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China Maritime Report No. 10: PLAN Force Structure Projection Concept, A Methodology for Looking Down Range

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PLAN Force Structure Projection Concept

A Methodology for Looking Down Range

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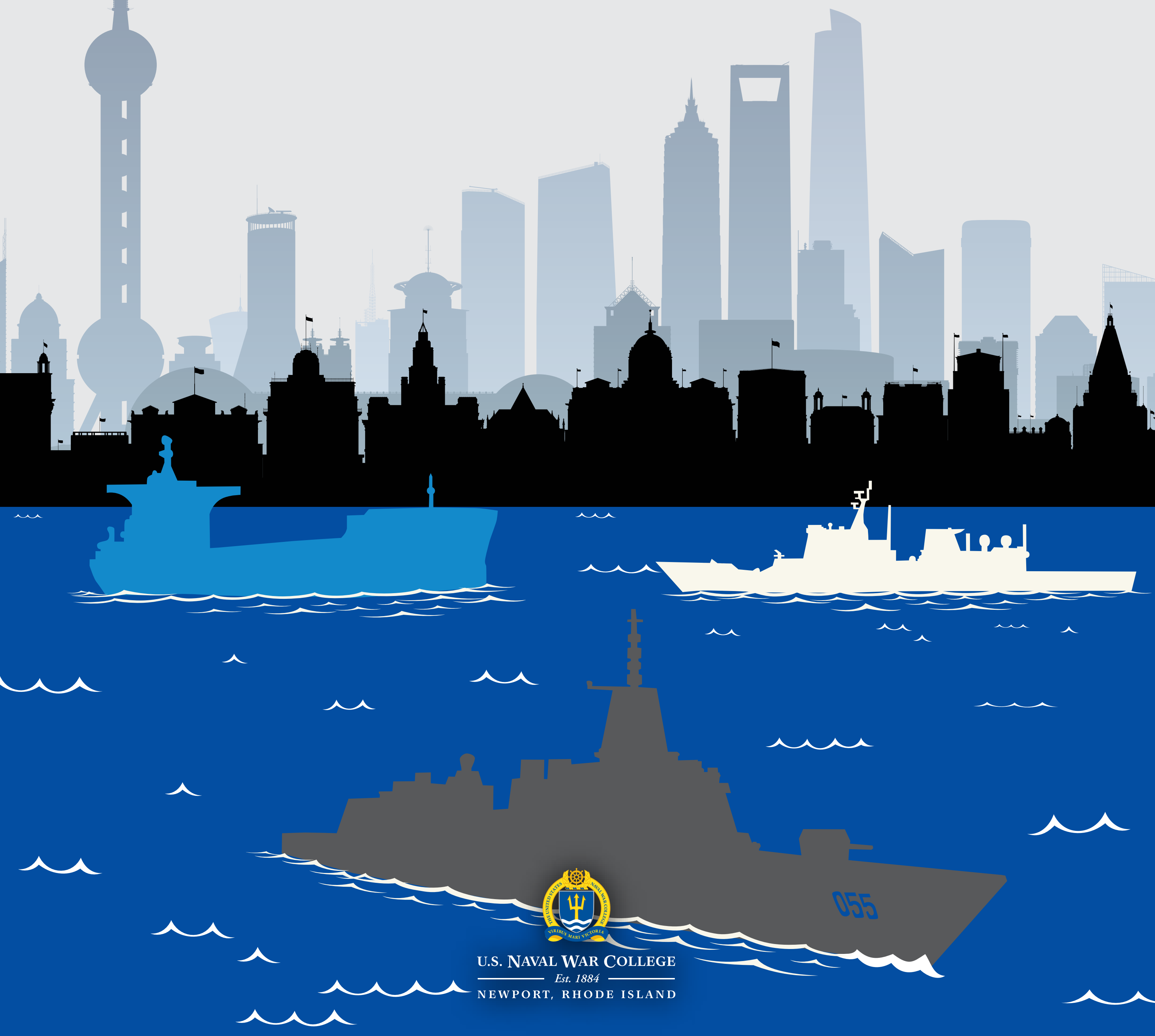

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It's tough to make predictions, especially about the future. –Danish Proverb

Summary

Force structure projections of an adversary's potential order of battle are an essential input into the strategic planning process. Currently, the majority of predictions regarding China's future naval buildup are based on a simple extrapolation of the impressive historical ship construction rate and shipyard capacity, without acknowledging that the political and economic situation in China has changed dramatically. Basing force structure projections on total life-cycle costs would be the ideal metric, but there is little hope of getting reliable data out of China. A reasonable substitute in shipbuilding is to look at the construction man-hours, as direct labor accounts for 30-50 percent of a ship's acquisition cost, depending on the ship type, and is therefore a representative metric of the amount of resources and effort applied to a ship's construction. The direct labor man-hours to build a Chinese surface combatant can be estimated by linking a ship's outfit density to historical U.S. information. This analytical model also allows for the inclusion of the mid-life overhaul and modernization for each ship, which is a major capital expense in the out years following initial procurement. For the naval analyst examining the Chinese Navy's future force structure, the outfit density concept provides a tool to evaluate the degree of national effort when it comes to military shipbuilding.

Introduction

The future is a mysterious, shadowy concept that has vexed humans for millennia. Philosophers and scientists alike have tried to comprehend this nebulous notion, with varying degrees of success. Because the future does not exist in an observable form—at least, not yet—it is really hard to even say what the future could be. But in the grand scheme of intelligence analysis, the future is in high demand by senior policymakers. Why? Their primary goal is to prevent a conflict from occurring, and achieving this goal requires diligent strategic-level, long-term planning.[1] Strategic intelligence informs this process, and a key foundation of strategic intelligence is making predictions of the future.

Predicting the long-term force structure of the People's Liberation Army Navy (PLAN) is currently a popular topic and the subject of numerous analytical journal articles and book chapters. And yet, the majority of the predictions are based on a simple extrapolation of historical Chinese ship construction that is itself based on shipyard capacity. While extrapolation is a useful tool, there are two problems with this technique.

First, while shipyard capacity is certainly necessary for the production of warships it is not sufficient in and of itself. Chinese shipyards build civilian ships as well as warships, with the former generating revenue. Building warships is far more expensive than income-earning merchant ships and requires national intent and the funding to back it up.

Second, extrapolation is based on what has happened in the past and implicitly assumes that the forces influencing Chinese national policymakers will remain the same in the future.[2] This assumption is problematic. While the modernization of the People's Liberation Army (PLA) is, without question, a top national priority, it is not the *only* national priority and President Xi Jinping's vision of achieving a rejuvenated China by 2049 entails an impressive number of reforms that will require considerable government funding. At the same time, China's economy is slowing down. It

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[1] Robert M. Clark, *Intelligence Analysis: A Target-Centric Approach, 2nd ed* (Washington, DC: CQ Press, 2007), p. 48-49.
[2] Ibid., p. 195.

faces an unhealthy increase in national debt, an unresolved trade war with the United States, and growing push back against Chinese economic policies in Europe and elsewhere—a very different fiscal environment than in the recent past.

Now add to the equation the mounting costs associated with building, operating, and maintaining a large navy and it becomes challenging to embrace an assumption of the continuing acceleration in regard to shipbuilding. Indeed, it is conceivable that the PLA might have to compete for future funding with other priorities associated with Xi's "China Dream."[3]

There is an old adage in naval acquisition that a ship is purchased roughly three times over the course of its service life. The first purchase is the actual acquisition cost, which is accounted for in the extrapolation approach. However, the second and third purchases are linked to operating and maintaining the ships. These costs are usually combined under the umbrella label of "operating and sustaining" as illustrated in Figure 1 (below).

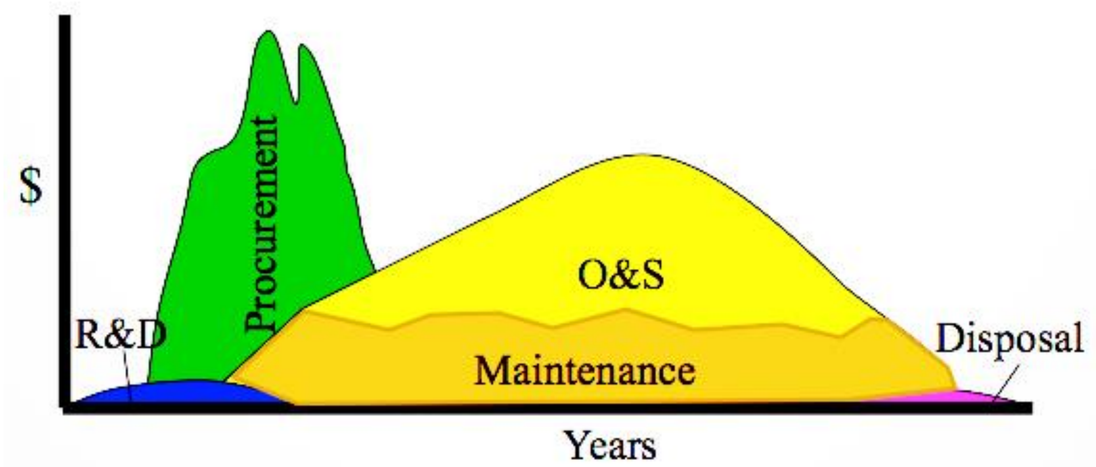

Figure 1. Lifetime costs of a ship. (Defense Acquisition University)

These costs are rarely given much consideration under the extrapolation approach whose advocates seem to implicitly assume that everything else outside of the procurement process happens as a matter of course. And yet, the cost of operating and maintaining a large navy has been the "rocks and shoals" upon which every major sea power has run aground, to include the United Kingdom's Royal Navy, the Soviet Navy, and the U.S. Navy. One has only to read the articles covering the heated debate on whether or not to fund the refueling and complex overhaul (RCOH) for USS *Harry S. Truman* (CVN 75) to see the fiscal implications of a major overhaul and combat capability modernizations.[4]

[3] This possibility was first suggested in an International Institute for Strategic Studies analysis of the second Belt and Road Initiative forum in April 2019 which stated, "ambitions for defence modernization and reform may have to jostle for resources in the future with the country's other broader national strategic ambitions." See Meia Nouwens, "China's defence spending: a question of perspective?", IISS Military Balance Blog, May 24, 2019, www.iiss.org/blogs/military-balance/2019/05/china-defence-spending

[4] Sydney J. Freedberg, Jr, "Pentagon To Retire USS Truman Early, Shrinking Carrier Fleet To 10", Breaking Defense, February 27, 2019, https://breakingdefense.com/2019/02/pentagon-to-retire-uss-truman-early-shrinking-carrier-fleet-to-10/

So if the extrapolation approach is only a partial answer, and shipyard capacity is inappropriate as the sole metric, what does an analyst use to measure the level of national effort in shipbuilding? Money? Total lifecycle costs would certainly provide a more complete assessment of a nation's intent. But given the vague and uncertain state of the *renminbi* and the likely hidden supplements to the PLA budget, this would be a fool's errand. No, what is needed is something that is intrinsically tied to the production of a ship, such as the number of labor man-hours required to build it.

Direct labor accounts for 30-50 percent of a ship's acquisition cost, depending on the ship type, and is therefore a representative metric of the amount of resources and effort applied to a ship's construction.[5] Unfortunately, observing and accurately measuring labor man-hours is about as elusive as figuring out how much China truly spends on a ship. There is, however, a way to approximate the total direct labor man-hours through the use of the naval architect concept called outfit density.

In 2008, LT Benjamin Grant submitted a master's thesis to the Naval Postgraduate School proposing that density be considered as a cost driver instead of weight for submarine construction.[6] In his thesis, LT Grant argued that the internal density of a submarine was a defendable proxy for design complexity and that it could be used in the estimation of cost and production hours.[7] His approximation of internal density was the sum of the weights of the Ship Work Breakdown Structure (SWBS) Groups 200 through 700 divided by the submarine's internal volume.[8] Weight groups 200 through 700 are collectively referred to as outfitting (Figure 2, below).

100	Structures	
200	Propulsion Systems	
300	Electrical Generation & Distribution	
400	Electronics & Navigation	
500	Auxiliary Systems	
600	Outfit & Furnishings	Outfit
700	Armament	
800	Technical Support	
900	Shipyard Services	
1000	External Fees, Insurance & Extras	

Figure 2. Ship Work Breakdown Structure. (SPAR Associates, Inc)

This is hardly the first time the concept of outfit density has been suggested as an alternative metric of ship construction effort. This concept appeared in professional journal articles and academic theses written in the 1990s, but Grant's thesis seems to have born some fruit within the United States naval architecture community.[9] By 2010, outfit density began appearing with greater frequency in

[5] Mark V. Arena, Irv Blickstein, Obaid Younossi, and Clifford Grammich, *Why has the Cost of Navy Ships Risen? A Macroscopic Examination of the Trends in U.S. Naval Ship Costs over the Past Several Decades*, (Santa Monica, CA: RAND Corp, 2006), p. 24.

[6] Benjamin P. Grant, *Density as a Cost Driver in Naval Submarine Design and Procurement*, Master of Business Administration Thesis, Naval Postgraduate School, June 2008.

[7] Ibid., pp. 53, 58.

[8] Ibid., p. 54.

[9] Two examples of documents from the 1990s are Mark H. Spicknall's and Michael Wade's paper, "Reducing the Construction Contract Cycle for Naval Auxiliary Ships," presented at the Society of Naval Architects and Marine Engineers (SNAME) 1992 Ship Production Symposium; and Andrew D. Humphries doctoral thesis, *The Development and*

costing models proposed by elements of the U.S. government such as the Naval Sea Systems Command (NAVSEA) 05C Cost Engineering and Industrial Analysis Division and naval architecture contractors like Ship Design USA, SPAR Associates, Inc., and First Marine International.[10] The major point stressed by all advocates of the outfit density approach is the denser the ship—that is, the more equipment that is stuffed into a hull—the greater its complexity, which increases the labor man-hours required to build the ship and ultimately its cost.

For the naval analyst, the outfit density concept provides a useful tool to evaluate the degree of national effort when it comes to military shipbuilding. First, outfit density is flexible. It can use detailed design information should it be available, or basic ship characteristics (waterline length, beam, draft, light displacement, etc.) found in unclassified sources. Second, there is a reasonable correlation between a ship's outfit density and the number of production man-hours per ton of lightship displacement.[11] This relationship enables the calculation of the total direct labor hours needed to build a ship. Additional benefits to using man-hours as the production metric include the incorporation of the "learning curve" associated with series production at a shipyard, as well as some aspects of depot level maintenance that can now be included in the analysis.

Outfit Density and Production Man-Hours Calculations

As stated earlier, outfit density is the sum of the weight of the outfit (SWBS Groups 200 through 700) divided by the ship's volume. The method of calculating outfit density used in this paper is similar to that proposed by SPAR Associates, Inc. that uses the ship's volume displacement or molded volume.[12] The NAVSEA calculations appear to have the benefit of using the actual volume of the ship's hull and superstructure.

$$\text{Outfit Density} = \frac{\text{Weight of SWBS Groups 200-700 (Metric tons)}}{\text{Volume Displacement (cubic meters)}}$$

– Weight of SWBS Groups 200-700 is assumed to be 50 percent of lightship displacement[13]

– Volume Displacement = Waterline length x beam x draft x C_B
Where C_B is the Block Coefficient[14]

Application of Warship Cost Estimating Methods, University of Southampton, April 1995. The latter piece is a strong endorsement for the use of outfit density in estimating ship production costs and man-hours.

[10] Robert G. Keane, Laury Deschamps, and Steve Maquire, *Reducing the Work Content in Early Stage Naval Ship Designs*, Presentation given at the Acquisition Research Symposium, Naval Postgraduate School, May 14, 2014. Available through DTIC, document A624052.

[11] Lightship displacement is the weight of the ship including hull, structure, machinery, equipment, furnishings, and liquids in machinery. It does not include crew, armament, fuel, stores, or potable water. A NAVSEA 05C chart showing this relationship can be found in Keane et al, p. 27.

[12] *SPAR Cost Models: Estimating Ship Design & Construction*, SPAR Associates, Inc, revised April 13, 2017, p. 61.

[13] For surface combatants, SWBS Group 100 Hull and Structure and the weight margin is approximately 47 percent to 53 percent of the lightship displacement. For this analysis, it is assumed that Group 100 and margins for Chinese surface combatants is 50 percent of the lightship displacement. For the Type 001/002 aircraft carriers this value is assumed to be 65 percent.

[14] The block coefficient is the ratio of the ship's molded volume (below the waterline) to the volume of an imaginary rectangle of the same dimensions. The larger the block coefficient the fuller, or more block-like, is the ship's hull. For this analysis, PLAN frigates and corvettes are assumed to have a C_B of 0.46, destroyers 0.49, the Type 055 cruiser/large destroyer 0.50, and the Type 001/002 aircraft carriers 0.61.

Example: Outfit density of a Type 054A Frigate (Figure 3, below)

– Waterline Length: 125.6 meters
– Beam: 16.0 meters
– Draft: 5.0 meters
– C_B: 0.46
– Lightship Displacement: 3,121 metric tons

Outfit Density = (3,121 MT x 0.50) /(125.6 x 16.0 x 5.0 x 0.46) m^3

Outfit Density = 1,561 MT / 4,622 m^3

Outfit Density = 0.34 MT/m^3

By comparison, the U.S. OLIVER HAZARD PERRY (FFG 7) class has an outfit density of 0.36 MT/m^3 with the following characteristics.

– Lightship displacement: 2,898 MT
– Group 200-700 weights: 51 percent of lightship displacement
– Waterline Length: 124.4 meters
– Beam: 14.3 meters
– Draft: 4.9 meters
– C_B: 0.47

Figure 3. Type 054A frigate being launched at the Guangzhou-Huangpu shipyard. (china-defence.com)

To determine the number of man-hours per ton of lightship weight (LSW) for the lead ship in a class, plug the outfit density value (Do) into the equation in Figure 4 (below) based on U.S. warship data.[15]

[15] The man-hour production values in Figure 4 correlate well, from a relative position perspective, with the same classes in the NAVSEA 05C chart found in Keane et al (p. 26), even though there are *no* numbers on the NAVSEA chart. In

This value is then multiplied by the lightship displacement to derive the total number of man-hours to build the ship.

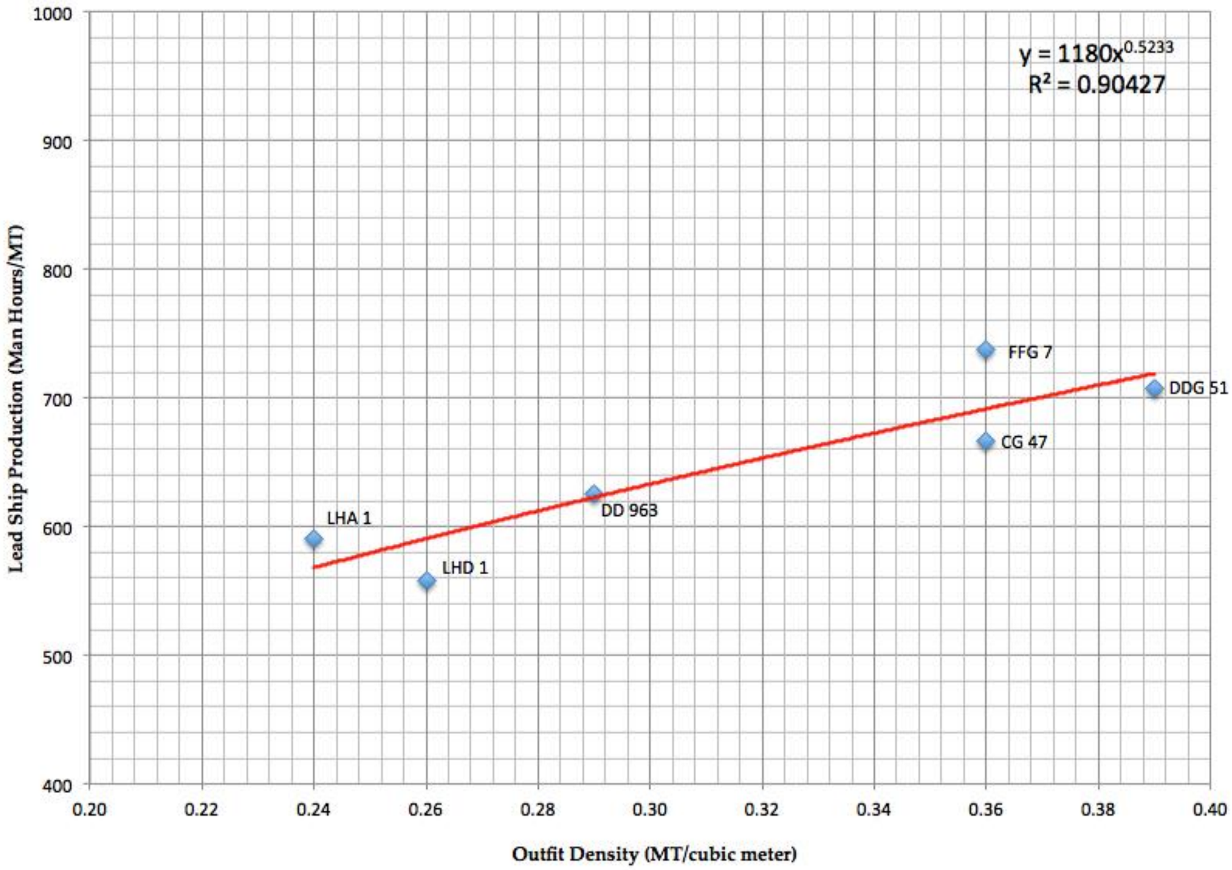

Figure 4: Lead Ship Production Man-hours per Ton Lightship Weight (Author)

This equation assumes that any shipyard, worldwide, is considered on par with U.S. shipyards. This arguably affords some benefit of the doubt to Chinese shipyards, which on a hull-by-hull basis, on average, take slightly longer to build a ship than a U.S. shipyard. But for the purposes of this analysis this assumption will be retained.[16] In the case of the Type 054A frigate above:

Man-hours/ton LSW = $1180 \times (Do)^{0.5233}$

Man-hours/ton LSW = $1180 \times (0.34)^{0.5233}$

Man-hours/ton LSW = 671

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addition, the average production value of 685 man-hours/ton LSW for the four surface combatants is in good agreement with the 710 man-hours/ton LSW average found in the graphic in the RAND report, *Why has the Cost of Navy Ships Risen?* (p. 26). A word of caution is required, however, as the RAND report uses long tons (2,240 lbs/ton), whereas this analysis uses metric tons (2,204.6 lbs/ton). A slight difference to be sure, but a difference nonetheless.

[16] Julian Snelder makes a compelling argument that in regard to civilian ship construction, China is still not the equal of Japan and South Korea when it comes to the construction of complex ships. Given that warships are considerably more complex than any civilian merchant ship, one could, by extension, argue that Chinese shipyards are less efficient than a U.S. shipyard and that the man-hours per ton LSW should be higher for a given outfit density. See Snelder, "China's Civilian Shipbuilding in Competitive Context: An Asian Industrial Perspective", in Andrew S. Erickson, ed., *Chinese Naval Shipbuilding: An Ambitious and Uncertain Course*, (Annapolis, MD: Naval Institute Press, 2016), p. 199.

Total Man-hours = 671 MH/ton LSW x 3,121 MT

Total Man-hours = 2,094,191

There are very few published articles to compare the results of this model, but Gabriel Collins made an admirable attempt in his 2015 article, "How Much Do China's Warships Actually Cost?"[17] Collins' estimate of 3.2 million man-hours to build a Type 054A frigate appears to be based partly on ship weight and partly on the assumption of significant inefficiencies at Chinese shipyards vis-à-vis U.S. shipyards. Still, a difference of over 50 percent in the number of man-hours is hard to reconcile and argues, in this author's opinion, for a more methodological approach instead of informed professional opinion.

Learning Curve

The man-hour value from Figure 4 represents the production effort for the first ship of a class, built at a particular shipyard. Follow on ships usually see a reduction in time and/or effort due to the effects of the learning curve. Theoretically, the direct labor man-hours to complete a repetitive production process should decrease by a constant percentage each time the quantity is doubled.[18] In essence, as a production team repeats a process, it becomes more efficient in executing it and takes less time to do so. If the experience gained results in a 10 percent reduction in man-hours every doubling of the production run, then the learning curve is 90 percent. If the improvement were a 20 percent reduction, this would be an 80 percent learning curve. Historically, U.S. Navy ship production learning curves tend to fall between 88 percent and 93 percent. For the purposes of this analysis it is assumed Chinese shipyards have a 90 percent learning curve.

Figure 5 (below) shows the production man-hours for the first five hulls of the Type 054A frigate, out of a total of 15, built at the Hudong shipyard. The same class of ships built at the Guangzhou-Huangpu shipyard would have its own independent learning curve. The production effort is distributed over the approximately four year construction period with a distribution of 15%/35%/25%/25%.[19] With this approach, a much-expanded table can be constructed that covers all PLAN construction over any analytical time period.

[17] Gabriel Collins, "How Much Do China's Warships Actually Cost?", *The Diplomat*, June 18, 2015, https://thediplomat.com/2015/06/how-much-do-chinas-warships-actually-cost/?allpages=yes&print=yes

[18] Ellen Barber, *Application of Learning Curve Theory to Systems Acquisition*, Defense Acquisition University, February 2011, B-25, https://www.dau.edu/cop/ce/DAU%20Sponsored%20Documents/B5%20Application%20of%20Learning%20Curve%20Theory%20Feb%2011.pdf.

[19] The Type 054A frigate construction period was estimated to be 3.8 years, with 2.8 years on the building ways and fitting out and one additional year for long lead procurement and the start of module construction. The distribution of man-hours is consistent with Figure 35: Expenditure Curves in the NAVSEA *2005 Cost Estimating Handbook*, Section 6B-4. Depending on size, the construction period is between 3.5 to 5.0 years for Chinese surface combatants, and 5.5 to 7.0 years for aircraft carriers depending on the size and type (CV or CVN).

Hull Overall	Builder Number	Hull Number	Production Man-hours	1st Year	2nd Year	3rd Year	4th Year
1	1	529	2,094,191	314,129	732,967	523,548	523,548
3	2	568	1,884,772	282,716	659,670	471,193	471,193
5	3	569	1,772,117	265,818	620,241	443,029	443,029
8	4	549	1,696,295	254,444	593,703	424,074	424,074
10	5	546	1,639,724	245,959	573,903	409,931	409,931

Figure 5. First five Type 54A hulls produced at Hudong shipyard. (Author)

Depot Level Maintenance

If a ship is to remain functional and safe to operate throughout its service life, it must undergo periodic maintenance to repair or replace broken and worn out equipment. This maintenance is usually conducted at three levels with increasing resources and manpower: organizational, intermediate, and depot. Organizational level maintenance is largely done by the ship's crew, although under some circumstances naval base support maybe necessary. Intermediate level maintenance is usually done at a naval base or minor repair facility, with the possible outsourcing of work to a civilian contractor. Depot level maintenance is where the expensive, big-ticket repairs are done. It is conducted at a naval or civilian shipyard.

Organizational and intermediate maintenance are virtually impossible to discern as the ship more than likely simply stays in its homeport and spotting the repair efforts is very difficult. Depot level maintenance, on the other hand, involves a transfer of the ship for one or more years, and the work is much easier to observe. Depot level maintenance can also be measured, as it requires multi-year planning of the overhaul to include direct labor man-hours.

The U.S. Navy's Chief of Naval Operations issues a periodic letter that describes the amount of depot level maintenance each ship class is to receive over an expected service life. Included in an enclosure to this letter is the number of man-days allocated for each type of maintenance activity. The maintenance activity with longest time period is called the Extended Docking Selected Restricted Availability (EDSRA), or what this analysis refers to simply as the "overhaul."

In the case of a DDG 51 Flight II destroyer, each ship in the class is to receive 312,000 man-days (2,496,000 man-hours) of maintenance over the course of its service life, with the overhaul/EDSRA taking 79,100 man-days (632,800 man-hours).[20] This is approximately 13 percent of the effort to build a new destroyer, and covers repairs to the hull, machinery, electrical (HME), and existing payload (sensors, combat system and weapons). Improvements to the payload, or the combat capabilities, of a ship fall under the definition of "modernization," and that is a different pot of money.[21]

[20] Representative Intervals, Durations, and Repair Man-days for Depot Level Maintenance Availabilities of U.S. Navy Ships, SER N83/18U137005, Enclosure (1), May 24, 2018, 4.

[21] The lead DDG 51 Flight II ship is assessed to require 4,800,000 man-hours to build. All overhaul analysis uses the lead ship production man-hours. The learning curve values are not used, as each ship comes into an overhaul with varying needs and all the work is done in hull. In terms of manpower, in hull work is far less efficient, requiring considerably more effort to do the same thing that was done during construction in a module or block or even a grand block (multiple blocks put together).

For this analysis, the following assumptions were made in regard to PLAN maintenance requirements for surface combatants and aircraft carriers.

– Service life is 30 years.

– The major overhaul occurs at mid-life, at the 15-year point.[22]

– There are four types of overhauls:

1) Basic HME and payload repairs: 15 percent of new ship production man-hours and takes one year.

2) Basic HME and minor payload modernization: 30 percent of new ship production man-hours and takes two years.

3) Basic HME and major payload modernization: 40 percent of new ship production man-hours and takes three years.

4) Service life extension program (SLEP): 70 percent of new ship production man-hours and takes about five years.[23]

For example, the Type 051B destroyer, *Shenzhen*, underwent an overhaul with major modernization from 2014 through 2016 (Figure 6, below). The estimated effort to build a Type 051B is 3,444,764 man-hours, with the overhaul and modernization requiring 1,377,906 man-hours–40 percent of the build effort. The primary reasons why any modernization is so costly is that all work is done in a completed hull, which is far less efficient than working on a block or grand block, and that old equipment must first be removed before new equipment is put in place. And even though this analysis folds in the mid-life overhaul into an overall PLAN level of effort assessment, a reminder is needed that the mid-life overhaul is just a fraction of the entire depot level maintenance total with the HME portion alone coming in at 25-30 percent of the total man-hours.

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[22] Limited evidence from the major overhauls of the Type 052, 051B, the first 052B, and the first two Project 956E destroyers support this assumption.

[23] Minor payload modernization is assumed to involve the replacement of a weapon or sensor without the need to reconfigure the hull or superstructure. A major modernization entails hull and superstructure work. The SLEP is included for completeness and is required for a ship to significantly exceed its service life.

Figure 6. Type 051B destroyer, *Shenzhen*, undergoing a major refit at the Zhanjiang shipyard. (weibo.com)

PLAN Level of Effort Analysis

With the labor requirements for PLAN new construction and the mid-life overhaul defined, it is now possible to begin examining China's naval shipbuilding efforts across multiple ship classes and shipyards—in this particular case, larger surface combatants and aircraft carriers.[24] For each ship, produced at each shipyard, the production effort is plotted out on a spreadsheet by class taking into account any benefits from the learning curve. The production hours can be anchored to the year of commissioning, launch, or laydown depending on the available information. The production hours are then summed by year, with the mid-life overhaul values incorporated to estimate the total level of effort.

Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
001/002	6,503,988	5,203,191	5,203,191	3,902,393	2,601,595	0	2,601,595	6,503,988	5,203,191	5,203,191	3,902,393
052	0	0	976,771	3,350,255	5,640,438	7,914,634	7,489,514	8,748,076	9,420,383	8,032,296	9,458,815
054	2,911,432	3,422,793	4,169,477	4,477,609	4,660,688	4,153,258	3,345,276	4,140,131	3,366,680	2,453,371	1,389,552
055	0	0	0	0	0	0	637,144	3,695,436	6,944,872	6,812,608	8,790,829
056	0	0	0	3,150,839	3,926,037	4,465,908	3,895,151	4,305,699	3,498,965	3,966,891	3,164,980
Mid-life OH	0	0	1,030,626	1,030,626	0	183,582	642,881	642,884	642,881	779,937	2,136,604
Year Total:	**9,415,420**	**8,625,984**	**11,380,064**	**15,911,721**	**16,828,759**	**16,717,383**	**18,611,562**	**28,036,215**	**29,076,972**	**27,248,294**	**28,843,172**
Type Total:	**210,695,544**										

Figure 7. PLAN shipbuilding and overhaul level of effort 2008-2018. (Author)

For the last eleven years, China has racked up an impressive ship construction and maintenance effort totaling nearly 211 million man-hours as shown in Figure 7 (above). This is approximately a five-fold increase over the preceding eleven-year period (1997–2007), with significant jumps in 2011, due to the Type 052C/D and Type 056 series production, and in 2015 with the laydown

[24] This same analytical technique could be used to assess the production effort required for patrol craft, amphibious assault ships, logistics ships, auxiliaries, and submarines—but it would require a massive spreadsheet.

of the Type 002 aircraft carrier, *Shandong*. This analysis illustrates what has happened; let us now consider what the future could hold.

There is no shortage of future PLAN force structure estimates to examine, but this analysis will consider a February 2019 article by Rick Joe in *The Diplomat*.[25] Mr. Joe's article is, by his own admission, an extrapolation of the past build rate coupled with shipbuilding way space availability. The article argues for a continuing of the robust production program of the past decade with an increase in the production rate of high-end warships. Specifically, the article forecasts a 2030 PLAN surface combatant force structure to include:

– Two ski-jump aircraft carriers (Type 001/002)

– Two catapult, conventional carriers (Type 003)

– 16–20 Type 055/055A cruisers/large destroyers

– 36–40 Type 052D/E destroyers

– 40–50 Type 054A/B frigates

Mr. Joe also proposes that nuclear aircraft carrier construction could be well along and that a total of six aircraft carriers by 2030 cannot be ruled out. He also posits an equally ambitious production schedule for submarines and amphibious assault ships. Logistics support ships were not included in his projection. It is unclear why Mr. Joe did not include the Type 056 corvettes in the order of battle, or the earlier Type 051 and 052 destroyers that have had, or are undergoing, major modernization. The article does not address PLAN maintenance requirements.

With this impressive list, the production and maintenance man-hours can be calculated and summed for surface combatants and aircraft carriers. And while Mr. Joe's article goes out to 2030, to enable a fair comparison with Figure 7, the present analysis considers a future eleven-year segment from 2019-29. The outcome displayed in Figure 8 (below) is telling.

Type	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
CV/CVN	9,659,195	17,643,999	14,115,199	14,115,199	10,586,399	16,640,610	9,583,011	19,166,021	19,166,021	19,166,021	9,583,011
052	8,366,899	9,842,807	8,777,068	6,370,923	8,199,592	10,405,418	12,847,724	10,417,080	5,567,644	1,800,852	0
054	845,712	2,734,469	3,901,162	5,032,957	4,721,889	5,152,793	5,832,782	5,269,855	5,158,613	3,427,428	2,002,579
055	8,468,303	4,737,055	3,681,813	2,967,298	5,534,247	8,579,795	10,782,726	12,244,170	10,524,112	6,877,758	3,946,306
056	2,999,881	1,357,370	615,648	0	0	0	0	0	0	0	0
Mid-life OH	2,713,340	3,112,956	3,600,281	1,843,998	1,881,164	1,376,908	1,376,908	1,032,681	3,894,436	6,499,821	10,538,580
Year Total:	**33,053,329**	**39,428,655**	**34,691,170**	**30,330,375**	**30,923,292**	**42,155,523**	**40,423,150**	**48,129,807**	**44,310,826**	**37,771,880**	**26,070,476**
Type Total:	**407,288,483**										

Figure 8. PLAN shipbuilding and overhaul level of effort 2019-2029. (Author)

To achieve the force structure proposed by Mr. Joe, China would have to increase the number of man-hours by 93 percent, essentially doubling the resource allocation from 2008-18. This is a very significant increase, one that would require an equally significant increase in funding—a capital investment that would have to be provided from a Chinese economy that is growing at a far slower

[25] Rick Joe, "Predicting the Chinese Navy of 2030," *The Diplomat*, February 15, 2019, https://thediplomat.com/2019/02/predicting-the-chinese-navy-of-2030/

rate than earlier periods even as labor costs continue to rise. Of note, the maintenance burden becomes quite substantial beginning in 2028 as many of the Type 052C, 054A, and 056 ships come due for their mid-life overhauls.[26] Given the fiscal challenges facing China today and in the near future, this very robust force structure projection is questionable. There is little doubt that China desires to continue building surface combatants at an accelerated rate, but the resource requirements to achieve this desire are daunting and may be beyond even its reach.

Conclusion

There is more to predicting the future PLAN force structure than just surveying shipyard capacity and drawing a straight line. Building way space is absolutely necessary, but it is not a sufficient driver in and of itself to justify a particular order of battle. Direct labor man-hours are a more demonstrative metric for analyzing shipbuilding *and* depot-level maintenance requirements.

Maintenance is an important, if often overlooked, consideration in projecting future naval orders of battle. Its inclusion in the force structure analysis is necessary as procurement represents just the beginning of the resource needs to keep a ship functional throughout its service life. And while the major mid-life overhaul is only a part of the total depot level maintenance needs of a particular ship, the cumulative total in the out years is just as demanding in resources as new construction.

The use of outfit density allows the naval analyst a way to estimate the production and overhaul man-hours for each ship within a class, and at a particular shipyard. This tool does not require detailed naval architecture data of the ship classes involved in the analysis, which is seldom available or may not even exist for ships that have not yet been built.

The labor-based shipbuilding metric is a structural analysis tool that can be used to explore different views regarding any future PLAN force structure. By evaluating each proposed future naval order of battle in a consistent manner—an apples-to-apples comparison—the debate going forward can focus more on the degree of resource support the Chinese Communist Party would have to provide to the PLAN and not rely simply on vague statements of intent.

[26] These ship classes are assessed to only get minor modernizations along with the basic HME overhaul; that is, 30 percent of the lead ship production man-hours.

About the Author

Christopher Carlson is a retired Navy Reserve Captain and Department of Defense naval systems engineer. He began his navy career as a submariner, and transitioned to the naval technical intelligence field in both the reserves and in his civilian job with the Defense Intelligence Agency.

He has co-authored several published works with Larry Bond, to include a short story, "Burial at Sea," in the Tombs anthology, and eight full-length military thriller novels.

Being an avid wargamer from an early age, Carlson is one of the co-designers, along with Larry Bond, of the Admiralty Trilogy tactical naval wargames: *Harpoon V*, *Command at Sea*, *Fear God & Dread Nought*, and *Dawn of the Battleship*. He has also authored numerous articles in the Admiralty Trilogy's bi-annual journal, *The Naval SITREP*, on naval technology and combat modeling.

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