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Global Combat Support Basing

Robust Prepositioning Strategies for Air Force War Reserve Materiel

Ronald G. McGarvey, Robert S. Tripp, Rachel Rue,
Thomas Lang, Jerry M. Sollinger, Whitney A. Conner,
Louis Luangkesorn

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Summary

Background and Purpose

The Air Force has transitioned into an expeditionary force to provide better support to national security in the current operational environment, which is characterized by continuous engagement across geographically disparate locations. More than two-thirds of the materiel tonnage required to support expeditionary operations (excluding fuel) is War Reserve Materiel (WRM) resources that do not belong to the flying units.[1] The rapid deployment time lines required of expeditionary forces preclude moving all heavy WRM assets from the continental United States (CONUS) to forward operating locations (FOLs) in response to emerging contingencies.[2] Instead, WRM assets are prepositioned at forward support locations (FSLs) around the globe, ready for use by deploying Air Force units.

In FY03 and FY04, the Air Force Deputy Chief of Staff for Installations and Logistics (AF/IL) sponsored RAND Project AIR FORCE research that developed an approach for considering the global prepositioning of WRM assets in an expeditionary environment. The primary contribution of the FY03 research was an optimization model

[1] Mahyar A. Amouzegar, Robert S. Tripp, Ronald G. McGarvey, Edward W. Chan, and Charles Robert Roll, Jr., *Analysis of Combat Support Basing Options,* Santa Monica, Calif.: RAND Corporation, MG-261-AF, 2004.

[2] Kristin F. Lynch, John G. Drew, Robert S. Tripp, and Charles Robert Roll, Jr., *Supporting Air and Space Expeditionary Forces: Lessons from Operation Iraqi Freedom,* Santa Monica, Calif.: RAND Corporation, MG-193-AF, 2005.

that computes a least-cost allocation of resources among existing and potential storage locations and determines a transportation network, including vehicle routings, necessary to satisfy operational requirements.[3] The FY04 analysis employed these models in a review of the global WRM prepositioning posture.[4]

In FY06 and FY07, the Air Force asked RAND to revisit global WRM prepositioning (1) to evaluate the "Virtual Afloat" concept (which was consistent with recommendations made in Amouzegar et al., 2006), wherein some WRM assets would be prepositioned in shipping containers at or near seaports and then moved to vessels to be transported by sea to support deployment requirements, and (2) to analyze the costs and benefits associated with building "reliability in the event of disruption" into the WRM prepositioning posture. This research focused on a subset of WRM, the Basic Expeditionary Airfield Resources (BEAR) that provide the capability to open an austere airbase, and WRM vehicles (WRMVs).

Results

From our analyses of WRM prepositioning strategies evaluated across a broad range of operational scenarios, we developed the following general findings and policy recommendations.

A large and geographically dispersed set of WRM FSLs is attractive when considering the balance between predictable and contingency-dependent costs. (See pp. 34–43; 64–73.) The traditional approach to identifying prepositioning postures is to select a set of FSLs that satisfies the major combat operations' (MCOs) delivery requirements while minimizing the predictable costs that can be included in the Air Force's annual budget submission. These costs include facility construction, operations and maintenance, asset procurement, and the one-time movement of assets to their new storage

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[3] Amouzegar et al., 2004.

[4] Mahyar A. Amouzegar, Ronald G. McGarvey, Robert S. Tripp, Louis Luangkesorn, Thomas Lang, and Charles Robert Roll, Jr., *Evaluation of Options for Overseas Combat Support Basing,* Santa Monica, Calif.: RAND Corporation, MG-421-AF, 2006.

sites. Contingency-dependent transportation costs associated with moving assets from FSLs to FOLs typically were not included in such analyses, because MCO execution costs would be funded through a supplemental request, outside the budget submission. However, recent Office of the Secretary of Defense (OSD) guidance directs that the Armed Forces plan for continuous engagement in multiple small deployments around the globe while maintaining the capability to execute MCOs. Because many of these lesser contingencies will likely require the use of WRM, it is unclear to what extent the costs associated with moving WRM to support these smaller deployments, many of which may be exercises, should be included in the services' programmed budgets as opposed to supplemental budget requests; MCO execution costs would continue to be supplementally funded.

The ability to satisfy time-phased WRM delivery requirements remains the primary consideration; thus, throughout our analysis, all prepositioning postures that are presented will satisfy the deployment effectiveness constraints. Each alternative posture can then be evaluated with respect to its level of cost and risk.[5] We first used our optimization model to determine minimum-cost FSL postures that meet the future deployment requirements (both steady-state and MCO), as defined by DoD Strategic Planning Guidance (SPG), considering only predictable costs. The model identified postures that use a small number of FSLs, concentrated in existing locations, as indicated by Figure S.1 for the BEAR prepositioning posture. We then used the optimization model to identify postures that minimized the total system costs (i.e., the sum of predictable and contingency-dependent costs, excluding MCO transportation costs). These postures were geographically dispersed into a large number of FSLs, often at new locations, with most new sites storing a relatively small amount of BEAR assets,[6] as indicated by Figure S.2.

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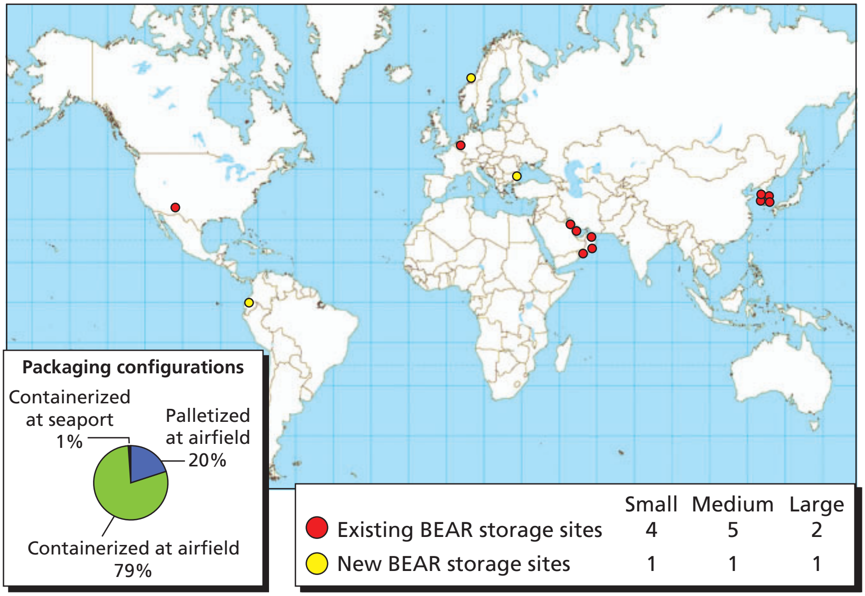
5 Thus, the analysis presented in this monograph can be viewed as a constant-effectiveness, variable-cost, and variable-risk analysis.

6 We define a "small" site as one that stores between one and six BEAR sets, a "medium" site as one that stores between seven and 15 BEAR sets, and a "large" site as one that stores 16 or more BEAR sets.

Figure S.1
BEAR Posture Optimized Against Predictable Costs



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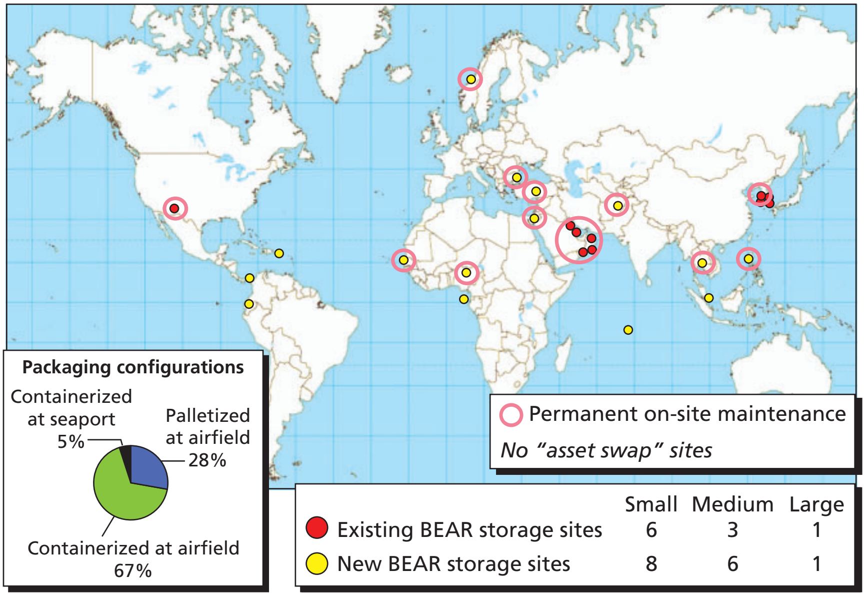
These very different WRM prepositioning strategies have significant cost implications. Figure S.3 presents the total system costs, in total present value (TPV) over six years, for the current BEAR posture (leftmost bar), the posture optimized against only predictable costs (center bar), and the posture optimized against total system costs (rightmost bar). For both the current posture and the one optimized against only predictable costs, the transportation cost associated with support to non-MCO deployments in SPG environments is significantly larger than all other cost categories combined. This suggests that excluding these costs from consideration when developing a prepositioning posture may be a flawed strategy, even if many of these costs cannot be accurately forecast.[7]

[7] Note that the costs associated with deployment in support of exercises and other planned missions can be forecasted, however.

Figure S.2
BEAR Posture Optimized Against Total System Costs



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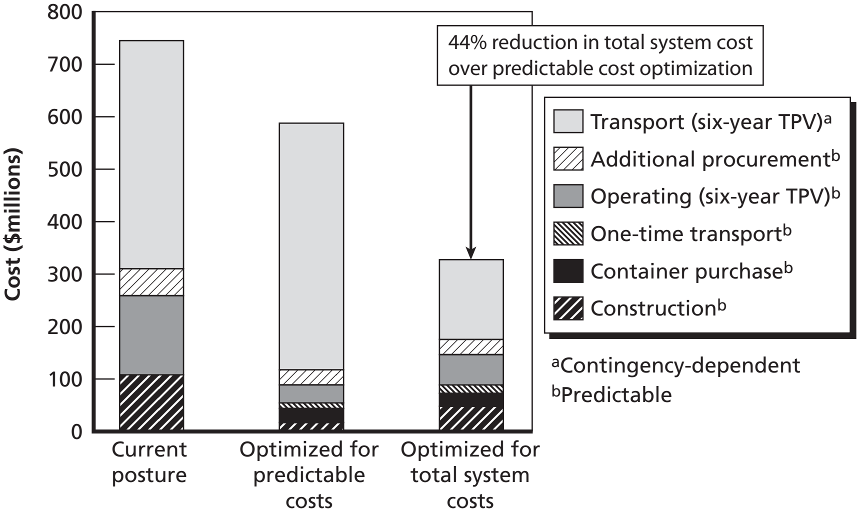
The strategy that also considers contingency-dependent transportation costs accepts additional investment in predictable costs (an investment of $176 million in TPV, compared with $118 million TPV for the posture optimized against predictable costs only), because these cost increases are more than offset by significantly reduced non-MCO transportation costs ($152 million for the total system cost optimization and $470 million for the predictable cost-only optimization). The finding that a relatively small additional investment in predictable costs for a dispersed set of WRM FSLs would be offset by much larger reductions in contingency-dependent costs held constant across all the sets of scenarios that were examined for both BEAR and WRMV, including scenarios in which the non-MCO deployment demands were reduced significantly.

Figure S.3
Cost Comparison Considering Total System Costs for BEAR



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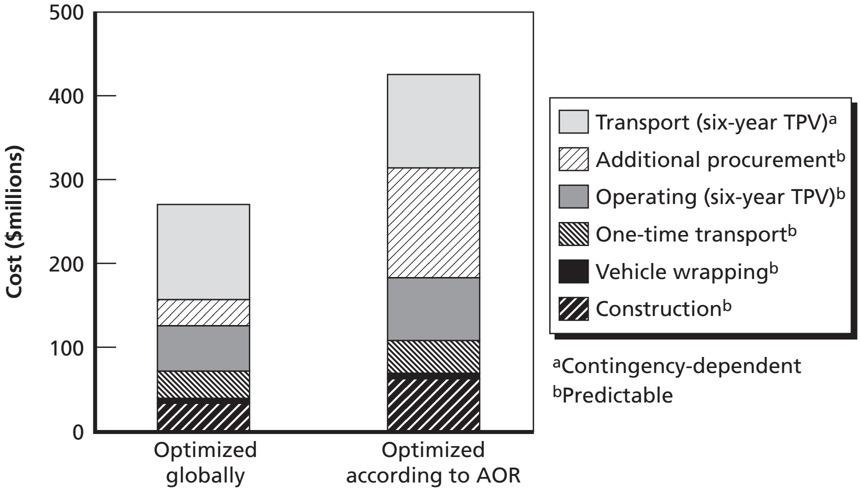
Alternative packaging configurations and maintenance concepts can allow such dispersed WRM prepositioning postures without incurring significant investments in infrastructure construction. (See pp. 26–32; 58–63.) Policymakers may be averse to a dispersed posture, even if it achieves significant reductions in total system cost, if it required a large investment in permanent infrastructure at foreign sites. If BEAR assets, which are currently stored in warehouses on pallets, were instead packed in steel shipping containers, much of this construction cost could be avoided because these shipping containers do not require inside storage. Our optimization models found containerization to be an attractive strategy, as indicated by the pie chart in Figure S.2, with solutions across multiple scenarios storing between 70 and 75 percent of BEAR assets in containers, of which 5 to 10 percent were stored in a "Virtual Afloat" configuration at seaports.

Storage in commercial containers also offers other benefits, such as allowing assets to blend in with the large number of nonmilitary containers moving through civilian supply chains. Our analysis also identified a cost-effective alternative packaging configuration for WRMV, in which vehicles are shrink-wrapped in plastic and have preservatives added that allow the vehicle to remain ready without regular maintenance for up to three years.

This analysis also considered alternative maintenance concepts for the periodic maintenance inspections performed on WRM. The traditional approach uses a permanent maintenance capability collocated with the WRM storage site. We examined two additional concepts: traveling maintenance teams, where a team of maintainers periodically travels from a site with permanent maintenance to storage sites lacking a permanent maintenance capability, and asset swap, where assets requiring maintenance are moved out of storage sites that do not have a permanent on-site maintenance capability and are replaced with serviceable assets sent from an FSL with permanent on-site maintenance. The cost-optimized postures produced by our models made extensive use of these alternative maintenance concepts, as indicated in Figure S.2. Employing these alternative maintenance concepts at new FSLs can further lower the facility and infrastructure investments because of the reduced requirement for maintenance facilities and equipment.

Cross-AOR support can significantly reduce WRM requirements and cost. (See pp. 47–50; 73–75.) WRM assets are currently positioned on an area of responsibility (AOR)-specific basis, with a focus on support of MCOs within each AOR. Although some capability currently exists for cross-AOR support, where assets stored in one AOR are used to support operations in another, moving assets across AOR boundaries requires approval from quite high up the Air Force chain of command, which can cause such long delays that tight delivery time lines may not be met. Our analysis suggests that an optimized global WRM management construct, where assets can be moved between any FSL and FOL without any additional delay for cross-AOR shipments, can achieve large cost reductions when compared with an optimized posture that does not allow for such support. Figure S.4 depicts these cost reductions for WRMV, which occur primarily because a shared global WRM pool reduces total requirements. Further, when considering that combat operations may occur near the boundary of geographic commands (e.g., the Caucasus region near the

Figure S.4
Cost Comparison Between Global and AOR-Specific WRMV Support



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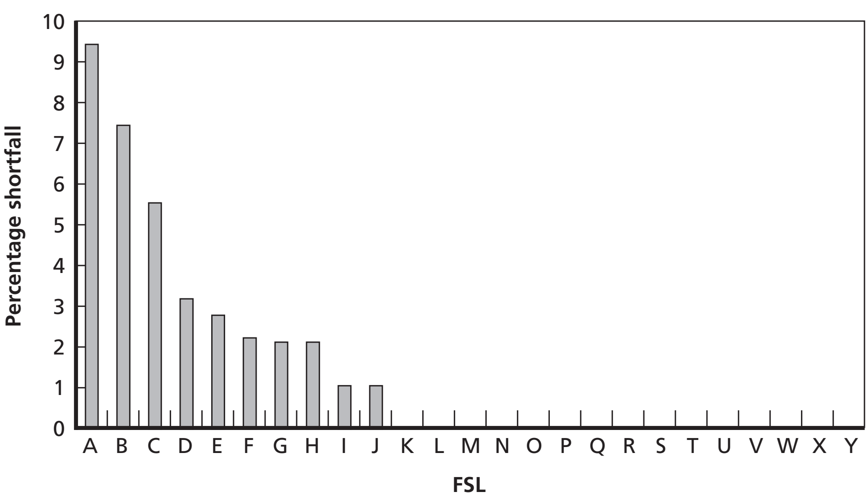
boundary of U.S. Central Command [CENTCOM] and U.S. European Command [EUCOM]), posturing WRM assets from a global perspective may enhance U.S. capabilities and responsiveness along such "fault lines."

Substantial robustness and reliability can be designed into WRM prepositioning postures at relatively little cost. (See pp. 83–95.) When a WRM posture is designed to support one set of future deployment requirements but a different set occurs, it may not be able to satisfy the time-phased demands at all FOLs. We demonstrated this concept with an example that considered three potential futures derived from the SPG. When a BEAR posture was optimized against a single future, it could not support the deployment requirements for either of the other two futures. We developed a "robust optimization" model that identified a single posture that could meet all deployment requirements across these three alternative futures, with total costs that were only 4 to 8 percent greater than the nonrobust minimum cost for each future.

The design of a prepositioning posture should also consider the effects of disruption to the network. Loss of access to a prepositioning site could occur for a number of reasons, such as a refusal on the part of the host nation to permit U.S. access to its WRM, a natural disaster, or a targeted attack on an FSL by an adversary. Unfortunately, cost-optimized network designs often generate a relatively "brittle" posture that performs poorly in the event of network disruption. This occurs because a traditional cost-optimization approach usually depends heavily on a small number of very cost effective nodes. Using such a cost-optimization strategy can lead to demands not being satisfied in the event of disruptions, particularly when an adversary can target a network's most vulnerable points.

We demonstrated this concept with an application to BEAR. As presented in Figure S.5, for the minimum-cost posture identified previously by our model, loss of access for 30 days to the most critical FSL (denoted FSL A) can cause nearly 10 percent of all time-phased

Figure S.5
Shortfall Below Demand Resulting from the Loss of an FSL, Cost-Optimized Posture for BEAR



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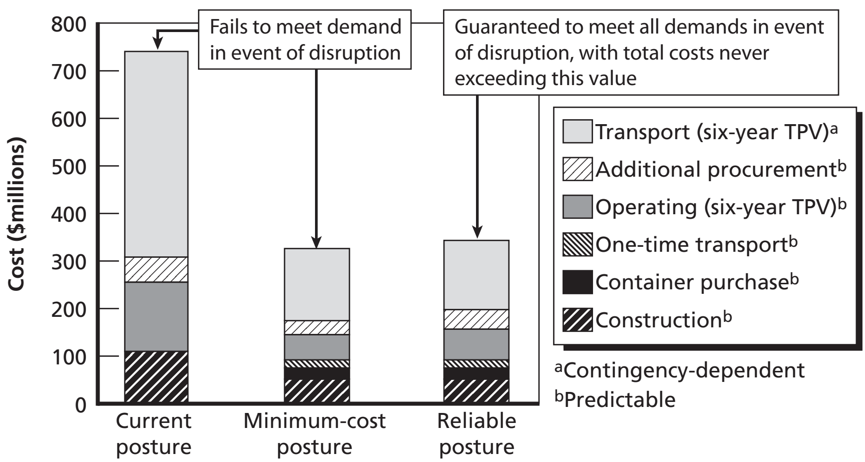
demands at FOLs to be unsatisfied. If access were lost at another particuarly critical site instead (denoted FSL B), nearly 8 percent of demands would go unmet.

We developed a "reliable optimization" model that guarantees that all demands would be met in the event of such a disruption to any one FSL. This approach identified a posture whose worst-case costs are only 6 percent greater than the best-case costs for the nonreliable, minimum-cost posture (whose worst-case performance, as demonstrated in Figure S.5, leaves over 9 percent of demands unsatisfied). Both the robustness and reliability analyses identified highly dispersed WRM postures. This dispersal appears to be both cost- and risk-effective, with geographic dispersal increasing the likelihood that assets are stored near unexpected deployment locations and dispersal of assets reducing the risk associated with denial of access to any FSL.

Figure S.6
Effect of Reliability for BEAR Prepositioning



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