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DESIGNING THE SUPPORT LOGISTICS FOR THE FAA ACE-IDS SYSTEM

Ricki G. Ingalls
John W. Nazemetz

School of Industrial Engineering and Management
322 Engineering North
Oklahoma State University
Stillwater, OK 74078, U.S.A.

ABSTRACT

The Federal Aviation Administration (FAA) is beginning to field the Automated Surface Observing System Controller Equipment – Information Display System (ACE-IDS) and required a study on the service logistics for the system. The ACE-IDS is a combination of commercial-off-the shelf (COTS) and custom built hardware and software components interfaced with existing FAA and National Weather Service (NWS) systems. The ACE-IDS includes a set of networked workstations capable of displaying selected subsets of data from 10,000 predefined screens and extends the capability of the current Automated Surface Observing System (ASOS). These screen displays are populated in real time using data from a variety of FAA and NWS systems such as the ASOS, the Automation of Field Operations and Service (AFOS), and the Flight Data Input/Output (FDIO) systems. This paper outlines a simulation study that was used to develop spares and inventory strategies for the deployment of ACE-IDS.

1 INTRODUCTION

The ACE-IDS system is a combination of ACE Control Cabinets (ACCs), Tower Control Cabinets (TCCs) and workstations. These network systems supply information to the controllers on various types of data, including information from FAA and National Weather Service databases.

This paper outlines the details of the simulation analysis used to propose a logistics system for the FAA ACE-IDS System. This simulation study was part of a larger maintainability study commissioned by the FAA in response to a proposal submitted by the Center for Aircraft and Systems/Support Infrastructure (CASI), a consortia of the University of Oklahoma (OU) System, the University of Tulsa (TU), and Oklahoma State University (OSU) and the A&M System. CASI functions as a statewide center of excellence under the aegis of the Oklahoma State Regents for Higher Education (OSRHE). This simulation analysis was performed in order to estimate the cost, service levels and inventory levels of the system based on the random failures that are expected to be seen in the installed base.

The ACE-IDS system has plans to be deployed to 9 different Terminal Radar Approach Controls (TRACONs) over the next 2 years. A TRACON controls the inbound and outbound traffic to a region about 100 miles in diameter. The TRACONs included in this study are: Atlanta (A80), Boston (BCF), Dallas/Fort Worth (D10), Hawaii (HCF), Northern California (NCT), Oklahoma City (OKC), Potomac (including DCA) (PCT), Seattle (S46), and Gateway-St.Louis (T75). Each of these TRACONs will have their own spares inventories in order to quickly serve the towers in their region. Each tower in a TRACON region could have workstations and/or TCCs.

The Oklahoma City (OKC) Depot serves as a central repair and inventory facility that is used to replenish the TRACON inventories.

The basic problem is as follows:

1. Determine the installation schedule for the ACE-IDS systems at the different TRACONs.
2. Determine the level of TRACON spares inventory and the level of OKC Depot spares inventory based on the installed base.
3. Based on random failures of the installed base, determine the cost, service levels and inventory levels of the system for various spares inventory sizing policies.

2 BASIC PROCESS FLOW

The process flow of any line replaceable unit (LRU) in the ACE-IDS systems begins when the LRU fails in the field. These LRUs are the only parts that flow through the system. This triggers the movement of several parts in the system. The logic outlined below is for three different physical parts (labeled “A”, “B”, and “C”) which are all the same part number and are form, fit and function compatible with each other.

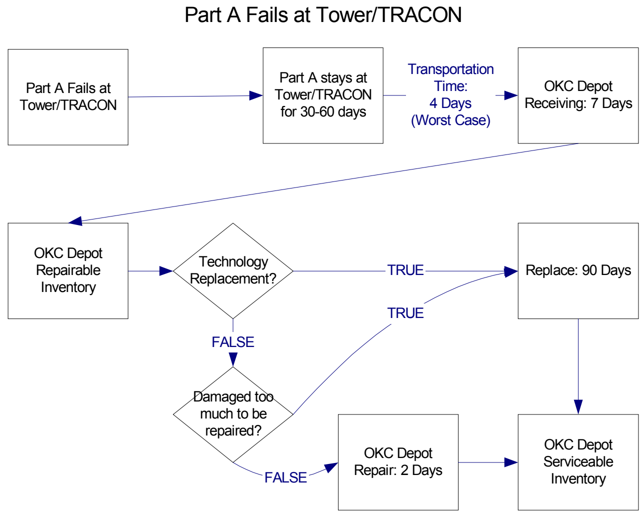

Figure 1: The Logic for the Part that Fails at the Tower/TRACON

As shown in the logic outlined in Figure 1, the flow of part A is tracked, which fails at the tower or at the TRACON. In the simulation, the failure is randomly generated based on the MTBR. When part A fails, it stays at the site for 30-60 days. The simulation assumes that the part stays at the Tower/TRACON for 30 days. At that time, the part is shipped by ground transportation to the OKC Depot. This takes up to 4 days. Upon reaching the Depot, the part is received, which can take 7 days. Once part A is received, it is placed in the OKC Depot repairable inventory, where it stays until the inventory levels in the OKC Depot serviceable inventory become too low for that type of part. When part A is pulled from the repairable inventory, the first decision point is whether or not this part needs to be replaced because a form, fit and function (FFF) technology replacement has been identified. If that is true, then the part is disposed of and a replacement is ordered, which takes approximately 90 days. There is an assumption in the simulation that if a part has been in service for over 5 years and it fails, it will not be repaired because a technology upgrade has been identified. If the part does not have to be replaced because of technology reasons, then there is a chance that the part is simply too damaged to be repaired. If it is too damaged to be repaired, then the part is discarded and a replacement is ordered. There is an assumption that the probability of a part being too damaged to repair is 5%. If part A does not need a technology replacement and can be repaired, then it is sent to the OKC Depot repair and is repaired in approximately 2 days. After the part is either repaired or replaced, then it is put in the OKC Depot serviceable inventory.

The logic outlined in Figure 2 tracks the flow of part B, which is used to replace part A. Part B can come from either the TRACON inventory or the OKC Depot serviceable inventory. Since the preferred source of this part is the local TRACON inventory, the first step is to determine

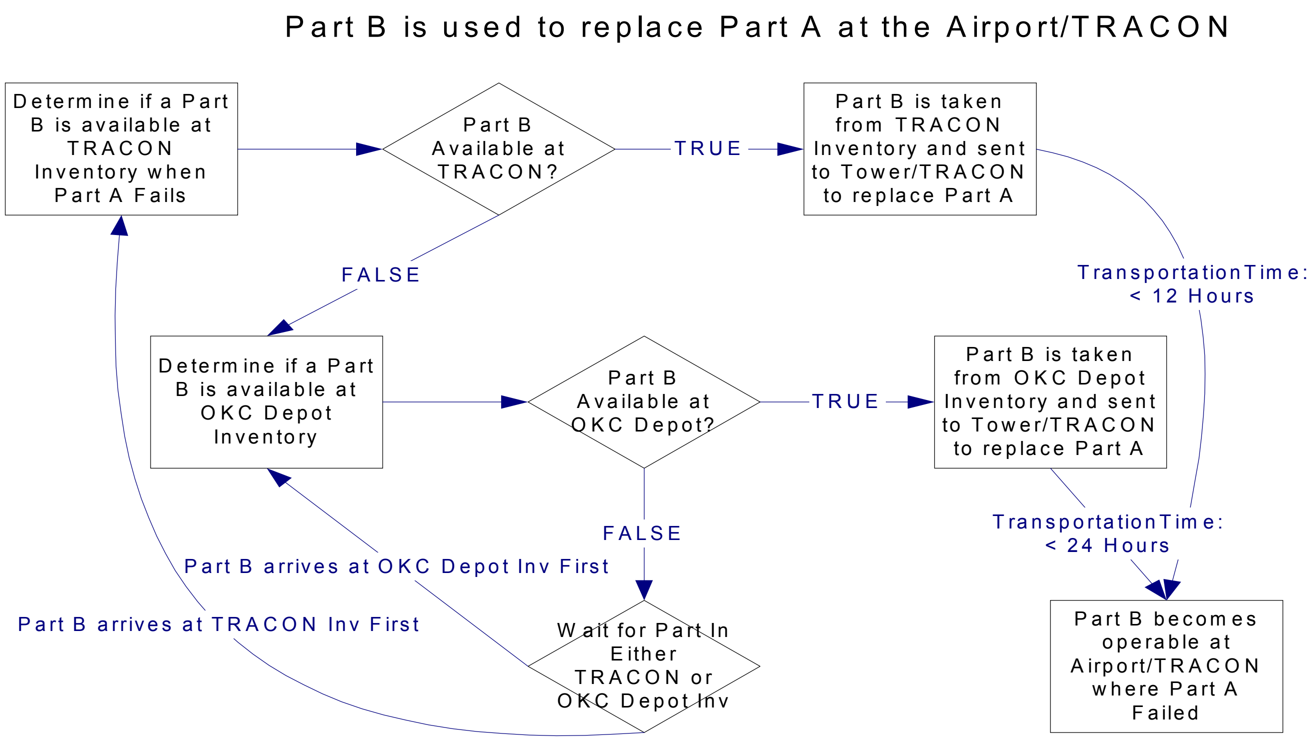

Figure 2: The Logic For the Part that Replaces the Part that Fails at the Tower/TRACON

if part B is available at the TRACON inventory. If it is available, then part B is taken from the TRACON inventory and taken to the Tower/TRACON where part A has failed and installed in part A's place. If the part is not available at the TRACON inventory, then we determine if part B is available at the OKC Depot serviceable inventory. If it is available, then part B is priority 1 shipped (likely by commercial air carrier) from the OKC Depot to the Tower/TRACON where part A failed. It is then installed in part A's place. If neither the TRACON inventory or the OKC serviceable inventory has an available unit of part B, then which ever facility receives a unit of part B first will immediately sends that part to the Tower/TRACON where part A has failed and it is installed in part A's place.

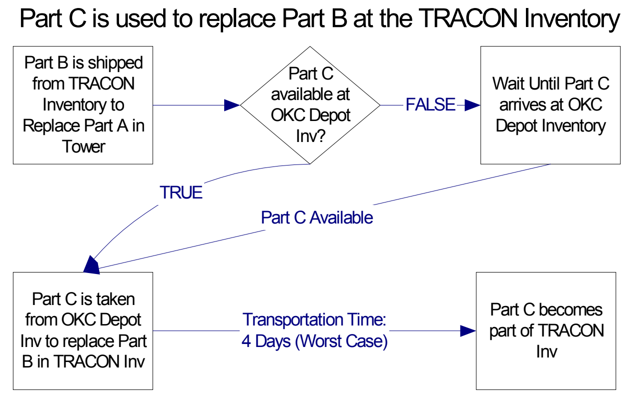

Figure 3: The Logic for the Part Taken from the OKC Depot and Shipped to the TRACON Inventory

The logic outlined in Figure 3 tracks the flow of part C, which is used to replace part B in the TRACON inventory if part B was pulled from the TRACON inventory (which would be the normal flow of material). When part B is pulled from the TRACON inventory, an order is sent to the OKC Depot to send a replacement for part B. If a replacement part (part C) is available, then it is taken from the OKC Depot serviceable inventory and shipped to the TRACON inventory as cheaply as possible. The normal mode of transportation would be ground shipment, which could take up to 4 days. Upon arrival at the TRACON inventory, part C is immediately available to be used as a replacement part for any failures in that TRACON. If part C is not available when the order is received, then the order is backlogged. As soon as a part is available to fill the order, then the part is shipped to the TRACON inventory.

3 METHODOLOGY

The methodology used to perform this analysis was a discrete-event simulation model built in Arena 5.0, a simulation package developed and sold by Rockwell Software [Kelton, et.al, 2001]. This model was run for a 20 year horizon for 20 iterations. Each iteration generates a different random pattern of failures in the field and gathers data on how the proposed system performs under those conditions.

3.1 Scenarios

In order to perform the analysis, 10 different scenarios were developed and analyzed. Scenario 1 sets the TRACON Inventory at 20% of the TRACON installed base, the OKC Depot Inventory at 10% of the total installed base, and the OKC Depot Serviceable Inventory at 3 months of the historical demand. Scenario 2 is the same as scenario 1 except that the TRACON inventory is set at 10% of the TRACON installed base. Scenario 3 is the same as scenario 1 except that the TRACON inventory is set to 5% of the TRACON installed base. Scenario 4 is the same as scenario 1 except the TRACON inventories and the OKC Depot inventories are set by a safety stock formula chosen by the CASI team. This formula, adapted from Simchi-Levi (2000), is shown in equation 1.

$$\begin{array}{l} FL + z\sqrt{FL} \\ \textit{where} \\ F: \ \text{expected failures in a year} \\ L: \ \text{expected lead time for replinishment} \\ z: \ \text{z value for service level desired} \\ \text{(Simchi - Levi, 2000)} \end{array} \qquad (1)$$

For scenario 4, the TRACON service level is set at 99% and the OKC Depot service level is set at 95%. Scenario 5 is the same as scenario 1 except that the TRACON inventories and the OKC Depot inventories are derived by an approximation of the FAA Spares Planning Model (SPM). Scenarios 6 through 10 are the same as scenarios 1 through 5, respectively, except that no repairable inventory is kept at the OKC Depot. Table 1 summarizes the 10 scenarios in the analysis.

Table 1: Scenario Summary

	TRACON Inv	**OKC Depot Inv**	**OKC Depot Serviceable Inv**
1	20% of install	10% of install	3 months
2	10% of install	10% of install	3 months
3	5% of install	10% of install	3 months
4	CASI formula	CASI formula	3 months
5	SPM approx	SPM approx	3 months
6	20% of install	10% of install	No limit
7	10% of install	10% of install	No limit
8	5% of install	10% of install	No limit
9	CASI formula	CASI formula	No limit
10	SPM approx	SPM approx	No limit

These scenarios were chosen for two primary reasons. First, the CASI team has determined that the methodology for setting inventory levels varies inside the FAA. The scenarios reflect several different strategies for setting inventory levels that have been encountered during the study. Scenarios 1, 2, 3, 6, 7, and 8 reflect fixed percentage sparing strategies that were found to be used by the FAA. The CASI approach (scenarios 4 and 9) is a standard safety stock calculation that takes into account the failure rate, the failure variance and the lead times. This standard approach is included to determine if a more standard practice is preferable to strict percentage methods. Scenarios 5 and 10 reflect an approximation of the FAA Spares Planning Model. Using data supplied by the FAA on the SPM, a percentage approximation of the method was developed.

The second reason for the choosing this set of scenarios was to examine the practice of holding inventory at the OKC Depot in "Repairable Inventory." This practice will hold a failed LRU in inventory until that LRU is needed to replenish the OKC Depot serviceable inventory. This practice may help with scheduling during peak periods, but it can arbitrarily hold back inventory that could be repaired and be put into serviceable inventory.

3.2 Data Inputs

Data inputs were taken from a variety of sources, both public and from FAA. The data inputs included deployment schedules, spares calculation methodology, failure rates, transportation rates, material costs, and repair costs.

3.3 Key Assumptions

There are several key assumptions in the model. It is the belief of the investigators on this project that none of these assumptions would substantially change the outputs or the recommendations in the model. The key assumptions in the model are outlined in Table 2.

4 ANALYSIS

As outlined above, the analysis studied 10 different scenarios. Together, the 10 scenarios provide an interesting picture of the effects of inventory policy and the OKC Depot repairable inventory. The first two figures, 4 and 5, show the total cost over the twenty-year horizon of the model. Figure 4 shows that scenarios 4 and 9 are clearly the least expensive and Figure 5 shows why. It is simply because less material is bought in the program startup and throughout the life of the program. Another key observations is the relatively small amount of transportation cost when compared to the material and depot costs in the system.

In Figures 6 and 7, it is shown that scenarios 4 and 9 do not hurt service levels at either the OKC Depot or at the TRACONs. It also shows that the scenarios that do not have repairable inventory (scenarios 6-10) consistently outperform the scenarios that keep repairable inventory (scenarios 1-5). The OKC Depot service level increases by 1.6% to 2.3%. For this analysis, service level for the OKC Depot is defined as the percentage of time that inventory is available to fill an order as soon as the order is placed. For the TRACONs, service level is defined as the percentage of time that TRACON inventory is available when a part fails in the TRACON.

Table 2: Model Assumptions

Assumption	Justification of Assumption
All LRUs in the system could be repaired by the depot.	We did not have good information on which parts would have to be replaced instead of repaired.
The technology cycle is 5 years. If a part is in use for 5 years and fails, then it is replaced by a FFF upgrade.	It is a reasonable assumption that these COTS parts would have technology FFF replacements in 5 years
All installed base parts were installed at the TRACONs and not at the towers.	We never received detailed information on how many units (i.e. workstations) would be installed at each tower. Although the simulation was programmed to use this information, there is very little (if any) impact on the output of the model because of this assumption.
The implementation schedule is 1 year behind schedule provided by FAA.	This seems reasonable since the OKC TRACON/Tower installation is shown as March, 2001, and that installation has just begun. The overall costs of the program would not be affected by this shift in installation.
MTBR is exponentially distributed	This is a common assumption on electromechanical components.
If a replacement part is not available at either the local TRACON or at the OKC Depot, we do not take it from another TRACON.	Although this might happen in practice, the logic is very complicated and it is a very rare occurrence.

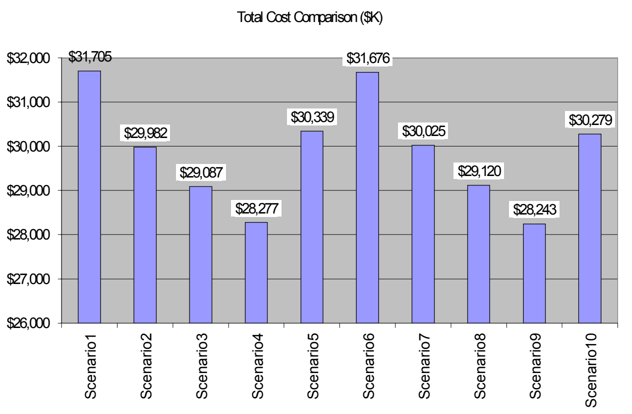

Figure 4: Total Cost Comparison

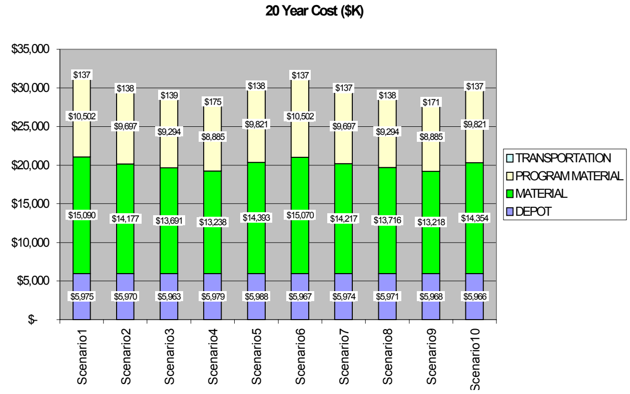

Figure 5: Total Cost Comparison Broken Down by Category

In Figure 8, it is shown that inventory values are greatly reduced in scenarios 4 and 9. As mentioned above, service levels do not decrease for these scenarios as compared to the others.

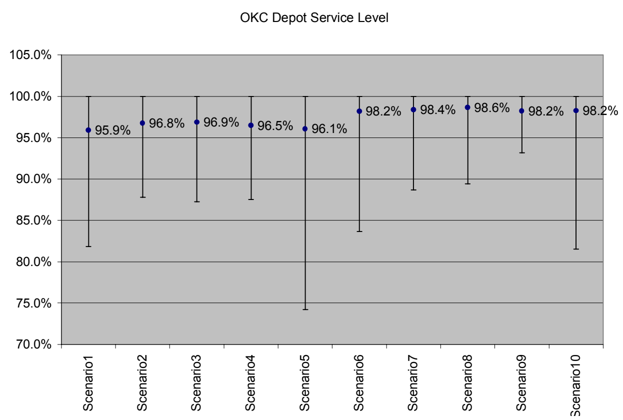

Figure 6: OKC Depot Service Level Comparison

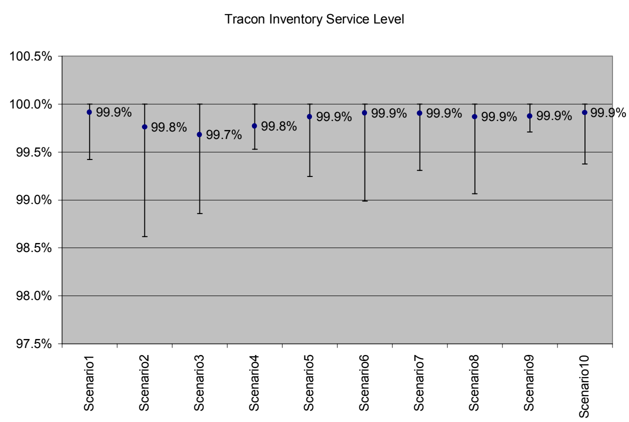

Figure 7: TRACON Service Level Comparison

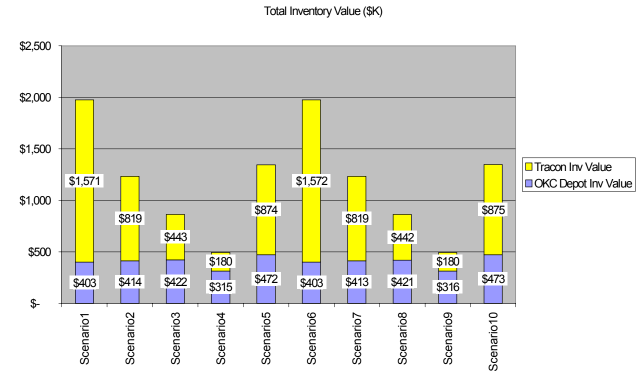

Figure 8: Total Inventory Value Comparison

5 RECOMMENDATIONS

This study provides recommendations in two areas, inventory policy and the use of repairable inventory. With regard to the inventory policy that FAA should adapt for the ACE-IDS product, we recommend a standard safety stock calculation for spares levels as shown in scenarios 4 and 9. We recommend this approach because of the reduced cost and reduced inventory value without a loss of service level.

With regard to whether or not repairable inventory is necessary at the OKC Depot, we recommend that repairable inventory should be eliminated. Parts that arrive at the OKC Depot should be repaired or replaced as quickly as possible and placed into serviceable inventory. We recommend this based on the better service level performance in scenarios 6-10 as compared to scenarios 1-5. The OKC Depot service level should increase between 1.6% and 2.3%.

The combination of both recommendations can be found in scenario 9. The combination found in scenario 9 provides the highest service levels for the least cost and the lowest inventory levels.

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AUTHOR BIOGRAPHIES

RICKI G. INGALLS is an Associate Professor and the Director of the Supply Chain Design Lab in the School of Industrial Engineering and Management at Oklahoma State University. He joined OSU after 16 years in industry with Compaq, SEMATECH, General Electric and Motorola. He has a B.S. in Mathematics from East Texas Baptist College (1982), a M.S. in Industrial Engineering from Texas A&M University (1984) and a Ph.D. in Management Science from the University of Texas at Austin (1999). His research interests include the supply chain design issues and the development and application of qualitative discrete-event simulation. He is a member of IIE. His email address is <ingalls@okstate.edu>.

JOHN W. NAZEMETZ is an Associate Professor and Director of the Manufacturing Systems Engineering Master's Program in the School of Industrial Engineering and Management at Oklahoma State University. He received his B.S. (1973) and his Ph.D. (1978) in Industrial Engineering from Lehigh University. His research interests include manufacturing systems, manufacturing information modeling and exchange, and support of the development of ISO standards for industrial data.