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THE APPLICATION OF SUPPLY NETWORK OPTIMIZATION AND LOCATION ANALYSIS TO A DoD REPAIR SUPPLY CHAIN

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A major responsibility of the military and its suppliers is to provide an adequate supply of parts and materials to support warfighters throughout the world. This article reviews a process used by an Army global supply chain to make a location decision for a critical distribution center. Additionally, it demonstrates the applicability of network optimization techniques to a DoD supply chain location analysis problem. Finally, it investigates the feasibility of making a $15 or $25 million capital investment to provide an alternative repair facility.

A major responsibility of the military and its suppliers is to provide an adequate supply of parts and materials to support warfighters throughout the world. The exploitation of supply chains has proven to be critical to the efficient delivery of these resources. One of the major decisions for supply chain managers is to determine the most appropriate location for supply chain facilities such as distribution centers.

Traditional business firms routinely make location decisions. Decisions about where to locate retail outlets, warehouses, offices, and manufacturing facilities are common supply chain decisions (Byrom, Bennison, Hernandez, & Hooper, 2001). Nevertheless, these decisions can become rather complicated as the firm attempts to optimize supply chain performance. The selection of the appropriate blend of proximity to customers, vendors, suppliers, materials, and labor resources while managing financial goals such as lower shipping costs is a significant task for any supply chain

manager (Hernandez & Bennison, 2000). The purpose of this article is to: (a) review a process used by an Army global supply chain to make a location decision for a critical distribution center, and (b) provide a prescriptive procedure for other agencies with similar location decision requirements.

We begin this study by briefly reviewing two relevant location theory frameworks. We then describe the situation underlying the study and the critical supply chain issues. Next, the method and software used in the study are discussed. Following the presentation of the results of the study, we summarize the study and discuss its implications.

LOCATION DECISION THEORY

Two distinct frameworks are used in location theory to describe location decision making in supply chains. The first framework focuses on minimizing cost, while the second framework focuses on market area and demand location. All other approaches to location decision making are combinations of these two major frameworks.

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Minimizing cost and, by proxy, maximizing profit is the first framework in location decision theory. This approach focuses on transportation as the major driver of cost. Nevertheless, transportation must be segmented into the inbound and outbound logistics to gain a complete understanding of its impact on the overall transportation cost. Inbound logistics include all the necessary parts for the production or overhaul of the product. The outbound logistics include all the work in process or final products being shipped to an end consumer or warehouse for storage. Additionally, any items stored at an intermediate storage facility incur additional costs such as transportation cost and carrying cost. Carrying cost includes costs such as storage, re-handling, and in many cases, accounts receivable (Stock & Lambert, 2001).

The second framework is a contrast to the low-cost approach and is based on being customer-centered. The market area or demand-oriented framework proposes that the least-cost approach is only one of multiple approaches to profit maximization (Stock & Lambert, 2001). This argument is based on the notion that customers and suppliers are unevenly dispersed. Hence, a firm can be better served by locating close to its suppliers. Moreover, the firm can better serve its customers by locating close to the customers. This approach would suggest that better serviced firms can better serve their customers, which should yield better satisfied customers. The results should be more repeat customers and greater profits. Of course, maximizing revenue would rarely be the primary objective for a government application. More relevant objectives might include warfighter/customer satisfaction, coverage, or cost minimization.

While both location decision frameworks have their distinct advantages, location decisions in supply chains with complex products and widely dispersed customers require the analyst to account for multiple suppliers and varying supply chains. Therefore, multiple perspectives must be included in a complete analysis of a location decision. Most effective location analyses require that the analyst consider both the cost minimization framework and the customer service framework.

The analysis in this study considers the trade-offs between logistics pipeline costs, in transit time, and the potential capital investment required for a new overhaul facility. The analysis includes the shipment, repair, and return of damaged helicopter blades to and from all key global demand areas to include South Korea, Europe, Southwest Asia (SWA), and installations within the Continental United States (CONUS). Specifically, we use one helicopter platform and its respective blade repair and replacement needs for our analysis. For the purpose of this article, we use the name *Algonquin* rather than the actual name of the helicopter platform.

This study demonstrates the applicability of network optimization techniques to a DoD supply chain location analysis problem. The focus of the study is to determine an estimate of the total annual cost of a particular helicopter platform supply chain operation under several different scenarios. This particular analysis is designed to determine the feasibility of making a $15 or $25 million capital investment to provide an alternative repair facility.

SITUATION AND DECISION PROCESS

The U.S. Army currently operates and maintains a global fleet of approximately 1,700 Algonquin (not the actual name) helicopters of which about 100 belong to the U.S. Air Force. The operating aircraft are equipped with approximately 9,800 blades, which include four main rotor blades on each helicopter and blades that are in the supply system. Over 1,000 (12 percent) of these blades will need maintenance or repair above the field level. The distribution of Algonquin aircraft and the FY06 demand for blade repairs are shown in Table 1.

TABLE 1. GLOBAL DISTRIBUTION AND BLADE REPAIR REQUIREMENTS

Algonquin 2006 Global Distribution and Blade Repair Requirements		
Location	Air Craft	Blades Requiring Repair
CONUS	1076	550
Europe	133	50
Japan	54	11
Hawaii	5	64
Korea	64	22
SW Asia	286	450
Total	**1618**	**2**

The Army Aviation and Missile Command (AMCOM) Integrated Material Management Center (IMMC) manages the transportation, repair, and procurement of Algonquin blades. In FY06, this consisted of 8,300 blades including those installed on helicopters, those in the repair pipeline, and serviceable blades in inventory. Blades removed from helicopters during routine maintenance undergo a comprehensive evaluation. Currently, blades are either repaired at Corpus Christi Army Depot (CCAD), returned to the Original Equipment Manufacturer (OEM) for repair, or scrapped.

As shown in Figure 1, in FY05, CCAD completed repairs on 785 blades and the OEM completed 110. Since some blades are lost or scrapped due to damage or excessive wear, customer demand requires that the overhaul process must be supplemented by the procurement of new blades. Figure 1 also includes the relationships between the number of blades repaired at the CCAD, the number repaired by the OEM, and the number of new blades from procurement contracts for FY04–FY06. Figure 2

FIGURE 1. BLADE REPAIRS AND PROCUREMENT

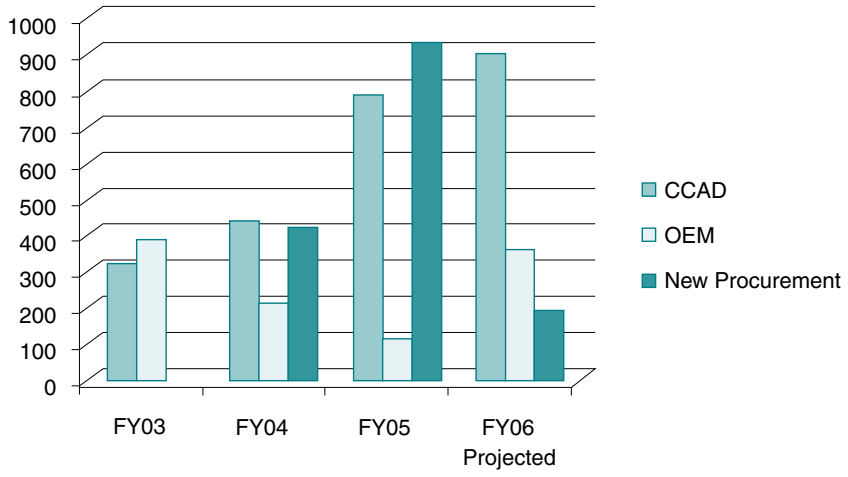


FIGURE 2. GLOBAL REGIONAL DEMAND FOR BLADES

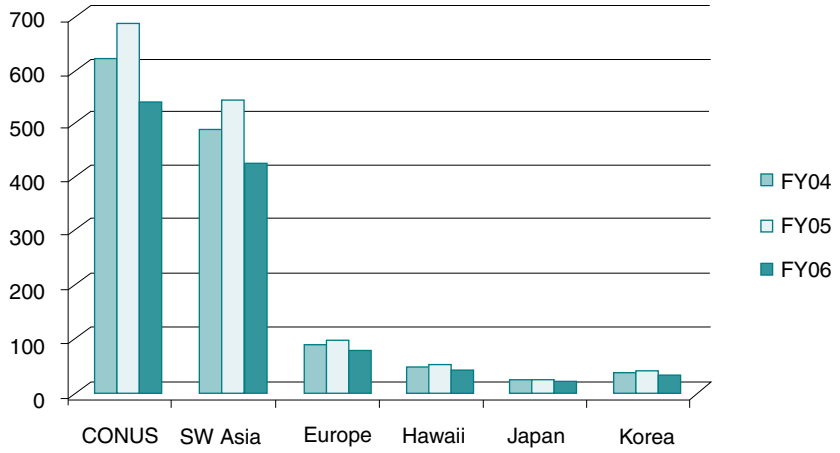


FIGURE 3. ALGONQUIN GLOBAL SUPPLY CHAIN NETWORK

provides a sense of the geographical distribution of blade demand by reporting the global regional demand for blades.

Figure 3 presents an overview of the Algonquin global supply chain network. While the need to return costly blades to the field, the need for good stewardship of the taxpayer's money, and the need to plan for unexpected demands as the military responds to global crisis were the key drivers for the analysis, our effort to identify the optimal supply chain required that we specifically address each of the following issues:

- Where should manufacturing, overhaul/repair, and distribution facilities be located?
- How many facilities are required? Which customers are sourced by which facilities?
- What are the trade-offs between:
  - inbound and outbound transportation costs
  - fixed and variable facility costs?

Responses to these questions require an assessment of several critical input factors:

- customer demand, location, transportation
- production capacities and limitations
- cost differentiation between locations:
  - transportation, distribution, and inventory costs
  - asset limitations.

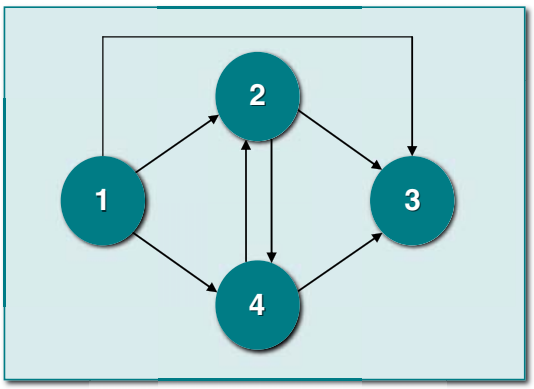
METHOD

THE NETWORK FLOW PROBLEM

The problem to be solved falls within a class of problems known as network flow problems. Network flow problems are essentially an extension of the classic

transportation (and assignment) problem where the task is to determine a feasible transportation pattern for shipping items from a set of origins to a set of destinations in a way that minimizes the total transportation cost. Hitchcock (1941) is generally credited with the original formulation and solution of the transportation problem. The extension to more general network flow problems was a natural progression. Since that time, the fundamental network flow problem and solution techniques have been applied and extended to problems in many areas, including transportation planning (Magnanti & Wong, 1984), location analysis (ReVelle & Eiselt, 2005), production management (Brown, Geoffrion & Bradley, 1981), cash management (Srinivasan, 1974), patient flows in hospitals (Mitropoulos, Mitropoulos, Giannikos, & Sissouras, 2006), and shop floor flows in manufacturing (Stafford, Tseng, and Gupta, 2005).

FIGURE 4. SAMPLE NETWORK



In order to conceptualize the fundamental minimum cost network flow problem, consider a directed network, G, that consists of a finite set of nodes, $N = \{1, 2, \ldots, m\}$ and a set of n directed arcs, $S = \{(i,j), (k,l), \ldots, (s,t)\}$ that join pairs of nodes in set N. Arc (i,j) is said to be incident with nodes i and j, and is directed from node i to node j. As an example, Figure 4 illustrates a network with four nodes and seven arcs. A number, b_i, is associated with each of the nodes in G. A $b_i > 0$ represents an available supply of an item, and $b_i < 0$ represents the required demand for the item. Nodes with $b_i > 0$ are sometimes called sources, and nodes with bi < 0 are sometimes called sinks. If $b_i = 0$, then none of the item is available at that node and none is needed. A node with $b_i = 0$ is sometimes referred to as a transshipment (or intermediate) node. The best example of a transshipment node is a warehouse. Items pass through the node but it is neither their source nor destination. For each arc (i,j), let x_{ij} be the amount of flow on the arc, and c_{ij} be the unit shipping cost along the arc.

Simply stated, the basic problem is to transport the available supply through the network to satisfy demand at minimal cost. Mathematically, the problem can be expressed as:

$$\textit{Minimize} \quad \sum_{i=1}^{m} \sum_{j=1}^{m} c_{ij} x_{ij}$$

$$\textit{Subject to} \quad \sum_{j=1}^{m} x_{ij} - \sum_{k=1}^{m} x_{ki} = b_i \qquad i = 1, \ldots, m$$

$$x_{ij} \geq 0 \qquad i, j = 1, \ldots, m$$

This basic formulation of the problem can be generalized and extended in many ways to include other aspects of network optimization problems. See Hillier & Lieberman (2001) and Winston (1994) for excellent treatments of various applications and solution techniques.

Commercial Off-the-Shelf (COTS) network design software is widely available to design, solve, and analyze many different types of complex network flow problems. LogicNet Plus® was used to perform the optimization modeling for this project. The software is developed by LogicTools Inc. LogicTools specializes in supply chain planning and has a variety of tools in its supply chain suite of software. The LogicNet Plus® software is a design tool that is capable of modeling many aspects of network flow problems, including facility location, warehousing, service requirements, transportation modes, production capacities and limitations, and multiple time periods. The model input requirements include variables related to inbound and outbound transportation costs; fixed facility costs; customer demand, location, and service requirements; and transportation lane constraints.

BASELINE PROBLEM DEFINITION

Recall that the baseline problem in this application assumes the Army Depot at Corpus Christi, Texas (CCAD), is the only repair facility used. As previously discussed, each of the Algonquin helicopters has four main rotor blades. Approximately 12 percent of these blades must be removed each year for maintenance and overhaul. Each blade removed must be shipped from key global demand areas around the world (South Korea, Europe, SWA, and installations within CONUS) to CCAD.

The first step is to develop the basic network configuration. In the baseline problem, the network consists of 11 nodes and 10 arcs, or transportation lanes. A geographical representation of the Algonquin global supply chain network was shown in Figure 3.

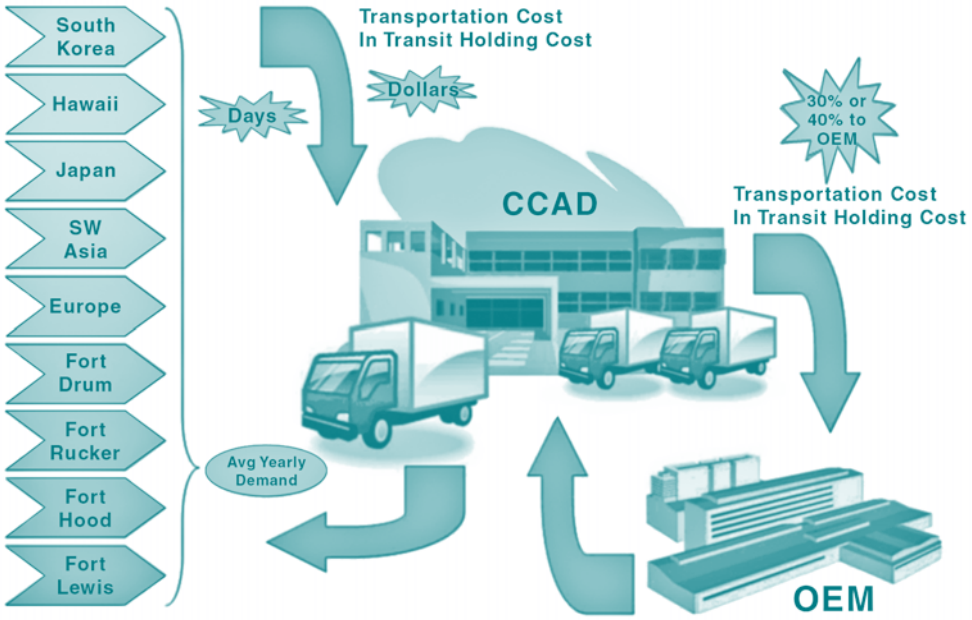
In FY06, the source of blades shipped to CCAD for inspection and repair included approximately 550 blades from installations in CONUS; over 450 blades shipped from SWA; 50 blades from Europe; and about 130 blades from Hawaii, Japan, and Korea. Blades removed during routine maintenance undergo a comprehensive evaluation resulting in the repair categories listed in Table 2.

Currently, blades are repaired at CCAD, the Original Equipment Manufacturer (OEM), or are scrapped. All inspections and all CAT II and CAT III repairs are completed at CCAD. All main rotor blades needing major repairs above the CAT III level

TABLE 2. ARMY REPAIR CATEGORIES

■ CAT I: Unserviceable or waiting inspection
■ CAT II: Repairs up to, but not including, the heat mat
■ CAT III: Candidate for the A3 (RECAP) repair program. *(The difference between the CAT II and CAT III helicopter blade repair is the heater mat for de-icing is replaced at the CAT III level.)*
■ CAT IV: Beyond repair at the Army Depot level, candidate for commercial repair by the OEM on a commercial specification commonly known as strip and rebuild

FIGURE 5. ALGONQUIN GLOBAL BLADE TRANSPORTATION PROCESS



are forwarded from CCAD to the OEM in the northeast United States. A graphical overview of the Algonquin global blade transportation system is illustrated in Figure 5.

Having established the basic supply chain network, there are four principal input data elements to the model:

- **Transportation Cost** represents the cost to ship one helicopter blade from point A to point B. It is based on actual data from historical sources or from direct communication with commercial transport carriers.
- **Transportation Time** represents the time a blade spends in transit. It is based on actual data in the Logistics Information Warehouse (LIW), a database hosted by the U.S. Army Materiel Command, Logistics Support Activity (LOGSA). The segments and time frames are well defined within LOGSA's parameters, and thus are consistent in their development and representation.
- **Demands** are the number of blades demanded by each installation. The demands for a particular region are based upon the total demand worldwide and pro-rated based upon the number of aircraft in that region. For aircraft in SWA, demands are based upon an increased flying hour funding program of three times the level of other regions.
- **Location of Aircraft** is a destination site (i.e., node) where a blade is being shipped. Japan, Hawaii, South Korea, Europe, SWA, and CONUS were determined to be the key destination locations for the blades since they are the locations from which most of the demands originate. CONUS is allocated into four regions with a central location for each of the regions. The central sites were the heavy user sites for helicopters.

The two key sources of data were the LOGSA and U.S. Army Aviation and Missile Command (AMCOM). From AMCOM, the main provider was the Integrated Materiel Management Center (IMMC). LOGSA provided most of the transportation times, and the IMMC provided most of the transportation costs.

Two important additional parameters must be specified for this application. First, recall that not every blade must be returned to the OEM to be refurbished. Therefore, the supply and demand of units across the transportation lane from CCAD to the OEM is a parameter of the model. In the base case scenario, it was assumed that 30 percent of the blades require shipment to the OEM. Second, the number of aircraft stationed in a particular geographic region affects the supply and demand of units across various transportation lanes. Therefore, a second parameter of the model is a reallocation of the number of aircraft across geographical regions. The base case represents the current allocation, but different scenarios are investigated that consider substantial troop withdrawals and redistributions across the world.

Having established the basic network structure with flows and transportation lanes, identified the transportation costs, and defined the transportation times, LogicNet Plus® performs the mathematical optimization that analyzes the various trade-offs between costs and service requirements. LogicNet Plus® is capable of analyzing and displaying a number of solution variables. The purpose of this study is to demonstrate the applicability of network optimization techniques to a DoD supply chain location analysis problem. Hence, we are primarily interested in determining an estimate of the total annual cost of the Algonquin supply chain operation under several different scenarios. The differential annual costs will allow us to determine if making a $15 or $25 million capital investment to provide an alternative repair facility is feasible.

RESULTS

BASELINE PROBLEM

Network optimization software such as LogicNet Plus® is a useful tool for analyzing different network alternatives, as well as the impact of changes in different parameters such as demand, transit times, transportation costs, location, or capital investment costs. Several critical factors are important to the decision in this application. The baseline problem represents the current state of operations where all repairs are handled at CCAD and 30 percent of repairs must be sent to the OEM (i.e., CAT IV repairs). Table 3 summarizes the relevant input variables and parameters of the baseline problem. The per blade transportation costs represent the cost of transporting a single blade from a base facility to CCAD. Retrograde costs correspond to the cost of shipping a blade back to the base from CCAD. Recall that a certain percentage of the blades must be returned to the OEM for repairs. The baseline scenario estimates this percentage at 30 percent. The baseline scenarios also reflect the current allocation of aircraft across the global arena. No reallocation of aircraft is considered. Since no new repair facilities are proposed in the baseline case, there is no capital investment. According to the network model, the baseline supply chain operation for Algonquin rotor blades has an annual cost of $17,990,558. Scenario 1B simply increases the

TABLE 3. BASELINE NETWORK CONFIGURATIONS/DATA/PARAMETER

Model Input Variables	Scenario 1A		Scenario 1B	
Per Blade Transportation Cost	**Forward**	**Retrograde**	**Forward**	**Retrograde**
Fort Lewis	$1714	$1915	$1714	$1915
Fort Hood	$733	$730	$733	$730
Fort Rucker	$1092	$1035	$1092	$1035
Fort Drum	$1604	$1693	$1604	$1693
Hawaii	$6118	$6118	$6118	$6118
Japan	$3811	$3811	$3811	$3811
Korea	$4436	$4915	$4436	$4915
Europe	$3568	$3568	$3568	$3568
SW Asia	$5415	$5415	$5415	$5415
CCAD to OEM	$1599	$1599	$1599	$1599
Days in Transit	**Forward**	**Retrograde**	**Forward**	**Retrograde**
Fort Lewis	9	9	9	9
Fort Hood	1	1	1	1
Fort Rucker	4	4	4	4
Fort Drum	6	6	6	6
Hawaii	50	50	50	50
Japan	42	42	42	42
Korea	42	42	42	42
Europe	196	132	196	132
SW Asia	128	90	128	90
CCAD to OEM	5	5	5	5
Average Yearly Demand				
Fort Lewis	250		250	
Fort Hood	250		250	
Fort Rucker	250		250	
Fort Drum	250		250	
Hawaii	64		64	
Japan	21		21	
Korea	42		42	
Europe	128		128	
SW Asia	788		788	
Study Parameters				
Percent of Blades Sent to OEM for CAT IV Repairs	30%		40%	
Global Aircraft Allocation	Current Allocation		Current Allocation	
Capital Investment	0%		0%	
TOTAL ANNUAL COST	**$17,990,558**		**$18,666,050**	

TABLE 4. ALTERNATIVE NETWORK SCENARIOS

Study Parameters	Repair Location(s)	Percent of Blades Sent to OEM for CAT IV Repairs	Global Aircraft Allocation	TOTAL ANNUAL COST	Annual Cost Savings	Capital Investment	Discounted Payback Period
Scenario 1A (Baseline)	CCAD	30%	Current	**$17,990,558**	--	--	--
Scenario 1B (Baseline)	CCAD	40%	Current	**$18,666,050**	--	--	--
Scenario 2	CCAD Europe	30%	Current	**$14,752,908**	$3,237,650	$15,000,000	**5.4 Years**
Scenario 3A	CCAD SWA	30%	Current	**$9,931,944**	$8,058,614	$15,000,000	**2.01 Years**
Scenario 3B	CCAD SWA	40%	Current	**$11,386,462**	$7,279,588	$25,000,000	**4.3 Years**
Scenario 4A	CCAD	30%	25% SWA Reduction	**$15,568,540**	--	--	--
Scenario 4B	CCAD	30%	50% SWA Reduction	**$13,126,569**	--	--	--
Scenario 4C	CCAD	40%	50% SWA Reduction	**$13,716,095**	--	--	--
Scenario 4D	CCAD SWA	30%	50% SWA Reduction	**$9,097,262**	$4,029,307	$15,000,000	**4.2 Years**
Scenario 4E	CCAD SWA	40%	50% SWA Reduction	**$10,076,303**	$3,050,266	$15,000,000	**5.8 Years**

assumed percentage of blades that must be sent back to the OEM for CAT IV repairs. Increasing that percentage to 40 percent increases the annual cost of the network by $675,492 or 3.75 percent.

LOCATIONAL ANALYSIS

Once the baseline cost of the network has been established, the impact of a change in the network or assumption about the network can be determined. Table 4 summarizes a series of alternative scenarios.

The second and third set of scenarios investigates the feasibility of establishing a second repair depot under various assumptions. Scenario 2 looked at a number of different network configurations that added a second repair facility in either Europe or Korea. The best alternative was to locate the facility in Europe. The annual cost of the network decreases to $14,752,908, producing an annual savings of $3,237,650. Assuming it requires a capital investment of $15 million to build the facility, a simple discounted payback calculation will approximate the financial breakeven point and net present value of the alternative. The discounted payback period (assuming a discount rate of 5 percent) is about 5.4 years for Scenario 2.

The third set of scenarios looked at different network configurations that added a second repair facility in Europe, Korea, or SWA. The best alternative was to locate the facility in SWA. In this case, the annual cost decreased to $9,931,944, an annual savings of $8,058,614. Assuming a capital investment of $15 million, the discounted payback period is just slightly over 2 years. In fact, even if we assume that 40 percent

of the blades must be sent to the OEM and the capital investment is $25 million, the discounted payback period is still 4.3 years (see Scenario 3B). It is not surprising that an additional repair facility in SWA is financially viable. The war in SWA is currently the largest source of demand for blade repairs (see Figure 2). Hence, a repair facility located in the region would drastically reduce the total transportation and in-transit costs associated with shipping blades to and from the largest demand facility.

In anticipation of aircraft being pulled out of SWA, the fourth set of scenarios analyzed the impact of reducing the number of aircraft in the region by 25 and 50 percent. The aircraft were redistributed around the world with the demands adjusted accordingly. The overall effect of such reductions on the total annual cost of the Algonquin supply chain network is substantial. For example, compared to the 1A baseline scenario, the effect of a 25 percent SWA reduction (shown under Scenario 4A) is a decrease in total annual cost of about $2,422,018 (13.5 percent). Reducing the number of SWA aircraft by 50 percent decreases the 1A baseline annual cost even more, to $13,126,569, a 27 percent reduction (see Scenario 4B). If the percentage of blades sent back to the OEM is increased to 40 percent, then the 1B baseline cost is reduced a similar 26.5 percent (see Scenario 4C).

An important question is whether an additional repair facility is still warranted in SWA if there were to be a significant redistribution in the number of aircraft from the region. Scenarios 4D and 4E consider the feasibility of an additional repair facility under such conditions. In Scenario 4D, the number of SWA aircraft is reduced by 50 percent with 30 percent of the blades returned to the OEM. The total annual cost of the network is $9,097,262. This is an annual cost reduction of $4,029,307 over the Scenario 4B cost. The discounted payback period of the cost savings is 4.2 years with a $15 million capital investment, and 7.6 years with $25 million.

If 40 percent of the blades must be returned to the OEM (Scenario 4E), the total annual cost of the network is a little higher at $10,076,303. While this is still an annual cost reduction of $3,050,266 over the Scenario 4C cost, the discounted payback period is 5.8 years with a $15 million capital investment, and over 10 years with $25 million. In this case the project is not financially viable at either a $15 or $25 million capital investment.

SUMMARY AND CONCLUSION

The purpose of this article is to present an analytic process used by an Army global supply chain to make a location decision for a critical distribution center. The task is to determine a feasible transportation pattern for shipping items from a set of origins to a set of destinations in a way that minimizes the total transportation cost. Specifically, the article describes the use of commercial off-the-shelf network design software (LogicNet Plus®) to assess the feasibility of locating additional distribution centers in a global supply chain network designed to support the delivery of helicopter parts.

The process involved first establishing a baseline model (scenario 1), which proposed no new distribution facilities and no reallocation of aircraft. Once the baseline

was established, we considered the feasibility of adding an additional repair facility in Europe or Korea (scenario 2). The analysis revealed that the addition of a $15 million facility in Europe would result in an annual savings of about $3.2 million with a discounted payback of 5.4 years. A third set of alternatives (scenario 3) considered the impact of locating the additional $15 million repair facility in Europe, Korea, or SWA. This analysis revealed that the superior alternative would be to locate the additional facility in SWA with an annual cost reduction of about $8.1 million. The discounted payback would be approximately 2 years. The analyses also considered the impact of changes in the percentage of helicopter blades that would be sent to the OEM for repair. Since the war in SWA is currently the largest source of demand for helicopter blade repairs (see Figure 2), this analysis revealed that the location of a repair facility in SWA would dramatically reduce total transportation and in-transit cost associated with shipping blades from the largest demand facility.

To consider the impact of a redistribution of aircraft in the region, we conducted additional analysis (scenarios 4A and 4B) that considered a reduction of aircraft in the region by 25 and 50 percent. The results of the analysis revealed that the reduction of both 25 and 50 percent results in substantial reductions in total annual supply chain cost. The final analysis (scenarios 4D and 4E) considered the feasibility of adding the $15 or $25 million repair facility under the assumption of a 50 percent reduction in aircraft, as well as alternative assumptions about the percentage of blades that would be sent to the OEM for repair. The results suggest that locating a new facility in SWA, while simultaneously reducing the number of aircraft in the region, would not be financially viable.

This study demonstrates the importance of considering all relevant parameters and alternatives when making decisions about supply chain networks. For instance, assumptions about the size of the customer base (e.g., aircraft) and the number of tasks performed (e.g., number of items repaired in existing facilities) can substantially impact the financial implications of location decisions. The results of this study suggest that the validity of distribution location decisions depend on a comprehensive understanding of the make-up, geographical distribution of customers, and all relevant customer service costs. Also, the cost structure of the network must be known with some certainty to estimate the effects of changes to the system. Finally, this study reveals that sound location decisions require that the both the analysts and managers perform a comprehensive investigation that includes a sensitivity analysis with multiple scenarios.

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