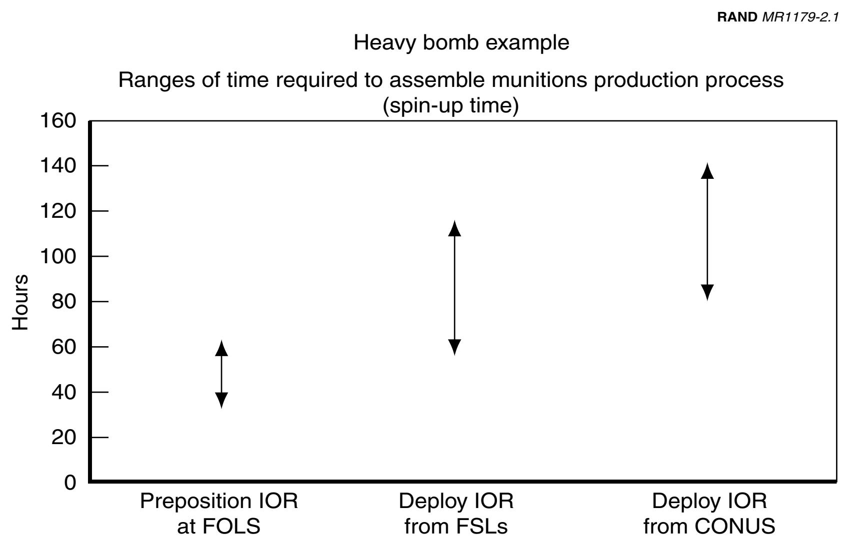
Chapter Two

THE ACS/MOBILITY SYSTEM DESIGN TRADE SPACE

Some of the key variables affecting ACS/mobility decisions are employment options, FOL capabilities, alternative technologies, resupply times, ACS policies and practices, and mobility capabilities. Employment options affect force composition, employment timelines, and operating tempo (optempo). FOL capabilities include infrastructure and resource availability and the risks associated with prepositioning those resources at the FOL. Technology options, such as new test equipment, munitions, or support equipment, can affect requirements dramatically. Resupply time affects the initial operating requirement of resources that need to be on-hand before combat operations can begin. Alternative support policies, such as conducting repair operations at consolidated support centers rather than at the deployed unit, affect deployment and sustainment airlift requirements. Finally, mobility capacity (e.g., strategic and tactical airlift), can affect ACS solutions. To illustrate, we describe how the employment timeline, munitions and support equipment technologies, and resupply time will affect the solution direction for the ACS/mobility system.[1]

Figure 2.1 shows the relationship between the time it takes to support combat operations (the spin-up time) and alternative ways of satisfying the resource requirement. As shown in the figure, the initial operating requirement can be supplied from resources prepositioned at the FOL or moved to the FOL from an FSL or CONUS. In

[1]Much of the material in this chapter is drawn from Galway et al. (2000), which describes the analysis, the munitions, and other models.



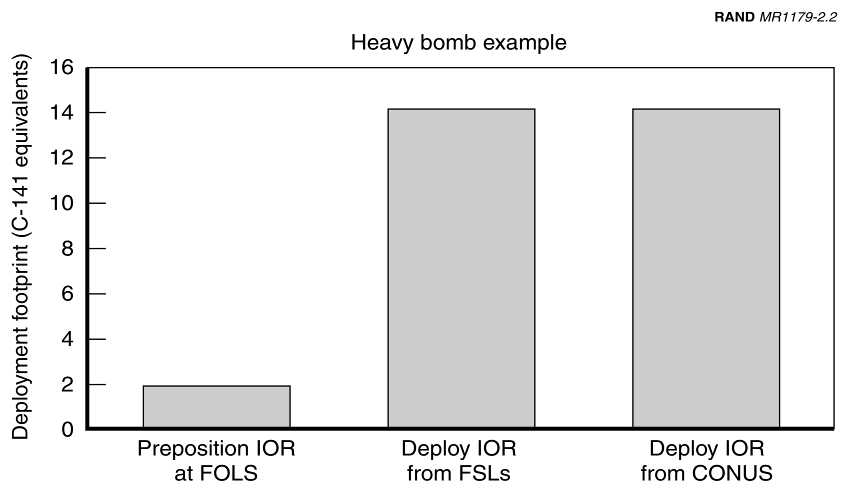
Deployment times and distances are based on Southwest Asia. FOLs are assumed to have adequate runway and ramp space.

SOURCE: MR-1075-AF.

Figure 2.1—Spin-Up Time as a Function of Resource Location

this example, a munitions model was used to determine the requirements for munitions and an options analysis model was used to calculate the timelines for each alternative for satisfying the IOR for a given force that had air-to-ground mission responsibilities. Notice that the timelines are longer and have more variability when the resources are supplied from remote sources—whether from an FSL or CSL. In these cases, there are more nodes and handling required than with prepositioning the IOR at the FOL.

Figure 2.2 shows the footprint, measured in terms of C-141 equivalents, of the heavy munitions (e.g., GBU-10s) that would have to be moved to meet the IOR. In this case, the IOR was set at three days



Deployment times and distances are based on Southwest Asia. FOLs are assumed to have adequate runway and ramp space.

SOURCE: MR-1075-AF.

Figure 2.2—Deployment Footprint as a Function of Resource Location

and the amounts are those necessary to support 12 F-15Es flying at surge rates.[2]

Figure 2.3 shows the cost of the heavy bombs that would have to be prepositioned to support two simultaneous AEFs flying F-15Es at surge rates. The figure reflects the fact that the AEF operations might be required in two theaters. Calculations also assume that access to the FOLs is uncertain, and that five bases in each theater would have to be resourced to have a high probability of gaining access to an FOL when needed. Thus, the prepositioning option requires that heavy bomb bodies be prepositioned at ten bases.

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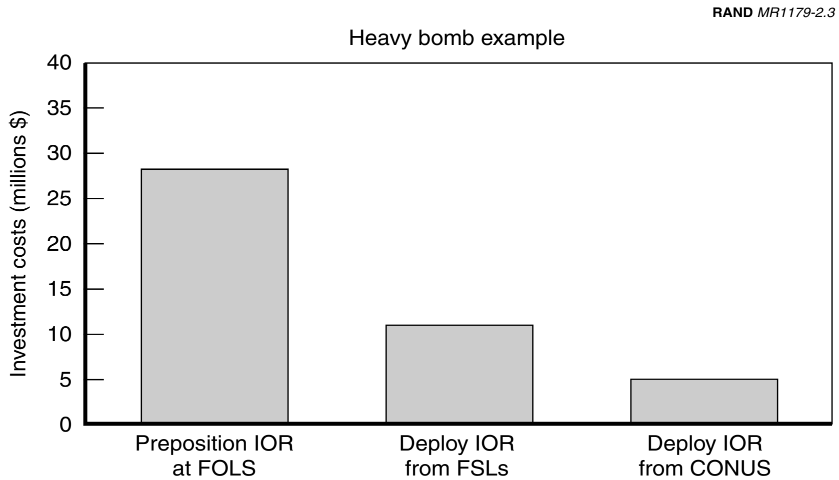
[2]A reviewer of this report noted that recent operations have not typically flown at surge rates. We used surge rates in our analysis to present a stressing case. If planners decide that this flying rate is not probable for a particular area, our planning methods could generate investment numbers for the lower rates and some decisions might be altered.



Investment costs to cover two regions with five possible FOLs in each region. Assumes two simultaneous AEFs must be supported.

SOURCE: MR-1075-AF.

Figure 2.3—Cost of Heavy Bomb Bodies "Invested" in Each Support Option

If heavy bomb bodies are supplied from the FSL, only the IOR for four bases needs to be positioned at the FSLs. Each FSL would then have the resources to cover two AEFs (in case both operations were in a single theater). If supplying the resource from a CSL, only the resources necessary to cover the IOR investment in heavy bombs to support the two simultaneous AEFs need be stored at the designated CSL. This assumes immediate access to the resource to support AEF operations from CSLs.

Figure 2.4 illustrates the tradeoff between spin-up time and "investment cost." Prepositioning IORs at FOLs requires less movement to begin operations, leading to shorter spin-up times, but this option requires a larger materiel investment cost. The ACS design selected depends upon what the Air Force values most. There are no right or wrong answers. Decisions must be made between ACS postures with very different characteristics. Analyses such as these pro-

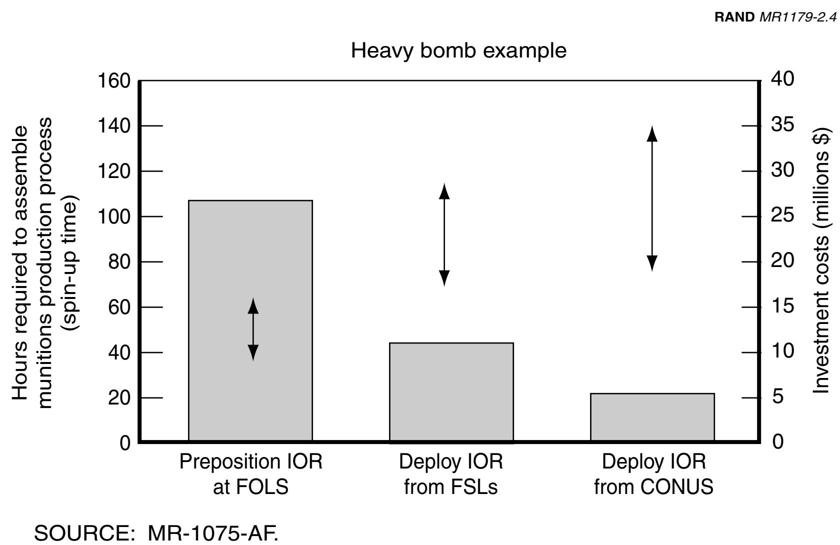


Figure 2.4—Tradeoff Between Spin-Up Time and Investment Cost

totypes are needed to inform difficult decisions on alternative resource expenditures.

Technology investment can change support option characteristics. The left panel of Figure 2.5 shows some of the equipment required to build and move heavy bombs (such as the GBU-10, which weighs 2000 lb). The right hand panel contrasts the GBU-10 (on the bottom) with a lighter "small smart munition," which is designed to attack many of the same targets against which the GBU-10 is used. This munition, if it meets the operational requirements, could reduce greatly the support footprint at an FOL.

Figure 2.6 shows the effect that this technology could have on spin-up time and deployment footprint. The technology makes storing the IOR at FSLs and CSLs competitive with prepositioning the munition at FOLs. In addition, if a fuse could be developed that would allow dense packing of the munition on aircraft, munitions-build operations may not have to take place at the FOL. This could further reduce forward deployment requirements and spin-up time.

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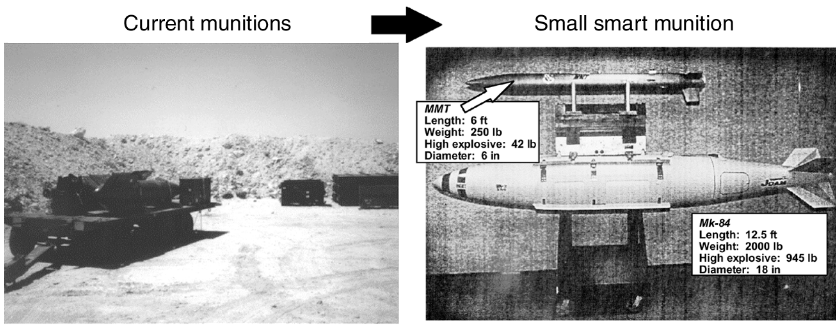
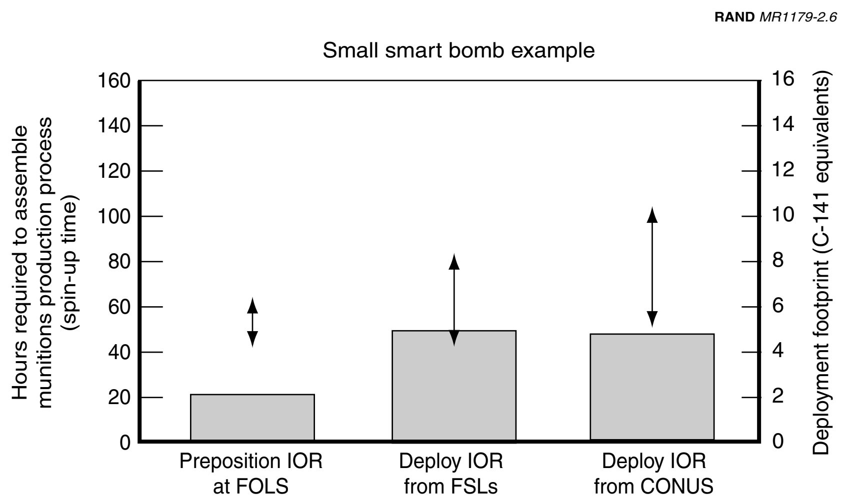


- Small smart bomb technology can reduce footprint
  - Smaller logistics footprint
  - Less support equipment
  - Fewer support personnel
- Fusing technology advances can further reduce footprint
  - Allow bomb build at FSLs
  - Allow denser packing

Figure 2.5—Small Munitions Characteristics

Support policy options significantly affect EAF efficiency. In Figure 2.7, we show some results of our F-15 avionics analysis, in which we compared the effects of differing maintenance policies on deployment footprint (among other things). We also compared the effects of alternative tester technology under the differing maintenance support options. The left side of the figure shows the effects of consolidating intermediate avionics maintenance activities. Some 700 people would need to deploy in a two-MTW scenario under the current policy of deploying intermediate maintenance capability with the deploying units.

If maintenance activities were to be consolidated at three or five regional facilities (two to four FSLs for theater support plus one CSL, denoted as "2R+C" in Figure 2.7), the deployment requirements would drop to around 100 persons. These people would deploy from the CSL to the FSLs rather than to FOLs as under current policy to handle the increased workload. If the entire force were supported by one CSL, there would be no deployment requirements. If support was consolidated, the support to the deployed force would be de-



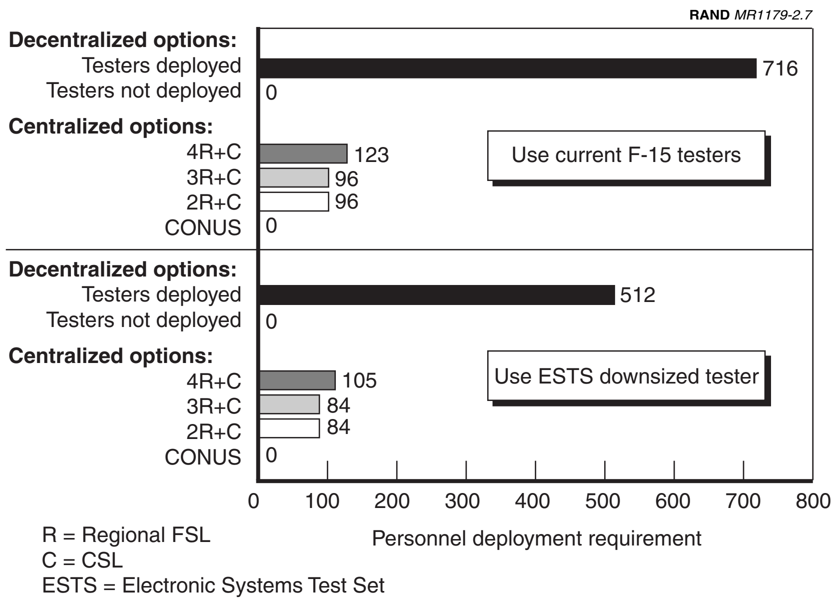
Deployment times and distances are based on Southwest Asia. FOLs are assumed to have adequate runway and ramp space.

SOURCE: MR-1075-AF.

Figure 2.6—Effect of the Small Smart Munition on Spin-Up Time and Deployment Footprint

pendent upon assured transportation and additional spares may be required to cover the pipelines between units and their FSLs or CSL. Again, tradeoffs must be made in designing the future ACS system.

The right side of Figure 2.7 shows the effects on personnel deployment of acquiring the F-15 downsized tester—the Electronic Systems Test Set (ESTS). In this case, the investment in ESTS technology reduces the deployment footprint by approximately 200 people if the Air Force continues its current decentralized approach to F-15 intermediate-level avionics repair. However, notice that this technology does not cut personnel deployment requirements as much as does a change in policy from decentralized to consolidated repair. Consolidated maintenance does not require as many testers because of economies of scale and better utilization rates of equipment. Thus, technology may not reduce footprint under



NOTES: Boiling peacetime (small AEF) deployments do not require deployment of maintenance personnel to FSLs. Base-case deployments are to FOLS. Deployments to FSLs are augmentees from CONUS.

Figure 2.7—Personnel Deployment Requirements for F-15 Avionics Support Options

existing policies as much as would a change in policy itself. Again, our analysis shows that an organized and structured approach is needed to evaluate how alternative policies, practices, and technologies affect EAF operations.

Resupply time can also affect ACS design options. It is a major determinant of the IOR for commodities, such as munitions that need to be prepositioned at FOLs to support immediate employment of forces. As the resupply time is cut, the amount of IORs and the initial deployment requirements can also be decreased. Resupply time also affects the choice of repair process locations—whether forward at FOLs, at consolidated points within the theater, or at consolidated points within CONUS. If resupply time is long, maintenance equipment and personnel either have to be deployed with the units to keep them operational or large quantities of spare parts will be needed to fill longer pipelines to and from the units and their sources of repair. Beyond reducing cost and thereby making consolidated repair feasible, short resupply times are effective in dealing with uncertainties brought about by the inability to predict requirements or by changes in requirements resulting from enemy actions. A short resupply time provides the ability to react quickly to inevitable surprises, thereby mitigating their effects.

To illustrate the importance of resupply time in the decision of where to locate repair processes and to get a rough idea of what is feasible in the near term, we turn to two separate studies we have made on maintenance support in an expeditionary environment: the repair of LANTIRN (Low Altitude Navigation and Targeting Infrared for Night) pods[3] and of F-15 avionics.[4] Both of these studies examined a range of maintenance structures from forward, decentralized repair to consolidated repair, either in the theater or CONUS, over a range of potential resupply times. Essentially, they both show the resupply time breakpoints at which consolidated repair becomes preferable (in terms of aircraft supportability and/or cost) to decentralized, forward repair.

We start by examining what we might expect resupply times to be for theaters where the United States has vital interests. What will these resupply times be in wartime or during crises? The future ACS system needs to be designed around realistic wartime resupply times, not peacetime resupply possibilities. Figure 2.8 shows theoretical and empirical curves that illustrate the resupply performance for a number of current transportation alternatives.[5] The left-most curve

[3]Forthcoming report by Amatzia Feinberg, Hyman L. Shulman, Louis Miller, Eric Mazlik, and Robert S. Tripp.

[4]Forthcoming report by Eric Peltz, Hyman L. Shulman, Robert S. Tripp, Timothy L. Ramey, Randy King, and John Drew.

[5]All of the distributions in Figure 2.8 are for nonbackordered shipments. These curves examine the capability of the distribution system. Of equal concern to the effectiveness of consolidated maintenance, though, is whether items are on the shelf ready to be shipped at the consolidated repair location when required by FOLs. High backorder rates would shift the upper portion of each curve substantially to the right (which is why these curves may appear much better than performance normally experienced in the Air Force today). The stockage requirements calculated from the ex-

(AMX-C Sim) in Figure 2.8 shows the theoretically optimum distribution of expected resupply times for small items (e.g., 150 lb or less) that could be shipped via express carriers to Southwest Asia (SWA) from CONUS using AMX-C/BDS.[6] This distribution includes the entire resupply time, including the time from requisition submission to receipt of the item by base supply, and has a mean of about four days (including weekends, holidays, and pickup days). This curve was generated from a simulation model of the AMX-C plan and current Air Force and joint processes; it uses optimistic times for materials handling and customs, assumes no queueing resulting from resource constraints,[7] and allows no delays for weather, mechanical problems, or enemy action. It represents a "current process optimum" to points within SWA.

The next curve (ONA DLA MICAP) shows the empirical distribution of resupply times for MICAP (mission incapable, parts) requisitions filled from the Defense Logistics Agency (DLA) during Operation Noble Anvil (ONA). Although this represents a mixture of transportation modes, most went by World Wide Express (WWX).[8] It is the current best case—the requisitions are high priority, the dominant transportation mode uses an established commercial network, and the source is a high-volume shipping facility. This curve shows that the system can approach the AMX-C simulation for the bottom half of the distribution. However, its longer "tail" shows the real-world variability resulting from resource constraints and delays (e.g.,

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pected pipeline lengths and the safety stock levels determined from availability objectives need to be satisfied.

[6]AMX-C/BDS is a system planned for wartime distribution of small items. AMX-C would bring small packages via military and commercial transportation within the United States to a U.S. hub, where a civilian contractor would consolidate the shipments for overseas transportation (either military or civilian, depending on destination and threat levels). At the overseas destination, BDS (battlefield distribution system) would deliver the shipments in the theater.

[7]Everything in the commercial CONUS aerial ports of embarkation (APOEs) at the time of scheduled daily departure gets on the aircraft. The same occurs at all transshipment points. The theater distribution system is considered to consist of trucks; the trucks picking up material at the theater hub arrive randomly but without resource constraints.

[8]WWX is a Department of Defense (DoD) contract with commercial express carriers to move small items within CONUS and from CONUS to the rest of the world. The contract specifies guaranteed in-transit delivery times for shipments between specific locations.

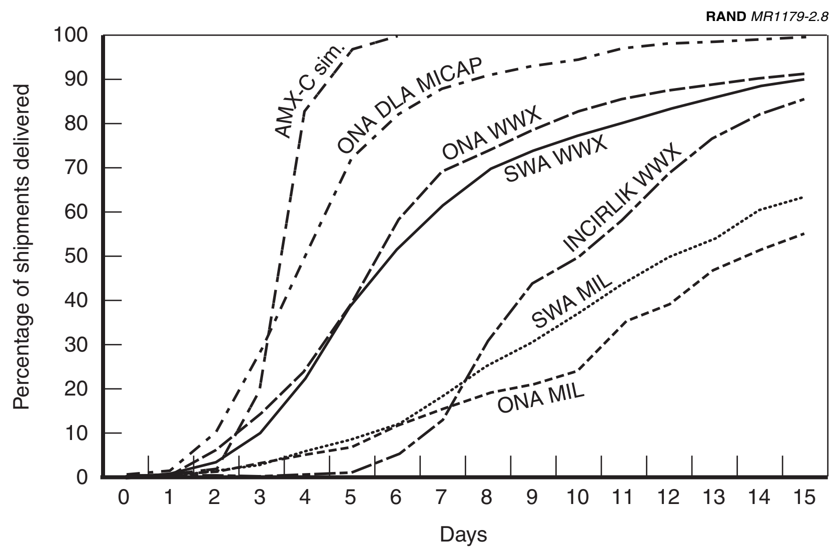

Figure 2.8— Empirical and Theoretical Resupply Times for Various DoD Transportation Channels

weather) not included in the simulations. The next two curves (ONA WWX and SWA WWX) show the distribution of WWX deliveries to ONA and to current deployments in SWA. They give a good indication of current WWX capabilities to areas with well-established distribution networks. The next curve (WWX Incirlik) is the current distribution of resupply time via WWX to Incirlik, Turkey, and shows that current WWX performance can be somewhat worse to locations other than SWA and Western Europe. The final two curves (ONA MIL and SWA MIL) show the distribution of resupply times to ONA and SWA of shipments of "big and ugly" cargo carried by military air. (Other analyses of military air shipments show that these curves are representative of the current performance of this transportation mode). These last curves are relevant to the following discussion of LANTIRN transportation needs, because LANTIRN pods are both heavy and contain classified components that require either military transport or escort by a cleared courier.

DoD recently established a resupply time goal of five days to overseas locations and directed that inventory levels be adjusted downward to reflect these new goals. These empirical and theoretical curves indicate that in the very best circumstances this goal to overseas FOLs can be met for small items in wartime environments, but they also indicate that even to a theater as close and well developed as Europe the current system does not meet the goal for all shipments of small items. And it is vital to remember that, even in the best of circumstances, the system can barely achieve the goal without backorders.

We can now examine the LANTIRN pod and F-15 avionics studies against this resupply analysis. For LANTIRN targeting pods, we require a resupply time of two days (for getting a serviceable pod from the repair facility) to provide pod availability equivalent to having the repair capability at the operating base. The timeline is very short because of the lack of spare pods, and no new buys of the targeting pod are planned. This resupply time is clearly out of reach from CONUS based on the times in Figure 2.8 (and might even be a stretch for in-theater transportation). However, deployment of LANTIRN repair capability to FOLs is not an attractive option because the test equipment used is heavy and can be unreliable when moved. If intratheater distribution can achieve two days, then consolidation at a regional facility may be the best option, but beyond that, deployment of repair capability to FOLs would likely be necessary.

For F-15 avionics, the situation is much more complex because the Air Force is still buying spares, and comparison of consolidated repair options must take into account the cost of spares to cover longer pipelines. However, consolidation of repairs at regional or CONUS facilities sharply reduces personnel, as well as the need for some upgrades currently being considered to repair equipment. Our analysis shows that the resupply time from consolidated repair facilities to FOLs must be under about five days or the longer pipeline will require substantial investments in new spares to maintain capability. Data from theater support of MICAP requisitions show that transportation times from regional FSLs could meet this time,[9] but Figure

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[9]Data collected from AEW 4 deployment to Doha, Qatar, from May 1997 to August. MICAP requisitions that were processed at Prince Sultan Air Base in Saudi Arabia averaged less than five days. At that time, Prince Sultan Air Base and Doha were con-

2.8 shows that transportation from CONUS might not be fast enough.[10]

Models of individual support processes can yield insights into the functioning of these processes for expeditionary operations. To plan for an ACS/mobility system, we need to integrate the outputs of models of different processes and consider mixes of options, such as prepositioning some material, deploying other material from FSLs, and deploying still other material from CONUS. Research continues on this topic, and we are exploring the use of optimization techniques to help integrate support options.

Before summarizing some of our findings, we note that a potential operation may be found to be unsupportable from a process capability or a cost standpoint. Senior leaders may then devise an alternative operational strategy that would achieve their goals but with a lower cost or risk. Our framework is therefore not just for ACS/mobility analysis; it encompasses an integrated analysis of operations, ACS, and mobility.

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nected by scheduled military resupply flights. During ONA, resupply time from RAF Lakenheath (UK) to F-15 FOLs in Italy averaged about two days for avionics Line-Replaceable Units (LRUs).

[10]However, the research indicates that even if the wartime resupply could achieve this breakpoint, the peacetime cost of operating only consolidated CONUS repair locations would be significantly higher than today's cost. The number of peacetime aircraft collocated with repair locations can be as important as the resupply time in some cases. With regional repair locations, several wings could be collocated with peacetime repair locations versus only one wing with consolidated CONUS repair.