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TECHNICAL REPORT

# A Methodology for Estimating the Effect of Aircraft Carrier Operational Cycles on the Maintenance Industrial Base

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Prepared for the United States Navy

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*Left cover image: The Nimitz-class aircraft carrier USS Ronald Reagan,*

*U.S. Navy photo by Photographer's Mate 1st Class James Thierry*

*Right cover image: The Nimitz-class aircraft carrier USS George Washington,*

*U.S. Navy photo by Mass Communication Specialist 2nd Class Peter D. Blair*

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## Summary

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Over the next two decades, the United States Navy will, at any one time, have a fleet of ten to 12 aircraft carriers. Of these, two or three will be continuously deployed and on-station at any one time in its major overseas operational areas of the Mediterranean, the Indian Ocean and Persian Gulf region, and the Western Pacific, in support of combatant commanders. In addition, the Navy intends to surge carriers (including those already deployed) so that a total of six carriers can be provided to combatant commanders within 30 days and another carrier within 90 days.

The ability of the Navy to meet all these requirements is constrained both by the six-month limit on deployment length and by the intensive training and maintenance demands of aircraft carriers. The Navy has considered the six-month limit on deployments and the predictability of Carrier Strike Groups (CSGs) rotation key to maintaining forward presence while meeting personnel recruiting and retention goals. In addition, maintenance is constantly being performed on aircraft carriers, with nearly a third of a carrier's lifetime being spent either preparing for or actually in depot-level repair availabilities, in which it is not deployable.

Aircraft carriers are maintenance-intensive, and maintenance is constantly being performed on them. The most effective strategy for executing maintenance on aircraft carriers is through continuous maintenance and prevention of deferred work that would require long, out-of-service maintenance periods. Aircraft carriers must be maintained at a level of material readiness to support fleet operational requirements.

Carrier repair and maintenance requirements are distributed according to the Incremental Maintenance Plan (IMP). The IMP is a continuous-maintenance strategy, whereby maintenance and modernization depot availabilities are performed each cycle,<sup>1</sup> to ensure the material condition of the Nimitz class throughout its service life. The IMP cycle was 24 months in duration. Over time, the 24-month basis for IMP has been lengthened in practice to 27 months. The 27-month cycle was, in turn, formalized in a Fleet Response Plan. A distinguishing feature of the FRP was the integration of some training during maintenance to enable a ship to achieve a higher state of readiness sooner after maintenance is completed and to sustain that readiness longer, which increases the carrier's operational availability.

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<sup>1</sup> A *cycle* is the length of time that a carrier takes as it progresses through maintenance, training, deployment, and the sustainment of readiness both before and after deployment. The *cycle length* is measured from the end of one maintenance depot availability to the end of the next.

This increase in operational availability or surge readiness comes at a cost. With the constraint of conducting one deployment per maintenance cycle, the proportion of time that a carrier is actually deployed decreases as the cycle length is increased.

If the duration of a maintenance cycle is varied, there will be a trade-off between the proportion of a carrier's lifetime that is spent on deployment, the number of depot-level maintenance periods a carrier undergoes, and the proportion of time a carrier and its crew are surge-ready. As the cycle duration is increased, the proportion of lifetime spent on deployment and the number of depot-level maintenance periods decrease, whereas the proportion of time the carrier and its crew are surge-ready will increase. RAND researchers characterized these trade-offs and evaluated the impact they would have on the maintenance industrial base.

Our analysis focused on those demands that the ten Nimitz-class carriers that will be in operation over the next two decades (including the nine currently operating) will place on the maintenance industrial base. In particular, we focused on the effects that varying maintenance cycles for carriers would have on the workers at Norfolk Naval Shipyard (NNSY) and Puget Sound Naval Shipyard and Intermediate Maintenance Facility (PSNS & IMF) who support carrier maintenance.

To measure the effects of these changes on the maintenance industrial base, we use a model to estimate the magnitude and timing of work (demand) on all ships in the yards making up the maintenance industrial base. To understand the workforce implications of different maintenance cycles at the shipyards, we modified a RAND model that was initially used to analyze changes in ship-acquisition programs.<sup>2</sup> The model first estimates the workload demand at the trade-skill level (welders, electricians, etc.) over time at each of the shipyards. It includes workload demands resulting from maintenance, modernization, decommissioning, and other projects for the various ship classes supported by a shipyard. The model uses shipyard-provided current and future workforce supply at the shipyards and compares supply of workers to the workload demands for the options we examined, to illustrate how the workforce must be adjusted to accomplish the desired workload.

We use the model to compare the projected supply of skilled workers to the demand to understand the challenges in managing the workforce under different maintenance policies. We estimate the effects of a 27-, 32-, and 36-month maintenance/training cycle on managing the demands on the maintenance industrial base.

We drew from NAVSEA's Carrier Planning Activity's<sup>3</sup> analysis that estimates that, by extending the maintenance cycle to 32 months and eliminating some Planned Incremental Availabilities (PIAs) and Docking Planned Incremental Availabilities (DPIAs), the longer maintenance cycles can reduce the number of maintenance man-days a carrier will need over its lifetime by about 500,000. Increasing the cycle duration will also decrease the total number of depot availabilities. The remaining depot availabilities (PIAs/DPIAs) may require more maintenance days, causing demand on the shipyards to spike. The introduction of

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<sup>2</sup> Mark V. Arena, John F. Schank, and Megan Abbott, *The Shipbuilding and Force Structure Analysis Tool: A User's Guide*, Santa Monica, Calif.: RAND Corporation, MR-1743-NAVY, 2004.

<sup>3</sup> The CPA develops the maintenance and modernization work packages for aircraft carrier depot availabilities.

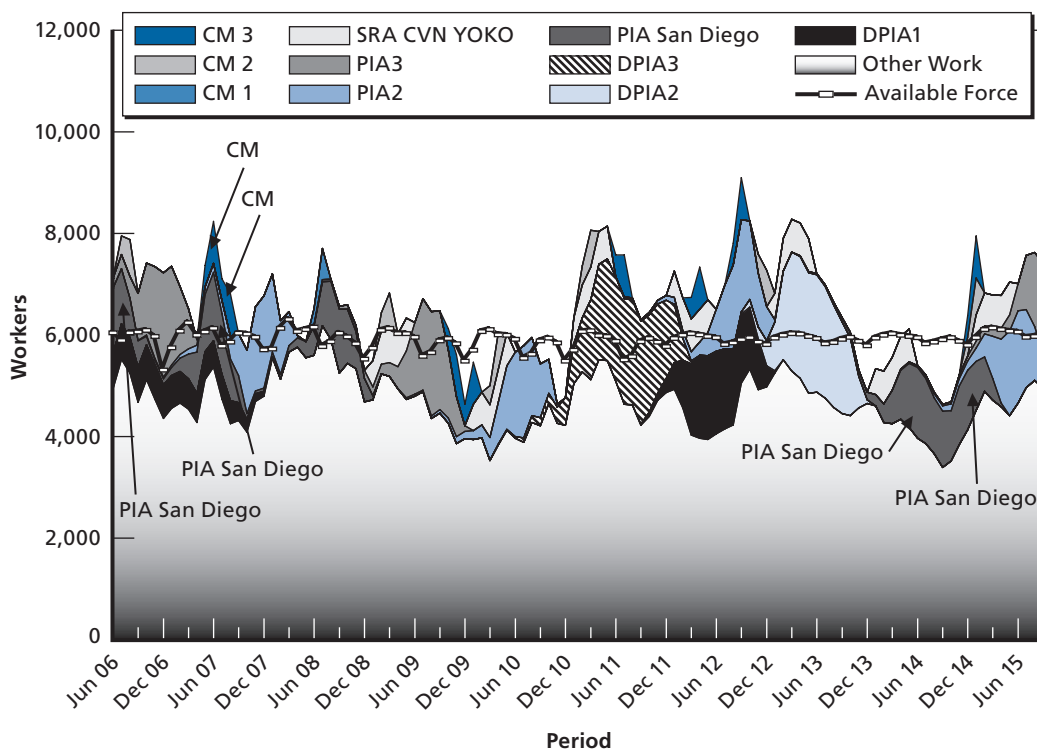
continuous-maintenance periods can help offset the depot maintenance packages, keeping them from becoming too large for the shipyards to handle.

We also consider an option in which the total maintenance workload over the life of an aircraft carrier was fixed and independent of the length of the cycle. We added the total maintenance and repair man-days for the PIAs and DPIAs under the 27-month schedule, and we distributed this higher total of man-days across the PIAs and DPIAs in both the 32- and 36-month schedules for a Fixed Lifetime Maintenance (FLM) case.

Through the analysis of CPA-estimated maintenance demands and the FLM option, RAND researchers identified some carrier maintenance scenarios under which projected workload could meet or exceed the number of available workers at both NNSY and PSNS & IMF. Under some carrier maintenance scenarios, the projected workload at NNSY could exceed more than 9,000 workers at some point in the next decade, or twice the number of available workers in the yard, and that at PSNS & IMF could exceed 10,000 workers, or about two-thirds more than the number of available workers in the yard. Surplus demand would be still higher should the longer maintenance cycle fail to reduce the total number of maintenance man-days a carrier requires in its lifetime.

As an example, Figure S.1 represents the PSNSY & IMF 32-month cycle using the CPA-estimated maintenance demands. The black-and-white curve at approximately the

**Figure S.1**  
**PSNS & IMF 32-Month Cycle**



RAND TR480-S.1

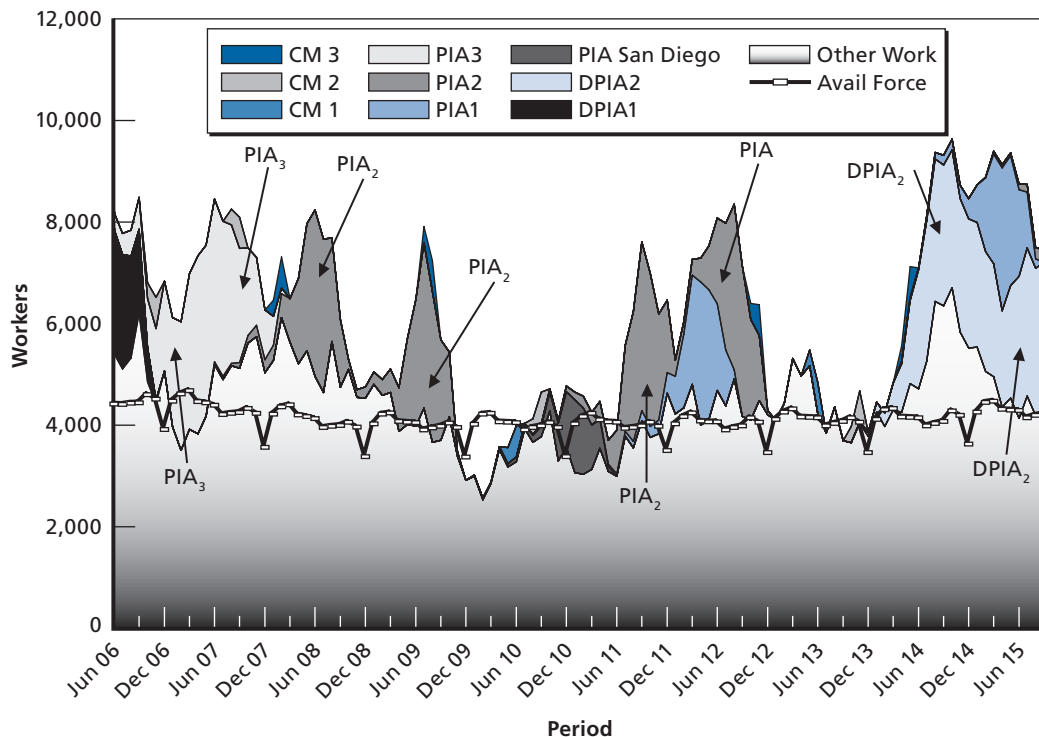
6,000-workers level represents the available workforce. While the workload demand exceeds the available force, the excess demand could be met through scheduling overtime and/or outsourcing the work.

Figure S.2 illustrates how the FLM option affects demand at NNSY under a 36-month cycle. Under this scenario, peak demand exceeds 8,000 workers several times throughout the next decade, including most of 2014 and 2015. While NNSY can manage excess demands through overtime, hiring of temporary workers, and subcontracting, high and sustained peaks (overdemand) stress the shipyard's ability to meet maintenance demands.

Changing the maintenance cycle by increasing the time between depot availabilities also affects the amount of time in which a shipyard has an oversupply of workers. Oversupply would exist at some point over the next decade at both shipyards and be more pronounced at PSNS & IMF under a 36-month cycle with unchanged man-day requirements.

Overall, we found that a 32-month cycle, should it be able to reduce total maintenance demands across the life of a carrier as projected, could do more to shift monthly distribution of workload throughout the next decade to a range in which neither supply of or demand for maintenance exceeds the other by more than 10 percent. The surplus of supply or demand could be reduced by shifting work among shipyards or sharing workers through the One Shipyard concept.

**Figure S.2**  
**NNSY 36-Month Cycle: FLM Case**

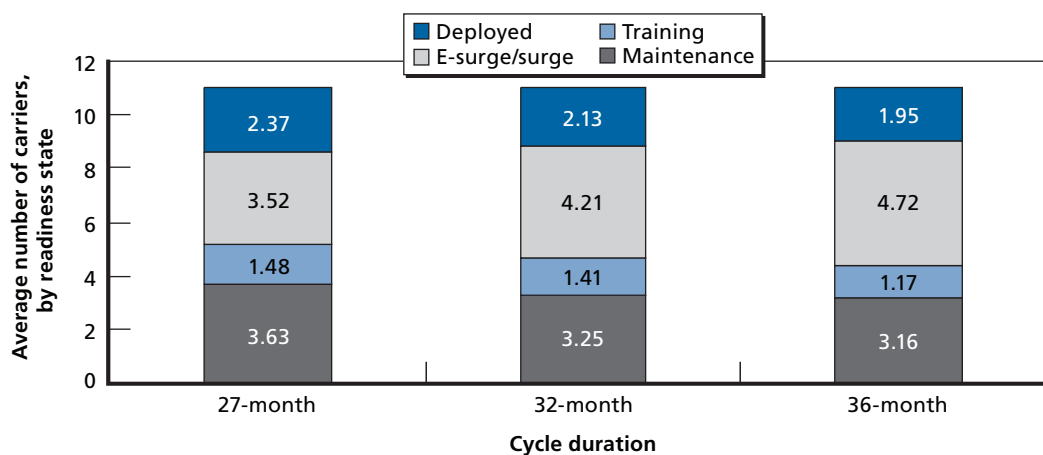


RAND TR480-S.2

Our assessment also examined the effects that different maintenance cycles would have on the number of aircraft carriers that are deployed or deployable in coming decades. Figure S.3 indicates that the number of surge-ready carriers increases as cycle length increases. Our modeling indicates that as the cycle length increases, with the limitation of a single six-month deployment per cycle, the number of deployed carriers decreases. Longer cycle times make carriers deployable for greater lengths of time, but we constrained our modeling to enable only a single six-month limit<sup>4</sup> on deployments for the one planned deployment between depot-level availabilities. In practice, we realize that aircraft carriers could and most likely would be deployed to a greater extent.<sup>5</sup> The increased number of average surge-ready carriers with increased cycle length enables more Nuclear Aircraft Carriers (CVNs) to be surged.

In sum, each cycle has its own features, the appeal of which may depend on operational and industrial goals. The 27-month cycle would provide a higher average number of carriers deployed at any one time, but there would be fewer additional deployable carriers. The 32-month cycle would minimize periods of strain on the maintenance industrial base. The 36-month cycle would have the highest number of deployable carriers but, assuming a six-month limit on deployments in a maintenance cycle, the lowest average number of carriers on deployment at any one time. The trade-off between deployed and deployable carriers could be

**Figure S.3**  
**Summary of Operational States of U.S. Aircraft Carriers for 27-Month, 32-Month, and 36-Month Cycles**



RAND TR480-S.3

<sup>4</sup> At the start of our study, personnel-tempo policy limited the length of deployments to six months, with a minimum of 12 months' time between deployments. A recent policy decision allows for an increased deployment length and reduced time between deployments.

<sup>5</sup> The impact of an increased number of deployments (and underway time) per cycle would increase maintenance demands. Analysis of the impact of increased deployments on aircraft carrier maintenance demands will be evaluated in follow-on work.

modified by changing deployment lengths, whereas changing deployment cycles can also strain or relieve the maintenance industrial base.