta Exercises: Overview

To test the China SCT as it was being developed, CSBA organized three exercises in which participants used beta versions of the tool to assess China's plausible defense modernization trajectories. Each exercise involved two Red teams, each with approximately four to eight participants. CSBA sought participants with a wide range of backgrounds, including academic experts on the PLA, current and former U.S. defense planners and policymakers, and defense industry analysts. The baseline, or default, force structure forecast built into the China SCT at the start of the exercise varied somewhat across the three exercises, but generally followed the force structure forecast provided in the appendix.

The Red teams were tasked to serve as advisory groups to the CCP Central Military Commission (CMC) regarding future force planning. The teams in the first two exercises were instructed to create a force structure in line with China's strategic objectives, as defined by the teams. In the third exercise, to force the teams to generate alternative force structures with starker differences, each of the two teams was provided different strategic guidance. One team was told that the CMC's primary strategic goal was "reunifying with Taiwan by the early 2030s." In contrast to that regional objective, the other team was told that the CMC's primary goal was "further expanding China's global influence and protecting China's growing global interests."[116]

Beta Exercises: Key Themes and Trends on PLA Modernization

Although the beta exercises were organized primarily to test the tool's features and assumptions, several preliminary themes and insights on the PLA's modernization emerged from the decisions of the various teams. The propositions below—that Beijing will prioritize

116 As background, the globally-oriented team was also told: "The CMC believes the Taiwan Strait military balance increasingly favors China. The PLA already can successfully deter both Taiwanese independence and third-party intervention in a Taiwan conflict." Since the Taiwan military situation was believed to be under control, the CMC sought to further develop China's global power projection forces and posture.

regional concerns over global ones, that the PLA Army will further reduce ground force structure, and that the PLA Air Force will substantially reduce its legacy capacity—are the consensus expectations of the players, who were predominantly American national security experts.

Importantly, an alternative force structure produced using the China SCT is not necessarily a prediction of the future. Instead, the output is a basis for more pointed discussions of the PLA's trajectory and the linkages between China's defense strategy, operational concepts, force structure, and resources. The China SCT functions as a hypothesis-generating tool: experts and generalists alike can select a range of force structure choices that serve as points of departure for further discourse and debate.

Consolidating Power Regionally, Then Expanding Globally

The sequencing of China's force structure investments may indicate the prioritization of China's strategic objectives. Rising powers generally consolidate power regionally and then seek to expand globally. Similarly, in our exercises, teams prioritized the further development of near seas capabilities first, followed by overseas power projection capabilities and posture. This sequencing would emphasize that regional goals, especially Taiwan, continue to have precedence over China's global ambitions. If China's investments in the coming years remain skewed toward near seas capabilities overall, that would corroborate these views. If Beijing shifts to large-scale production of large surface combatants and aircraft carriers, potentially complemented by retirements of near seas platforms such as missile boats and other coastal combatants, that could indicate that Beijing's gaze is directed further afield and that it is not anticipating a Taiwan contingency in the near term.[117]

Trading Away PLA Army Force Structure for Platforms in Other Domains

All teams in CSBA's exercises chose to pay for investments in their priority categories through cuts to the PLA Army, usually including cuts to modernization spending, reductions in Army force structure, and decreases in Army personnel levels.

Participants generally concluded that, despite large reductions to PLA Army personnel and units over the last several decades, further reductions were needed to free up funds sufficient to realize China's strategic goals in the maritime direction. Teams therefore accepted greater risk along China's continental fronts. They considered Russia as a low threat priority. Although tensions with India have increased in recent years, participants judged that the Army has more than sufficient forces to handle Indian ground forces, especially given that the mountainous Sino-Indian border restricts the maneuver of large ground armies.

117 These force structure developments offer just one potential indicator of Beijing's urgency to unify with Taiwan. Beijing's broader policy toward Taiwan depends on a variety of factors, including overall PLA capability, leadership confidence, domestic political concerns, and so forth, that are beyond the scope of this report.

In general, the cuts made by the teams served to create a smaller, lighter PLA Army. Teams on average cut ten combined arms brigades (CABs), with a range of 6 to 15 brigades cut among the six teams. Of the three types of CABs—heavy, medium, and light—all teams cut some number of heavy CABs, and four of the six teams cut medium CABs. Only one team targeted light CABs for cuts, retiring four. Teams also cut other ground force structure units. While specific decisions were less consistent across the exercises, cuts selected by at least three teams included: retiring air defense artillery units, retiring border defense brigades, and decelerating the rate of heavy CAB modernization. The units retired are assumed to operate the oldest equipment, so the substantial retirements also effectively lowered the average age of equipment in the force.

Among the teams, there was some debate about the acceptable limit to heavy CAB reductions given existing threats. Some teams argued that heavy brigades could be cut dramatically, primarily because conflict with Russia seems unlikely. At least one team disagreed, arguing that such cuts involved risky assumptions about the capability of medium brigades to meet Beijing's wide-ranging security objectives. PLA land forces, they argued, need the capability and scale to sustain potentially intensive land operations, from conventional conflict on the Korean Peninsula to internal security on the streets of Beijing.[118]

The exercises indicate that further PLA Army force structure reductions could be an important indicator of the pace and direction of future PLA modernization. Chinese strategists assess that China's main strategic direction is toward the maritime theater in the Western Pacific, with a need to project power farther from China's shores. Future cuts to the PLA Army would imply Beijing's determination that the PLA needs to continue its geographic reorientation, freeing up funds that will likely be used to further bolster maritime, air, amphibious, and other power projection forces. Alternatively, increases in PLA Army expenditures—such as a noticeable increase in Army modernization and/or the prioritization of armored vehicle and rotary-wing production for the Army over the needs of the growing PLA Navy Marine Corps—could reveal a hardened or even resurgent PLA Army that refuses to yield a greater share of resources to other services. It is also possible that the Army's size and budget share hold steady, perhaps reflecting a limit to Beijing's risk tolerance given existing continental threats.

Retiring Legacy Air Capacity to Invest in Modern Air Capabilities

In general, teams sacrificed legacy air capacity to free up the funds necessary to field more modern, though smaller, air forces that could project power farther from China's borders. Team choices resulted in a PLA Air Force (PLAAF) that, while still fighter-heavy, reflected a more diverse composition by 2031. Similarly, the PLA Naval Aviation fleet was generally

118 This debate about potential scope and scale of future PLA Army force structure reductions, including the assumed requirements and capabilities of different types of ground units, is an excellent example of the thought-provoking discussions that CSBA seeks to provoke among China SCT exercise participants.

reduced in terms of aircraft inventory but boasted greater capabilities by the end of the 2031 planning period.

All teams decided to retire essentially all PLAAF J-7 and PLAAF and PLAN J-8 tactical fighter aircraft. Four teams retired legacy H-6 aircraft (three teams cut PLAAF and PLAN H-6U refueling aircraft, and two teams cut older H-6 D/G/H/M bomber variants). Other retirement decisions varied across the teams, but at least two teams retired KJ-200 airborne early warning & control aircraft and retired PLAAF and PLAN Y-8 electronic aircraft variants.

PLAAF and PLAN aircraft procurement was already built into the baseline force structure forecast to 2031 (see appendix), but teams chose to increase the scale of several of these planned procurements, revealing the high priority teams placed on those capabilities. All teams procured additional Y-20A transport aircraft and H-20 stealth bombers. Five teams procured additional Y-20U refueling aircraft and J-20 stealth fifth-generation aircraft.[119] Four teams procured additional J-31 carrier-variant fifth-generation aircraft and KJ-500 airborne early warning & control aircraft. Three teams procured additional JH-XX fighter-bomber aircraft, Y-9 aircraft electronic variants, and the Y-8Q (KQ-200) anti-submarine warfare aircraft. Teams also procured various unmanned aerial vehicles. While all teams selected additional UAVs for aerial reconnaissance and targeting, the roles of the other UAV aircraft selected varied substantially across the teams.[120]

Whether and how quickly the PLA Air Force and PLA Naval Aviation proceed in this direction is an important indicator of China's military modernization and of Beijing's potential timelines for engaging in future conflicts. The large retirements of PLAAF and PLA Naval Aviation platforms that most teams selected in the SCT, especially in the first five-year move (2022-2026), reduced the PLA's total aircraft inventory by hundreds of aircraft. A short-term downsizing and restructuring of that scale could indicate that China is further committing to procuring the modern combat and support aircraft necessary for global power projection over the long term. Moreover, if the PLA undergoes such a disruptive large-scale restructuring process, that may indicate that Chinese leaders do not envision engaging in a conflict until at least the late 2020s, if not the 2030s.

In contrast, if the PLA chooses not to retire these aircraft, that would not necessarily mean that Beijing is preparing for a near-term conflict, but it may indicate a near-term risk threshold that China's leaders are unwilling to cross. In other words, Beijing may see large legacy capacity as valuable insurance against potentially high losses in conflict. The PLAAF and PLA Naval Aviation may also have several other reasons to be hesitant to dramatically cut legacy tactical aircraft. Large air inventories may indicate that the PLA still finds

119 Chinese aircraft generations differ from Western generations. What are considered fifth-generation aircraft in the West are considered fourth-generation aircraft in China. Similarly, fourth-generation aircraft by Western standards are regarded as third-generation aircraft by Chinese analysts.

120 UAV selections in particular were limited in the first and second exercises, which likely impacted this result.

value in training and sustaining large numbers of pilots and other support personnel. These personnel could be useful in withstanding combat losses in a prolonged high-intensity conflict. Maintaining a large stable of pilots and support personnel may reveal the scale of Beijing's ultimate modernization ambitions, perhaps indicating an aspiration to replace legacy aircraft one-for-one with more modern aircraft.

Continuing to maintain large numbers of legacy tactical aircraft may also reflect PLA assumptions about air combat in its likely future conflicts. Beijing may believe that legacy tactical aircraft, while inferior against modern U.S. aircraft, are still more than capable against China's numerous weaker neighbors. Moreover, these legacy aircraft may essentially provide the PLAAF with a cost-effective high-low mix. For instance, the PLA may assume that older, less survivable aircraft will be able to effectively conduct a range of strike and support missions once the PLA's more advanced aircraft and other power projection forces degrade the air and missile defenses of a neighboring state in the early days of a conflict.

Finally, the maintenance of large legacy air forces could reflect continued technological bottlenecks in aerospace research and development and production. If given an additional renminbi, the PLA may believe that it would enjoy a larger marginal benefit from spending it on sustainment of legacy aircraft rather than on aerospace R&D.

Beta Exercises: Assessing American Expectations of the PLA's Modernization

Since the People's Republic of China was founded, American experts have repeatedly been surprised by Beijing's strategic decisions, the capabilities of the Chinese defense industrial base, and the PLA's ability to undertake new types of operations. Beijing's intervention in the Korean War, China's development of nuclear weapons, and the PLA's recent tests of hypersonic missiles are just a few of many examples.[121] In a broad and blunt characterization of U.S. intelligence about the PLA, Admiral Robert Willard, the former commander of U.S. forces in the Pacific and the former commander of the Pacific Fleet, stated in 2009: "I would contend that in the past decade or so, China has exceeded most of our intelligence estimates of their military capability and capacity every year. They've grown at an unprecedented rate in those capabilities."[122] Although the severity and the sources of past misjudgments have varied, a clear need exists for the policy community to continually reassess the validity of its expectations.

121 On the U.S. intelligence community's misunderstanding and underestimation of the Chinese nuclear program in the 1960s, see "Senior Review Panel Study of Intelligence Judgments Preceding Significant Historical Failures: The Hazards of Single-Outcome Forecasting," Central Intelligence Agency, NIC 9079-83, December 16, 1983. On China's advancements in hypersonics, see Michael R. Gordon, "China's Hypersonic Missile Test Is Close to 'Sputnik Moment,' U.S. Military Chief Says," *The Wall Street Journal*, October 27, 2021, available at https://www.wsj.com/articles/u-s-military-chief-says-chinas-hypersonic-missile-test-is-close-to-sputnik-moment-11635344992.

122 Bill Gertz, "Inside the Ring," November 5, 2009, available at https://www.washingtontimes.com/news/2009/nov/05/inside-the-ring-70787975/.

Given that the beta exercises predominantly consisted of players from the United States, the exercise results necessarily reflected the assumptions and preconceptions among American experts about likely developments in Beijing's defense strategy, operational concepts, and force planning over the coming decade. These exercises therefore provided a means to clearly define certain American expectations and subject those assumptions to inquiry.

Our initial exercises revealed that American players may hesitate to explore departures in Chinese nuclear strategy, downplay the unique force structure requirements of China's complicated near seas security environment, and overestimate the likelihood of future reductions in PLA ground forces.

Underestimating Beijing's Incentives to Develop and Expand Nuclear Forces

On nuclear forces, in our first two exercises, only one of the four teams decided to develop and expand China's theater-range nuclear forces.[123] For the third exercise, the White Cell provided one of the Red teams with an explicit objective to develop China's theater-range nuclear forces to achieve theater escalation dominance, yet that team only decided to develop and procure a low-yield nuclear warhead for ballistic missiles and a nuclear-capable CJ-10 ground-launched cruise missile (with an associated cruise missile nuclear warhead), despite being presented with a variety of other air- and sea-based nuclear investment options. Moreover, none of the teams chose to invest in silo-based nuclear forces, with two teams actually retiring some silo-based missiles. In what was an unintended experiment, these exercises occurred prior to news reports in June 2021 about the expansion of Chinese nuclear missile silos. These team decisions may both underscore enduring obstacles in Western forecasts of PLA force planning and highlight the need to mitigate or overcome these obstacles in future China SCT exercises.

The team decisions above may reflect projections based on the momentum of longstanding historical trends, namely the limited aims of China's nuclear strategy and the modest size of its nuclear arsenal. In other words, participants may have extrapolated trends from the past when thinking about the future possibilities. More broadly, these choices may also hint at deeply-embedded American habits of thought formed in the post-Cold War era, during which nuclear weapons have been perceived as having less utility than conventional forces.

123 For the one team that did choose to develop China's nuclear forces, that team's nuclear-related decisions were driven by one exercise participant. Without that individual's participation, it is likely none of the teams would have chosen to explore a departure from existing Chinese nuclear strategy.

An entire American generation has not lived under the nuclear shadow and has had limited incentives to consider nuclear matters.[124]

Yet, in the case of Chinese nuclear modernization, linear extrapolations of past trends could lead to grave strategic misjudgments. China historically confined itself to a defensive nuclear strategy, focused on responding to an adversary's offensive nuclear strike. This posture in part resulted from Beijing's belief that nuclear weapons were of limited utility in conflict, but it also reflected the technological limitations of China's nuclear-capable platforms and delivery vehicles.[125] Today, even along its existing course, PLA nuclear modernization is yielding an expanded and more diversified nuclear arsenal that will open new options for policymakers in Beijing. China has developed dual-capable theater-range ballistic missiles, including the DF-17, DF-21, and DF-26, that can penetrate modern air defenses and strike mobile military targets. Although the PLA has traditionally lacked the survivable platforms and precision-guided delivery vehicles necessary to make a warfighting strategy possible, those limitations are quickly evaporating.

Theater-level nuclear weapons are relatively cheap but powerful tools that could be rapidly expanded to undermine U.S. extended deterrence and credibility. Nuclear warhead development and production is a high fixed-cost, low variable-cost endeavor. As noted in Chapter 2, although establishing the infrastructure necessary to support nuclear weapons development and production carries substantial upfront costs, the variable cost of developing and producing new types of nuclear warheads is relatively low.[126] Given the large scale of China's existing nuclear program, additional investment in developing new nuclear capabilities may be relatively cheap. Compared with the PLA's other major acquisition programs, nuclear investments are also likely low-cost, based on CSBA's estimates. Rather than cost, the major limiting factor in China's production of nuclear warheads has been the production of weapons-grade plutonium, yet this constraint may be dramatically easing in coming years due to China's use of fast reactors.[127]

124 These exercises occurred in March 2020, April 2021, and May 2021, prior to news reports from June 2021 about the expansion of Chinese nuclear missile silos and additional reports in October 2021 regarding China's testing of a potentially nuclear-capable hypersonic missile earlier in the summer. Were these exercises held in late 2021, the teams may have been more eager to explore potential nuclear investments. Joby Warrick, "China is building more than 100 new missile silos in its western desert, analysts say," *The Washington Post*, June 30, 2021, available at https://www.washingtonpost.com/national-security/china-nuclear-missile-silos/2021/06/30/0fa8debc-d9c2-11eb-bb9e-70fda8c37057_story.html; Michael R. Gordon, "China Tests Hypersonic Missile in Military Expansion," *The Wall Street Journal*, October 20, 2021, available at https://www.wsj.com/articles/china-tests-hypersonic-missile-in-military-expansion-11634744351.

125 For a historical overview of China's limited nuclear strategy and an examination of the various external and internal forces that may lead Beijing to develop a more robust nuclear strategy and posture, see Mahnken et al., *Understanding Strategic Interaction*, pp. 59-83; Eric Heigenbotham et al., *China's Evolving Nuclear Deterrent: Major Drivers and Issues for the United States* (Santa Monica, CA: RAND Corporation, 2017), pp. 57–120.

126 Interview with U.S. government nuclear forces cost analysts.

127 Thomas B. Cochran and Henry D. Sokolski, "How Many Nuclear Warheads China Might Acquire by 2030," in Henry D. Sokolski (Ed.) *China's Civil Nuclear Sector: Plowshares to Swords?*, (Arlington, VA: Nonproliferation Policy Education Center, 2021), pp. 6–24.

Undervaluing Conflicting Force Structure Requirements in the Near and Far Seas

Another analytic tendency among the teams was the underestimation of the diverse security requirements imposed by China's complex maritime geography. Rather than needing small surface combatants that can hide and survive throughout the near seas, several participants believed that the PLA Navy can use general-purpose large surface combatants in both near and far seas conflicts. These teams also believed that large surface combatants could accomplish lower-end missions, even though they may not fulfill those missions as efficiently as smaller vessels. These participants were quick to trade away large numbers of small surface combatants in return for a much smaller number of global power projection platforms.

Given the prevalence of this thinking in the first two Strategic Choices Exercises, the two teams in the third Strategic Choices Exercise were given dramatically different guidance to encourage divergent thinking. One team was tasked to focus regionally, prioritizing unification with Taiwan, while the other group was tasked with defending China's global interests and expanding China's global influence. Yet even the regionally-focused team still chose to divest dozens of small surface combatants to free up funds for general purpose vessels. This team argued that, despite the differing guidance, there was still overlap in force planning requirements, as global power project platforms would improve the PLA's ability to keep U.S. and other foreign forces farther away from mainland China in any regional conflict.

Despite that reasoning, the threats to large surface combatants in littoral areas and enclosed seas remain formidable. As Milan Vego explains, the littorals "generally limit maneuverability, speed and the use of weapons and sensors by one's surface ships and submarines, primarily designed for employment on the open ocean."[128] Large vessels also face a range of risks from littoral naval capabilities, as well as nearby land-based strike platforms and systems. Depending on U.S. and allied posture and capabilities along the first and second island chains, the PLA could be compelled to stretch its resources by procuring and operating separate near seas and far seas capabilities.[129] Prospective American efforts to capitalize on the island chains' geography, especially through fielding dispersed land-based anti-ship forces, seem poised to exacerbate the challenges to large PLAN vessels in the years ahead.[130]

Assuming Additional PLA Army Force Reductions Over the 2020s

A third analytic pattern that emerged from the exercises was the downward pressure on the PLA Army's future trajectory. All teams made considerable cuts to PLA Army force

128 Milan N. Vego, *Naval Strategy and Operations in Narrow Seas* (London: Routledge, 1999), pp. xv–xvi.

129 Yoshihara and Jack Bianchi, *Seizing on Weakness*, pp. 60–65, 97–102.

130 For example, see U.S. Marine Corps, *Force Design 2030* (Quantico, VA: U.S. Marine Corps, 2020). On potential concepts for exploiting the island chains geography vis-à-vis China, see Thomas G. Mahnken, Travis Sharp, Billy Fabian, Peter Kouretsos, *Tightening the Chain: Implementing a Strategy of Maritime Pressure in the Western Pacific* (Washington, DC: Center for Strategic and Budgetary Assessments, 2019).

structure, modernization funding, and personnel—sometimes cutting well over 100,000 Army personnel—in order to generate funds for investment priorities in other domains. Teams frequently cited warm Sino-Russian relations as a major factor enabling additional downsizing in the 2020s, following multiple instances of downsizing in recent decades.

Despite the resounding consensus among the teams, additional PLA Army reductions may prove difficult to implement due to the nature of earlier reductions, China's external and internal security requirements, and the persistent bureaucratic strength of the Army.

The PLA has been downsized repeatedly since 1985, shedding roughly 1.7 million personnel in total.[131] The Army, specifically, is now under one million personnel for the first time in the PRC's history. The latest reduction of 300,000 personnel announced by Xi Jinping in 2015, which primarily affected the Army, was aimed at support units rather than combat units.[132] Thus, the easiest cuts have likely already been made, and additional cuts would more directly test Beijing's willingness to downsize the Army's combat strength given potential threats.

Although relations with Russia are at their strongest point since the 1950s, China's continental security concerns are complex and stand to be manpower intensive. Beijing requires ground forces capable of operating in varied environments across Central Asia, the Sino-Indian border, Southeast Asia, and the Korean Peninsula, in addition to the potential need for sizeable deployments abroad in the future. The Korean Peninsula alone presents a number of thorny challenges for ground forces, including the enduring prospect of renewed conventional operations against U.S. and South Korean forces and the potential for prolonged and extensive post-conflict stabilization operations along the border and on the peninsula. Similarly, a PLA operation intended to unify with Taiwan would involve large-scale amphibious landings by PLA Army forces and likely require a protracted presence for stabilization operations.

In terms of internal security requirements, the PLA is fundamentally a party army intended to preserve and strengthen the CCP's domestic monopoly on power. While the People's Armed Police (PAP) has grown rapidly in size and funding since the 1989 Tiananmen Square protests and would be called in before the PLA to respond to domestic unrest, the PLA must still prepare to be the ultimate guarantor of the Party's survival. The PAP is now composed of roughly one million personnel—a sizeable force—but, in a country of over one billion, widespread protests in China's large urban areas could quickly strain even those numbers.[133]

131 Adam Ni, "Why China is Trimming Its Army," *The Diplomat*, July 15, 2017, available at https://thediplomat.com/2017/07/why-china-is-trimming-its-army/.

132 David M. Finkelstein, *Get Ready for the Second Phase of Chinese Military Reform* (Arlington, VA: CNA, 2017), available at https://www.cna.org/cna_files/PDF/DOP-2017-U-014677-Final.pdf.

133 For a detailed examination of the PAP's history, organizational reforms, and missions, see Joel Wuthnow, *China's Other Army: The People's Armed Police in an Era of Reform* (Washington, DC: National Defense University, 2019).

Bureaucratically, the Army has seemingly been losing clout to the other PLA services, which have risen in importance as Beijing seeks to conduct operations in the air, maritime, space, network, and electromagnetic domains in areas further from China's shores. Yet, historically, the PLA has been dominated by the Army, and there are indications that it is not simply standing aside for the other services in debates over funding and authority. For instance, from 2016 to 2021, half of the officers promoted to the rank of general come from the Army and even the Southern Theater Command, which arguably is the PLA theater command with the most important maritime responsibilities, is now commanded by a PLA Army General after being led by a Navy Admiral from 2017 to 2021.[134]

In sum, just as with assessments of China's future nuclear forces, changes in context and driving forces may limit the future relevance of past trends on Army force structure and personnel reductions.

Implications for Allied Strategy

The insights above from the beta exercises raise several preliminary implications and opportunities for allied strategy as the PLA continues to modernize.

First, the allies should be prepared to face a China that poses both a regional and, increasingly, a global military threat. Beijing seems likely to have sufficient resources to maintain a large continental army and a substantial regional force structure composed of air, sea, and land-based missile capabilities, while simultaneously expanding its air, sea, and amphibious capabilities for global power projection. As it continues to modernize, the PLA will be able to place bets on a variety of platforms and technologies, increasing the complexity and uncertainty that allied planners face in assessing future operational scenarios involving Chinese forces. For Washington and its allies, pursuing cost imposition strategies against China will become increasingly important, especially as the U.S. defense budget likely faces relatively flat real growth in the years ahead.[135] Given China's resources, any one cost imposition strategy will not bankrupt the PLA. But over time, the cumulative effect of a set of cost imposition strategies that stress the PLA in multiple directions could prevent the PLA from mustering sufficient resources to accomplish its major objectives.

Second, if the United States seeks to limit the PLA's ability to fight and win conflicts in the Western Pacific, it would behoove U.S. and allied policymakers to reduce Beijing's desire and ability to further downsize the PLA Army. Despite several reductions over the previous decades, the PLA Army is still approximately half of the entire PLA in terms of personnel. As

134 Reginald Lin and Eli Huang, "China Military Watch," *The Strategist*, October 1, 2021, available at https://www.aspistrategist.org.au/china-military-watch-11/.

135 Travis Sharp, *Slow and Steady: Analysis of the 2022 Defense Budget Request* (Washington, DC: Center for Strategic and Budgetary Assessments, 2021).

demonstrated in our exercises, teams sought to pay for their priority investments, especially in the air and sea categories, through additional cuts to ground forces.

Allied policymakers should thus seek to raise China's perceived continental threats. A more capable Indian military and the increased prospect of conflict along the Sino-Indian border could go far in changing threat calculations in Beijing. Similarly, the continuing prospect of a contingency involving the Korean Peninsula would also induce PLA leaders to maintain large ground forces, both to confront South Korean and U.S. forces and to handle the potential influx of refugees. If South Korean ground forces modernize with the goal of deterring and, if necessary, stymieing PLA ground intervention, that could further stress Beijing's force planning.[136] Although a seeming lost cause at the moment, the Allies should also remain open to ways to increase friction in Sino–Russian relations, potentially on issues such as Central Asia policy, nuclear arms control, theater range missile proliferation, and access to the Arctic.

The Allies could also consider ways to increase the relative bureaucratic strength of the PLA Army. Although shaping the PLA's internal power dynamics is a difficult endeavor, there are potential creative opportunities to do so. For instance, selective public disclosures of corruption in the other services could weaken their strength and legitimacy. Opportunities for corruption in the Navy and Air Force, for instance, may increase as they pursue expensive power projection platforms and seek overseas basing and access agreements in developing countries where political corruption is prevalent.[137] Likewise, public discourse of political unreliability or disloyalty in the other services would reduce the trust of central leaders in the willingness of those services to maintain the CCP's monopoly on power.[138] Efforts by the Allies to encourage defections of non-Army PLA personnel, who will increasingly operate overseas and likely face easier opportunities to defect, could also undermine CCP faith in certain PLA services and lead to restrictions on the operations and modernization of those services. Such limits would be reminiscent of the limitations the PLAAF

136 On the Republic of Korea's defense modernization and the operational requirements imposed by China's military modernization, see Josh Chang, Regan Copple, Madison Creery, Jack Bianchi, and Evan Braden Montgomery, *Aligning South Korea's Defense Strategy and Capabilities* (Washington, DC: Center for Strategic and Budgetary Assessments, 2021), available at https://csbaonline.org/uploads/documents/Aligning_ROK_Defense_Strategy_and_Capabilities.pdf.

137 Teddy Ng, "Former Boss of China Aircraft Carrier Programme in Corruption Probe," *South China Morning Post*, May 13, 2020, available at https://www.scmp.com/news/china/military/article/3084131/former-boss-china-aircraft-carrier-programme-corruption-probe; Julie Watson, "US Navy Admiral Sentenced to 18 Months in 'Fat Leonard' Bribery Scandal," *Navy Times*, May 17, 2017, available at https://www.navytimes.com/news/your-navy/2017/05/17/us-navy-admiral-sentenced-to-18-months-in-fat-leonard-bribery-scandal/.

138 The promotion of PLA general officers hinges on the officers' perceived loyalty to the CCP and, often, to the CCP General Secretary himself. Willy Wo-Lap Lam, "As Rival Factions Gain Traction, Xi Seeks to Secure Support from the Military," *China Brief*, January 25, 2022, available at https://jamestown.org/program/as-rival-factions-gain-traction-xi-seeks-to-secure-support-from-the-military/.

experienced in the 1970s and 1980s in response to Lin Biao's fall and the repeated defection of PLAAF personnel.[139]

The United States and its allies and partners admittedly have limited agency in directly impacting Beijing's assessments of continental threats, Chinese public perception of PLA corruption, and the power balance between the various PLA services. Nevertheless, Washington and allied capitals should be prepared to opportunistically seize on events as they occur to exacerbate these various problems for Beijing.

Third, the Allies have strong incentives to limit China's technological advancements in both defense-related areas and a wide range of dual-use categories. Across the exercises, teams were eager to develop and procure advanced indigenous aerospace platforms, but whether these investments can be realized will depend on the progress made by China's scientists and engineers over the next decade. For instance, China's aerospace industry is still struggling to produce modern jet engines and avionics necessary for advanced military aircraft. Given that such aerospace technology is inherently dual-use, combined with Beijing's longstanding efforts to integrate civilian and military research and production, allied policymakers have strong reason to limit China's advancements in aerospace research.

The Allies have considerable agency in shaping Chinese technological developments, and policymakers should consider a range of means to limit China's absorption of Western technology and know-how. These measures could include: expanding and strengthening controls on exports and inbound and outbound foreign investment; limitations on foreign study and research by individuals affiliated with the Chinese military and defense industry; and offensive operations that undermine, sow doubt within, or otherwise interfere with China's research and development efforts.[140]

More broadly, the exercises demonstrate that Sino-U.S. security competition extends beyond the military domain to areas including technology, trade, finance, and politics that are critical to China's overall security strategy. U.S. and allied policymakers must consider a variety of military and non-military means to impose costs on China's military modernization and uphold the existing U.S.-led international security order.

139 Beijing grew distrustful of the PLAAF's loyalty, particularly during the Cultural Revolution, when Mao criticized political leaders close to the PLAAF, including Lin Biao. This distrust continued through the 1970s and into the 1980s due to repeated defections of PLAAF personnel who escaped China by flying their military aircraft to foreign countries. Loyalty concerns seemed to hobble the PLAAF for decades by limiting its missions and its ability to coordinate operations with other PLA services. For additional detail, see Ken Allen and Cristina Garafola, *70 Years of the PLA Air Force* (Montgomery, AL: China Aerospace Studies Institute, 2021), pp. 80–81.

140 For an overview of a potential U.S. and allied technology cost imposition strategy toward China, see: Jack Bianchi, "Fear Not Technological Disengagement and Competition with China," *War on the Rocks*, January 14, 2020.

CHAPTER 4

Future Applications

Looking ahead, the China Strategic Choices Tool could be applied in a variety of ways to further analysis of the PLA's modernization and of U.S. and allied competitive strategies toward China.

First, similar to the three exercises covered above, additional exercises could be organized in which Red teams rebalance PLA force structure.[141] The teams could be provided a free hand to shape PLA force structure as they wish in order to assess various potential PLA trajectories. Alternatively, the Red teams could be provided specific strategic guidance, similar to the third exercise CSBA organized above, to examine how PLA force planning would vary based on differing CCP strategic objectives. Examples of such strategic guidance could include unifying with Taiwan on a deadline, expanding China's global influence and posture, or rebalancing PLA force structure to primarily target one particular adversary (e.g., the United States, Taiwan, Japan, the Republic of Korea, etc.). Yet another alternative would be to provide Red teams with differing budget constraints—either higher or lower than the tool's default growth rate—to assess how Beijing might adjust the PLA's modernization in various fiscal environments.

Second, CSBA could organize exercises between competing Blue and Red teams to study the strategic interaction between the two sides. The Blue and Red teams would use the U.S. SCT and China SCT, respectively, in a move-countermove exercise. After the first five-year move, the teams would be provided with the choices made by their adversary. After examining those choices, teams would then proceed with the second five-year move, reacting against the choices made by their adversary in the first five-year move.[142] Such dueling exercises could help players identify U.S. and Chinese actions that maintain stability, intensify the competition, instigate crisis or conflict, or foreclose adversary, U.S., and allied options.

141 An example of such an exercise series is contained in Bianchi and Creery, *China as a Dynamic Strategic Competitor*.

142 A more advanced version of this exercise would be to use mathematical optimization to see if, given fixed resources, each side can converge on an 'optimal' force structure in response the other's force structure.

The exercises could also identify steps that the United States could take to shore up deterrence and reassure allies. Action-reaction cycles are neither linear nor continuous, as attested to by the history of past great power rivalries.[143] Some actions calibrated to provoke may be ignored or missed altogether by the target audience, while other actions considered mundane may unintentionally stimulate an overreaction by the opponent. An understanding of these dynamics—inherent to any interaction between two living forces—is crucial if the United States aims to deter China and maintain its lead in the peacetime competition. Using the U.S. and Chinese force structure trading tools, the interactive exercises led by CSBA will simulate these action-reaction cycles in a structured environment that does not exist elsewhere. Played iteratively, these games can help observers recognize patterns, identify critical tipping points in the competition, and plot likely trajectories of the Sino-U.S. rivalry.

Third, the U.S. and China SCTs can be integrated into wargames to assess how varying force structures may perform in plausible future conflicts. Analysts could assess how program of record and alternative Blue force structures might perform against alternative Red force structures, which will aid U.S. decision makers in creating a force structure that is more robust and resilient in the face of uncertainty over the PLA's modernization trajectory. For instance, in a multi-day wargame, an initial set of U.S. and Chinese forces could confront each other in one or more operational scenarios. Based on the lessons from this experience, teams could then use the U.S. and/or China SCT to rebalance and improve their future force structure. On the final days of the game, the teams could then refight the original operational scenarios with the rebalanced forces in order to determine how the scenarios' outcomes could potentially differ.

Fourth, future Green-Red exercises would enrich the perspective of how the PLA may develop in the future, in part by balancing out potential biases among U.S. players. Green teams may envision PLA force structures tailored more to their own particular disputes with China, rather than a U.S.-China conflict. As noted above, U.S. players assumed that the PLA would shift away from small surface combatants primed for near seas conflicts toward general purpose blue water naval vessels. Green teams, composed of Korean, Japanese, or Taiwanese players, for instance, may envision a PLA maritime force that remains composed of large numbers of small surface combatants, which can more actively and credibly advance China's various maritime claims compared with a smaller number of power projection surface vessels which would be more vulnerable in narrow littoral areas. Equally important, such Green-Red exercises could uncover biases and blind spots about the PLA that allies share with the United States. CSBA already has several Green SCT databases for U.S. allied and partner countries that could be used in these types of games.

Fifth, Blue-Green-Red exercises, potentially with integrated wargames, could examine ways of complicating PLA planning and stretching PLA force structure requirements. For instance, a game involving U.S. and Taiwanese players could examine more effective,

143 For example, see Mahnken et al., *Understanding Strategic Interaction in the Second Nuclear Age*, pp. 5–10.

complementary American and Taiwanese force structures in potential Taiwan Strait conflicts. American and Taiwanese participants could confront the PLA with two starkly different U.S. and Taiwanese force structures, for example. The U.S. force structure could include a variety of long-range power projection capabilities in the air and sea domains, while Taiwanese forces could focus on ground-based air and sea denial forces aimed at stymying any PLA advance. How the Red team reacts to these types of complementary allied force structures will provide insight into how the allies can best coordinate their respective force structure investments.

Finally, exercises could be organized to examine the effects of potential geopolitical tectonic shifts. For instance, the Red SCT could be used to examine how unification between China and Taiwan would impact PLA force structure. In such an exercise, teams could be told that unification with Taiwan occurred at the end of the first five-year move. Teams could start the SCT in the second five-year move and rebalance PLA force structure accordingly. The exercise could assume that unification occurred peacefully and that PLA forces are all intact. Alternatively, teams could be told that unification occurred by force and that a smaller PLA force remains due to losses sustained in the conflict. The former scenario could test how the PLA might divest from forces no longer needed for a Taiwan contingency and reorient investments toward other regional and global missions. The latter scenario could test how the PLA might recapitalize its forces in a hostile postwar environment as the United States and its allies rally against China's forcible reunion with Taiwan.

Across these various events, the observations and insights generated by iterative exercises with the tool will aid U.S. and allied competitive strategy development toward China. The tool can help users better understand the strengths and weaknesses of the U.S., the Allies, and China in a protracted competition. For example, through repeated Blue-Red exercises, participants will be able to identify key U.S. and Chinese characteristics and features, such as sunk costs in the existing force structure; overinvestment or underinvestment in certain assets; duplicative capabilities; enduring strengths and weaknesses in the defense industrial base; institutional biases arising from the structure of the CCP, the PLA, and the defense industrial base; bottlenecks or vulnerabilities in the supply chain or production processes; and so forth. In sum, these attributes create a strategic profile, which may reveal proclivities, some perhaps deeply embedded, that could in turn be subjected to an adversary's competitive strategies. Through these exercises, participants will be able to devise U.S. competitive strategies toward China and suggest responses to potential Chinese competitive strategies against the United States.

In the above exercises, players can employ the competitive strategies framework to attempt to answer a variety of questions concerning China, the United States, and U.S. allies and partners, including:

- How might China develop a force structure that attempts to take advantage of critical U.S. vulnerabilities in potential Indo-Pacific conflicts, such as America's need to conduct expeditionary operations across the Pacific far from its major supply centers at home?

- How might China attempt to drive U.S. investment toward expensive and costly defensive systems, such as missile defense, and thereby limit U.S. investment in offensive capabilities?
- How can the United States and its allies make cost-effective investments that would potentially either render certain classes of Chinese systems obsolete or compel China to invest in defensive or unproductive military programs?
- What are the best ways for the United States and its allies and partners to head off potential Chinese competitive strategies?

Answers to these questions, even if speculative, would go far to help policymakers think through effective and durable strategies for competing with China over the long term.

Beyond answering the specific substantive questions above, continued exercises with the China Strategic Choices Tool will pay dividends for the U.S. and allied national security community. For almost a decade, CSBA has employed its U.S. Strategic Choices Tool and wargame exercise methodology to conduct a series of one-day and multi-day events with different groups, including uniformed and civilian DoD personnel, Hill staffers, industry experts, defense officials from allied countries, and defense analysts from other think tanks, reaching thousands of individual participants. These exercises have influenced thinking on Capitol Hill, within the Pentagon, and in allied capitals in a way that written reports and briefings cannot; the exercises allow participants to explore strategic alternatives for themselves rather than being handed a result.

The China SCT will have similar reach and longevity. We expect the China SCT to generate analytically rich debates about the specific tradeoffs Beijing policymakers face and the potential alternative trajectories of PLA modernization. Moreover, through various exercises, workshops, and wargames that feature the China SCT, CSBA anticipates developing new networks between various communities that are too often isolated from each other, including PLA experts, cost analysts, economists, defense planners, intelligence analysts, senior military officers, defense industry experts, and defense policymakers. The substantive lessons and professional connections developed at these events will be critical in helping the entire U.S. national security community prepare for the greatest strategic challenge of our era for years to come.

APPENDIX

The Starting Point: CSBA's Cost-Informed 2021–2031 PLA Force Structure

This appendix contains the China SCT's default (baseline) 2021-2031 PLA force structure forecast that was used for the China SCT beta exercises held in early 2021 (Chapter 3).[144]

In general, the China SCT's default force structure projection is not a prediction of what will be. As explained in Chapter 1, any point estimate forecast will almost certainly be incorrect. Instead, the projection is merely a starting point for the China SCT's users, who are free to depart from the default projection by making their own rebalancing decisions. The individual line items in the projection are less important than the cumulative amount of spending, which users can reallocate by selecting investment and divestment options in the tool.

The cost-informed force structure projection below relies on our platform and unit-level cost estimates, which include research and development, procurement, operations and maintenance, and personnel costs tied to force structure. The projected real annual budget growth rate varies by PLA service, based on our assessment of Beijing's defense strategy and force structure requirements, though generally the tool assumes that force structure-related spending increases over 2021-2031 at approximately a three percent real annual growth rate.

The SCT is primarily a platform-centric analytical framework but, beyond the specific platforms and units shown below, the SCT contains numerous options for space systems, cyber forces and capabilities, electronic warfare systems, battle network investments, research and development, munitions, basing and posture, and readiness, among other areas. By situating

144 CSBA's project team modified this projection as the China SCT was developed, expanded and tested. The force structure forecast therefore varied somewhat across the exercises, though most of the major platforms and units were not significantly altered.

this platform-centric tool within exercises and wargames, the China SCT can contribute to broader analysis of how force structures may evolve and how future conflicts may unfold, given the rising importance of information dominance and system-of-systems warfare.[145]

This force structure forecast was developed in early 2021 for a set of China SCT exercises held in spring 2021. The 2021 column effectively reflects 2020 year-end/2021 year-start inventory numbers rather than confirmed 2021 year-end inventory numbers.[146] CSBA will be updating this tool annually.

PLA NAVY[147]

Platform	2021	2026	2031
Aircraft Carriers	2	3	5 (1 CVN)
Cruisers	2	12	16
Destroyers	32	45	45
Frigates	47	54	63
Patrol/Coastal Combatants	206	196	194
SSBNs	6	8	10
SSNs	10	14	18
SSKs	46	44	49
Principal Amphibs	7	12	19

145 Robert O. Work, *A Joint Warfighting Concept for Systems Warfare* (Washington, DC: Center for a New American Security, 2020), available at https://www.cnas.org/publications/commentary/a-joint-warfighting-concept-for-systems-warfare.

146 For more recent PLA inventory data, consult International Institute for Strategic Studies, *The Military Balance* 122, no. 1 (Oxfordshire, UK: IISS, 2022), pp. 255–264.

147 CSBA estimated PLA Navy ship inventory by consulting various sources, including "China–Navy," *Jane's World Navies Equipment in Service Inventory*, May 4, 2021; International Institute for Strategic Studies, *The Military Balance* 121, no. 1 (Oxfordshire, UK: IISS, 2021), pp. 251–253; and Ronald O'Rourke, *China's Naval Modernization: Implications for U.S. Navy Capabilities–Background and Issues for Congress* (Washington, DC: Congressional Research Service, January 27, 2021), p. 10.

PLA AIR FORCE AND NAVAL AVIATION[148] [149]

Platform	2021	2026	2031
Bombers	220	202	235 (H20: 18; JH-XX: 10)
5th-gen Fighters	J-20: 34	J-20: 102 J-31 (carrier): 12	J-20: 192 J-31 (carrier): 66
4th-gen (& earlier) Fighters/Attack	1908	2159	2335
AEW&C/ISR	151	209	295
Tankers	18	26	56
Transport	329	352	470

148 Western, rather than Chinese, fighter aircraft generations are used in this table. On the differences between Western and Chinese aircraft generations, see Allen and Garafola, *70 Years of the PLA Air Force*, p. 129.

149 CSBA estimated PLA Air Force and Naval Aviation aircraft inventory by consulting various sources, including Andreas Rupprecht, *Modern Chinese Warplanes: Chinese Naval Aviation–Aircraft and Units* (Houston, TX: Harpia Publishing L.L.C., 2018); FlightGlobal, "World Air Forces 2021," *FlightGlobal*, 2020, pp. 15–16; International Institute for Strategic Studies, *The Military Balance* 121, no. 1 (Oxfordshire, UK: IISS, 2021), pp. 253–255; and "China–Air Force," *Jane's World Air Forces Equipment in Service Inventory,* March 1, 2021.

PLA ARMY[150] [151] [152]

Units	2021	2026	2031
Heavy CAB	27	27	27
Medium CAB	23	23	23
Light CAB	24	24	24
Divisions (various)	6	6	6
Air Assault Brigades	2	2	2
Amphib Assault Brigades	6	6	6
Border Defense Brigades	16	16	16
Border Defense Regiments	15	15	15
Coastal Defense Brigades	19	19	19
Air Defense Brigades	15	15	15
Special Ops Brigades	15	15	15
OPFOR Brigade	1	1	1

150 International Institute for Strategic Studies, *The Military Balance* 121, no. 1 (Oxfordshire, UK: IISS, 2021), p. 250.

151 The PLA Army continues to maintain a small number of independent divisions. In the China SCT, those divisions are converted into brigade equivalents for ease-of-use considerations.

152 Western estimates of the number of Combined Arms Brigades vary. For the purposes of the China SCT, users can assess strategic-level tradeoffs within and between PLA services even if the exact number of CABs in the inventory is still debatable. For additional information on PLA CABs, see Dennis J. Blasko, "The Biggest Loser in Chinese Military Reforms: The PLA Army," in Phillip C. Saunders, Arthur S. Ding, Andrew Scobell, Andrew N.D. Yang, and Joel Wuthnow, eds., *Chairman Xi Remakes the PLA: Assessing Chinese Military Reforms* (Washington, DC: National Defense University Press, 2019), pp. 345–392; Department of the Army, *Chinese Tactics* (Arlington, VA: Department of the Army, 2021); International Institute for Strategic Studies, *The Military Balance* 121, no. 1 (Oxfordshire, UK: IISS, 2021), p. 250; and Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China, 2021* (Arlington, VA: Office of the Secretary of Defense, 2021), p. 45.

PLA ROCKET FORCE[153]

Type	Units	2021	2026	2031
ICBM	DF-4	1	0	0
	DF-5A/B/C	3	3	3
	DF-31(A)	3	1	0
	DF-31A(G)	2	5	8
	DF-41	2	4	5
IRBM	DF-26	5	7	8
MRBM	DF-16	2	3	4
	DF-21A/E	6	6	6
	DF-21C/D	2	2	2
SRBM	DF-11A/DF-15B	3	2	0
GLCM	CJ-10(A)/CJ-100	2	3	3
	Surface-to-surface	3	5	6
HGV	DF-17	1	2	3

153 CSBA arrived at a final PLARF unit inventory estimate by consulting various sources, including International Institute for Strategic Studies, *The Military Balance* 121, no. 1 (Oxfordshire, UK: IISS, 2021), p. 249; Hans. M. Kristensen and Matt Korda, "Chinese Nuclear Weapons, 2021," *Bulletin of the Atomic Scientists*, 77, no. 6, 2021, p. 325; and the Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China, 2021* (Arlington, VA: Office of the Secretary of Defense, 2021), p. viii.

LIST OF ACRONYMS

APUC	Average procurement unit cost
AVIC	Aviation Industry Corporation of China
CAB	Combined Arms Brigade
CIA	Central Intelligence Agency
CCP	Chinese Communist Party
CER	Cost estimating relationship
CMC	Central Military Commission
CSBA	Center for Strategic and Budgetary Assessments
DIA	Defense Intelligence Agency
GDP	Gross domestic product
IISS	International Institute for Strategic Studies
O&M	Operations and maintenance
O&S	Operations and sustainment
PAP	People's Armed Police
PLA	People's Liberation Army
PLAAF	People's Liberation Army Air Force
PLAN	People's Liberation Army Navy
PLARF	People's Liberation Army Rocket Force
PPP	Purchasing power parity
R&D	Research and development
RMB	Renminbi
SCE	Strategic Choices Exercise
SCT	Strategic Choices Tool
SIPRI	Stockholm International Peace Research Institute
USD	U.S. dollars

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