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Managing Military Readiness

by Laura J. Junor

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Cover: Marines fire M777A2 Howitzer aboard Marine Corps Air Ground Combat Center, Twentynine Palms, California (U.S. Marine Corps)

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Executive Summary

Understanding the limits of the Nation's ability to generate and deploy ready military forces is a basic element of national security. It is also the element most likely to be taken for granted or assumed away despite ample historical evidence of the human and operational costs imposed by such an error. As budgets shrink and threats grow more diverse, national security leaders need a specific accounting of the readiness limits of the force and the consequences of those limits as well as the insight to make timely and effective mitigation decisions.

This paper presents an analytic framework that builds from previous work to yield the systematic and defendable readiness analysis that must underlie decisions ranging from budget allocation to force employment and even strategy development. To manage readiness, the Department of Defense (DOD) must balance the supply and demand of deployable forces around the world. The readiness of an individual unit is the result of a series of time-intensive force generation processes that ultimately combine qualified people, working equipment, and unit training to produce military capabilities suitable for executing the defense strategy. While this discussion is a basic tenet of production theory, it had not been commonly applied to readiness management until recently. The important point here is that understanding *how* the readiness of military capabilities is generated provides the clearest picture of the current readiness status and whether that status is likely to change over time. Furthermore, it provides the best shot at identifying effective management policies to ensure that DOD can generate the capabilities that the Nation asks of it. This paper argues that traditional unit-level readiness metrics are useful as part of a larger readiness management construct, but by themselves they do not provide enough information to proactively manage strategically. This approach provides a clear explanation of the causes of readiness degradations and options for how to mitigate them that can be traced to precise resource investments.

The approach outlined here may seem impractically complex, and if we were starting out knowing very little about how ready forces are generated, that might be true. But we are not starting out with a blank sheet—DOD has been investing in analyses and production management schema for decades. Moreover, we are discussing a key strategic management function that oversees the value of billions of dollars in scarce defense resources. The effectiveness of the oversight and the validity of redirected funding during periods of such scarce resources must be based on a clear foundation. Dollars miscast on bad information undercuts the role of strategic managers and corrupts overall department readiness. This is why this subject is so vital.

Introduction

Policymakers commonly express the importance of maintaining ready military capabilities. They also generally agree that every function of our roughly $580 billion defense enterprise should support the generation of ready forces directly or indirectly, now or in the future. However, they often have very different perceptions about what readiness is and, consequently, how to manage it. Indeed, over time, the formal definition of *readiness* has varied from the narrow view of it as "the capability of a unit to accomplish the missions for which it was designed" to the broader view of it as "the ability of U.S. military forces to fight and meet the demands of the national military strategy."[1] Informal definitions offer even more variation and often include the technical aspects of issues such as weapons system availability.[2] None of these definitions are wrong; in fact, they are all absolutely correct. Much of the confusion about the definition of readiness is caused by complexities in how military readiness is created, consumed, and degraded.

The Department of Defense generates ready forces using hundreds of interconnected production pipelines that begin with elements of the labor pool and the industrial base, incorporate the throughput of maintenance depots and training ranges, and conclude with units that deploy with the resources and training they need to sustain their assigned missions until they have met their objectives. Therefore, managing readiness is as much about understanding the complexities of human resource management and the technical details of weapons system availability as it is about measuring the ability of U.S. forces to support the national security strategy.

An understanding of how ready forces are created requires knowing how these pipelines work, including how they are related to each other, the quantity and quality of inputs, and the perishability of resource stocks. Perspectives on readiness will depend entirely on where individuals are in this complex process. The pipelines that feed the throughput at maintenance depots, for example, involve factors such as the health of the industrial base that supplies repairable spare parts, as well as recruiting and retaining a qualified maintainer workforce. Readiness management in this sector requires understanding the number of available competing spare parts, component failure rates, retention of talented senior maintenance artisans, preventative maintenance, and a host of other concerns that limit their ability to feed downstream producers.

The processes that feed combatant commanders (CCDRs) look very different. While the upstream throughput at maintenance depots certainly matters, readiness at the combatant commands more directly concerns the capabilities of the units currently assigned to them and the likelihood that the Services would be able to generate suitably capable units and transport them to theater in time should an emergent operational demand arise.

This distinction highlights two important facts about readiness management. First, the readiness of most organizations involves a mix of direct and indirect factors. The direct factors (for example, the number of functioning aircraft in an aircraft squadron) will likely affect readiness of deployable units quickly. The effects of indirect factors (such as mid-grade pilot retention) will take much longer to manifest in units; that lag offers a valuable shot at heading off a problem before it progresses too far. Second, the supply of ready forces is only one part of the readiness calculus. In his seminal book on military readiness, Richard Betts argued that "ready for what" and "ready when" are fundamental questions.[3] As it turns out, the demand side of this equation matters too if our readiness measures are to be meaningful. The supply of ready forces must satisfy the demand for those forces, and that demand is parsed over time. The nature of readiness management then involves comparing the schedule of the supply of ready forces to the schedule of the demand for those forces. In turn, readiness managers must be able to identify supply-demand gaps along those schedules, the associated consequences, and the array of mitigation choices, including leaving the gap unfilled—all in fairly specific terms.

Like any other production process, the DOD network of production pipelines combines labor and capital to produce products that ultimately satisfy a specific demand signal. When the production time (including research and development) precludes the immediate satisfaction of demand, these production lines are calibrated to meet *expected* demand, and with that comes a need to adjust when expectations differ from what actually happens. In other words, the process may generate too little or too much product or even the wrong product entirely. In the case of DOD, some of these pipelines take years to yield a finished product (for example, an operational F-35 squadron), creating the real possibility that the Nation's demand changed in the interim.[4] Force providers like the military services and U.S. Special Operations Command derive their demand signals from strategy and planning processes, as well as emergent and sometimes unforeseen events. There will never be enough resources to be ready for everything, especially everything at once. Therefore, properly calibrating readiness production lines requires a clear articulation of national and military strategies, including a clear understanding of priorities and risk tolerances, in order to allocate resources effectively.

Readiness management is not limited to charting trends of the ordinal, unit-level readiness scores found in such traditional readiness reporting systems as the Status of Resources and Training System (SORTS) or the Defense Readiness Reporting System (DRRS),[5] which are adequate for measuring operational readiness. But at the strategic level and policy leader level at the Office of the Secretary of Defense, it is about managing the network of force generation pipelines to maximize the probability that they will produce capabilities that meet DOD's expected demand signal. Moreover, it is about understanding the implicit time dimensions of both the supply and demand sides of readiness and being able to articulate the consequences of not meeting a demand signal in the allotted time. The issue is not about a metric or even a set of metrics, although accurate data are critical elements of success. Readiness management requires an understanding of the entire process of creating ready forces and spotting problems deep in the pipelines before they have had a consequential effect on the Nation's security. Betts advocates for triple ratings that focus on the answers to "of what," "for what," and "for when" and argues that while this would breed controversy, that "controversy would force policymakers to confront choices obscured in the past."[6] He makes an important point here: the key to successful readiness management and the identification of constructive mitigation strategies is an informed debate about causes, effects, opportunity costs, and ultimately a clear, candid conversation about risk.[7]

Betts also argues that readiness management cannot rely on the premise that its importance is self-evident.[8] When resources are scarce and degradations are numerous and varied, expecting readiness problems to be resolved purely on the merit that a degradation exists is not sufficient. Even when budgets were larger, there were never enough resources to mitigate all problems. Readiness managers must provide the data and logic to inform a risk-based debate about which deficiencies will be mitigated and how. They must appreciate the temporal dimension about how long it might take for either matériel or personnel solutions to be generated. They must be able to clearly, and with reproducible evidence, make the case that any given readiness deficiency has a consequence that matters more than the opportunity cost of the next-best use of resources expended to fix the problem. Otherwise, the best course of action for DOD is to allow the degradation to persist, but monitor it closely.[9]

In summary, a healthy readiness management framework must monitor DOD force generation pipelines well enough to signal critical deficiencies and their likely consequences clearly and before those consequences are high.[10] That warning must then be followed by a series of mitigation options and their associated costs, benefits, and risks. This paper presents a practical approach for readiness management that achieves these ends and is suitable for the complexities of today's environment. It does not yield a simple solution quickly because the problem itself is neither simple nor static. Much of the current Defense decisionmaking calculus is extremely challenging if not over-constrained.[11] Over the last several years, not only have Defense budgets been shrinking, but also they lack the stability needed to plan multi-year investments that are crucial to supporting long-term readiness recovery.[12] In February 2016, then–Director of National Intelligence James Clapper testified that the diversity of threats to our nation and allies has been unprecedentedly broad for the last 5 or 6 years.[13] Fifteen years of high-demand counterinsurgency operations in Iraq and Afghanistan created serious degradations in the DOD ability to generate other high-end capabilities. While the Services have invested in recovering those capabilities over the last 5 years, serious readiness deficiencies will likely persist into the foreseeable future.[14]

A nascent version of the approach outlined here was used over the last 5 years to communicate readiness status, challenges, and consequences to the Office of Management and Budget, the White House, and Congress, especially as furloughs and sequestration hit. Its use is documented in the series of Quarterly Readiness Reports to Congress from 2013 to 2016. Using these techniques, readiness managers from across the department were able to explain why DOD did not enter sequestration with full-spectrum capability or capacity and, specifically, how furloughs and sequestration made this bad situation worse. They explained the consequences of those degradations in terms of the ability to execute specific operational plans, and once degradations occur, they typically take time to resolve even with funding. These effective narratives, not from one person but from throughout DOD, were instrumental in earning the Bipartisan Budget Act of 2013[15] spending levels that offered some relief from the original Budget Control Act spending limits,[16] albeit in 1-year contingency funding. Within DOD, this framework allowed the Services to effectively argue the imperative of continuing investments in readiness recovery. That said, there is more work that DOD can do at every level to fully realize the management potential offered by this approach.

The Supply of Ready Forces

This section presents an explanation of how readiness is created and, conversely, how it is degraded. These observations not only contribute to a generalized approach for managing readiness, they also provide context for how to think about the most pressing concerns facing DOD as it navigates the transition from the counterinsurgency-centric capabilities generated in Operation *Iraqi Freedom* (OIF) and Operation *Enduring Freedom* (OEF) to a readiness posture that better reflects the expanding threats to our national security.

The Services have the lawful responsibility to man, train, and equip units to meet operational requirements.[17] In doing so, each creates a force generation process that combines the classic inputs of labor and capital to provide the requisite supply of ready forces. These processes start with upstream production lines where DOD's most basic inputs are eventually turned into downstream capabilities that execute assigned missions that support national security. The production method and inputs throughout this complex process naturally differ based on the particulars of the capabilities being produced and must be calibrated to meet the demand signal derived from current operations and strategic guidance. The product of one stage (for example, the production of trained maintainers) will generally be an input into the next stage (say, the production of fully operational aircraft).[18] Similarly, factors that directly affected the production at one stage may only indirectly affect the product of the next stage and often with a significant time lag. In essence, readiness management is about ensuring that these interconnected production lines stay healthy and calibrated to predictably produce required capabilities.

While this discussion is a basic tenet of production theory, it had not commonly been applied to readiness management until recently. The important point here is that understanding *how* the readiness of military capabilities is generated provides the clearest picture of the current readiness status and whether that status is likely to change over time. Furthermore, it provides the best shot at identifying effective management policies to ensure that DOD can generate the capabilities that the Nation asks of it. Traditional unit-level readiness metrics are useful as part of a larger readiness management construct, but by themselves they do not provide enough information to proactively manage strategically. The approach that follows provides a clear explanation of the causes of readiness degradations and options for their mitigation that can be traced to precise resource investments.

This section teases out the web of interconnected production pipelines to answer the following questions: Why are there so many different conceptions of readiness? What metrics should managers monitor? Are existing readiness reporting systems sufficient for managing readiness? Do predictive or leading indicators exist to support anticipatory actions, and how should DOD approach linking resources/budgets to readiness?

A Framework for Monitoring the Supply of Ready Forces

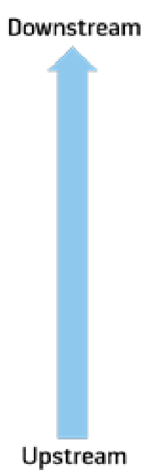
This framework characterizes readiness in terms of the stocks and flows of a series of critical products that are created as part of the DOD force generation process. The core of this framework is the series of output metrics that ultimately concludes with an accounting of the Department's ability to generate forces that are ready to execute operations required by the national security strategy. Put differently, the ultimate readiness assessment is whether DOD can generate a supply of ready forces that meets the specific demand for those forces—accounting for both "ready for what?" and "ready when?" considerations. The complexities of the demand signal and its relationship to the national security strategy are discussed elsewhere in the paper. The emphasis now is on identifying how to best monitor and manage the generation of ready forces.

The Services individually managed using this concept, but the Army was the first to formalize the approach. Army Regulation 525–30, *Army Strategic Readiness*,[19] incorporates the assessment of readiness pipelines to monitor leading indicators and identify policy levers to effectively mitigate deficiencies.[20]

The temptation to focus readiness management exclusively on SORTS and DRRS measures is strong, probably because they seem to provide a simple summary indicator of readiness at both a tactical and an operational level. These metrics contain critical information and have their place in readiness management. However, they have never been sufficient to fully characterize the health and durability of the force generation pipelines that are essential for effective readiness or force management. Furthermore, they provide little indication of the original source of degradations, nor do they help much in identifying the most effective mitigation strategies. Finally, the sections that follow argue that they are at best concurrent, if not lagging, indicators of the ability to successfully respond to and maintain operations.

Consider figure 1 as an illustration of the pipelines involved in one part of the force generation process. While the most downstream elements of this process may be the most widely cited by readiness pundits, they could not exist without the upstream products that feed them. For example, the two most downstream products in figure 1 (the ability of CCDRs to execute their assigned plans, and the ability of any given unit to execute its missions) are captured by traditional SORTS and DRRS readiness measures. The problem with truncating the assessment here is that managers will never see advanced indications that readiness at this level is in jeopardy.

Figure 1. Illustrative Force Generation Pipeline



Level	Example
Product Level 4	A Combatant Commander (e.g. USPACOM) ready to perform one of its assigned operational plans
Product Level 3	A deployed or deployable unit (e.g. a VMFA squadron) assigned to a carrier battle group ready to conduct its assigned mission
Product Level 2	An aircraft depot (e.g. Fleet Readiness Center Southwest, North Island (CA) producing enough mission capable aircraft (e.g. F/A-18s) for units so they can meet deployment and pre-deployment requirements
Product Level 1	Inventory of enough qualified maintainers able to generate required throughput at depot-level maintenance facilities

Thus, they are blind to a pending problem, as foresight into readiness shortfalls is not apparent. The readiness at the CCDR level is determined in part by the readiness of the units currently assigned to it (and not allocated elsewhere), as well as the likelihood that the Services can generate units that are ready to perform to mission specifications along the required timeline and until their objectives are complete. The Defense Readiness Reporting System captures elements of this assessment by requiring CCDRs to assess their ability to accomplish the individual essential tasks that comprise those operations. However, those assessments are not enough to fully diagnose and predict readiness degradations. Consider the likelihood of the Services to generate the quantity of forces that are ready for a given operation plan along the timelines dictated by that plan. While this is a complex question, it is possible for force providers to calculate the number of ready units they can generate now as well as the number that could be ready in subsequent periods, in part because we can see the detailed readiness assessment of individual units for assigned and designed missions.[21] We can also see which of those units are committed elsewhere. This provides a snapshot assessment of the likelihood of satisfying CCDR requests.

This information must be augmented by understanding the myriad of pipeline processes that generate the people, training, and equipment that individual units require and are beyond what the unit commander understands or controls at the time of the DRRS assessment. For example, one of the most critical pipelines is geared toward ensuring a sufficient stock of working equipment to meet unit requirements. A unit's stock of working equipment is, in turn, determined in part by the maintenance system's ability to generate that working equipment. This process keeps unfolding until the most downstream output in this example is reached: an inventory of qualified maintainers able to generate the throughput required to satisfy maintenance demand at all levels. Therefore, regular monitoring of the health of these pipelines not only warns of degradations before their full effect is realized across the force, it also clarifies the cause and scope of the problem; this is essential information to senior leaders when considering risk and mitigation options. The remainder of this section explores how to assess the supply of ready forces.

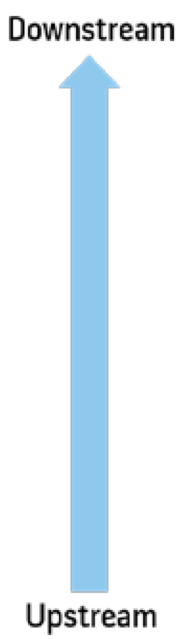
Characteristics of Output Measures

The key element of a robust readiness management framework is the explicit monitoring of final and intermediate outputs generated by the Services. Note that the examples in figure 1 are tangible, critical outputs that together inform the likelihood of generating the naval aviation capabilities required by an operational plan and along the timelines dictated by that plan. This section more broadly discusses the attributes of useful output metrics and how to use them in readiness management. These attributes are summarized in figure 2.

Upstream measures should ideally begin with basic inputs such as critical labor and capital. Recruiting and retention are important readiness indicators, especially for personnel in occupations that take years to produce and for which there is robust labor market competition (for example, aviation, highly skilled maintenance, and cyber). These data are generated and archived by DOD personnel specialists and should be fed to successive production levels as leading indicators of their processes. Likewise, the depth of the organic and industrial production bases also merits close scrutiny, and these data are resident within and among DOD acquisition managers. Similarly, the status of these output metrics should also feed the assessment at higher levels.

Product level 2 reflects the production capacity of those intermediate goods that directly feed the readiness at individual units (product level 3). These include schoolhouse production rates for critical skills, maintenance throughput at depot and intermediate maintenance activities, and training throughput at "graduate" training ranges. It is not practical for managers at this level (for example, personnel specialists, individual and unit trainers, or maintenance facilities) to report their output metrics to every reporting unit. However, this information can and should be fed through the readiness directorates within the Service headquarters as leading

Figure 2. Attributes of Output Metrics Throughout the Production Pipeline



Level	Example
Product Level 3	Focuses on the reporting units and would ideally capture both SORTS and DRRS assessments of the unit's ability to perform assigned and designed missions by task. We should expect that the same unit may not be equally ready to perform all of its missions all of the time. Units should use the existing reporting systems to signal anticipated future readiness changes driven by things like personnel/equipment rotations and range availability.
Product Level 2	Focuses on the ability of the Department to turn the raw materials in the first level into intermediate outputs suitable for maintaining reliable stocks of personnel and equipment at deployable units. The output metrics are typically throughput at schoolhouses, training ranges and maintenance facilities (depot, intermediate and organic) and are calibrated by mission/occupation to meet deployment requirements.
Product Level 1	Considers stocks and flows of raw military resources including recruiting and retention of critical occupational skills that take significant time to learn; inventories of critical weapon systems and the long-lead, mission-essential components.

indicators of force generation potential. Because information at this level could easily become overwhelming, each of these metrics should have an associated threshold, expressed in terms of risk, to signal when throughput is insufficient for meeting current force requirements. That will allow readiness managers at more senior levels the ability to focus on the most problematic pipelines. Each metric should also include an indication of the maximum throughput or production capability in the event of a surge requirement. The professionals who manage the inventories and training of personnel, the inventories and maintenance of critical end items, and the throughput of unit training monitor these issues for a living. It is reasonable for them to be assigned production or performance thresholds, especially for key resources. It is also reasonable for them to report on issues that jeopardize these goals regularly. In summary, measures of the existing production rates, the sufficiency of these rates to meet current requirements, and the potential for surge are critical elements for assessing readiness at the unit level and higher.

Product level 3 includes SORTS and DRRS measures of the readiness of the individual units and, consistent with current reporting policy, includes every type of military capability, line or support, as well as units above and below the ship/battalion/squadron level. It also tracks the readiness of joint units and ad hoc units that are created specifically for a given mission. Service headquarters regularly track the readiness of units to accomplish both their assigned and designed missions.

The common element among these layers is the measurement of various stages of production not approximated by inputs, but measured as discrete outputs. In most cases the data exist but have not routinely been used as part of a strategic readiness process. There may well be suitable intermediate-level output measures that are nested between the production layers in this example. Regardless, there will be many unique pipelines associated with generating outputs below the CCDRs' assessments (production level 4).[22] In the above discussion, there would be metrics tracking the production and evolution of key personnel, systems, and unit training at a minimum. The upstream outputs will be important inputs downstream. The ability to trace the effect of a deficiency along this production process is the key to managing readiness and will be explored in depth in the sections that follow.

Calculating Readiness Effects—For Want of a Nail

The old proverb "for want of a nail" illustrates how even the smallest deficiencies can produce devastating outcomes.[23] That is essentially the concept behind tracing and understanding the consequences of readiness degradations, even those seemingly innocuous problems that are buried deep within the force generation pipelines. A discussion is in order of how to think about changes in the value of those output metrics. In other words, what is driving a given change, what is the likely duration of the problem, and can the problem be mitigated? If so, at what cost?

Effective readiness management requires quantitatively tracing the effects of positive or negative shocks through the network of pipelines and ultimately to the ability of DOD to execute the national security strategy. This section begins with a discussion of the basic elements of upstream and downstream readiness production and then turns to specific issues like direct and indirect effects, negative synergies, the durability of readiness degradations, and readiness cycles. The section concludes with practical guidance for quantifying readiness consequences that is supported by a sampling of empirical analytic products summarized in appendix B.

Direct and Indirect Effects. A direct effect refers to a causal factor that has an immediate effect on the organization's ability to produce. Indirect effects, in contrast, are those factors that are the product of an upstream production stage and, while relevant to the organization's production, may not affect it concurrently. Figure 3 builds on the example from figure 1 and provides examples of specific outputs at each production level. It also describes examples of factors that could cause an adverse change in these values.

Consider again the most upstream product at level 1: the inventory of qualified maintainers able to generate the throughput needed to satisfy maintenance demand at all levels. This value is fairly straightforward and usually can be drawn from transactional personnel data systems. The inputs or causal factors that most directly influence this variable include recruiting

Figure 3. Direct Effects on the Readiness of a Given Unit or Organization

Downstream

Level	Example	Some Direct Causal Factors*
Product Level 4	A Combatant Commander (e.g. USPACOM) ready to perform one of its assigned operational plans	• The readiness of assigned forces to perform that OPLAN • The probability the services can generate allocated units that are ready to perform that OPLAN • The probability the Services and functional combatant commands can sustain deployed capabilities until plan objectives are met
Product Level 3	A deployed or deployable unit (e.g. a VMFA squadron) assigned to a carrier battle group ready to conduct its assigned mission	• Billets filled with qualified squadron personnel • Inventory of equipment (e.g. aircraft) capable of performing the assigned mission • Individual and unit training requirements in support of assigned mission.
Product Level 2	An aircraft depot (e.g. Fleet Readiness Center Southwest, North Island CA) producing enough mission capable aircraft (e.g. F/A-18s) for units so they can meet deployment and pre-deployment requirements	• Depot billets filled with qualified maintenance personnel • Inventory of equipment (e.g. test benches) capable of meeting timely throughput requirements • Inventories of consumable and repairable spare parts
Product Level 1	Inventory of enough qualified maintainers able to generate required throughput at depot-level maintenance facilities	• Recruiting and retention of qualified maintenance personnel • Throughput of individual-level training

Upstream

*The items listed above are generalized and provide an illustrative rather than exhaustive list of direct causal factors and retention data for these occupational fields and the throughput of relevant training processes.[24] Degradation in either of these categories of causal factors will likely have a significant impact on the ability to keep enough qualified maintainers working in the depots.

The adequacy of qualified manning at the depots then serves as an input or causal factor in the next level of production—the aircraft depot's ability to produce enough mission-capable aircraft to satisfy the predeployment and deployment requirements of aviation squadrons. Here, depot manning is one of three illustrative causal factors that will likely directly influence the depot's ability to generate mission-capable aircraft. If there is a negative shock causing maintainers currently employed at the depot to leave or that is otherwise restricting their work (for example, stemming from a furlough or competition from other employers), we would expect to see immediate consequences in the output of the depot, holding other things constant. Negative shocks to maintainer recruiting, retention (outside of the depot), or training throughput would only indirectly affect the depot as the current stock of maintainers turned over. Therefore, managers at product level 2 should explicitly monitor those factors that directly affect their production activities as well as the indirect effects of the output levels from product level 1, especially when those outputs are not meeting standards.

Product level 3 in this example considers readiness at the ship/battalion/squadron level and is summarized by traditional DRRS and SORTS metrics. A large portion of DOD is focused on generating the pipeline products that are required to keep individual units ready. A degradation in these pipeline processes can take a significant amount of time to register a noticeable reduction in the number of ready units. Units that were already maxed out for people, equipment, and training will not register a change until the people rotate out, the equipment begins to break, and/or their training expires and the spigots that had typically fed them with more resources are now turned down low. Depending on the magnitude of the impact, a degradation will slowly manifest as an increasingly large percentage of unready units. Even then, units will go to great lengths to protect their readiness status and dampen these causal effects. For example, one common unit-level reaction to problems in the equipment pipeline is to sacrifice some system so that it serves as a local spare parts inventory, a process called cannibalization. While cannibalizations provide some buffer from a flawed supply pipeline, they can also create problems that range from accidental damage to the parts to masking serious degradations in the supply chain. This was so much of an issue during the 1990s that Congress required the Services to report every cannibalization action in the Quarterly Readiness Report to Congress. Holding other things constant, the typical unit's drive to maintain readiness at all costs means that it could take several months or longer for these impacts to accumulate enough of an effect to significantly restrict the number of ready units and affect ongoing operations. While the direct operational and unit effects seem to be the most startling, degradations in the upstream pipelines cause the most damage in the long run. They are undoubtedly the most important tool for proactive readiness management.

Individual units are well suited to track the personnel, training, and equipment resources they have on hand. However, they are not well suited to receive the myriad of metrics relating to the pipelines that feed these resources. Alternatively, headquarters-level readiness management divisions within the Services should receive output metrics from production level 2 pipelines, especially as individual metrics violate agreed-on production standards. They should also attempt to calculate the effects of any degradations on the production of ready units. Readiness managers should expect not to see significant impact on the number of ready units in the short run. However, they should be wary of rational acts at the unit level that mask these effects because often they are not the optimal solution to an upstream readiness problem.

Finally, the most downstream production level considers readiness at the level most related to the ability to support a national security strategy by addressing the likelihood that CCDRs can execute both ongoing and assigned contingency operations. A discussion of the inevitable risk will come later in this paper, but for now, the focus is on determining whether CCDRs can accomplish their assigned operational responsibilities. The most direct impact on this level of readiness is the readiness of the units currently assigned to the CCDR (and not allocated elsewhere), as well as the likelihood that the Services would be able to generate surge forces that are sufficiently resourced and trained to accomplish the operations associated with the contingency plans along the required timelines. The analysis conducted by headquarters readiness managers calculating both direct and indirect effects on the production of ready units is instrumental in operational readiness assessments.

Negative Synergies. Another factor that can increase the severity and duration of a readiness decline is negative synergies among degradations. Negative synergies exist when the combined effects of multiple readiness degraders are worse than the individual effects of those degraders. Consider the combined effect of a problem in the process that generates new pilots (for example, backlogs in training pipelines) with something that would affect the retention of existing pilots (such as a big improvement in the civilian labor market). The combined effect could easily have a profound impact on our ability to fill unit requirements, and given the time to generate a proficient pilot under the best conditions, this effect would likely take a long time to fix. Also consider the coincidence of shortages in spare parts inventories with shortages of qualified maintainers; the result will inevitably reduce maintenance throughput. Fixing problems in the revolving funds associated with spare parts and the generation of experienced maintainers are both notoriously long-term issues.

Another category of negative synergies comes from cross-Service dependencies and implications for joint readiness. The Services are still wrestling with understanding the full measure of the long-term individual consequences, and the potential joint and cross-Service concerns have yet to be determined.

Durability. Once an effect does becomes apparent, there are two factors that affect its durability: the inherent length of the pipeline process itself, and the duration of the degradation. As an example of the first factor, consider the production of high-skilled versus less-skilled labor. Military labor categories such as pilot and crypto-linguist require extensive training, and attaining master-level competence in most technical or leadership positions can take years to achieve. In most cases, chronic shortages in these categories cannot be recovered quickly. As a result, DOD tends to manage these skill sets carefully. In almost every case, however, the longer one of these pipelines is degraded, the more durable the degradation is likely to be because replacements cannot be directly hired from the civilian market. These skills must be grown from newly recruited novices. Therefore, any gap in mid- or senior-grade technical personnel will never be filled. Instead, the gap slowly attrits from the force within that cohort of people.

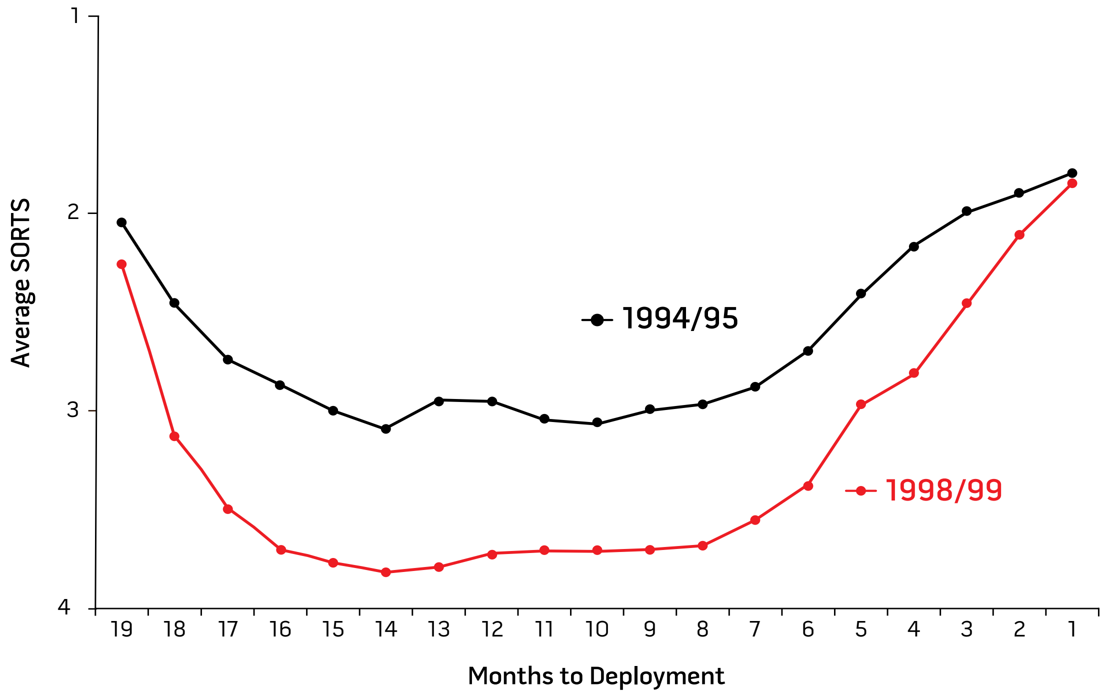
Consider the issue of pilot retention. It takes years to train a combat-ready pilot and even longer for a pilot to gain the experience necessary for operational leadership positions. When the civilian market for pilots heats up, DOD fears it will lose more pilots earlier in their career than would be desirable. The incentives from the civilian airlines tend to prompt military pilots to leave as soon as their obligation is up so they can maximize the salary and benefits offered by the airlines.[25] The consequence is a predictable and permanent reduction in the cohorts of experienced pilots that are lured into the civilian market. The reduction will have an immediate impact, but the consequence of the shortage in pilots will change as the cohort ages up and eventually out of service.

When General John Campbell was the Vice Chief of Staff of the Army, he explained the consequences of a similar degradation to the Senate Armed Services Committee.[26] He explained that in 2013, the 2nd Armored Brigade Combat Team of the 4th Infantry Division (2-4) went to the National Training Center for a direct action/unified land operations rotation for the first time since 2002.[27] Between 2002 and 2013, this unit had conducted three mission readiness exercises in preparation for deployments. These exercises prepared them for the counterinsurgency (COIN) missions they were facing but did not reinforce their direct action (full-spectrum) skills, which atrophied as a result of serial counterinsurgency deployments. General Campbell explained that once they resumed full-spectrum training again in 2013, they realized that "many tank platoon sergeants had never performed as a member of a tank crew, some company commanders had never maneuvered their units as a part of a combined arms team, and Field Grade officers often had no experience in combined arms maneuver. The lack of leader experience in these skills prevented 2-4 from achieving the maximum readiness that a CTC [Combat Training Center] rotation would normally provide." The significance here is that these leaders will likely always have less full-spectrum experience than leaders in previous cohorts. Full-spectrum skill atrophy over the course of prolonged and high-demand COIN operations between 2001 and 2014 was a common concern across the Services by the end of 2014.

Cycles. The controversy over managed readiness cycles has been around for a long time. Every deployed unit experiences some kind of readiness cycle that coincides with its deployment cycle. Units that are by all indications ready during their deployment come home and reset their equipment and disburse a significant portion of their personnel either for much-needed rest and recovery or to send them to schools. In most cases, a unit's readiness falls to some degree, for some period of time, just after a deployment, and that may not necessarily be a problem. Betts notes that a "country is militarily ready as long as the time needed to convert potential capability into the actual capability needed is no longer than the time between the decision to convert and the onset of war."[28] In essence, as long as units can recover their readiness completely before they next deploy, then there is no harm from the decline. He makes the case that allowing for such a decline is efficient so long as the recovery criterion is met.

In fact, the Navy operated under this paradigm for a very long time, viewing it as an efficient management of equipment, human, and fiscal resources. For a Service as equipment-intensive as the Navy, it actually made sense. Long deployments, regular maintenance requirements, and the insidious effect of salt water on equipment required extended periods during which ships and aircraft simply were not available to either train or deploy again during what they called the "inter-deployment" period. In the late 1990s, however, the Navy recognized that these inter-deployment readiness declines were not constant, especially for its carrier-based aircraft. The trend is depicted in figure 4, which shows the pattern in average SORTS between deployments. The horizontal axis measures the time between deployments so that the graph begins roughly when the last deployment ends and, ends with, the beginning of the next deployment. The black line indicates average scores for airwings deploying in 1994 or 1995, and the red depicts airwings deploying in 1998 or 1999. The chart clearly shows that the readiness cycles became more severe over this interval with readiness (primarily driven by training scores), falling lower and flattening out at that lower level until a few months before deployment. The airwings seemingly

Figure 4. Average Overall SORTS Scores for Carrier-Deployable Airwings Between Deployments

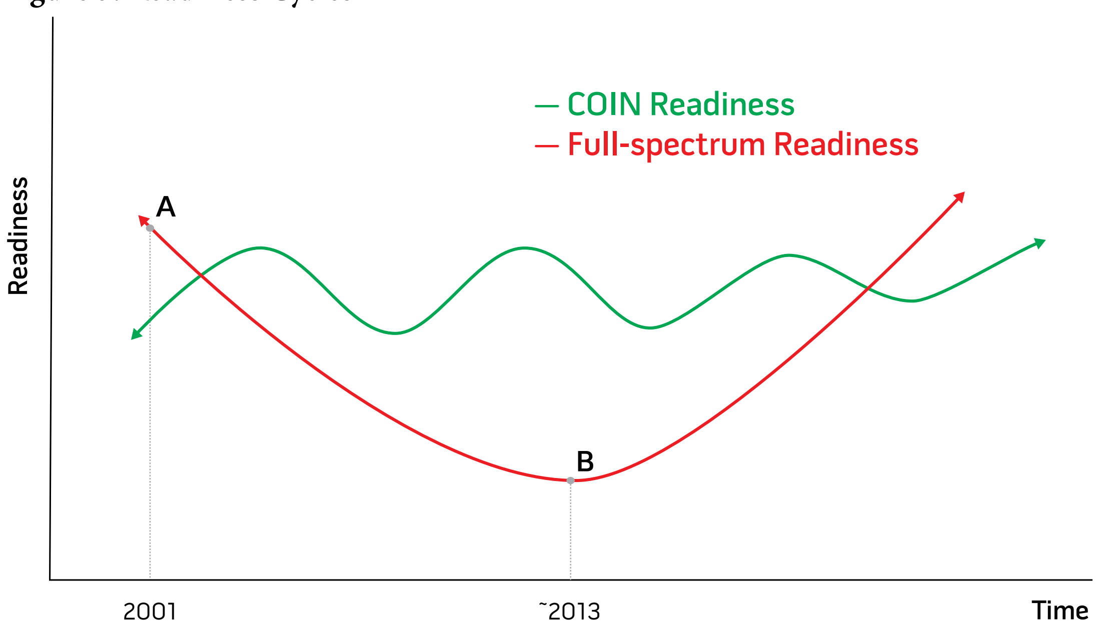


crammed most of their training qualifications in the last 3 months prior to deployment. This prompted questions of what was driving the decline and whether a recovery that rapid was real. The cause ended up being an unfortunate combination of flight hour reductions just as training requirements increased.[29] The question of whether the sudden ramp-up in readiness was real or whether proficiency had suffered was a much more difficult question to answer.

This is precisely why using readiness cycles as a means of managing readiness is so controversial. Managing the depth and duration of these cycles to ensure that we do not deploy unready forces requires information about the limits of individual and unit skill recovery, dependable equipment management, and dependable deployment timelines—a very tall order. Put differently, managers need to understand the specifics about the pipelines that create readiness in these dimensions. Logically, deep readiness cycles are not suitable for units on call to rapidly deploy under emergent circumstances. Similarly, degradations that will take so long to restore that the units effectively become unusable are also not efficient. This concern became real when DOD had to draw extensively on Reserve Component units in the early phases of OIF and OEF. Decades earlier, the Reserve Component's readiness had been allowed to atrophy largely to protect the readiness of Active Component forces.[30] Despite the influx of operational funding, these units initially struggled to recover readiness in time to meet U.S. Central Command's requirements. These observations warrant a caution that if readiness falls too far for too long, the pipelines themselves atrophy, and recovery will likely not meet even the latter end of emergent deployment timelines.

The most difficult aspect of this problem is managing the proficiency of the unit. Equipment management comes with rules of thumb like "Change the oil in your car every 3,000 to 5,000 miles." Will the car fail on mile 5,001? Probably not, but lots of data and analyses indicated that this is the maintenance interval that balances the expense of new oil and the expense of major engine damage. Readiness managers do not have complete information about unit and individual proficiency, probably because it is difficult to measure well. It is important, however. Consider figure 5 in the context of the preceding discussion about full-spectrum readiness. The readiness of many ground and aviation units for counterinsurgency has likely been cycling steadily since OEF began in 2001 (point A) to the present day. Their readiness improves as they prepare to deploy, and then falls to some degree after the deployment concludes and they return to home station. However, the readiness trough never gets so low that they cannot repeat the cycle in time for the next deployment. That pattern is illustrated by the green line. At the same time, readiness for full-spectrum skills (the red line) began atrophying as COIN

Figure 5. Readiness Cycles



training dominated their preparation. Since these skill sets are perishable, it did not take long for atrophy to set in; the beginning of the trend is approximated by point A. Full-spectrum readiness declined until about 2013 to 2015, when funding and operational demand allowed for the beginning of skill recovery on a unit-by-unit basis. It is not at all clear when these skills will be fully recovered (point B). Since the atrophy was force-wide, the senior trainers' skills are also diminished, calling into question the true recovery time.[31]

This is a complex issue to understand and manage effectively, but readiness managers have no choice but to develop much better metrics on individual and unit proficiency in order to manage these declines and express risk in fairly clear and certain terms. Counting on readiness to remain constant at a suitably high level all the time is futile.

Tiered Readiness. The concept of tiered readiness is closely related to readiness cycles and is at least as controversial. It means different things to different people. For some, it is essentially about creating an "immediate response force" and "follow-on forces." The immediate response force is resourced to be ready on a relatively short timeline. The follow-on forces are given just enough to be viably ready on a longer timeline. The attractive feature of this construct is that it conserves resources while providing a means of building up the readiness of forces when they are needed. However, as was the case with pronounced readiness cycles, employing this force management technique leaves a lot of room for miscalculations that can jeopardize military objectives and military lives. This is why the Services generally loathe tiering as a management tool. It works as long as the time and resources it takes for the follow-on forces to become ready are well understood and the recovery time does not cause the military a significant operational disadvantage. This is a very tall informational requirement. It also is predicated upon a well-understood demand signal and stable mission timelines. Note that the recovery time is a function of associated production pipelines; many military capabilities simply cannot be generated in a few weeks or even a few months. Following the preceding discussion on cycles, the information needed to convincingly meet these criteria does not come easily.

A slightly different concept of tiered readiness involves dividing the force to respond to different mission types. A simple example is the X team and the Y team. The X team is resourced to be ready for mission X, and the Y team is resourced to be ready for mission Y. This too can be a viable plan when the capacity of the X and Y teams is truly sufficient for their respective missions, and we fully understand the time and resources it takes to turn an X team into a Y team (and vice versa). In the event we need more of the X team, and the timeline allows for a Y team conversion, then the advantage of this approach is that it too conserves resources and addresses the challenge of competing mission priorities at least to some degree. However, it breaks down if the conversion was not well understood and if the recovery timeline causes a significant operational disadvantage. This gets to the issue of understanding the right missions and the element of risk for senior policymakers. In each of these cases, the imperative is on maintaining accurate information on current readiness and the timeline for readiness recovery that is accurate and without prejudice.

The Role of Analysis

The approach outlined above may seem impractically complex, and if starting from a point of knowing little about these production pipelines, that might be true. But we are not starting with a blank sheet—DOD has been investing in analyses and production management schema for decades. Moreover, we are discussing a key strategic management function that oversees the value of billions of dollars in scarce defense resources. The effectiveness of the oversight and the validity of redirected funding during periods of such scarce resources must be based on a clear foundation. Dollars miscast on bad information undercuts the role of strategic managers and corrupts overall DOD readiness. This is why this subject is so vital.

The value of analysis and studies is not the precise measurement of action and readiness consequence. In fact, readiness management is far too complex to rely on a "black-box" empirical tool to auto-manage readiness. The empirical work, however, is immensely valuable in developing a better understanding of how processes work and what appears to drive the production of quality output. In that respect, sound studies are an indispensable readiness management tool. Appendix B contains summaries of empirical readiness research that provide some insight into how to glean metrics and performance thresholds from these findings.

Summarizing Supply Side of Readiness Management

Determining the supply of ready forces is a complex and highly quantitative effort. As difficult as it is, it yields a convincing and accurate assessment of current and future readiness as well as useful insights into the most likely mitigation mechanisms. Some observations from this section are that:

- Readiness managers must monitor the viability of the production lines that trace from basic upstream products through to downstream products. This must be a recurring information feed that is provided according to a well-defined readiness management plan.

■ Readiness management cannot be successful if it is only done at the headquarters level. Higher headquarters must lead this initiative, and that begins by specifying how pipeline components should feed information downstream. Professional managers of personnel, equipment, and training processes must be actively integrated into the readiness management process.

■ Upstream managers must push information to downstream managers at the first sight of a consequential degradation. This means that output metrics should include performance thresholds to signal problematic production. This will help senior readiness managers or producers at the next level monitor a potentially unwieldy amount of individual metrics.

■ Readiness management cannot be successful if it only involves SORTS and DRRS metrics. These metrics, while an important gauge of unit readiness, will not yield advanced indications of readiness degradations. They are also not designed to diagnose the cause or durability of any given problem in isolation. While individual units may not be well suited to receive volumes of indirect readiness data, Service readiness staffs should be able to process that data.

■ Because the volume of information could easily be overwhelming, readiness managers should prioritize those capabilities and production processes that are most directly associated with operational success and involve expensive or long-lead production processes.

■ Existing studies and analyses can help here, as can the functional expertise of producers and managers at every production level. These assessments throughout the pipelines should include indications of the timing and magnitude of any upcoming shocks that will affect the next tier of production. Specifically, look for unanticipated effects or relationships. The pipelines are complex, evolve over time, and are susceptible to exogenous factors (for example, global technology, demographic, and economic events).

The Demand for Ready Forces

The previous section presented a framework for understanding the systemic nature and causes of readiness deficiencies, but that is only half of the information necessary to adequately manage readiness. Readiness is contextual; without a framework for articulating what forces should be ready for, and when they should be available, it is nearly impossible to determine whether the current supply of readiness is adequate or whether it jeopardizes national security. With only supply information, all we can say is that more readiness is better than less, holding all other things constant. Even then, once budget limits are considered along with the associated opportunity costs of achieving more military readiness at the expense of other critical investments, such a simplistic assessment offers no value in constrained decisionmaking or risk assessment.

Ultimately, readiness managers must be able to assess the consequence of any given readiness deficiency on the ability to successfully execute the individual and combined components of national strategy. Without understanding the likelihood and magnitude of that consequence, it is impossible to determine whether national security would be better served by mitigating that problem or another. This is important in a zero-sum fiscal environment; it is essential in the negative-sum context of declining budgets because as budgets decrease, the opportunity costs of reallocating funding to fix readiness deficiencies increase. Consequently, we must be able to explain the effect of readiness deficiencies on whether individual CCDRs are currently able to execute their *ongoing* operations successfully. We must extend that analysis to their execution of assigned *contingency* operations. In that case, could DOD generate the requisite forces along timelines associated with mission success and without unnecessary casualties? If not, why not? What happens when operational simultaneity is considered? We have to be prepared to describe those risks in fairly specific terms that can be understood by those outside DOD.

Two General Demand Signals

There are two general categories of the demand for forces: the rotational demand for presence and ongoing operations, and the demand for contingency operations. While popular discussion tends to focus on typical combat capabilities (infantry, intelligence, surveillance, and reconnaissance [ISR], or tactical aviation), readiness managers must focus equally on enablers (such as operational medicine, transportation, operational energy, ordnance, and matériel stocks). Together, these two demand signals along with simultaneity assumptions form the essence of the operational requirements in national strategy. This section briefly describes the origin and considerations involved in assessing demand.

Rotational Demand. Rotational demand is the ongoing demand signal that covers rotational forces supporting operations across the globe ranging from “advise and assist” operations in Iraq and Afghanistan to routine presence and engagement. This demand signal also includes emergent events such as humanitarian assistance and rapid evacuation response. Because it deals with force demand in near–real time, and in many cases for planned or otherwise routine events, much of this demand signal is predictable and well understood. Some of this demand is filled using forces assigned to CCDRs. When assigned forces are insufficient (or nonexistent), CCDRs request additional forces to be allocated to them to fill specific requirements. This portion of the demand signal is drafted each year in the Global Force Management Allocation Plan (GFMAP), which represents an arbitrated reconciliation of the Services' ability to supply additional forces and the CCDRs' demand for forces in the coming year. Because the world continues to change, the "base" or initial GFMAP is amended frequently with emerging CCDRs' requirements through the deployment orders process. Deployment orders, like the base plan in the GFMAP, represent an arbitrated solution that, once again, attempts to balance the operational needs of the CCDRs with the force generation realities of the Services, but this time in the face of emerging circumstances. These are critical mechanisms for managing the supply/demand conundrum.

While the majority of requests for forces (RFFs) are sourced (met) without much debate, there are always a fair number of requests that exceed the Services' ability to source without significant cost. Force managers—ultimately the Chairman of the Joint Chiefs of Staff and then the Secretary of Defense—must make these difficult choices. From the supply perspective, when the Services have to generate ready forces at unsustainable levels, there are two potential risks. The first is that there are simply no available forces that are ready for that mission at the time they are required. This finding compels a decision between not filling the latest demand for those forces/capabilities and reallocating forces from existing tasking to fill the new demand. Such a tradeoff requires specific information about the relative value of filling each demand (and the consequences of not filling them) as well as any supply considerations that may be involved in reallocating forces (for example, the potential for extending their deployment, transportation and transit concerns, or whether they are prepared for the new mission).

The second risk concerns forces that can be generated now, but the damage to the production lines will mean less forces will be generated in the coming year. Consider the demand for Navy ships, which always greatly exceeds the Navy's ability to supply them without skipping or otherwise shortchanging overdue maintenance availabilities.[32] The cost of jeopardizing maintenance availabilities includes the potential worsening of underlying, undiagnosed maintenance problems and presence gaps in the coming year as the maintenance availabilities eventually become non-negotiable.

The demand for ISR is also extraordinarily high and, while the limiting factor is generally insufficient capacity, their availability is further restricted by increasing shortages of trained Air Force personnel to "pilot" them. Much like the surface ship case, the Air Force argued that at some point, sourcing more of these pilots would mean that they would have to deploy training personnel, which would further reduce their force generation capability. There are also several other personnel-oriented capabilities, like pararescue jumpers, that have been deploying so frequently that the Air Force is concerned they have been risking the resilience, if not retention (and thus future supply), of those Servicemembers. Finally, there are a number of ground and aviation capabilities whose full-spectrum capabilities have atrophied because of the decade-long need to generate skill sets to support COIN operations.

Without allowing these forces the recovery time to fill training voids, we risk an inadequate response to a major contingency—an issue that puts American lives and security at risk. General David Goldfein, USAF, made that point clearly in his September 2016 testimony to the Senate Armed Services Committee: "To put it simply, Defense Strategic Guidance places demands on the capability and capacity of the Air Force that consume its resources in today's fight and exceed our capacity to address readiness requirements for a high-end fight against a near peer adversary. If Airmen are unprepared for all possible scenarios, it could take longer to get to combat, jeopardize our ability to win, and cost more lives."[33] In the same hearing, General Robert Neller, USMC, and Admiral John Richardson, USN, expressed similar concerns about the sustainability of their highest-demand capabilities.[34] Meticulous attention to the pipelines that generate these capabilities provides the Services a very specific description of the origin, magnitude, approximate duration, and supply-side mitigation options for these issues.

From the demand or CCDRs' perspectives, the risks of not meeting their demands will vary depending on the nature of the demand. Combatant commanders must be able to explain the magnitude and general probability of those risks. For example, if the Services cannot generate forces for presence and engagement missions, then allies and aggressors could doubt U.S. commitment in the region, which could be destabilizing. Failing to respond quickly in the event of an American citizen evacuation from foreign soil or to a sudden act of aggression could result in the loss of American lives or jeopardy to U.S. security interests. Inadequately meeting a CCDR's request for ongoing operations could have equally serious consequences.

Much like the Services' responsibility to forecast and articulate the consequences of deficiencies in their force generation pipelines, CCDRs must be equally clear about the expected consequences of not having individual requests for forces filled. These consequences should be logically consistent, defendable, and explicitly consider how they will manage the risk of any resulting future force generation constraints (for example, presence gaps) that would result from failure to fill demand now. This is admittedly extraordinarily difficult to do, but it is an inherent requirement for a theater command before requesting additional resources. Unfortunately, there is not a lot of empirical work that estimates the value of overseas presence and engagement either in terms of global security or global economics, leaving readiness and force managers little more than anecdotes to consider.[35] Recent work begins to fill this information void by estimating the impact of reductions in U.S. external security commitments on various U.S. economic concerns and the prevalence or intensity of civil conflict abroad.[36]

Contingency Demand. The second demand signal covers large-scale contingencies that have been deemed DOD strategic priorities. The demand signal here can also be fairly specific in terms of required forces and timelines and is derived from existing operational plans or defense planning scenarios used in developing strategy. Some plans are far more complete in this regard than others. Many of the high-likelihood/high-consequence plans are typically explicit in terms of the demand for specific force elements and the timeline for this demand. However, such specificity requires assumptions and in that sense, it is more theoretical than the rotational demand described above. The assumptions range from geopolitics to adversary motivations to available transit routes/mobility pipelines.

The likelihood of executing contingency operations is arguably lower than the likelihood of rotational demand, but the consequences of failing to execute them well can be unacceptably high. Senior leaders like the Secretary of Defense and the Chairman of the Joint Chiefs of Staff need to be aware of such consequences. Failure to anticipate problems in meeting contingency demand, or failure to imagine that they could occur at all, are mistakes the Nation has made before. The Korean War is but one example where the United States paid dearly, in terms of both military casualties and lost security objectives, for sending unready forces into harm's way.[37] The preceding section on force generation pipelines explained that for many capabilities, mitigations can take months or even years to have an effect and are not conducive to fixing "just in time" for the next contingency.

The most significant analytic challenge here involves the inherent limits of the plans for understanding how a contingency might unfold as well as the uncertainty involved in predicting hits/misses, wins/losses, and the degree of casualties associated with observed readiness degradations or force delays. Professional military judgment and policy inputs are invaluable, as is the need to recall that our adversaries "get a vote." Modeling and simulations can be tailored to provide useful and defendable insight, but only with the caveat that they are predictions that come with an error range and are based on a series of assumptions. Neither of these challenges should be regarded as a reason not to regularly assess the adequacy of force readiness.

Contingency demand can be evaluated in the context of an individual operation plan, a bundle of related plans that would likely be conducted at the same time, or defense planning scenarios. All have their place in terms of readiness and risk management. The choice among these matters a lot less than doing any of them well and frequently enough to maintain an active understanding of readiness-inducing limits to what our forces can do. The goal here is to indicate critical shortages and allow for proactive mitigations when that makes sense.

Methods of Integrating Supply and Demand Factors

Readiness consequences from both the supply and demand perspectives are very real and potentially severe. Adding to the difficulty of the decision calculus are the temporal issues on both sides. Producing unsustainable quantities of ready forces now may exact a price that does not come due for a year or more, essentially mortgaging our ability to respond tomorrow for a response today.

As long as the demand exceeds supply, important choices need to be made, and they must be informed by defendable analysis. Given that the projected security environment is dynamic in terms of threats and disruptive forces, getting a handle on the analytical foundation is important. The first part of this paper discussed the imperative of expressing the impact of degradations throughout the force generation pipelines. On the demand side, there is a similar imperative to explain what happens if a CCDR's force request cannot be filled or is filled late. Are there potential mitigations? When does it make sense to employ forces now at the price of having non-negotiable limited forces to employ later?

There are two general approaches for evaluating the supply and demand of ready forces: static and dynamic analyses. They are not mutually exclusive, and both have been routine in DOD for years. That said, investment in the efficacy of these tools and the routine use of their findings in setting defense priorities would provide for informed decisions ranging from defense strategic guidance to annual budget tradeoffs.

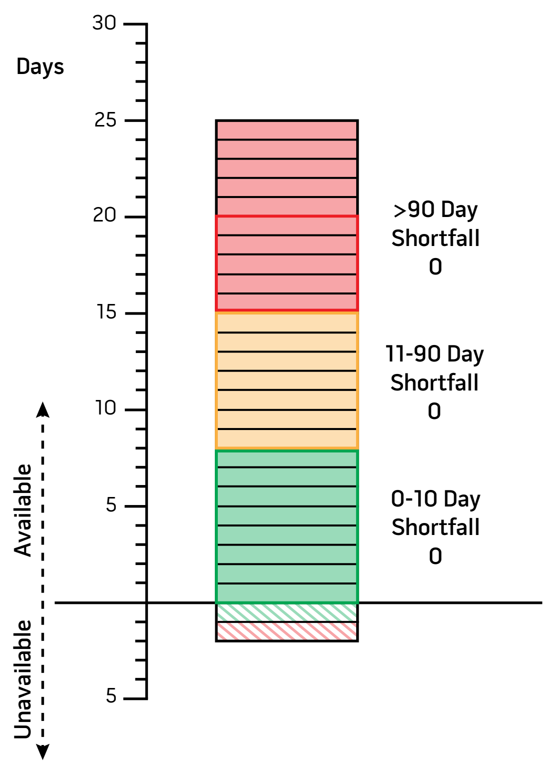
Static Analyses

Static comparisons of the supply of ready forces in the context of a very specific demand signal should be a regular spot check on the health of the force generation pipelines. They should also provide a first indication to CCDRs, force managers, and strategists of the potential for critical risks. These spot checks typically begin with a demand signal that includes the current GFMAP in addition to a high-priority contingency plan (or set of bundled plans). The demand signal is parsed over time to reflect when specific forces would be required. The Services then consider their pipeline analyses and describe the quantity of forces that are ready for those mission requirements now, and how many more they can generate in future intervals.

These findings are framed by the specific pipeline issues that are causing observed shortages or will likely cause shortages in the near future. Comparing supply and demand not only gives a sense of where there are absolute shortages, but also where investments in mitigating actions are most useful. These results have been captured for individual capabilities/force elements in both tabular form and in graphic form similar to figure 6.

Each block in the stack represents a ready unit generated by a Service. The green blocks are the number of units that the Service can generate within 10 days, orange blocks are the number that can be generated between 11 and 90 days, and red blocks are those that would not be ready until sometime after 90 days. The two blocks below the horizontal axis represent units that are currently being used for other operations outside of the measured scenario/plan's geographic region. Their readiness for the contingency represented in this analysis is indicated by the color of the hash marks. In this example, one of those units is currently ready for the contingency in this drill, and the other is not. That summarizes the supply side of the analysis. The demand side is depicted by the outlined "bins," which represent the demand for specific force elements over

Figure 6. Static Supply and Demand Comparison of a Military Capability



time. Each block in a bin is a required unit. Green corresponds to the number of units required within 10 days, orange corresponds to the number required between 11 and 90 days, and red corresponds to a demand beyond 90 days. The Services can meet the timelines required with ready forces if these "bins" can be "filled" (or overflowed) with the lighter-shaded blocks of the same color (representing units that are sufficiently ready on time based on Service analyses). In this example, the supply and demand for this force element is in balance; there are at least as many forces supplied as demanded for each time interval.

Dynamic Analyses

Static assessments are fairly straightforward and conducive to regular monitoring. However, they are not sufficient for evaluating whether the Services' supply of ready forces represents unmitigated national security risks. For that, leadership must consider the complexities of transit time and its associated assumptions, the availability of sustainment enablers including operational energy, the expected role of allies, the tolerance and reactions of adversaries, and the probability of success for each objective given readiness considerations. Given the inherent uncertainty involved in each of these assumptions, analysis should be repeated across reasonable values of determinants (such as strong versus weak ally participation, potential transit restrictions and clearance from neighboring countries, and variations in aggressor's tolerance for accelerating conflict). That type of assessment requires extensive modeling and simulation involving most elements of DOD force generation platforms. Despite the level of difficulty, the proceeds from this level of analysis are fundamental to readiness and national security decisionmaking.

The only routine plan assessment that comes close to meeting these requirements is the plan assessment within the larger Joint Force Readiness Review.[38] This assessment considers factors such as force readiness, transportation feasibility, logistics, and force sourcing in determining how well the current force can meet the specific requirements of select individual and bundled plans that comprise national strategy. These assessments are immensely valuable for understanding the seams of joint readiness and the limits of enablers. They also provide some insight into potential mitigation options, making this a valuable contribution to readiness management. It is not currently designed, however, to provide for an assessment of varied U.S., allied, or enemy alternative courses of actions in order to more comprehensively assess risk. DOD's renewed modeling and simulation efforts were in part designed to fill this void and therefore provide some degree of promise for readiness managers, planners, and strategists.[39]

However, these analytic-based assessments will have to explicitly factor in near-term readiness if this promise is to be realized.

While describing the consequences of failing to meet an operational timeline or individual plan objectives in specific terms is hard, there is no question that doing so is essential. Simply labeling plans or even the strategy of being at "high risk" or "very high risk" has virtually no meaning. Similarly, describing the ability of the U.S. military to meet the Defense Strategy as "bent but not broken" is simply confusing.[40] Such vaguely descriptive labels offer little chance of conveying serious consequences of current readiness (or force structure) deficiencies to the President, the National Security Council, or Congress. This is a real concern. The U.S. military has a long history of failing to adequately surge ready forces for large-scale operations.[41] The fate of Task Force Smith during the summer of 1950 is probably the most common cautionary tale of the needless bloodshed caused by deploying unready forces, but it is far from an isolated example.[42] Even in the cases of World War I and World War II, conflicts that the United States is credited with "winning," the initial surges took years to generate and even then, forces were handicapped by inadequate training and resourcing.[43] Objectives took longer than they should have to achieve and cost more casualties than was necessary. If DOD leaders hope to avoid similar repeat cases, they need to rethink the role and processes for properly defining and monitoring the key demand signals and the corresponding supply inputs. DOD leadership has an obligation to be very clear about these, even if that means investing in the time and means to conduct better, more frequent assessments.

When Supply Falls Short of Demand

Arguably, the most important step of readiness management is determining how to deal with deficiencies. The efforts described above on both the supply and the demand sides are essential elements of identifying mitigation strategies. Ideally, problems are detected before they constrain operational choices. Regardless, it is essential that readiness managers understand their consequences in fairly specific terms. It will never be possible to completely fix every readiness degradation; therefore, readiness managers and defense leaders must be able to prioritize readiness deficiencies based on their consequences.

Once a degradation is identified and its consequences determined, the next step for readiness managers is to determine the complete range of mitigation options. Each potential option should include a description of how it fixes the degradation, an estimate of how long that would take, and how much it would cost. One option should always be to do nothing, but that strategy must include a forecast of the longer term consequences should the degradation persist. Some mitigations involve supply-side considerations (for example, invest more resources), while others involve the demand side (for example, restricting or altering the demand signal). In either case, readiness managers must specify the opportunity cost or consequences of the individual mitigations so leadership can determine how the consequence of the mitigation compares with the consequence of the original degradation. On the supply side, some mitigations conceivably may crowd out other critical investments or even the opportunity to resolve other readiness problems. On the demand side, there may be operational or strategic consequences to altering the demand signal. In either case, this information is important for leadership as they determine what to mitigate and how.

Reducing valid performance standards is never a viable mitigation strategy. Doing so tends not to be an overt reaction to a persistent readiness problem. Rather, it happens slowly and incrementally over time, if only as a frustrated reaction to repeatedly missing seemingly impossible standards. It lends itself to the proverbial boiled frog syndrome, only in this case the outcome is forces that cannot execute a mission that they were purportedly ready to perform. One common variant of this tendency is the understandable conflation of assigned and designed mission assessments for individual units. For over a decade, brigade combat teams were regularly performing COIN missions in Iraq and Afghanistan. For many of the Soldiers in these units, this was the only mission they knew. It was no surprise to learn that they had abandoned reporting on their ability to conduct their designed (non-COIN) mission in SORTS and only reported on their current assigned mission. This distorted the critical signal of the atrophy of full-spectrum capabilities. Once Army leadership saw this shift in reporting, they swiftly and completely fixed it. Readiness managers and leadership alike must actively guard against this tendency.

Leadership's challenge is to weigh the value of fixing the problem with the value of the next best use of those resources. While readiness of the force is essential, other investments are also essential. Chief among these are investments in modernization and new technologies that are critical for tomorrow's readiness. This is precisely why DOD cannot afford to regard readiness as a self-evident priority. It must provide the data and logic to inform a risk-based debate about what deficiencies will be mitigated and how. Individual Services monitor degradations now in detail and mitigate the vast majority of degradations. However, problems that have joint consequences or for which the solution exceeds the ability of the Service to remedy typically require support from the Office of the Secretary of Defense and the Chairman of the Joint Chiefs of Staff. At these levels, the magnitude of competing priorities requires that arguments in favor of mitigating any given deficiency be clear and defendable.

A Leadership Imperative

To manage readiness, DOD must balance the supply and demand of deployable forces over time and around the world. In order for the Services to properly calibrate their force generation pipelines, they need a clear articulation of national and military strategies, including a clear understanding of priorities and risk tolerances in order to allocate resources effectively. These priorities should translate into individual Service readiness management plans that detail how managers at each level of production will report on the health of their pipelines, how this information will be used to detect current and future readiness problems, the consequences of those problems, and an array of mitigation options for each diagnosed readiness problem.

If the demand signal is vague and without priorities, each Service will have to use its best military judgment to interpret demand. While each will likely arrive at defendable solutions, they may not be consistent across the Services. For a joint force facing declining budgets, this is a problem.

Department leadership must also require regular assessments of the consequences of current readiness and force structure on the execution of operational plans and the strategy as a whole. These assessments must quantify these consequences as much as possible, explaining which operational objectives would be delayed, by how long, and why. Communicating risk through adjectives does not justly convey the significance of shortfalls to the country. The Chairman's quarterly plan assessment is an existing mechanism that provides valuable insight into the significance of current readiness status, but these assessments can and should be more comprehensive and analytically reproducible. DOD's renewed modeling and simulation efforts provide some promise to fill this void as long as they are explicitly designed to factor in readiness profiles. In fact, the next chapter of successful readiness management is the development of the more explicit consideration of readiness limits and consequences in the formulation of current strategy. This could take the form of an annual review of the DOD ability to generate forces capable of supporting the national military strategy.

There is nothing simplistic about this framework; in fact, the analytics are challenging and often involve both qualitative and quantitative factors. However, existing data and analytic mechanisms have already proved capable of yielding logically consistent and constructive readiness management insights. Improvements in measuring individual and unit performance as well as robust plan assessments would greatly improve DOD's ability to identify and mitigate the worst deficiencies and clearly communicate the consequences of those that cannot be mitigated quickly.

Appendix A. SORTS, DRRS, and the Chairman's Readiness System

This appendix briefly describes the components of the current DOD readiness reporting and assessment tools.[1]

Unit-Based Reporting

Units currently report their readiness using a secure information system called the Defense Readiness Reporting System–Strategic (DRRS-S). This platform contains two complementary ways of reporting readiness. One, the Status of Resources and Training System (SORTS), is input- or resource-based. The other, DRRS, is output- or mission-/task-based.[2] Together these assessments provide a complete view of a unit's capability status. The following provides a brief description of how readiness is assessed in each.

SORTS

SORTS generally depicts the adequacy of each unit's resources relative to its assigned and designed missions. The resources are assessed by assigning an ordinal score that corresponds to the quantity of resources on hand relative to the quantity required for the unit's mission. It is a two-stage assessment that begins with resource scores in the categories of personnel (P-level), equipment condition (R-level), equipment and supplies on hand (S-level), and unit training (T-level). The instructions that detail exactly which resources are counted for each type of unit and how those values correspond to an ordinal grade in each of these four resource areas are unique to each Service.[3] Generally, though, in each of these broad resource bins, the unit is evaluating one or more ratios of the resources it actually has on hand relative to what it is supposed to have on hand. The value of these ratios maps to a score that ranges from 1 (most ready) to 4 (least ready). Scores of 1 and 2 are generally considered sufficiently resourced for deployment. These ratios used to be recorded and calculated by hand. Recently, authoritative data are automatically fed into the system, allowing the ratios and resource level scores to be automatically calculated.

The second step takes the lowest/least ready score of the four resource areas and uses that as the unit's overall score. For example, a unit that has scores of P-1, S-1, R-1, and T-2 would report an overall value of C-2 corresponding to the lowest value of T-2. The C-levels are also ordinal rankings that range from C-1 to C-5:

- C-1: The unit can fully carry out its wartime mission

- C-2: The unit can carry out most of its wartime mission
- C-3: The unit can carry out portions of its wartime mission
- C-4: The unit needs additional resources to perform its wartime mission
- C-5: The unit is out of reporting status.

Again, a unit must be either C-1 or C-2 to deploy. A score of C-5 is typically used for units that are undergoing major modifications such as drydock for ships or a major unit restructure. Unit commanders have the ability to subjectively upgrade or downgrade this assessment (for example, from a C-1 to a C-2, or vice versa) if they believe the raw calculation does not adequately convey their readiness. Such an override requires written justification within the reporting system.

DRRS

DRRS depicts a unit's assessment of its ability to conduct the collective tasks that comprise each of its assigned missions. It is based on the mission-essential task list (METL) construct complete with the conditions under which each task is expected to be executed, and a set of standards that reflect successful accomplishment of the task. Units can also link their tasks to those of parent and/or subordinate units to offer a more complete picture of force readiness.

A unit commander assesses missions in three categories. The first, *core tasks*, reflects the unit's designed missions. The second and third categories (*named operations* and *top-priority level 4 plans*) correspond to the assigned missions of the unit. Not every reporting unit will have missions in each of these categories. For those that do, reporting across the spectrum of assigned and designed missions allows force and readiness managers to understand those capabilities that are currently ready and those that have atrophied.

Like SORTS, DRRS is a two-stage assessment beginning with collective task assessments and ending with an assessment for the METL as a whole. Again, the capabilities corresponding to each mission are articulated according to its METL, complete with conditions and standards. The unit commander begins his or her assessment by individually depicting whether the unit met the conditions and standards for each task. For each mission and underlying METL, the commander assigns a rating of:

- Yes: The unit can accomplish task to established standards and conditions

- Qualified Yes: The unit can accomplish all or most of the task to standard under most conditions. The specific standards and conditions, as well as the shortfalls or issues impacting the unit's task, must be clearly detailed in the METL assessment.

- No: The unit is unable to accomplish the task to prescribed standard and conditions at this time.[4]

There is no algorithmic rule that maps task assessments to mission assessments. This is up to the unit commander; however, the commander's assessment must be supported by qualitative data and be visible to higher headquarters. Finally, DRRS, unlike SORTS, especially in its earlier days, is well designed for joint units including combatant commanders (CCDRs). It provides their most regular vehicle for depicting their ability to execute their operational responsibilities.

Risk Assessments and the Chairman's Readiness System

The Chairman's Readiness System is designed to help the Chairman understand and mitigate operational risk. In doing so, it uses a combination of information from the unit-based assessments described above as the basis for a more strategic-level risk assessments using the Joint Combat Capability Assessment (JCCA). JCCA is not a reporting system; rather, it is a collection of near-term analyses depicting the force's ability to execute required priority plans. The JCCA includes three assessments:

- Joint Force Readiness Review (JFRR)

- Plan Assessments

- Readiness Deficiency Assessment (RDA).

The JFRR is conducted quarterly and combines readiness input from a variety of perspectives including individual units, CCDRs, the military Services, and combat support agencies to assess the DOD ability to conduct missions corresponding to the National Military Strategy (NMS). The commanders, Service Chiefs, or directors in charge of reporting organizations assign an overall readiness assessment (RA) level that is determined by their synthesis of task/

METL assessments, the results of recent plan assessments, and readiness deficiencies. The RA levels have the following meaning:

- RA-1: Issues and/or shortfalls have negligible impact on readiness and ability to execute assigned mission(s) in support of the NMS as directed in the Guidance for Employment of the Force (GEF) and Joint Strategic Capabilities Plan (JSCP)

- RA-2: Issues and/or shortfalls have limited impact on readiness and ability to execute assigned mission(s) in support of the NMS as directed in the GEF and JSCP

- RA-3: Issues and/or shortfalls have significant impact on readiness and ability to execute assigned mission(s) in support of the NMS as directed in the GEF and JSCP

- RA-4: Issues and/or shortfalls preclude accomplishment of assigned mission(s) in support of the NMS as directed in the GEF and JSCP.[5]

Plan assessments are comprehensive evaluations of the DOD ability to successfully execute a specific contingency plan or a set of bundled plans. The assessment includes evaluations of force flow and the likelihood of meeting objectives and timelines. Plan assessments are very detailed and, for that reason, are only done on a quarterly basis. They may be done out of cycle to assess the risk of a plan that is deemed likely to be executed. The product of these assessments is a detailed narrative of the ability to execute the plan, including details of likely problems, potential failures, consequences, and mitigation discussions.

The Joint Staff submits the RDA each year as a culminating assessment of the impact of reported deficiencies on the ability to conduct the NMS. The RDA includes a strategic assessment that focuses on readiness trends in each of the Joint Capability Areas.[6] It also includes an operational assessment that considers the consequences of CCDR/combat support agency deficiencies on top-priority plans, named operations, and mission assignments.

Appendix B. Readiness Analyses

This appendix summarizes a series of representative studies that offer insight into the production of ready forces overall and within the areas of personnel, equipment, and unit training. It provides a foundational literature review of existing studies and demonstrates how they support readiness management.

Systemic Effects

Laura Junor and Jessica Oi present early findings of direct and indirect effects of inputs on the amount of time Navy ships spent in the highest Status of Resources and Training System (SORTS) status (C-1) each quarter.[1] This recursive model of six equations used a panel dataset comprised of quarterly data capturing almost every ship in the Navy from 1978 through 1994.[2] The model and significant determinants are summarized in table 1.

There are several substantive findings in this study:

- *Empirical measurement of direct and indirect effects*. For example, personnel quality, quantity, and turnover directly influence every resource dimension measured in SORTS. Equipment readiness is a direct determinant of a unit's training SORTS score. Equipment readiness is a product of the unit's failure and repair rates. Therefore, the determinants of the unit's failure rate (for example, the quality/quantity of its maintainers) have an indirect effect on training readiness.

Table 1. Direct and Indirect Readiness Effects

Unit Personnel SORTS Unit's inventory of qualified people relative to requirements	= *ƒ*(quality and quantity of personnel, unit turnover, position in the deployment cycle, operational tempo, deployed status...)	
Unit Equipment SORTS Unit's inventory of operable equipment relative to requirements	= *ƒ*(time between failures, time to repair a failure...) time between failures = *ƒ*(quality and quantity of personnel, unit turnover, recent overhaul/modernization, operational tempo, deployed status...)	time to repair = *ƒ*(quality and quantity of personnel, unit turnover, consumables inventories, repairable inventories, investment in small support equipment, recent overhaul/modernization, equipment age, deployed status...)
Unit Training SORTS Unit's training accomplishment	= *ƒ*(quality and quantity of personnel, ordnance, equipment SORTS, position in the deployment cycle, operational tempo...)	

*Includes organizational, intermediate and depot level repairs

■ *There is an optimal amount of operational tempo (steaming days).* Up to a point, more steaming is good for the equipment and provides training opportunities. Beyond that point, the readiness returns diminish either because of damage to the equipment or diminished training or maintenance opportunities. The study did not explore this finding in detail. This topic is explored in more depth as one of the case studies in this appendix.

■ *Managed readiness variation before, during, and after deployment*. The Navy has a history of cyclical readiness patterns that correspond to the increasing intensity of deployment preparation, investments in maintaining high readiness throughout a deployment, and a managed post-deployment decline in readiness as the personnel rotate and the equipment is reset.

■ *Personnel metrics are the most important determinant of readiness in this system*. Personnel quality and quantity have system-wide effects and their explanatory power is among the highest of all the independent variables. Extensions of this finding are explored in more detail in the next section.

■ *SORTS data can be explained well by more objective readiness metric*s. Despite being widely criticized as too subjective, objective metrics corresponding to the resource category scores were very significant and together explained most of the variation in the SORTS data.[3]

Personnel

Several studies link aspects of the quality and quantity of personnel to downstream metrics such as unit SORTS scores, sortie generation potential, unit proficiency, and productivity in technically demanding occupations. This section gleans a variety of studies to suggest four primary personnel output metrics and offers a series of upstream metrics that may be important in forecasting readiness.

Downstream Personnel Output Metrics

There are four personnel metrics that are most commonly linked to downstream readiness (see table 2).

The first two metrics are the most commonly cited in literature and are the percentage of billets filled in a unit or organization (sometimes called “fill”) and the percentage of billets filled

Table 2. Downstream Personnel Output Metrics*

The percentage of billets filled in a unit or organization (or billet "fill")
The percentage of billets filled with people that meet billet requirements
The quality of personnel
Unit/organization turnover
*These metrics should be calculated by occupation and by unit or organization in order to effectively trace the effects upstream

with people who have the right seniority and skills training (sometimes called "fit"). [4] There have been a multitude of studies that empirically link variations of fit or fill to aspects of equipment pipelines. Those studies will be discussed in more detail in the next section.[5] The third metric is the quality of the personnel in a unit/organization. Much like fit and fill, aspects of personnel quality have also been linked to various dimensions of readiness including equipment condition and unit training.[6] Two previous studies defined this metric as an index (first principal component) of five correlated measures of quality:

- percentage of the unit with a high school degree
- percentage of the unit testing in the upper mental group on the Armed Forces Qualification Test (AFQT)[7]
- experience measured as average length of service in the unit
- percentage of the unit demoted within a given quarter
- frequency of rapid advancements.[8]

Of these five metrics, the one most often linked to downstream readiness is length of service or experience.[9] In the late 1980s, Mark Albrecht found a statistical relationship between productivity and experience, especially for the most technical occupations.[10] Two other studies found evidence linking cross-training and the consolidation of occupational specialties on aspects of maintenance effectiveness in the Air Force. The logic underlying these results is that the cross-training provided a deeper knowledge base and/or created the opportunity for increased employment of these diversely trained personnel.[11]

The turnover of personnel within the organization (unit) is most commonly measured as the number of personnel in a given time period who were not there the previous time period. Previous studies found an inverse statistical relationship between Navy crew turnover and various unit-level readiness measures.[12]

Upstream Drivers

Table 3 shows specific drivers mapped to the four metrics in table 2. The ability to get the right people to the right jobs (or billets) at the right time is most simply an issue of aligning the supply and demand for specialized people. There have been several studies that suggest determinants of billet fill. Many of the studies investigated aspects of the individual training and education pipelines. James Grefer investigated factors that determine the length of time it would take an occupational community to resolve significant gaps in Navy fit metrics.[13] These include the length of the training pipeline (measured as the historical average of the length of time between entry to joining the fleet), the relative seniority of personnel (measured as the proportional billets in each pay band), and the relative sea-centricity (measured as the proportion of full-duty billets that are sea-duty).

A 2016 study of Navy enlisted personnel found that the most significant determinant of Navy enlisted code (NEC) fit is the alignment of training pipelines and ship modernization plans. They found that when units receive equipment upgrades that translate into new NEC requirements, it can take up to 15 months to reach steady state.[14] This result was supported by a

Table 3. Personnel Pipeline Metrics

<table>
<tr><th>Downstream Metrics</th><th colspan="2">◄──────►</th><th>Upstream Metrics</th></tr>
<tr><td>Fit/Fill</td><td><u>Overall Inventory</u>
▪ Size of the distributable inventory
▪ Relative seniority of personnel
▪ Number of trained personnel per occupational skill area

<u>Factors Influencing Individual Training & Education</u>
▪ Capacity to train
▪ Large variations in A-school throughput
▪ Length and complexity of training pipeline
▪ Alignment of training and major weapons system modernization plans
▪ Absorption rates</td><td rowspan="3">▪ Recruiting
▪ Retention</td><td rowspan="3">Labor Market</td></tr>
<tr><td>Quality/Experience</td><td></td></tr>
<tr><td>Personnel Turnover</td><td></td></tr>
</table>

similar Navy manning study. David Rodney, Steven Belcher, and Karen Schriver (2016) studied the Navy's ability to meet the manning requirements of their Optimized Fleet Response Plan.[15] The Navy adopted the plan as a means of producing rotationally deployed forces to meet global force management commitments while maintaining a viable surge capability. They found that the largest NEC gaps were for information technology, signals intelligence, AEGIS equipment, and supervisory air intercept controller. One of the primary drivers was the lack of coordination among weapons systems modernization planning, the implementation of those plans, and the personnel pipelines that train personnel and manage the billet files. Other determinants of gaps include:

- The number of trained personnel per NEC (occupational skill area)—a 10 percent increase in supply of trained personnel leads to a 4.4 percent decrease in NEC fit gaps
- Misalignment between pay grade structure of NEC requirements and personnel management and career paths.

Belcher et al. (2014) asserted that the most basic determinant of Navy manning was the size of the distributable inventory (that is, Sailors available for full-duty assignments) and how that inventory is parsed between sea and shore assignments.[16] They found that the size of the distributable inventory is governed by total end strength (relative to authorizations) and non-available personnel (students, transients, prisoners, patients, and holdees and Sailors in limited duty status). Large year-to-year changes in the following determinants also mattered:

- intra-year fluctuations in accessions
- number of A-school students per rating due to bottlenecks in training pipelines
- complexity of training pipelines[17]
- execution-year changes to accession plans
- misalignment of tour lengths and personnel obligations.

Similarly, Albert Robbert et al. studied the issues of Active Component fighter pilots in the Air Force and determined that the size of the distributable inventory of pilots was a function of the capacity to train new pilots, the capacity to introduce new pilots into operational units and give them enough flying time to turn them into experienced pilots, and the retention of experienced pilots.[18] Bruce Orvis et al. developed a model to predict high-quality Army enlisted accessions.[19] The four main determinants were the:

- number of on-production recruiters
- expenditures on television advertising
- enlistment incentives (or bonuses) for high-quality prospects
- national unemployment rate (ages 16 and older).

They also acknowledge several external determinants that include the population of eligible youth (for example, those that meet requirements in AFQT scores, legal history, and medical qualifications), the propensity for these individuals to enlist, and macroeconomic conditions affecting the competitive labor pool.

In 2016, Michael Mattock et al. confirmed a statistical relationship between Air Force pilot retention and the labor market.[20] This study modeled Air Force pilot retention under projected favorable civilian labor market conditions where the demand for and salary paid to civilian pilots were projected to increase. They project that in 2018, civilian pilot pay will be 17 percent higher than it was in 2014 and that demand will continue to grow over the next decade. Based on the career paths of the civilian airlines, they conclude that military pilots have the incentive to leave after their initial commitment and not after serving 20 years. Their simulation suggests that the steady-state retention effect of an increase in major airline hiring from 1,700 to 3,200 pilots per year corresponds to the probability of an Air Force pilot being hired by these airlines increasing from 10 to 50 percent. That, in turn, corresponds to a likely decline in retention of post-commitment pilots of 6.3 percent. In order to negate this effect, the average retention bonuses would have to increase from $25,000 per year to $48,500 per year—a 94 percent increase.

Equipment

Equipment pipelines are one of the most studied aspects of readiness, especially for weapons systems such as ship and aviation platforms that maintain comprehensive, detailed, and timely transactional data on most aspects of equipment condition, spares inventories, failure rates, repair rates, and maintainer workforce characteristics.[21] Some of those findings are summarized in table 4.

Sortie generation rates are a key downstream metric that has direct relevance to both unit and combatant commander ability to accomplish specific operations, and they have been successfully modeled in several studies.[22] Generally, this body of work empirically relates the number of operational or training sorties to determinants such as mission length, aircraft configuration, composition of strike package, material condition of aircraft, aircrew time constraints (including safety restrictions), and deck constraints (including spotting servicing and loading).

Several other studies consider slightly more upstream issues that affect the stock of working weapons systems. Glenn A. Gotz and Richard E. Stanton considered the mix of maintainers on aircraft availability and developed an empirical framework for measuring the effects of changes in maintainers, spare parts, and job assignment rules on aircraft availability rates, the number of non-available aircraft by day of the war, and the average repair time.[23] One of their key findings was that flexible resources mitigated the inherent uncertainty involved in operations. They found that cross-trained maintenance personnel were particularly valuable precisely because of the flexibility their expanded training afforded. In 2016, Thomas Light et al. supported these findings using data on maintenance specialties for mobility aircraft.[24]

Roland Yardley et al. (2016) studied the effects of longer employment periods on presence, training, and equipment readiness.[25] In the course of this study, they were able to explore the effects of significant changes in maintenance availabilities and crew training on presence, cost, and the expected service life of the ship. Chad Meyerhoefer et al. (2003) found that fatigue life is a significant determinant of aircraft service life.[26] Robert Button et al. (2016) investigated the determinants of operational availability and the expected service life of ships and found that maintenance deferrals result in significantly higher maintenance costs.[27]

Table 4. Equipment Pipeline Metrics

<table>
<tr><th>Downstream Metrics</th><th colspan="4">◄────────────────────►</th><th>Upstream Metrics</th></tr>
<tr><td rowspan="4">Sortie generation rates</td><td rowspan="3">• Equipment condition/ availability rates</td><td rowspan="2">Repair rates</td><td>• Maintainer quantity
• Maintainer training</td><td>Training pipelines</td><td>Labor force</td></tr>
<tr><td>• Spares inventories</td><td>Supply Chain health</td><td>Industrial base</td></tr>
<tr><td>Failure rates</td><td>• Maintenance availabilities</td><td colspan="2"></td></tr>
<tr><td>• Mission length
• Aircraft and strike package configuration</td><td></td><td colspan="3"></td></tr>
</table>

Alan Marcus, James Jondrow, and Peter Francis (2002) found that the number of missing components in aircraft (often called "holes") reveals important trends in spare parts inventories. They observed that consolidations of holes onto a single platform in any unit indicates cannibalization, and that is a leading indicator of supply problems.[28] Similarly, Christopher Duquette and Laura Junor (1999) considered determinants of carrier airwing material readiness during Navy graduate training exercises (the command and control exercise) and found that the local inventory of aviation repairable spare parts was a significant driver.[29]

Moving further upstream, there are several studies that provide valuable information for managing the maintenance spare parts pipelines. James Jondrow and Ronald Nickle's empirical work (1998) determined that gross effectiveness (measured as the probability that a mechanic on a ship can draw any part from the ship's local supply) is the best indicator of Navy supply performance from an empirical perspective.[30] Elvira Loredo, John Raffensperger, and Nancy Moore (2015) considered risks associated by the industrial base in documenting a process and tool that the Army can use to assess supply chain risk by supplier, part, and weapon system.[31] Some of the key risk factors include the size of the current stock of repair parts, high-risk suppliers that provide many parts (even if the risk per part is low), whether vendors have contingency plans for natural disasters, foreign, single-sourced vendors, and repair cycles associated with repairable spare parts.

Unit Training

Two empirical studies investigated determinants of aviation training readiness. Laura Junor, Ted Jaditz, and R. Derek Trunkey (2000) used empirical modeling to explain the 12-year decline in Navy carrier airwing training readiness.[32] Specifically, this study focused on why readiness between deployments was falling lower each year, and it found an imbalance between funded flight hours and training requirements. The study documented the effects of the number and type of flight hours, the quantity and experience level of the aircrew, the material condition of aircraft, the number of aircraft, and the quality and quantity of enlisted personnel on the training Status of Resources and Training System scores. Sarah Evans (2016) considered the impact of factors such as frequency and duration of sorties, a collocated simulator, the proportion of temporary duty training, and role specialization on the costs of continuation training.[33]

Operations Tempo

Earlier portions of this paper have alluded to the toll that a very high operations tempo can have on readiness. In particular, the high demand signal from Operation *Iraqi Freedom* and

Operation *Enduring Freedom* has adversely affected the readiness of the force. For example, the demand for Air Force capabilities has been high; however, these operations have largely been executed in a permissive air environment, offering no experiential training in contested, nonpermissive environments. Training time and resources over the majority of the last 10 years have been understandably directed toward counterinsurgency missions (for example, Green Flag events) versus the full-spectrum training (for example, Red Flag events) that they need to mitigate atrophied skill sets. As the above research suggests, the training pipelines are long, and the fixed throughput at ranges does restrict the rate at which units can recover their full-spectrum skills. In addition, the Air Force will have to monitor the series of enablers or determinants in order to maintain a sufficient recovery rate. That includes flying the required number of training flight hours, which in turn requires funding as well as enough of an operational pause to find the time to train.[34] Both are difficult to control in the current environment. In addition, the Air Force will also need to ensure the availability of its weapons systems.[35]

The effect of a high operations tempo on the Navy manifests differently. In 2014, Admiral Michelle Howard explained that "the reality of the past decade has been the continuing employment of our contingency response capacity to generate increased presence, while driving up maintenance requirements and in turn squeezing the time available to complete required maintenance and training."[36] The Navy's backlogged maintenance is well documented; however, the incessant demand for more pressure is slowing down recovery in the material readiness of those surface platforms. As a result, when ships do go into maintenance, the availabilities tend to be more complex and consequently take longer. That, in turn, squeezes training time for the following deployment. The Navy's material readiness pipeline is also long—this recovery will probably take years. If operations tempo does not provide for more maintenance availabilities, the recovery time and consequences should be predicted to grow.

Glossary

Allocated forces: One of the Global Force Management processes. The Secretary of Defense may allocate either assigned or unassigned forces to combatant commanders in order to execute specific operational requirements. These forces become attached to the receiving command when they are transferred. The Secretary will define the new command relationships of the gaining and losing commanders. The authority is outlined in Title 10, U.S. Code, Section 162.[1]

Assigned forces: One of the Global Force Management processes. The Secretary of Defense places assigned forces under the combatant command (command authority) of a unified commander. Those forces are available for normal peacetime operations. Not all forces are assigned; some remain unassigned and under the control of the military services. The authority is outlined in Title 10, U.S. Code, Sections 161, 162, and 167.[2]

Contingency: A situation that likely would involve military forces in response to natural and man-made disasters, terrorists, subversives, military operations by foreign powers, or other situations as directed by the President or Secretary of Defense.[3]

Contingency plans: Developed in anticipation of a potential crisis outside of crisis conditions. There are four levels of planning detail for contingency plans, with an associated planning product for each level:

- Level 1 Planning Detail (Commander's Estimate). This level of planning is the least detailed and focuses on producing multiple courses of action to address a contingency. Products at this level can include briefings or memoranda.

- Level 2 Planning Detail (Base Plan). This planning level offers more detail than a commander's estimate as it includes anticipated timelines and concepts for support.

- Level 3 Planning Detail (Concept Plan). This level of planning is significantly more detailed than a base plan but does not meet the requirements for an operation plan (next level). Building on the information from the base plan, the concept plan usually includes annexes on intelligence, operations, logistics, command relationships, communication, special technical operations, interagency coordination, and distribution.

- Level 4 Planning Detail (Operation Plan). An operation plan builds from the detail in the concept plan including the annexes listed above and complete phased for deployment data detailing the schedule for the movement of units, personnel, and equipment. This is the most detailed level of planning.[4] See Operation plan.

Cyclic readiness: The natural readiness cycles of many deploying units. Generally, units reach their peak readiness just prior to deployment. After deployment, units disband to some degree in order to recover their personnel and equipment. The controversial nature of cyclic readiness refers to how "unready" force managers instruct the unit to become and for how long. If the cycles involve purposefully long periods of low readiness, cyclic readiness begins to be a form of tiered readiness. See Tiered readiness.

Defense planning scenarios: The set of scenarios that the Secretary of Defense approves for evaluating the sufficiency of the defense program. The scenarios are detailed and include a depiction of a threat to international security, a corresponding mission for U.S. military forces, and a strategic-level concept of operation for carrying out that mission. They are typically focused out 8 to 20 years in the future and are useful for analyzing capabilities and comparing alternate solutions.[5]

Defense Readiness Reporting System: A mission- and task-based readiness reporting system that answers the question of what units (including joint units and combatant commanders) are ready to do. It is based on the mission-essential task construct. For more information, see appendix A.

Deployment order: A planning directive from the Secretary of Defense and issued by the Chairman of the Joint Chiefs of Staff that authorizes and directs the transfer of forces between combatant commands by reassignment or attachment. A deployment order normally specifies the authority that the gaining combatant commander will exercise over the transferred forces.[6]

Direct effects: These generate an immediate impact on the organization's ability to produce. See also Indirect effects.

Downstream production: The final part of the production process. In readiness, this is the production stage where the intermediate production of skilled personnel, functioning equipment, and unit/combined training feed the ability of units and ultimately combatant commanders to execute operations. See Upstream production and Intermediate production.

Durability: How resistant a readiness degradation is to mitigation attempts.

Global Force Management: Guides the global sourcing processes of combatant command force requirements. It provides the Joint Staff and force providers a framework for making assignment and allocation recommendations to the Secretary of Defense and apportionment recommendations to the Chairman of the Joint Chiefs of Staff. It also allows the Secretary of Defense to make proactive, risk-informed force management decisions.[7]

Global Force Management Allocation Plan: The Secretary of Defense's plan for the annual allocation of forces for the next fiscal year. This plan is routinely updated throughout the year of execution based on emergent requirements. An emergent request for forces is a request from a combatant commander for units and capabilities that were not anticipated in the annual Global Force Management Allocation Plan submission and cannot be met by the requesting headquarters, its components, or their assigned or allocated forces. Modifications to the Global Force Management Allocation Plan, in support of emergent requirements, are vetted by the Joint Staff and globally staffed and approved through the Secretary of Defense.[8]

Indirect effects: They are caused by factors that are the product of an upstream production stage, and while relevant to the organization's production, may not affect it concurrently. See also Direct effects.

Intermediate production: The production stage in the force generation process between the upstream and downstream production processes. During this stage, inputs from the industrial base and labor market are transformed into outputs like skilled labor and operational weapons systems that, in turn, feed the most downstream production stages at the unit and combatant command level. See also Downstream production and Upstream production.

Joint Capability Area: A collection of like Department of Defense capabilities functionally grouped to support capability analysis, strategy development, investment decisionmaking, capability portfolio management, and capabilities-based force development and operational planning.[9]

National Defense Strategy: Flows from the National Security Strategy (NSS), informs the National Military Strategy, and provides the foundation for building the legislatively mandated quadrennial defense review, which focuses Department of Defense strategies, capabilities, and forces on operations of today and tomorrow. The National Defense Strategy addresses how the Armed Forces of the United States will fight and win America's wars and describes how the Department of Defense will support the objectives outlined in the National Security Strategy. It also provides a framework for other Defense Department strategic guidance, specifically on deliberate planning, force development, and intelligence.[10]

National Military Strategy: The National Military Strategy, derived from the National Security Strategy and National Defense Strategy, prioritizes and focuses the efforts of the Armed Forces of the United States while conveying the Chairman of the Joint Chief of Staff's advice concerning the security environment and the necessary military actions to protect vital U.S.

interests. The National Military Strategy defines the national military objectives (ends), how to accomplish these objectives (ways), and addresses the military capabilities required to execute the strategy (means). It provides focus for military activities by defining a set of interrelated military objectives and joint operating concepts from which the Service chiefs and combatant commanders identify desired capabilities and against which the Chairman assesses risk. Subordinate to the National Military Strategy are branch national military strategies. For example, the *National Military Strategy to Combat Weapons of Mass Destruction* further develops the combating weapons of mass destruction guidance in the National Military Strategy by establishing military strategic objectives and military mission areas, and defining the guiding principles and strategic enablers for the military's role in combating these weapons.[11]

National Security Strategy: A comprehensive report required annually by Title 50, U.S. Code, Section 404a. It is prepared by the executive branch of the government for Congress and outlines the major national security concerns of the United States and how the administration plans to address them using all instruments of national power. The document is purposely general in content, and its implementation relies on elaborating guidance provided in supporting documents (such as the National Defense Strategy, Guidance for Employment of the Force, and National Military Strategy).[12]

Negative synergies: These exist when the combined effects of multiple readiness degraders are worse than the individual effects of those degraders.

Operation plan: A complete and detailed joint plan that identifies the specific forces, functional support, and resources required to execute the plan and provide closure estimates for their flow into the theater. It is normally prepared when the contingency is critical to national security and requires detailed prior planning, the magnitude or timing of the contingency requires detailed planning, detailed planning is required to support multinational planning, or detailed planning is necessary to determine force deployment, employment, sustainment, and redeployment requirements, determine available resources to fill identified requirements, and validate shortfalls.[13] See Contingency plan.[14]

Production pipelines (or force generation pipelines): The myriad of upstream and downstream production processes that ultimately transform raw materials into end products. In readiness, these pipelines combine the raw materials of labor and capital to generate intermediate goods reflecting the development of personnel, equipment, and unit-level training. These intermediate products then serve as inputs into the generation of the final downstream production of units and ultimately combatant commanders that are capable of executing operations. See also Downstream production, Intermediate production, and Upstream production.

Request for forces: Request from a combatant command or Force Provider for units or capabilities to address emergent (unforecasted) requirements within their area of responsibility that cannot be met by the requesting headquarters or its components, or the combatant command's assigned or allocated forces. They augment the annual Global Force Management Allocation Plan.

Rotational force planning/Rotational demand: During execution, planning continues. During Operations *Iraqi Freedom* and *Enduring Freedom*, the Secretary of Defense directed that force requirements be reviewed and revalidated annually. This revalidation became the basis for rotational force planning. Today, all combatant commanders review their ongoing operations and submit force requirements for the upcoming fiscal year in their annual submission. The annual submission is, essentially, a consolidated request for forces for the entire year. Combatant commanders must review every operation in progress and determine what forces are needed for each operation. The combatant commanders must also project the force requirements for engagement and shaping operations to the maximum extent possible.[15]

Sourced: The identification of actual units or capabilities to fill operational requirements.[16]

Status of Resources and Training System: The input-based readiness reporting system that the Defense Department uses to evaluate the readiness of reporting units. It is a two-tiered assessment that focuses on the health of unit resources in the categories of personnel, equipment condition, supplies on hand, and training. Overall unit assessments are based on the lowest assessment value of each of these four resource categories. For more information, see appendix A.

Tiered readiness: An often controversial method of managing readiness that generally involves purposely allowing for differing levels of readiness across the force. In some cases it refers to cyclic readiness. In others, it can also refer to dividing the force into "ready" and "unready" pools, where the ready pool would be used either for emergent events or to serve as a first wave of response in the event of a contingency. Unready pools would be made ready when they are required. In still another version of tiering, the force is divided based on mission type, with some forces being ready for one mission type (say, irregular warfare) and other forces being ready for other mission types (say, conventional warfare).

Upstream production: The first stage of the production process that combines raw materials to form intermediate goods that are inputs into the final production of downstream products. In readiness, it is the stage where inputs from the industrial base and labor market are transformed into the intermediate products of skilled personnel, functioning equipment, and unit-level training. See also Downstream production and Intermediate production.

Notes

[1] Chairman of the Joint Chiefs of Staff (CJCS) Guide 3401D, *CJCS Guide to the Chairman's Readiness Reporting System* (Washington, DC: The Joint Staff, directive current as of November 25, 2013), 1, available at <www.dtic.mil/cjcs_directives/cdata/unlimit/g3401.pdf>.

[2] Richard K. Betts, *Military Readiness: Concepts, Choices, Consequences* (Washington, DC: Brookings Institution, 1995), 4.

[3] Ibid.

[4] Years in the sense that it takes time to fully train professional skill sets like pilots and unit commanders. The complete timeline may well be over a decade if the research, development, and production timelines for major weapons systems are considered.

[5] A more complete discussion of SORTS and DRRS is in appendix A.

[6] Betts, 245–246.

[7] The question of "ready for how long" deserves thought as well. While closely related to "ready for what," it does emphasize the need for the production lines to afford a sustained output of a specific skill set. In the short term, this could be done by reallocating existing resources that were intended to support other demand signals or operational requirements. Sustaining a long-term demand signal may require investments in additional structure (personnel and equipment).

[8] Betts, 4.

[9] Consider the perennial tension between investments in current readiness and investments in modernization that would be essential to the viability of the future force. Under some circumstances, it may make sense to allow moderately consequential current readiness degradations to persist in order to provide for modernization funding. The importance of current readiness is not self-evident. The decision to invest in current readiness (or not) should be a regular evaluation of cause, consequence, and risk.

[10] The force generation pipelines include all the processes that yield the essential elements of a ready force. At a minimum, they include the spectrum of personnel, equipment, and training processes. In a broader sense, they would also include enabling functions such as transportation and logistics stockpiles.

[11] Office of the Secretary of Defense (Comptroller), *Defense Budget Overview, United States Department of Defense Fiscal Year 2017 Budget Request* (Washington, DC: Office of the Secretary of Defense, February 2016), chapter 1, available at <http://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2017/FY2017_Budget_Request_Overview_Book.pdf>.

[12] U.S. House of Representatives, Letter from Office of Management and Budget Director Shaun Donovan to Honorable Hal Rogers, Chairman Committee on Appropriations, June 1, 2015, available at <www.whitehouse.gov/sites/default/files/omb/legislative/letters/dod-house-letter-harold-rogers.pdf>.

[13] U.S. Senate, James Clapper, "Worldwide Threat Assessment," testimony before the Committee on Armed Services, February 9, 2016, 31, available at <www.armed-services.senate.gov/imo/media/doc/16-12_2-09-16.pdf>.

[14] U.S. Senate, General Daniel Allyn, General David Goldfein, General John Paxton, and Admiral Michelle Howard, "The Current State of Readiness of U.S. Forces in Review of the Defense Authorization Request for Fiscal Year 2017 and the Future Defense Program," testimony before the Subcommittee on Readiness and Management Support, Committee on Armed Services, March 15,

2016, available at <www.armed-services.senate.gov/hearings/16-03-15-current-state-of-readiness-of-us-forces>.

[15] H.J. Res. 59; Pub. L. 113–67.

[16] Pub. L. 112–25, § 365, 125 Stat. 240, enacted August 2, 2011.

[17] Title 10, U.S. Code, §§ 3013, 5013, and 8013.

[18] For early discussions of the use of production theory for managing readiness, see Laura J. Junor, *Towards a Theory of DOD Readiness Metrics*, CME D0006093.A1 (Alexandria, VA: CNA Corporation, 2002), and Jim Jondrow, *Military Readiness, Budget Programming and Economic Theory*, CPP-2014-U-007332-Final (Alexandria, VA: CNA Corporation, 2014).

[19] Army Regulation 525-30, *Army Strategic Readiness* (Washington, DC: Headquarters Department of the Army, June 3, 2014), and Department of the Army Pamphlet 525-30, *Army Strategic Readiness Assessment Procedures* (Washington, DC: Headquarters Department of the Army, June 9, 2015).

[20] This regulation explains that the Army uses this analysis to "provide a strategic level assessment of the Army's near-term (0–2 years) and future readiness (2–6 years). These assessments allow the Army to report on strategic readiness and provide information to Army senior leaders to inform critical resource decisions necessary to address and mitigate shortfalls in Army readiness."

[21] It is worth noting that there is ample flexibility in both SORTS and DRRS to report on a given unit's ability to conduct the precise tasks (with conditions and standards) needed to successfully perform specific missions. There is no need to restrict reporting to the "most difficult" mission by asserting that other missions "are lesser and included" in that harder mission. Furthermore, reporting this way censors critical information on what a unit can and cannot do. If the missions of one task are perfectly nested within the tasks of another (which is seldom the case), then reporting on them individually requires almost no additional effort and sends a clear message of the readiness for both missions. This visibility is essential in the (more likely) event that the readiness for one mission is not a perfect indicator of the readiness for another. The atrophy of brigade-level artillery skills in the Army during Operations *Iraqi Freedom* and *Enduring Freedom* and their coinciding readiness to execute security-related missions was a critical trend in readiness management from about 2005 to the present. The reverse trend going forward will be equally important as uncertainty about where and when the demand for stability operations persists.

[22] Laura J. Junor et al., *Managing Readiness*, CRM 97-127 (Alexandria, VA: CNA Corporation, 1998), and Junor, *Towards a Theory of DOD Readiness Metrics*.

[23] There are several variations of this proverb:

> *For want of a nail the shoe was lost.*
>
> *For want of a shoe the horse was lost.*
>
> *For want of a horse the rider was lost.*
>
> *For want of a rider the message was lost.*
>
> *For want of a message the battle was lost.*
>
> *For want of a battle the kingdom was lost.*
>
> *And all for the want of a horseshoe nail.*

[24] In turn, the recruiting and retention trends can be predicted using even more upstream indicators of trends in civilian labor markets, among other factors.

[25] Michael G. Mattock et al., *Retaining U.S. Air Force Pilots When the Civilian Demand for Pilots Is Growing*, RR1455 (Santa Monica, CA: RAND, 2016), available at <www.rand.org/pubs/reports/RR1455.html>.

[26] U.S. Senate, General John Campbell, "The Current State of Readiness of the U.S. Forces," testimony before the Subcommittee on Readiness and Management Support, Committee on Armed Services, March 26, 2014, 7, available at <www.armed-services.senate.gov/imo/media/doc/Campbell_03-26-14.pdf>.

[27] This rotation is where the unit would receive graduate-level, full-spectrum training that would have met the requirements for operations against a peer aggressor.

[28] Betts, 28.

[29] See a lengthier discussion in appendix B and in the original study: Laura J. Junor, Ted M. Jaditz, and R. Derek Trunkey, *Trends in Interdeployment Training Readiness: A Study of the Bathtub*, CRM D0002077/final (Alexandria, VA: CNA Corporation, 2000).

[30] Janet A. St. Laurent, "Reserve Forces: Army National Guard and Army Reserve Readiness for 21st Century Challenges," testimony before the Commission on the National Guard and Reserves, September 21, 2006, GAO-06-1109T, available at <www.gao.gov/assets/120/114888.pdf>, and Commission on the National Guard and Reserves, "Transforming the National Guard and Reserves into a 21st-Century Operational Force," final report to the Congress and the Secretary of Defense, January 31, 2008, 52, available at <www.loc.gov/rr/frd/pdf-files/CNGR_final-report.pdf>.

[31] For an extension of this discussion, see the section below on the effects of high operations tempo on readiness.

[32] Government Accountability Office (GAO), *Military Readiness: DOD's Readiness Rebuilding Efforts May Be at Risk Without a Comprehensive Plan,* GAO-16-841 (Washington, DC: GAO, September 2016), 7, 22–23, available at <www.gao.gov/products/GAO-16-841>.

[33] U.S. Senate, General David Goldfein, "Long-term Budgetary Challenges Facing the Military Services and Innovative Solutions for Maintaining our Military Superiority," testimony before the Committee on Armed Services, September 15, 2016, available at <www.armed-services.senate.gov/hearings/16-09-15-long-term-budgetary-challenges-facing-the-military-services-and-innovative-solutions-for-maintaining-our-military-superiority>.

[34] U.S. Senate, General Robert Neller and Admiral John Richardson, "Long-term Budgetary Challenges Facing the Military Services and Innovative Solutions for Maintaining our Military Superiority," testimony before the Committee on Armed Services, September 15, 2016, available at <www.armed-services.senate.gov/hearings/16-09-15-long-term-budgetary-challenges-facing-the-military-services-and-innovative-solutions-for-maintaining-our-military-superiority>.

[35] There are logical foreign policy arguments both for and against overseas posture investments. One of the best examples arguing in favor of overseas presence is Michèle Flournoy and Janine Davidson, "Obama's New Global Posture: The Logic of U.S. Foreign Deployments," *Foreign Affairs* 91, no. 4 (2012), 54–63.

[36] See Garett Jones and Tim Kane, "U.S. Troops and Foreign Economic Growth," *Defence and Peace Economics* 23, no. 3 (2012), and Daniel Egel et al., *Estimating the Value of Overseas Security Commitments*, RR518 (Santa Monica, CA: RAND, 2016), available at <www.rand.org/pubs/research_reports/RR518.html>.

[37] T.R. Fehrenbach, *This Kind of War: The Classic Korean War History* (50th Anniversary Edition) (Washington, DC: Brassey's, 2000).

[38] CJCS Guide 3401D.

[39] Michael Peck, *The Return of Wargaming: How DOD Aims to Re-Imagine Warfare*, April 5, 2016, available at <www.govtechworks.com/the-return-of-wargaming-how-dod-aims-to-re-imagine-warfare/#gs.vuQjkaM>.

[40] *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* (Washington, DC: Department of Defense, January 2012), available at <archive.defense.gov/news/Defense_Strategic_Guidance.pdf>.

[41] Betts, 3–23.

[42] Fehrenbach, 65–71.

[43] Charles E. Heller and William A. Stofft, eds., *America's First Battles, 1776–1965* (Lawrence: University Press of Kansas, 1986).

Appendix A

[1] For more information on any of these topics, see Chairman of the Joint Chiefs of Staff (CJCS) Guide 3401D, *CJCS Guide to the Chairman's Readiness Reporting System* (Washington, DC: Joint Staff, directive current as of November 25, 2013), 1, available at <www.dtic.mil/cjcs_directives/cdata/unlimit/g3401.pdf>, and R. Derek Trunkey, *Implications of the Department of Defense Readiness Reporting System*, Working Paper 2013-03 (Washington, DC: Congressional Budget Office, May 2013), available at <www.cbo.gov/sites/default/files/cbofiles/attachments/44127_DefenseReadiness.pdf>.

[2] Note that DRRS-S generally refers to the information technology platform on which the two readiness assessment processes (SORTS and DRRS) reside.

[3] Each Service has its own SORTS instruction: Air Force Instruction (AFI) 10-201, Army Regulation (AR) 220-1, OPNAVINT 3501.360A; Manual: Navy Tactical Reference Publication (NTRP) 1-03.5, Marine Corps Order (MCO) 3000.13.

[4] CJCS Guide 3401D, 18.

[5] Ibid., 17.

[6] According to the Joint Capability Area Management Plan, a *Joint Capability Area* is "Collections of like DOD capabilities functionally grouped to support capability analysis, strategy development, investment decision making, capability portfolio management, and capabilities-based force development and operational planning." See James N. Miller and Lloyd J. Austin III, *Joint Capability Area Management Plan* (Washington, DC: DOD, January 27, 2010), 5.

Appendix B

[1] Laura J. Junor and Jessica S. Oi, *A New Approach to Modeling Ship Readiness*, CRM 95-239 (Alexandria, VA: CNA Corporation, 1996).

[2] The six dependent variables are the percentage of a quarter a ship spends in C-1 for personnel, equipment, supply, and training. The equipment equation is the product of two subordinate equations, one modeling the mean time between mission degrading failures (failure rate) and the mean time to repair a mission degrading failure (repair rate).

[3] This study was followed by a parallel analysis of Navy aircraft squadrons, with similar results. See Laura J. Junor, James M. Jondrow, Peter Francis, and Jessica S. Oi, *Understanding Aircraft Readiness: An Empirical Approach*, CRM 97-014 (Alexandria, VA: CNA Corporation, 1997).

[4] Steven W. Belcher et al., *Improving Enlisted Fleet Manning*, DRM-2014-U-007586-Final (Alexandria, VA: CNA Corporation, 2014); David M. Rodney, Steven W. Belcher, and Karen A. Schriver, *O-FRP Manning During a Surge*, DRM-2016-U-013581-Final (Alexandria, VA: CNA Corporation, 2016); Mark J. Albrecht, *Labor Substitution in the Military Environment: Implications for Enlisted Force Management*, R2330-MRAL (Santa Monica, CA: RAND, 1986), available at <www.rand.org/pubs/reports/R2330.html>; Laura J. Junor et al., *Managing Readiness*, CRM 97-127 (Alexandria, VA: CNA Corporation, 1998); Junor and Oi; Laura J. Junor et al., *Understanding Aircraft Readiness*; Steven W. Belcher, David L. Reese, and Kletus S. Lawler, *Improving NEC Fit*, DRM-2015-U-011116-1REV (Alexandria, VA: CNA Corporation, February 2016); Rodney et al., *O-FRP Manning*; James E. Grefer, *Attainable Enlisted Community Health and Fleet Fit*, DRM-2015-U-011249-Final (Alexandria, VA: CNA Corporation, 2015); Glenn A. Glotz and Richard E. Stanton, *Modeling the Contribution of Maintenance Manpower to Readiness and Sustainability*, R-3200-FMP (Santa Monica, CA: RAND, 1986), available at <www.rand.org/pubs/reports/R3200.html>; Albert A. Robbert et al., *Reducing Air Force Fighter Pilot Shortage,* RR1113 (Santa Monica, CA: RAND, 2015), available at <www.rand.org/pubs/reports/RR1113.html>.

[5] Glotz and Stanton; James M. Jondrow and Afi D. Harrington, *Observations on 25 Years of Readiness Research*, CAB 99-115 (Alexandria, VA: CNA Corporation, 1999).

[6] Junor et al., *Trends in Interdeployment Training Readiness*; Junor et al., *A New Approach to Modeling Ship Readiness*; Junor et al., *Understanding Aircraft Readiness;* Thomas Light et al., *Consolidating Air Force Maintenance Occupational Specialties*, RR1307 (Santa Monica, CA: RAND, 2016), available at <www.rand.org/pubs/research_reports/RR1307.html>; Glotz and Stanton.

[7] These are AFQT groups I, II, and IIIA.

[8] Defined as the percentage of E5s and above with less than 4 years of experience. This measure proxied lack of time in grade or the point when many senior enlisted leave and the organization or Service must promote to fill these vacancies.

[9] Henry S. Griffis and Laura Junor, *Predicting Navy Personnel Quality*, CAB 95-134 (Alexandria, VA: CNA Corporation, 1995).

[10] Mark J. Albrecht, *Labor Substitution in the Military Environment: Implications for Enlisted Force Management*, R2330-MRAL (Santa Monica, CA: RAND, 1986), available at <www.rand.org/pubs/reports/R2330.html>.

[11] For more, see Thomas Light et al., *Consolidating Air Force Maintenance Occupational Specialties*, RR1307 (Santa Monica, CA: RAND, 2016) available at www.rand.org/pubs/reports/ RR1307.html; Glotz and Stanton.

[12] Alan J. Marcus, James M. Jondrow, and Peter J. Francis, *Quarterly Readiness Update with Special Topics*, CAB D0007469.A1/final (Alexandria, VA: CNA Corporation, December 2002).

[13] James E. Grefer, *Attainable Enlisted Community Health and Fleet Fit*, DRM-2015-U-011249-Final (Alexandria, VA: CNA Corporation, September 2015).

[14] Belcher et al., *Improving NEC Fit*.

[15] Rodney et al., *O-FRP Manning During a Surge*.

[16] Belcher et al., *Improving Enlisted Fleet Manning*.

[17] The more complex, the more likely bottlenecks will limit flow through the training pipeline.

[18] Albert A. Robbert et al., *Reducing Fighter Pilot Shortages,* RR-1113 (Santa Monica, CA: RAND, 2015), available at <www.rand.org/pubs/research_reports/RR1113.html>.

[19] Bruce R. Orvis et al., *Recruiting Strategies to Support the Army's All-Volunteer Force*, RR1211 (Santa Monica, CA: RAND, 2016), available at <www.rand.org/pubs/reports/ RR1211.html>.

[20] Mattock et al., *Retaining U.S. Air Force Pilots*.

[21] Junor, *Towards a Theory of Metrics*.

[22] James Jondrow, Laura Junor, and Ted Jaditz, *A Sortie Generation Module for DRRS-N*, CRM-D0009204.A2 (Alexandria, VA: CNA Corporation, December 2003).

[23] Glenn A. Gotz and Richard E. Stanton, *Modeling the Contribution of Maintenance Manpower to Readiness and Sustainability*, R-3200-FMP (Santa Monica, CA: RAND, January 1986), available at <www.rand.org/pubs/reports/R3200.html>.

[24] Light et al.

[25] Roland J. Yardley et al., *Extending Depot Length and Intervals for DDG-51-Class Ships: Examining the 72-Month Operational Cycle*, RR1235 (Santa Monica, CA: RAND, 2016), available at <www.rand.org/pubs/research_reports/RR1235.html>.

[26] Chad D. Meyerhoefer et al., *Managing Airframe Fatigue: Results for the F/A-18, EA-6B, and S-3B*, CRM D0009223.A2/Final (Alexandria, VA: CNA Corporation, 2003).

[27] Robert W. Button et al., *Assessment of Surface Ship Maintenance Requirements*, RR1155 (Santa Monica, CA: RAND, 2016), available at <www.rand.org/pubs/reports/ RR1155.html>.

[28] Marcus et al., *Quarterly Readiness Update*.

[29] Christopher M. Duquette and Laura J. Junor, *The Process of Aviation Material Readiness: A Logistics Perspective*, CAB 99-109 (Alexandria, VA: CNA Corporation, October 1999).

[30] Jim M. Jondrow and Ronald H. Nickel, *Constructing an Index of Supply Support*, CRM 97-137 (Alexandria, VA: CNA Corporation, February 1998). They found that the most important driver of carrier airwing material readiness during the major predeployment training exercise is the depth of the on-ship aviation supplies.

[31] Elvira N. Loredo, John F. Raffensperger, and Nancy Y. Moore, *Measuring and Managing Army Supply Chain Risk: A Quantitative Approach by Item Number and Commercial Entity Code*, RR902 (Santa Monica, CA: RAND, 2015), available at <www.rand.org/pubs/reports/ RR902.html>.

[32] Junor et al., *Trends in Interdeployment Training Readiness.*

[33] Sarah E. Evans, *Improving the Cost Efficiency and Readiness of MC-130 Aircrew Training: A Case Study*, RGSD364 (Santa Monica, CA: RAND, September 2015), available at <www.rand.org/pubs/reports/RGSD364.html>.

[34] Government Accountability Office (GAO), *Military Readiness: DOD's Readiness Rebuilding Efforts May Be at Risk Without a Comprehensive Plan,* GAO-16-841 (Washington, DC: GAO, September 2016), available at <www.gao.gov/products/GAO-16-841>.

[35] U.S. Senate, General David Goldfein, "The Current State of Readiness of U.S. Forces in Review of the Defense Authorization Request for Fiscal Year 2017 and the Future Defense Program," testimony before the Subcommittee on Readiness and Management Support, Committee on Armed Services, March 15, 2016, available at <www.armed-services.senate.gov/hearings/16-03-15-current-state-of-readiness-of-us-forces>.

[36] U.S. Senate, Admiral Michelle Howard, "The Current State of Readiness of U.S. Forces in Review of the Defense Authorization Request for Fiscal Year 2017 and the Future Defense Program," testimony before the Subcommittee on Readiness and Management Support, Committee on Armed Services, March 15, 2016, available at <www.armed-services.senate.gov/hearings/16-03-15-current-state-of-readiness-of-us-forces>

Glossary

[1] Joint Publication (JP) 5-0, *Joint Operation Planning* (Washington, DC: The Joint Staff, August 11, 2011), H-1–H-2.

[2] Ibid., 5-0, H-1.

[3] Ibid., xvii, GL-7.

[4] Ibid., II-23–II-24.

[5] J7, Joint Experimentation, Transformation, and Concepts Division, "Definition from Future Joint Warfare," and Chairman of the Joint Chiefs of Staff Instruction 3010.02B, *Joint Operations Concepts Development Process* (Washington DC: The Joint Staff, January 27, 2006), A-5.

[6] JP 5-0, II-34.

[7] Ibid.

[8] Ibid., H-1, H-2, H-7.

[9] James N. Miller and Lloyd J. Austin III, *Joint Capability Area Management Plan* (Washington, DC: Department of Defense, January 27, 2010), 5.

[10] Ibid., II-3.

[11] Ibid., II-4, II-5.

[12] Ibid., II-2.

[13] Ibid., II-23.

[14] Ibid., GL-13.

[15] Ibid., H-8.

[16] Ibid., IV-49, H-5.

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