With the definition of FOLs and the functions of FSLs, we can begin to address how to supply the requirements for each category of FOL, how long each option takes, and roughly estimate the costs for different options. Options are analyzed by the third model component (“TradeMaster”), which uses the outputs from the employment-driven models to compute the values of some of our metrics. In this chapter, we present a prototype analysis that gives the flavor of the analysis that is needed to make strategic infrastructure decisions. We first discuss briefly the scenario we use for this analysis and the metrics for measuring the deployment performance.

**EAF SCENARIOS**

As described in Chapter Two, our analytic method uses employment scenarios to derive logistics requirements. In this analysis, we give primary attention to a scenario that places heavy demands on those commodities (munitions, POL support, unit maintenance equipment, vehicles, and shelters) that account for most of the support footprint. Although we treat only this one scenario in detail (together

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1. There is a TradeMaster model for each of the commodity models. Although each shares a common structure, this structure is modified for each commodity.
2. In this report, we have focused on munitions and POL support, with some attention to vehicles and shelter. We have also estimated the footprint of maintenance equipment from the maintenance models and for other resources such as communications equipment and medical facilities from the deployment list (TPFDD) of a recent AEF deployment to SWA.
with a small excursion), our models can easily compute requirements and extend this analysis for other scenarios.

The scenario elements that determine the requirements for the major commodities are the number of aircraft and their types (MDS), their sortie rates, their missions (which determine the munitions they carry), and their munitions expenditure rates. The requirement models’ key outputs are the people, equipment, and consumables needed. In this analysis, we do not use the personnel requirements, and the equipment and consumables requirements are aggregated for most purposes into costs and gross weight (which can be converted into airlift requirements by using accepted planning factors).

The example scenario illustrated here is heavily influenced by operations in SWA, primarily because attention has been focused on quickly mounting combat operations to that region from CONUS to reduce burdensome repetitive temporary deployments. Therefore, the aircraft, missions, and sortie rates are taken from CENTAF experience.

The basic ASETF in the analyses below consists of

- 12 F-15Cs for air superiority
- 12 F-15Es for ground attack with GBU-10s (2000-lb laser-guided bombs)
- 12 F-16CJs for SEAD (Suppression of Enemy Air Defense) missions.

In our baseline scenarios, these aircraft execute 80 sorties per day (utilization rates of 2.3, 2.3, and 2.0, respectively, assuming all aircraft are always fully mission capable). We consider only materiel required to carry out the first seven days of operations.

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3 An example is deployments such as Phoenix Scorpion in 1997, which was a response to Iraqi troop maneuvers near the Kuwaiti border, not to the rotations for enforcement of the various no-fly zones.

4 This is a demanding scenario, and some have questioned whether such a small force could sustain this optempo for even seven days.

5 Seven days has emerged as a canonical planning parameter for the initial operation. Clearly, if combat operations are initiated and extended beyond seven days, daily resupply will be a necessity.
PERFORMANCE METRICS

In comparing the performance of infrastructure components both individually and in different configurations, five metrics are of primary interest: timeline, deployment footprint (equipment and people), cost, flexibility, and risk. Our analytic method provides quantitative treatment of the first three, which will be described in more detail below.

Unfortunately, risk and flexibility are more difficult to quantify. One aspect of risk is the probability of having access to an FOL or FSL when a crisis arises. Access can be denied either politically or by military action (a concern especially on the Korean peninsula for FOLs near Seoul). Flexibility is also important: centrally held material can be “swung” more easily to various conflicts than material prepositioned at an FOL. The latter option essentially bets that the conflict will occur within effective range of the FOL.

Risk and flexibility depend heavily on aspects of the global security environment such as where vital U.S. interests are, how greatly they are threatened, and the friendliness of foreign nations that could provide FOLs or space for FSLs. RAND is examining those issues, and in the ongoing work on the integrating model mentioned in Chapter Two we are considering possibilities for quantifying risk and flexibility, but for now decisionmakers must judge the quantitative tradeoffs provided by the logistics modeling with the subjective factors of risk and flexibility.

SCENARIO DEPLOYMENT PERFORMANCE

Figure 4.1 displays the estimates made with the employment-driven and TradeMaster models for six configurations of FOLs and FSLs or CONUS support (each of three categories of FOL in combination with the two options for supplying the remainder). The metrics are displayed in a single figure so that comparison is easier with other configurations and policy or technology options, one of which will be treated later in this report for contrast. We now describe each part of Figure 4.1 for our chosen scenario.

Timelines

Logistics Footprint

Recurring Cost

Investment

Figure 4.1—Metrics for GBU-10 Case
Timelines to Deploy to Categories of FOL

Each commodity's TradeMaster begins with a list of activities that must be done to set up the process that provides the commodity—deploying personnel from CONUS, moving equipment to the FOL if it is not prepositioned, setting up the equipment, and providing enough support to begin operations. In the TradeMaster, each task requires a deterministic time to complete: some of these times are computed by the requirements models (e.g., the time to set up POL storage facilities or to build the first load of munitions), whereas others are derived from expert judgment or as an assumption (e.g., 22 hours to deploy personnel from CONUS to the FOL). TradeMaster attempts to give an estimate of variability: to a selected set of tasks it adds a (subjective) increment to get a “pessimistic” timeline in addition to the more “optimistic” one.

In some cases, activities can be done in parallel; for example, we assume that, if equipment needs to be moved to the FOL, movement and unloading can be done before the unit personnel arrive. This assumes that the advance teams and particularly the Tanker Airlift Control Element (TALCE) will unload any airlifters in an organized fashion so that incoming personnel can quickly find and move their own equipment. This critical assumption allows us to make a first approximation in integrating the output of the various commodity models: we add the times required to unload the airlift (subject to the MOG constraint) and then take the maximum of that time and all of the other times to set up the various commodity processes and produce the first sortie. This is a rough estimate of the optimistic Initial Operating Capability (IOC). For the pessimistic IOC, we use a similar method on the individual pessimistic IOCs for each commodity and its unloading.

The timelines will also be affected by whether the resources that are not prepositioned are brought from an FSL or from CONUS, and whether in the former case they are moved by airlift or by truck. For

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7As noted above, these models are deterministic because they are intended to be used for strategic planning, not for analyzing specific execution situations.
our purposes, we assume that airlift is always used and that the FSL is four hours by air from the FOL.\textsuperscript{8}

The results of the timeline analysis for the three categories of FOL are shown in the upper left-hand panel of Figure 4.1.

The optimistic time to set up a Category-1 FOL is just under two days, even though most equipment is prepositioned. It is primarily driven by the time to deploy the people from CONUS and the time required to set up munitions and fuel-storage facilities. (We have assumed that U.S. forces must set up temporary fuel storage on a prepared site so that fuel for U.S. aircraft can have additives added independently of an ally’s fuel.)

For the other options, the times are primarily driven by the MOG and by the assumption of C-141s as the transport aircraft.\textsuperscript{9} The difference in timeline between CONUS and an FSL is minimal because the bottleneck is in unloading.\textsuperscript{10} For Category-3 FOLs, the primary time driver is unloading the bulky Harvest Falcon package (and setting it up requires 4.6 days with a dedicated 150-person crew in a temperate climate).

In summary, meeting the 48-hour timeline will be virtually impossible with current processes and equipment unless most equipment is prepositioned, and even then the timeline is extremely tight.

**Deployment Footprint**

We define the deployment footprint as the amount of materiel that must be moved to the FOL for operations to commence. It is derived from the model outputs: the model computes the amounts of equipment and vehicles needed for each commodity and then con-
verts them to airlift requirements using standard planning factors for each selected aircraft (raw short tons could be used as well). The upper right-hand panel of Figure 4.1 shows the initial airlift requirements for the three categories of FOL (i.e., the amount of airlift required to get the FOL operating).

**Peacetime Cost Estimates**

Although transportation and materiel costs may properly be ignored when a crisis looms, current fiscal concerns require that part of the evaluation of any set of options include the peacetime costs of setting up a given configuration (“investment”) and the costs of operating the system (“recurring”). For example, a Category-1 FOL will require prepositioning of three days’ worth of munitions, munitions assembly equipment, and POL storage and distribution equipment. Then the equipment must be maintained for use and be activated for ASETF exercises. If the munitions are to be stored at an FSL for transport to a Category-2 FOL, the FSL must contain enough sets of equipment to cover several ASETF operations in its area.

There are two major omissions from the investment cost:

- The facilities cost for building FSLs or constructing new FOLs. Such costs could be considerable, but FOLs in a theater of interest may be provided by the FOLs of a host country’s air force (e.g., Prince Sultan Air Base in Saudi Arabia) at no cost. If an FSL is placed in Europe, it may adapt existing facilities such as Ramstein or Spangdahlem in Germany, the Sanem WRM storage facility in Luxembourg, or Lakenheath in the UK. However, construction in less-developed areas such as at bases on Diego Garcia or in Alaska may be quite expensive. Because these costs

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11 The actual computations are a hybrid. For most equipment, we compute the weight in short tons and divide by the capacity of the aircraft that is used for airlift planning purposes. For some bulky equipment, we also use the area taken up to correct the computation or, in some cases, the pallet positions required. The different measures are usually quite close.

12 The airlift for shelter assumes that this is the housekeeping set (basic billeting, kitchen, power, water, sanitary facilities) in the Harvest Falcon bare-base billeting package.
are so dependent on the actual configuration under consideration, we defer them for this prototype analysis.

- Some of the equipment and consumable costs could be sunk. For example, the Air Force probably has enough GBU-10s to preposition them in almost every conceivable configuration of FOLs and FSLs without buying more. Similarly, there is considerable excess of many kinds of equipment available for storing at FSLs or FOLs as a result of the recent downsizing. However, new munitions such as the new standoff munitions coming into the inventory will need to be bought for any prepositioned storage. For this analysis, we present the total purchase price without considering the sunk costs.

The lower left-hand panel in Figure 4.1 compares investment costs for our canonical scenario: a 36-ship ASETF carrying out ground attack with GBU-10s, with moderate rates for missile expenditures. The configurations are two regions, five FOLs per region (any one of which might have to support the 36-ship ASETF), and two simultaneous ASETF operations (i.e., each central stock location, if any, must be prepared to support two ASETFs).

As expected, providing for five Category-1 FOLs per region is expensive, and munitions are by far the greatest cost (although recall that only three days’ worth of munitions are prepositioned at each FOL). Drawing materiel back from the FOLs decreases the cost, increases flexibility, and (may) decrease risk because each FSL requires only two sets of equipment. However, airlift requirements increase.

As noted, recurring costs have two components. First is the transportation cost for exercising ASETF deployments. Without a periodic schedule of exercises, the threat from an ASETF will not be credible to adversaries. (Of course, the schedule and scope of exercises is a decision variable.) The airlift cases we describe here use the Transportation Working Capital Fund (TWCF) price for airlift time.  

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13However, aggressive actions to shed excess may have depleted this source.
14Each FSL has two sets of equipment. If the materiel is supplied from CONUS, CONUS needs only two sets total.
15This is the rate that the Air Force pays to the U.S. TRANSCOM for peacetime shipments (formerly Defense Business Operating Fund-Transportation or DBOF-T).
The second recurring cost is for storage operations—the cost for having basic security and active maintenance of stored materiel.\textsuperscript{16} In the case of vehicles and shelters, we include a 10 percent charge to refurbish the materiel after each exercise, and for options where vehicles are rented we estimate a rental charge of 10 percent of the total cost.

The lower right-hand panel of Figure 4.1 shows our estimates of the recurring costs for these four commodities for the FOL configurations we examine. These recurring costs show a different pattern. The Category-3 FOLs supported from CONUS are very expensive to operate, primarily because of the large costs of transporting munitions and the Harvest Falcon sets twice a year for exercises.\textsuperscript{17}

Looking at Figure 4.1 as a whole, we can see that Category-1 FOLs give the fastest response but at high investment costs; Category-2 FOLs have longer response time but at lower investment costs; and FSLs have higher investment costs than stockpiling in CONUS but have lower recurring costs because of the shorter flying time to FOLs.\textsuperscript{18} This is an example of the kinds of tradeoffs that need to be considered in designing a strategic support infrastructure: fast response can be purchased by investing in Category-1 FOLs, but this

\textsuperscript{16}This cost is currently the softest of all of our inputs. It is based on a number of people for a given volume of materiel. However, because the successful deployment of ASETFs will depend on the immediate usability of equipment at FSLs and FOLs, the storage and maintenance policies for prepositioned equipment need to be carefully formulated and rigorously enforced, especially if contractors do some or all of the work. Expeditionary forces will fail if they fall-in on equipment that needs extensive maintenance work before it is serviceable: there simply is not enough time to make major repairs on support equipment and still maintain the credible threat that may be required. In our interviews with Air Force personnel who have taken part in expeditionary operations, this issue has been of serious concern. See General Accounting Office (1998) for more details.

\textsuperscript{17}Many of these costs, however, may not have to be borne by the Air Force alone. In some cases, host-nation support may provide some of the services needed. There is also the possibility of sharing facilities with other services: transportation hubs would be useful to the Navy and Army as well. And some USAF and/or Army "FSLs" could even be ship-based, protected by a carrier battle group and supplied by the battle group’s resupply pipeline.

\textsuperscript{18}Whereas the number of initial airlift is equal for FSL and CONUS options, the airlift for the latter option is strategic (intertheater) airlift—a global asset, as opposed to a theater asset.
may be wasteful if longer timelines can be tolerated because of lower threat or less-critical U.S. interests.

EFFECTS OF DIFFERENT TECHNOLOGIES ON DEPLOYMENT PERFORMANCE

We can use our modeling approach to compare technologies and policies for carrying out the required mission or providing the needed support. In this section, we examine the results of replacing the GBU-10 with the Small Bomb System (SBS), a 250-lb bomb that is designated to be used against approximately 70 percent of the targets that are appropriate for the GBU-10. The small bomb is much lighter than the GBU-10, and each F-15E can carry six small bombs versus two GBU-10s. Thus, the same number of bombs can be dropped in 14 sorties as in the 28 sorties using GBU-10s. This also reduces POL requirements and, with the right scheduling of sorties, refueler requirements. (We have assumed that the same number of air-escort and SEAD missions are flown.) The SBS is considerably more expensive than GBU-10s, however, and the effect on the costs of prepositioning options is uncertain because the bombs cost more but the reduced sorties mean lower missile expenditures. Figure 4.2 compares the alternative support options using the three metrics if the SBS substitutes for the GBU-10.

The general pattern of each metric seems similar in this case, but closer comparison shows significant differences between the two cases.

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19The SBS is only under test and has not been procured. The costs shown here are therefore dollars that must be programmed and expended, unlike the costs for the GBU-10, which are largely sunk. A more detailed analysis would need to compare the two sets of costs with the GBU-10 costs subtracted.
Expeditionary Deployment Performance: Prototype Analysis

Figure 4.2—Metrics for SBS Case
The SBS option as presented here does degrade the startup performance slightly, because the increased bomb load per sortie requires more bomb buildup work per flight (and hence more for the first flight). The SBS is supposed to be able to be shipped in a full-up configuration, however, so it may be feasible to prebuild the rounds on strategic warning at a storage site and reduce the time to IOC. As expected, the initial airlift required is somewhat smaller, although the weight of munitions-handling equipment is still significant. Finally, the investment and recurring costs are lower for the SBS option. The investment decreases because of fewer expenditures of air-to-air missiles—the mission can be carried out with fewer sorties. Recurring costs are reduced because airlift needed to transport SBSs for exercises is less. Note that this discussion has implicitly assumed that rapid transportation is available for movement of munitions to an FOL when the munitions are stored in an FSL or in CONUS.

One reviewer asked whether a deploying force might not elect to bring both SBS and older rounds, thereby not saving any deployment footprint. Our analyses have been predicated on specifying which munitions will be used and evaluating the deployment performance. Greater flexibility, in terms of a mix of munitions, must be paid for with more transportation or more prepositioning.

CONCLUSIONS

After looking at the current force structure and its support processes, our analysis leads to several conclusions concerning FOLs and their support.

- To get close to the 48-hour deadline from execution order to placing the first bombs on target, ASETFs must deploy to Category-1 FOLs. Further, given that a flight halfway around the world takes approximately 20 hours, pushing the timeline below 48 hours will require having people deployed, or materiel at an advanced state of preparation at the FOL, or both.

- Equipping several FOLs from scratch would be expensive. Although much of the cost for current processes might well be sunk, maintenance and storage costs will still have to be paid. Anecdotal accounts of current (non-urgent) deployments to SWA indicate that maintenance arrangements do not keep equipment
ready for immediate use, implying that these costs might be larger than are paid now. Further, future munitions and improved support equipment would have to be bought for the FOLs.

- FSls provide a compromise in cost between prepositioning at FOLs and deploying everything from CONUS.\textsuperscript{20} FSls have little effect on the timeline for initial capability, but they do avoid the necessity of a tanker air bridge for the extra strategic lift. Further, this strategic lift then becomes available for further deployments, which may be needed if the crisis is not resolved.

- Category-2 FOLs represent another compromise in cost and timeline. However, to deploy to a Category-2 FOL would take between two and three days to unload the airlift and about the same amount of time to set up munitions and POL storage, so increased ramp space would not significantly speed up the deployment process because operations could not commence until the setup was completed.\textsuperscript{21} Plus, arrangements for rental vehicles, medical facilities, and the like would probably require some time to finalize unless complete preparations had been made in advance.

- Category-3 FOLs are not useful as FOLs for very quick crisis response, given the time required to unload airlift and set up the processes. However, this is a function of the current processes, and the timeline estimated here is for a stressing scenario. A less-stressing scenario or a humanitarian operation might well be feasible from such a Category-3 FOL within the 48-hour timeline.

\textsuperscript{20}However, much of the difference in recurring costs arises because of the expense of running exercises from CONUS and the form of the exercises.

\textsuperscript{21}This assumes that POL and munitions troops and equipment arrive early in the deployment sequence.