Final Report For DLA Aging Aircraft Initiative: Managing Low Volume Parts

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Executive Summary:
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The Low Volume Parts Problem

Waiting for parts, or cannibalizing them from other systems, often characterizes planned and unplanned maintenance of Department of Defense (DoD) weapon systems. Late parts, in turn, keep those systems non-combat ready for unacceptably long periods of time. Further, conventional wisdom suggests that the main culprits are a relatively small minority of parts, namely low volume parts with complex components.

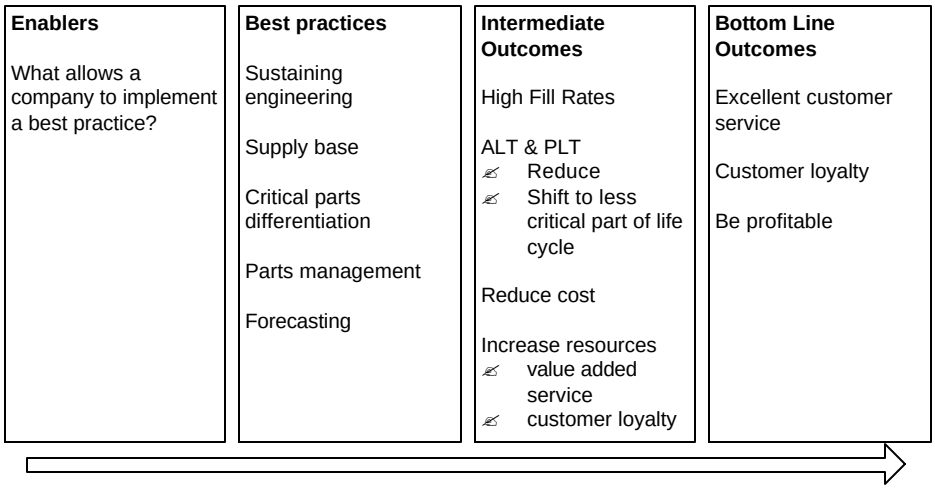
Search for Solutions: Interview Commercial Companies

The primary objective of this project was to improve our understanding of the problems involved with low volume, complex parts by finding and analyzing good practices in the commercial sector. The secondary objective was to develop a business case for the DoD to implement appropriate variants of those good practices. Since there are few analogous situations in commercial aircraft maintenance to benchmark against, we examined similar situations in other industries, primarily heavy machinery and heavy equipment industries, with some cases from commercial aircraft. To be included in the study, a company had to sell low volume, complex, mechanical parts to commercial (i.e. non-defense) customers. Eight companies were studied.

Findings

Interview results were content-analyzed with an eye toward understanding what companies did to manage low volume parts, how they were able to do it, and why particular results were achieved. A four-stage model emerged that suggests general organizational enablers promote specific best practices, and these best practices, in turn, improve intermediate and bottom line performance (Figure 1).

Figure 1:Causal Model of Findings



The key finding with respect to bottom line performance was that these companies were committed to, and succeeded at, maintaining customer loyalty while at the same time running their spares business at a profit. They saw maintaining loyalty as a critical strategic activity, primarily because their products were very expensive and very long-lived. For these companies, it was important to make sure that when a new purchase was made, perhaps only once every few decades, that return business was acquired. But because short-term profitability also mattered, selling spare parts had to be profitable.

Data concerning intermediate outcomes yielded three insights. First, is that considerable effort, including financial, was put into achieving lower costs, shorter lead times, and fast response to customer requests. Success in achieving these results is what allowed the companies to sell spare parts at a profit (often a high profit), and still maintain customer loyalty. Second, and less obvious, was how lower lead times were achieved. In many cases, administrative and production lead times (ALT and PLT) were reduced in absolute terms. In many other cases, however, the improvement came from shifting when lead time was incurred in a product life cycle, rather than in actually making the time shorter. The result was that while cycle time from for a process was little changed, *the customer saw very short lead times*. One example of this phenomenon is the stocking of critical parts. Neither PLT nor ALT between manufacturer and supplier change, but lead time from the customer's point of view is minimal. A second example is establishing blanket ordering agreements. Administrative lead time for this process might actually be quite lengthy, but its consequence is very short ALT when a customer's order needs to be passed from a manufacturer to a supplier. Finally, companies are acutely aware that sometimes improving both short and long term performance requires implementing business processes that increase costs. As examples, a company might stock "machine down" components in inventory, guarantee a customer's up time, or organize up to sell value-added inventory management services.

Best practices aggregated into five high level categories: Sustaining Engineering, Supply Base, Parts Management, Parts Differentiation and Forecasting. Sustaining Engineering is defined as engineering efforts aimed at improving product availability, reliability, and/or supportability. One major element of sustaining engineering is "tooling and technical data". All companies interviewed were able to access technical data for every part they ever made. The second important element of sustaining engineering is a collection of processes that related to the physical content and quality of parts. Examples of these practices include delayed product differentiation, technical assistance centers, parting out of components, and obsolescence management programs.

Supply base practices are formal and informal supply chain relationships that affect a company's ability to meet customer demand. These practices involve relationship mechanisms (contracts and trust), supply base structure, and materials and data exchange. While some companies used long term contracts and blanket orders to good effect, all worked deliberately at nurturing trust relationships. Supply base structuring involved a variety of activities, all generally aimed at rationalizing the supply base by either decreasing the number of suppliers, developing new (and if needed multiple) suppliers, or improving supplier management practices.

Parts management are practices for good parts and inventory management. Those we identified all had roots in three broad areas, how companies: dealt with organizational behavior and human resources, managed inventory, or interacted with customers. In the first instance, success was based on drawing on very experienced personnel, and deploying them in cross-functional, centralized teams. Inventory management was a collection of practices involving lead time reduction, systematic destocking, and obsolescence management. Interaction with customers was often used as a scanning mechanism to detect unexpected demand, or assuring that customers had access to empowered employees who could make price and delivery commitments.

Parts differentiation practices recognize that parts should be treated differently depending on variables such as criticality to a product in the field, or demand volume. Companies realized that good customer service and a profitable spare parts business requires investing inventory for parts that are critical and/or have long lead times. In addition to the question of simple availability, however, many companies instituted special business processes to assure that parts-specific problems could be solved. Examples include practices such as cross-functional problem solving groups, arrangements to draw spare parts from Production, or special service for parts that resulted in a "machine down".

All the companies regarded forecasting the demand for low volume parts as problematic. A few companies claimed to do reasonably good low volume forecasting, but the actual quality of their forecasting could not be determined, nor did project resources allow in-depth analysis of the forecasting techniques used. (Further investigation of these cases is most certainly warranted.) It is clear, however, that the lower the volume to be forecasted, the greater the reliance on combining human intelligence and knowledge with mathematical forecasting methods.

The best practices above are possible only because of more general cultural and organizational conditions within their host organizations. Four such enablers were discerned: organizational support for change human resources, data and information, and innovative business models. Organizational support was a combination of cultural values, formal incentive systems, and management support that allowed (and sometimes forced) innovation and experimentation. Very experienced and knowledgeable people who could be trusted to make commitments to customers, and to understand and solve internal problems implemented these changes. Throughout, people operated with good information. Whatever impediments people faced, one problem was not access to information. Whether it was the location of a part, or a technical question about its performance, people could safely assume that an expert or a database would provide trustworthy information. Finally, the companies in our sample were willing to risk experimentation with new business models. A few examples of these innovations are guaranteeing customers' up-time, managing customers' inventory, and sharing inventory with suppliers. It is not the details of these ventures that matter. What matters is that fact that companies realize that supplying low volume parts and maintaining customer loyalty requires new business models that go beyond high fill rates and short order lead times.

Implications for the Defense Logistics Agency

All the companies studied had a strong "low volume parts" culture and a pervasive commitment to customer satisfaction. Resources backed up culture and commitment, and all three factors combined to allow the companies to treat low volume parts differently from normal operations. In contrast, DLA appears to follow the same processes for all parts, regardless of volume. While DLA is not (and should not be) free to import any and all commercial practice, DLA can actively seek ways to adapt many of those practices in context-appropriate ways that recognize what the commercial world knows so well, that low volume parts need special treatment. One useful tactic is to implement procedures that substitute fast reaction for inventory. An important step beyond process improvement would be to investigate the feasibility of developing a separate organization within the DLA devoted to low volume parts. The focus would not be on dealing with emergencies, but with efficient routine ways to assure low volume parts when they are needed. Third, DLA might go even further, and consider a separate outsourced organization for low volume parts. Such an organization may be desirable because present DLA systems, practices, organizational structure, and culture are optimized for high volumes, or at least,

predictable demand. It may be disruptive to present efficiencies, and an impediment for effective low volume management, to tightly integrate high and low volume operations. Most of the findings and recommendations dealt with the organization of business process. However, some information on forecasting techniques was also uncovered. Our interviews produced solid evidence that some commercial firms are using a demand peak approach, of the coupled with strong human expertise. In light of this finding, DLA's current efforts to develop and deploy peak demand methods should be encouraged.

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1 Objectives and Expected Benefits

The primary objective of this project was to improve our understanding of the problems involved with low volume, complex parts, by finding and analyzing good practices in the commercial sector. Previous benchmarking type projects have been aimed at supply-chain issues, maintenance issues, and improving throughput in high volume, commercial product lines from companies like Boeing, Delta, Chrysler, etc. Our approach was targeted to the specific conditions of complex, low volume parts, which requires us to also look outside commercial aircraft.

The secondary objective of this project was to develop a business case based on processes to streamline and accelerate the production and delivery low volume parts with complex components in the commercial sector. There are few analogous situations in commercial aircraft maintenance to benchmark against, so we examined similar situations in other industries, primarily in heavy machinery and heavy equipment industries, with some cases from commercial aircraft.

2 Background

Waiting for parts, or cannibalizing them from other systems, often characterizes planned and unplanned maintenance of Department of Defense (DoD) weapon systems. This, in turn, keeps those systems non-combat ready much longer than anticipated. There is considerable anecdotal evidence to suggest that a minority of parts, namely low volume parts with complex components, cause the majority of problems. The lack of a single critical component is often all it takes to ground a plane. This study focused on systems having similar maintenance issues rather than focusing on similar products, as has generally been the case.

A major contributing factor to the lack of available parts problem is that many weapon systems have had their use life extended far longer than originally planned and provided for. Maintaining these systems is also made more difficult because:

- Many systems exhibit a high degree of variability. For instance, C-130s can differ considerably because of configurations due to modernization or modification for special missions.
- Many systems are technically complex.
- Technical data is sometimes either missing or out-of-date.
- Many of the original vendors of components are no longer in the business.
- Need is unpredictable, making forecasting extremely difficult.
- There are a lot of parts in major weapon systems which fail very infrequently, making stocking spares financially unrealistic.
- Many parts are long out of production.

All Services and the Defense Logistics Agency (DLA) experience problems with low volume parts containing complex components. As a result, there have been multiple efforts, by the Services, DLA, and various vendors to improve the forecasting, purchasing, stocking, and delivery of parts in support of maintenance functions. Considerable progress has been made in dealing with high volume, predictable-demand items using arrangements including Prime Vendor, Virtual Prime Vendor, Corporate Contracts and Strategic Sourcing Alliances. To date, however, none of these programs have effectively addressed how to deal with low volume and unpredictable component demand. These efforts indicate both the difficulty and the need for creating a good business case for low volume parts with complex components within the defense industry.

3 How Companies Were Selected for the Study

3.1 Selection Criteria

Companies were selected for this study based on the following five criteria:

3.1.1 Low Volume

The company performs a low volume parts supply function. Since there were a variety of industry sectors included in the study, it was decided to define low volume in terms of the unpredictability of demand as well as the number of units. The Defense Logistics Agency uses the 4/12/12 rule to decide whether or not to stock an item, defined as 4 demands over a 12-month period for 12 units. Companies were selected that roughly fit within an envelope of four or fewer demands in a 12-month period for a total of 11 or fewer units.

3.1.2 Mechanical and Electromechanical

The low volume parts involved were predominantly mechanical or electromechanical. The Diminishing Manufacturing Sources and Material Shortages (DMSMS) Program is already dealing with electronic parts.

3.1.3 Complex:

The companies have a significant number of low volume parts that are relatively complex. The implications of complexity are two-fold. One is a general relationship between complexity and cost. More complex items generally cost more and would therefore enable the analysis of the parts management process where there is financial pressure to not inventory these items. A second implication involves the relationship between complexity to lead-time and number of sources. The greater the complexity the longer the expected lead-time and the fewer the number of sources. This makes managing low volume parts more difficult

Complexity also includes the technical complexity of the part, amount of unique content and complexity of the supply chain for that part. Technical complexity is defined as the extent to which a part is difficult to make (i.e., requires a specialized process). Unique content is whether the part requires an exotic material or a hard to find component. While a part may not be particularly technically complex, its unique content could make getting the part when needed a real problem. Complexity of the supply chain is also important. The supply chain for a part could be very large and or require sophisticated suppliers (e.g. a technically complex manufacturing process).

3.1.4 Commercial

The companies selected were primarily commercial or the government portion was organizationally separate from the commercial. The purpose of the project is to look at commercial practices, so we avoided companies whose practices are likely to have been influenced by government procurement.

3.1.5 Willingness to Participate

Last but not least, the company must be willing to entertain a visit from the project team. Companies that we have had on-going relationships with were contacted first to see if they would be willing to participate.

3.2 Industry Sectors in Priority Order

Considering the criteria above of low volume, complex, mechanical or electromechanical parts and commercial companies, the following four industry sectors were chosen to concentrate our efforts:

1. Aircraft
2. Machine tool
3. Heavy equipment and specialty trucks
4. Large engines and transmissions

3.3 Identifying Potential Respondent Companies

A list of possible respondent companies was developed from the background and experience of project staff, collaboration with the Aging Aircraft project oversight team, and a search of the Web. In all, 46 candidate companies were identified. Most of the candidates were called in order to generate our final sample of eight companies.

4 Data Collection Process and Protocols

4.1 Contacting Companies and Respondents Within Companies

The following steps were followed to contact companies and schedule data collection activities:

4.1.1 Identify Gatekeepers

Gatekeepers were identified as individuals within the respondent companies that either have or can easily acquire knowledge of and contacts with the LVP function. The ideal gatekeeper was defined as someone we know that is highly placed in the respondent company and responsible for low volume parts. In the absence of personal contacts with people in companies responsible for low volume parts, gatekeepers were identified from what personal contacts we did have in these companies and searches of the literature, including the Web.

4.1.2 Contact Gatekeepers

In some cases it took a number of calls within a company to reach a gatekeeper. The basic protocol was to provide whomever we were talking to with an overview of the project, Altarum, the topics that the study would cover, and what the respondent company would get out of participating in the project.

4.1.3 Identifying Individual Respondents and Scheduling Interviews

Once a gatekeeper was identified it was necessary to carefully probe the extent of his or her individual knowledge. For this project, we needed to know in general terms about strategy, and in more detailed terms about management processes and procedures, for dealing with low volume parts. In order for the respondent to understand both the breadth and depth of our information requirement, it was necessary to give them an idea of the questions that would be asked either over the phone or by email. This helped the gatekeeper to determine whom we should talk to during the interview. For scheduling the interviews, we were specific about time requirements. In general, the interview took about one hour per respondent.

4.2 Conducting the Interview

There are three major tasks involved with conducting the interview:

4.2.1 Getting Ready

After the interview was scheduled, data readily available from accessible sources, such as company Web pages was gathered. Further, company respondents were encouraged to send background information prior to the interview. A copy of the interview protocol was sent to the respondents to help them identify appropriate documents and otherwise get ready for the interview. The project members assigned to conduct the interview visited the company's Web page and read all available background information prior to the visit.

4.2.2 Administering the Interview

At least two people were assigned to each interview: one to be the primary interviewer and the other to be the primary note taker. The interviewer would also take notes, concentrating on key points that emerged. The interviewer was responsible for time management. The note taker was mostly silent talking only to clarify his notes, ask questions the interviewer had missed, or follow an important thought thread.

At the start of the interview we provided the respondents with an overview of the project, Altarum, the topics that the study would cover, and what the respondent company would get out of the study. The respondents were also given assurance of confidentiality in general publications of the results of the study. Tape recorders were used in some cases to help in taking notes.

4.2.3 Debriefing

As soon as all interviews were completed the interviewer and note taker went over their notes to clear up ambiguities or disagreements. They also discussed initial impressions of the main points that they would like to emphasize from the interview.

4.3 The Interview Protocol

The interview protocol covered the following general topic areas: (A complete copy of the protocol can be found in Appendix A.)

- Personal Information,
- Business Profile For Low Volume Parts,

- Organization Profile For Low Volume Parts,
- Process Overview For Outsourced Low Volume Parts Management,
- Process Overview For In-House Management,
- Demand Forecasting,
- Low Volume Parts Inventory Tactics For Safety Stock,
- Outsourced Production And In-House Production, and
- Low Volume Parts Performance.

4.4 Writing Up the Results of the Interview

Result write-ups went through a series of collaborations. First, the designated note taker wrote a draft and passed it to his interview partner, who added and modified as he deemed appropriate. Next, the entire project team reviewed the draft. They were given the opportunity to raise questions and suggest follow-up issues that might be addressed to respondents. We found this process to be extremely productive. The initial phase resulted in a complete set of notes, and the whole-team review revealed many important insights and ideas for further investigation. Notes were then passed to respondents for review, who were diligent in answering questions and making corrections. In fact, the process of internal review and communication with respondents often went through several rounds of both email and phone conversation. While the majority of this interaction occurred within a few weeks of the initial interview, in many cases it was a protracted process. As data were analyzed across interviews, it was common for the team to come up with new questions about particular issues in particular interviews. At these times respondents showed an admirable willingness to engage in further conversation.

5 Results

5.1 Companies Visited

Below is a brief description of the industry sector of each of the eight companies visited and how they defined low volume parts:

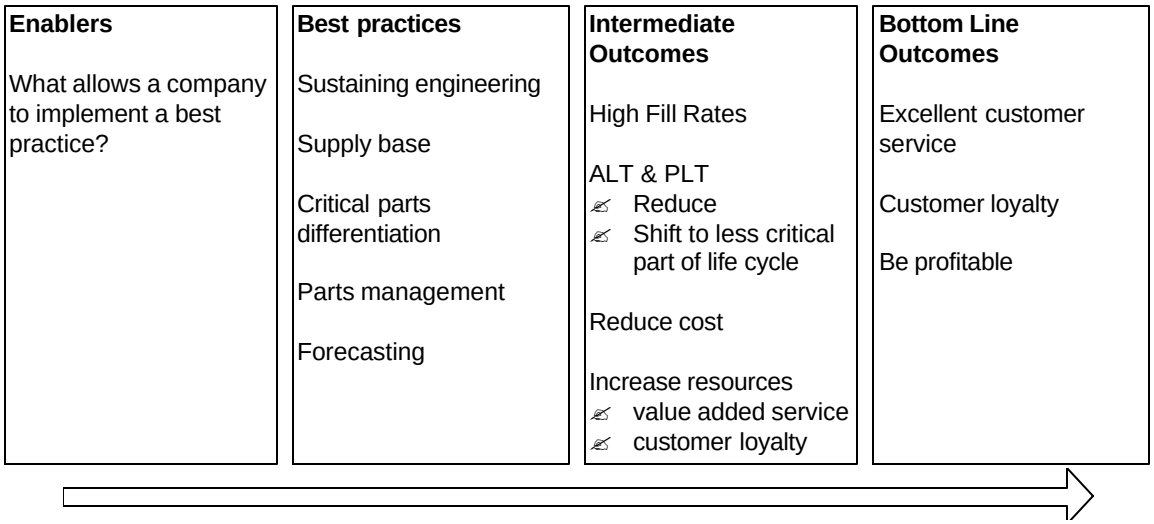
	Type of Manufacturer	**Definition of Low Volume Part**
1	Commercial aircraft	o No formal definition of “low volume” o Put special emphasis on “unplanned demand”, i.e. orders for which there was no forecast.
2	HVAC and refrigeration equipment for commercial, residential and transportation	o 1-2 or fewer parts annually
3	Construction and mining, diesel & natural gas engines, industrial gas turbines	o Less than one per month
4	Farm equipment, construction, forestry and lawn care equipment	o 1 to 100 demands annually or, o $1400 or less in orders annually.
5	Multi-national supplier of machine tools.	o One-of or very low lot sizes. o Essentially all spare parts are considered low volume.

	Type of Manufacturer	Definition of Low Volume Part
6	Trucks and truck bodies for defense, construction, fire/emergency, refuse and snow removal.	o 2 demands or less annually.
7	Elevators, escalators, moving walks, horizontal transportation systems.	o 1 –3 or fewer parts annually
8	Distributor of OEM approved out of production power train parts.	o All parts are low volume.

5.2 Variable Domains and Relationships Among These Domains

Interview results were content-analyzed with an eye toward understanding what companies did, how they were able to do it, and why particular results were achieved. From this exercise came the four stage model shown in Figure 1.

Figure 1: Causal Model of Findings



1. Bottom line outcomes: Business metrics that have an immediate impact on a company's viability, e.g. profit, customer loyalty.
2. Intermediate outcomes: Business metrics that can be affected directly by a procedure or an action, e.g. Administrative Lead Time (ALT), Production Lead Time (PLT).
3. Best practices: Specific activities or services that can effect desirable business outcomes, e.g. technical data management.
4. Enablers: Generalized cultural or organizational conditions that allow a best practice to be implemented and to work, e.g. incentive system, cultural willingness to change.

While findings from this study illustrate the general flow of relationships among elements of in the model, there was not enough quantitative data or in depth qualitative data to show causal relationships among particular enablers, practices, and outcomes.

5.3 Bottom Line Outcomes

There were three basic bottom line outcomes identified: (1) excellent customer service, (2) customer loyalty, and (3) profitability. All of the companies were concerned about maintaining customer loyalty and excellent customer service. Their products had very long life cycles and they all had an almost fanatical commitment to maintaining aging equipment. The business reason for providing excellent customer service was to assure customer loyalty through return business for spares (all companies) or for new replacement products (seven OEMs).

Making a profit was important in seven of the companies in both providing parts and services on low volume parts. In one case, low volume parts were considered a cost center, which was expected to breakeven on parts and services.

5.4 Intermediate Outcomes

Intermediate outcomes were high fill rates, short lead times (ALT and PLT), lower costs and increased resources for the low volume parts function.

5.4.1 Fill Rates

Fill rate is defined as having an item in stock when the order comes in. All but one of the companies had very high fill rates, and in that company the low fill rate was by design. No stock is kept for any part. In some cases respondents could easily specify their "fill rate" by citing a single number. In other cases, complexities of business process required a more complex answer. Fill rates for the companies interviewed were as follows.

	Type of Manufacturer	Fill Rate
1	Commercial aircraft	o All flight critical parts are maintained in inventory. o 55- 60% of non-stocked items are filled from inventory. o 97% of Web based catalogue items are filled from stock.
2	HVAC and refrigeration equipment for commercial, residential and transportation	o Recent improvement from 80% to 97%.
3	Construction and mining, diesel & natural gas engines, industrial gas turbines	o Parts can be filled from local and regional centers 95 – 96% of the time. o If one center doesn't have a part, another will 97 – 98% of the time. o If part is not available from any center, it can be found in suppliers' inventory and company production 99.7% of the time.

	Type of Manufacturer	Fill Rate
4	Farm equipment, construction, forestry and lawn care equipment	o 99.3% for machine down situations, with searches across local and regiona1 centers, suppliers' inventory and company production
5	Multi-national supplier of machine tools.	o 1%. Deliberately maintain minimal stock. o 70% of all orders ship within 30 days, 90% 60 days, and 98% 90 days.
6	Trucks and truck bodies for defense, construction, fire/emergency, refuse and snow removal.	o 80 – 92% depending on product lines.
7	Elevators, escalators, moving walks, horizontal transportation systems.	o 95%.
8	Distributor of OEM approved out of production power train parts.	o 95%

5.4.2 Lead Time

All of the companies interviewed emphasized reducing both ALT and PLT as a major effort for the low volume parts function. Typically the companies were involved in some form of process reengineering on a reoccurring or continuous bases. These efforts had resulted in absolute reductions in ALT and PLT. Some companies were engaged in very interesting and innovative ways of shifting ALT and PLT to less critical times in the life cycle. For example, one company maintained an inventory of long lead-time components, such as raw castings for parts suppliers. Another maintained raw castings that could be used for a variety of different parts.

In the companies interviewed ALT was generally 24 hours for stocked items. In one case it was four hours from order receipt to loading dock.

ALT was generally less than 3 days for not-stocked items. In three companies ALT had a three days maximum. In another company it was a five days maximum. All of the companies expressed astonishment (even disbelief) at DLA's typical ALTs.

While lead time for ALT and PLT for non-stocked items vary greatly, the general pattern was one of high responsiveness to customer needs, resulting in considerable effort to keep lead time to a minimum. A summary of lead times and responses to non-stocked items appears below.

	Type of Manufacturer	Lead Time
1	Commercial aircraft	o Not stocked items for AOG (aircraft on ground) = 60% of demand. o Even though the AOG designation by customers is often suspect, orders are given "24/7" attention. o Priorities are pushed down to suppliers, either

	Type of Manufacturer	Lead Time
		through contract provisions for priority parts or general cultural sensitivity in the industry to the need.
2	HVAC and refrigeration equipment for commercial, residential and transportation	o High cost, low volume, castings required in 20% of all parts ordered. Requires a three-week lead-time. o Made to order, engineered, suppliers out of business, or archaic materials account for 5% of orders and require 3 –12 weeks lead-time.
3	Construction and mining, diesel & natural gas engines, industrial gas turbines	o Backorders account for 2 to 3% of all orders and are processed within 24 hours. o Lead time for these orders ranges from four weeks to six months.
4	Farm equipment, construction, forestry and lawn care equipment	o ALT for not stocked items is three weeks maximum o PLT from 20 day to six months.
5	Multi-national supplier of machine tools.	o If possible, pull part from kit waiting assembly in new machine, or from suppliers selling to production. Otherwise… o ALT is 2 – 3 days o PLT 1 – 20 weeks
6	Trucks and truck bodies for defense, construction, fire/emergency, refuse and snow removal.	o Some not stocked items are commercial, usually commodity. Lead-time is 1 – 3 days. o For non-commodity, “approved” parts, overall lead-time is 8 to 12 weeks.
7	Elevators, escalators, moving walks, horizontal transportation systems.	o Similar to Company 6.
8	Distributor of OEM approved out of production power train parts.	o Overall lead time varies for manufactured parts from 3 – 12 weeks o 10 – 12 weeks for cast or machined parts

Long lead times among the companies visited were the result of a number of factors. There were special raw material requirements, often metals. There were also some very complex assemblies, where the build sequence is invariant and/or many parts of the sequence have moderate lead times and/or several rounds of machining and testing were required. Slightly more moderate lead times resulted from requirements for outside processing, particularly when the processing company has to be certified.

5.4.3 Cost Reduction

While we could not get data on dollar values of the cost reductions, it was evident that all the companies are putting a great deal of effort into cost reduction. Some examples of cost reduction activities include:

- Part simplification and part # reduction
- Good forecasting in lieu of inventory
- Destocking of obsolete or very low volume, non-critical parts
- Reengineering of material handling
- Outsource low volume commodity part management
- Long term agreements with suppliers
- Consolidate/centralize buying function

5.4.4 Invest Resources

All the companies interviewed realize that customer loyalty and profitability require investing resources in new services. Cost reduction alone will not keep them competitive. Two kinds of investment were evident: (1) improvements in services to lower prices to customers; and, (2) development of new value added services for which the customer will pay.

There were a wide variety of different improvements in services among the companies. Improvements implemented by two or more companies were:

- Obsolescence
  - Redesigning parts (two companies)
  - Tracking and qualifying new suppliers (two companies)
- Inventory
  - Commitment to high fill rates (eight companies)
  - Maintaining critical/high value components in inventory (four companies)
  - Technical support
    - Databases and people to assist dealers and customers (2 companies)

Almost all of the companies made investments in new services for their customers. These services included:

- Inventory management services: An experimental program to share consumption data with customers, and restock as needed.
- Inspection services: A low cost service keeps equipment running. The inspection reveals needed repairs that the company can provide. The inspection itself makes a little money, the resultant repairs even more.
- Refurbishing: The company refurbishes its equipment. This is profitable in its own right, and also generates low volume part demand in the refurbishment process.
- Guaranteed up time: The equipment manufacturer promises the customer the equipment purchased will be operational a high percentage of the time. Operationally this means that equipment must be repaired within 24 hours. This is a premium service offered at a premium price and/or a hefty penalty, so the OEM has a strong incentive to perform.

?? Fee for fast service: OEMs provide a price structure based on response time. Fast delivery means a premium price.

5.5 Best Practices

The core of the data analysis was an effort to identify business practices that led to the effective, efficient, and profitable management of low volume parts. Each interview revealed many such practices, with a range of consequences and a pattern of commonalities among them. Considerable effort went into understanding these findings. Eventually, an analysis plan was developed that consisted of three elements:

1. Practice category – Five high level categories emerged from the analysis
    a. Sustaining Engineering – general parts and inventory management procedures
    b. Supply Base – formal and informal supply chain relationships that affect ability to meet customer demand.
    c. Parts Management – general parts and inventory management procedures.
    d. Parts Differentiation – specific procedures to treat parts differently depending on criticality, volume, etc.
    e. Forecasting – use of technology and human expertise on a routine basis to determine inventory needs.
2. Impact on ALT and PLT lead time
    a. Absolute reduction
    b. Shift to a less critical period in the order fulfillment life cycle, i.e. efforts to make lead time invisible to the customer
3. Cost
    a. Reduce, or
    b. Increase for the sake of better customer service or improved business

5.5.1 Sustaining Engineering

Sixteen practices fell into two subgroups:

1. Tooling and technical data, and
2. Part content and quality.

Descriptions of these practices, and the team's assessment about their impact, appear in Table 1.

Table 1: Best Practices -- Sustaining Engineering								
		Domain of Substantial Impact						
	Company	Reduce PLT	Shift PLT	Reduce ALT	Shift ALT	Decrease Cost	Increase Cost
Tooling and Technical Data								
Tech data storage and access They keep all the old tech data Most not digitized. (If need paper or fiche and pull it, they digitize it. Too expensive just to go back and digitize it all.)	2	X					
Tech data storage and access Have all technical specifications. In addition have data base with approximately 100 attributes for each part, e.g. item manager, cost, weight, lead time. One reason they manage inventory so well.	3	X			X	X	
Tech data storage and access Maintained for 20+ years. Virtually all part numbers are in the system. Includes geometry, functions, materials.	4						
Tech data storage and access Have been scanning drawings to complete the data base.	4						
Tech data storage and access Data base on customer problems with specific parts and solutions to the problems.	4						
Tech data storage and access Quality Planning and Manf. Eng. Systems include mfg methods, tools, processes, etc. for each part.	4						
Tech data storage and access Has drawings for every machine it ever delivered.	5	X				X	
Tech data storage and access They keep all the old tech data, back to the Year One. Most of it is not digitized. (If they need paper or fiche and pull it, they digitize it, but its too expensive just to go back and digitize it all.)	7	X				X	
Obsolete material and processing data Old parts, tech data do not describe modern materials or processing. Lots of effort to update, which often amounts to reengineering. Typically, about 1000 hrs/year.	5	X					
Digitized tooling New technology decreasing the importance of old tooling, thus driving careful choices about what to keep. As an example, 6 years ago “digitized tools” were too expensive. Now, making use of them is cost effective.	1	X					
Tech data and tooling acquisition – product rights, blueprints, tooling, existing parts inventories, and proprietary data to provide built-to-OEM specifications repair are transferred to us.	8	X				X	
Ownership and storage of tooling – After a part out of production, Spares owns tooling. Storage facility 600,000+ pieces over last 30-40 years. Some suppliers of castings and forging will store at their facility.	1	X					
Part Content and Quality								
Delayed product differentiation Store raw castings, not finished parts. Less inventory for a greater range needs. Reduced lead time on non-stocked parts to 12 weeks or less. Particularly useful on very slow moving parts. On a per-part basis, raw castings are cheaper than finished goods. Also, an now help out Production more when they have a supplier problem.		X					
Quality assurance tests on all parts, including a metallurgy lab that does destructive testing, microscopic examination of metal grain, etc.	3						X
Part # management Maintain a data base on part dimensions, encourage design engineers to use fewer part numbers. Goal is 60% common parts. Putting 4-5 person years annually into the effort. Also trying to reduce parts from foreign suppliers.	4	X			X	X	X
Dealer Parts Assistance Center Group to solve problems. For instance, can contact factory or a buyer to research a problem. Data kept in public data base so others can learn. Technical as well as purchasing issues. e.g. checking with product support for work-arounds, opportunities to tear down assemblies, modify a “close” part.	4	X					

Table 1: Best Practices -- Sustaining Engineering								
		Domain of Substantial Impact						
	Company	Reduce PLT	Shift PLT	Reduce ALT	Shift ALT	Decrease Cost	Increase Cost	
Obsolescence tracking Steady flow of parts go obsolete, supplier goes out of business, no longer makes item, etc. Qualify new suppliers or reengineers the part. Notify owners that a new part is now available.	5		X		X		X	
Tech data and tooling control – they keep all the old tech data, tooling and patterns back to the Year One and have been successful acquiring data from suppliers.	6	X			X			
Parting out – reviewing old inactive components/assemblies for useable active parts.	7	X		X		X		
On-line Expert – Mostly there for tech field support, but has spare parts implications. Can suggest replacements, work-a-rounds, substitutes.	7	X		X				
Obsolesce Program – engineering reviews all obsolescent parts to determine either to maintain or discontinue. All product lines will still be maintained either with retrofits of a new design or continuation of the old parts.	7						X	

5.5.2 Supply Base

Seventeen practices separated into three subgroups:

1. Relationship mechanisms (contracts and trust)
2. Supply base structure
3. Material and data exchange

Descriptions of these practices, and the team's assessment about their impact, appear in Table 2.

Table 2: Best Practices - Supply Chain Relationships								
		Domain of Substantial Impact						
	Company	Reduce PLT	Shift PLT	Reduce ALT	Shift ALT	Decrease Cost	Increase Cost	
Relationship Mechanism -- Contracts and Trust								
Long term contracting Instituted long term agreements.	4			X		X		
Long term contracting Long term agreements with key suppliers has provided substantial discounts.	5			X		X		
Long term contracting Blanket Orders – Moving away from RFQ only approach. This allows for better pricing, and planning.	7			X		X		
Long term contracting Original supply base – they work with the original suppliers to manufacture LVP's. Most suppliers are on long term contracts.	8			X				
Trust Many suppliers been with company for a long time, (and many of them are small companies.) Not unusual for a supplier to divulge they are in financial difficulty and ask for help, or inform that they are planning to retire and close the business.	2	X		X	X	X		

Table 2: Best Practices - Supply Chain Relationships								
		Domain of Substantial Impact						
	Company	Reduce PLT	Shift PLT	Reduce ALT	Shift ALT	Decrease Cost	Increase Cost	
Trust Small # of trusted suppliers (machine shops), all in the geographical area. One for high precision, one for high volume, etc. About 4 in all.	8	X		X				
Supply Base Structuring								
Pre-qualification of alternate suppliers Selection based on skill, not existing product line, e.g. casting expertise in company that never made the specific kind of part they need. To assure efficiency when the supplier is needed, supplier are pre-qualified.	2	X		X				
Decrease # of foreign supplies Overseas suppliers add 35-40 days of lead time because of shipping and customs. Price an issue, but all things being (almost) equal, there is an effort to reduce lead time.	4	X						
Outsource LVP management For low volume, low value added parts, outsourced LVP management. For higher volumes and value add, it is worth it to maintain in-house expertise.	4					X		
Maintain alternate suppliers When needed, actively maintain 2 suppliers for the same part	4	X		X		X		
Assist new low volume parts supplier to establish a business A useful tactic for assuring supply into the future. For example, take a fabric supplier and help him produce entire interior component.	4	X		X		X		
Joint venture to assure supply. Some capital intensive industries don't like to manufacture in low volume, e.g. engines. Looking into a joint venture in remanufacturing business who is interested in low volume work.	4	X						
Lead time reduction – suppliers Asked for 20% lead time reduction last year from their suppliers and 12% lead time reduction this year	1	X				X		
Supply chain management in lieu of good forecasting LVP forecasting is problematic. To compensate we manage supplier relationships. POs are processed very quickly. Time from RFQ to placing an order is 2 days or less. Often do not compete RFQs, but spread work around. Sufficient level of business for suppliers. Eliminates waste for suppliers in providing quotes for business they won't get. Improves supplier loyalty and responsiveness.	5	X		X			X	
Material and Data Exchange								
Store castings at suppliers to be ready for machining. Owned by us but stored at supplier.	2	X		X		X		
Inventory sharing with suppliers Often suppliers sell the same parts as we do. We are looking into inventory sharing.	4		X		X	X		
Electronic Data Interchange of technical data We allow qualified suppliers to access very sensitive and proprietary drawings. We won't even give it to our service centers.	2	X						
Inventory Consignment – Vendors stock inventory with us, and are paid when sold. Works for about 100 parts/month. Started as inventory reduction initiative. Increased set up costs at suppliers and reduced their certainty. Consignment made sense for both parties.	7		X		X	X		

5.5.3 Parts Management

Twenty-four practices were found in three subgroups:

1. Organization and human resources
2. Inventory management
3. Interaction with customers / knowledge of market trends

Descriptions of these practices, and the team's assessment about their impact, appear in Table 3.

Table 3: Best Practices -- Parts Management

	Company	Domain of Substantial Impact					
		Reduce PLT	Shift PLT	Reduce ALT	Shift ALT	Decrease Cost	Increase Cost
Organization and Human Resources							
Cross functional teams to manage parts buying "Part type" teams (e.g. part material, source of supply). Allows cross functional experts to work together. Fewer hand offs, easier interaction. Personal relationships, harder to ignore requests. Collaboration by co-location, meetings, teleconferences.	1		X		X	X	
"Divisionalizing parts group" Centralize supply management for related engineering areas or company divisions. Groupings include production, service parts, and aftermarket engineering. In the old days there were 5 factories, each of which did its own buying. Now there are common buying groups.	4					X	
Combined Buyer groups – In the old days, there were 3 distinct groups – spares, production, and strategic. Now they all work together. they can support each other. Ex: easier for the "spares" people to get a part from production, or to lean on a supplier through the "strategic" group which looks at supplier selection.	6	X		X		X	
Highly Centralized Purchasing – Consolidating all purchasing activities from field/support offices into one location at main warehouse/service center.	7		X		X	X	
Planner/Buyer – combined the roles and responsibility of planners and buyers in to one. Buyers now do their own planning. No need for hand offs or collaboration. Much better decisions get made because the expertise domains are integrated.	7			X			
Sourcing management 5 buyers, 3 quality engineers who spend 70-75% of their time on sourcing issues.	4	X		X		X	
Empowered employees: -1 Frontline order processors: – When orders come in, order takers are empowered to make decisions, e.g. promise by date, price, supplier, etc. Idea is to avoid delay by bringing a case before a committee to make a decision.	6			X			
Empowered employees: -2 Plant schedulers, who work with buyers. When our own production manufacturing is involved, schedulers can adjust the schedule to meet customer needs.	6	X					
Experienced personnel All LVP work is done by 4 highly experienced people.	5			X		X	
Market Intelligence – Staffed by long-term parts professionals with over 100 years of parts knowledge and experience.	8			X			
Inventory Management							
Lead time reduction – internal process change Examples: 1- Create a local receiving area, use centralized receiving only for parts that need testing or intensive inspection. Parts could sit for 20 days in shipping areas. 2- Spares orders shipped directly to distribution center now. 3- Collaborate with QA on whether less inspection is sometimes acceptable.	1			X		X	

Table 3: Best Practices -- Parts Management								
		Domain of Substantial Impact						
	Company	Reduce PLT	Shift PLT	Reduce ALT	Shift ALT	Decrease Cost	Increase Cost
Customer responsiveness / warehousing / shipping Very highly automated warehouse. Bins for parts and parts themselves are bar coded and coordinated as order is processed. High degree of automated picking. No need for pallets to go back to original location, computer can find them. 4 hour turn around on *emergency orders,* from arrival of order to shipping dock.	3						X
Systematic De-stocking Decisions monthly by location. Automated based on demand, cost, weight, etc. Hierarchy of disposal methods: 1- make into another part, 2- parted out for new inventory, 3- used in a remanufacturing operation, 4- sold at a reduced price, 5- donated, 6- scraped. Service life determined by vintage and demand history. Minimum time before de-stocking is 10 years. No demand for 5 years, deemed obsolete.	3					X	
Innovative partnership for developing a new inventory management tool Present system is home grown. Upgrade needed. Took what for them was a leap by involving partners and a willingness to reveal sensitive information. Partner with ERP application developer and automotive OEM. They and OEM get to use the system on favorable terms, developer gets the rights to sell the system	3					X	
Obsolescence policy Obsolete if part more than 15 years old and fewer than 100 requests over past 4 years. Substantial aftermarket and salvage sources of supply are available.	4					X	
Interaction with Customers and Market Trends							
Direct contact with customers The planners deal directly with marketing and customers, can recognize trends. Ex: 1- Run on oil filters. Forecast says 800, planners intervene, order 1000. Ex 2- Long lead time epidemic failure. Vein in a 20 year old part may start to fail. Ordinarily, low volume, forecasting not useful. Because planner noticed problem in the field, a larger number are purchased.	2		X		X		
Share consumption data with customers Working with some customers to monitor consumption data, inventory, and forecast. In return we guarantee fill rate. We get historical data and projected use, not specifics on third-party purchases. Project just starting, impact not yet known.	1		X		X	X	
Technical support for aftermarket. Dealer technical and part availability problem help desk. Helps dealers understand technical and engineering characteristics of parts and components.	4						X
On-line part system – service centers and technicians have the ability to order all parts on-line.	6			X			
Market Intelligence – Staffed by long-term parts professionals with numerous years of knowledge and experience.	6		X		X		
Field Support – As part of a support contract, we have people in the field. Unexpected advantage is that support people provide intelligence on upcoming parts needs that should have been transmitted through regular channels, but were not.	6		X		X		
Inventory access – frontline staff have access to the entire inventory across warehouses and can fill orders from multiple locations and direct ship to the customer.	6			X			

Table 3: Best Practices -- Parts Management								
		Domain of Substantial Impact						
	Company	Reduce PLT	Shift PLT	Reduce ALT	Shift ALT	Decrease Cost	Increase Cost
Spare Lending – Rotate components. We send you ours, you send us your old one, which we will refurbish and keep in inventory. Used on electric motors and PC boards.	7	X		X		X	
Cost Base Service – selling parts at cost with an annual membership. "Customers" are not product users, but "Internal" service centers. Were never a profit center, but marked up prices enough to break even. Now sell at cost, but charge a fixed annual fee. Provides an incentive to service groups to use the centralized parts group, supports a long term effort at centralization.	7				X	X	

5.5.4 Critical Parts Differentiation

Eleven practices fell into two subgroups:

1. Inventory management
2. Business relationships with customers and suppliers

Descriptions of these practices, and the team's assessment about their impact, appear in Table 4.

Table 4: Best Practices - Critical Parts Differentiation							
		Domain of Substantial Impact					
	Company	Reduce PLT	Shift PLT	Reduce ALT	Shift ALT	Decrease Cost	Increase Cost
Inventory management							
Categorization of parts – Team analyzed LVPs. Categorized into 4 groups "stock", "managed stock", "lead time", and "made to order". Used findings to increase inventory by $300K, greatly improve delivery and customer satisfaction. Led to much better system and 97% overall fill rate. Customers felt we should have parts, did not want to schedule maintenance. Were 10 complaints/week now, almost none.	2		X		X		X
High stock on low volume parts Hard to predict LVP needs, and they also tend to have long lead times. To compensate and keep customers happy, we carry more inventory on these parts.	4		X		X		X
Invest in inventory Plant that makes high value added parts maintains about $11M in life time buy inventory	4		X		X		X
Inventory management for customer service on long lead time items ID parts with long lead times and annual demand. Made commitment to stock, even though it increases inventory costs. Ex: spindle bearing, 52 week lead time. 4-6 needed annually, breakage and stop a plant. Established safety stock, even though it's a $35K part.	5		X		X		X
Parts location Dealer can search for parts in other dealers' inventories, regional depots, or use special system to search all depots + factories	4		X		X		

Business Relationships With Suppliers and Customers						
Machine down procedure Four order classes: 1- Machine down need ASAP 2- Critical 3- Expedited – best lead time available 4- Routine – normal lead time OK. System is date driven, rewards using "machine down" rating. Expedited service will still be available, but at a cost, and will validate authenticity of claim. Direct ship per customer request. **4- Machine down** requests for parts not in stock = 60% of demand. Request goes to top priority, gets 24/7 attention. Can push priority onto their suppliers, either through contract language or general sensitivity/understanding of the problem.	1	X		X		
Guaranteed up-time For equipment where down time is very costly. Have some contracts wherein we assume responsibility for down time costs. Try to keep parts in stock. If not in stock, have expediting process with suppliers to direct ship to customer location within 24-48 hours.	4		X		X	X
"On-line Expert" to advice dealers, customers Mostly there for tech field support, but has spare parts implications. Can suggest replacements, work-a-rounds, or substitutes that may be revealed when a part has failed or needs repair.	7	X		X		
Review Board ✍ distributed collaboration – Started interdisciplinary team (engineers, manufacturing, purchasing, customer service). Met twice per week to deal with parts problems, difficult requests. As people got to know each other, informal communication took over from formal meetings. Communication to solve the problems stayed. Informal system degrades over time as new people enter the process. Periodic need to re-formalize.	7	X		X		
Dealer Parts Assistance Center Group that solves problems. Ex: Contact factory or buyer to research supply problem. Data kept in accessible data base so that others can see if something like their problem has come up before, what was done about it. Has "purchasing" aspect, but also "technical", e.g. check with product support for work-arounds, opportunities to tear down assemblies, modify a "close" part, etc.	4	X				
LVP relationship with production Strong relationship. LVP takes precedence over production, particularly with machine down situations.	5	X				

5.5.5 Forecasting

All eight companies found forecasting low volume parts to be a problem. There were insufficient resources among our team to do an in-depth analysis during the interviews. Further, respondents were reluctant to ask their technical people to talk to us in detail. However there were some possible best practices uncovered during the interviews. These are presented in Table 5.

Table 5: Best Practices: Forecasting

		Domain of Substantial Impact					
	Company	Reduce PLT	Shift PLT	Reduce ALT	Shift ALT	Decrease Cost	Increase Cost
Pair subject matter experts with software forecasting process 1 – Paired two SMEs with software to manage forecasting. Forecasting software works for high volumes, not so well for low , although even there, it produces some useful information. For LVPs, used subject matter experts who used forecasting output to augment their expertise. Human/computer combination produced good LVP forecasts. Resulted in less inventory. Took lead time from suppliers into account. Although its not a true JIT, the approach greatly cut down time material stays unsold in inventory.	2		X		X	X	
Pair subject matter experts with software forecasting process 2-- SMEs filters out low frequency high volume sales from true "low volume" orders, thus producing accurate LVP forecasting.	6		X		X	X	

Table 5: Best Practices: Forecasting							
		Domain of Substantial Impact					
	Company	Reduce PLT	Shift PLT	Reduce ALT	Shift ALT	Decrease Cost	Increase Cost
Part categorization and use of simulation Parts are assigned four classifications: lumpy, seasonal, random, and trend. Based on ordering behavior, and re-evaluated monthly. **1-** Lumpy (similar to LVP) – six months of no activity during a 12 month period. **2-** Seasonal – based on two years of historical data. **3-** Trend – up and down, predictable activity. **4-** Random – unpredictable activity. Service analysis of forecasts and distribution requirements. Simulate deployment real-time and distribution networks historically. Can simulate a set of part numbers to see how service who be effected by changing inventory.	2		X		X	X	
Data capture for regular and emergency orders Capture demand when dealer orders part, not when part is actually sold. Do forecasting differently for regular dealer stocking and emergency ordering. However, system does not work well for LVPs. To compensate, they carry inventory.	4		X		X		X

5.6 Enablers

Recall that we defined an "enabler" as a cultural or organizational condition that allows a best practice to be implemented and to work. Using this definition, we determined a number of enablers that we were able to categorize into four groups:

1. Organizational support for change.
2. Human resources.
3. Innovative business models.
4. Data and information.

Organizational support for change is a combination of company culture, formal management incentive systems, and management support for innovation and experimentation. Indications amongst the companies interviewed of organizational support for change were:

- ?? Developing an incentive system that utilizes four performance metrics per quarter, two of which deal with customer service. If the Spares department hits all four metrics, all staff members are eligible to receive $800.
- ?? Reorganizing from decentralized into centralize buying groups in part to better deal with low volume parts (parts management).
- ?? Establishing a joint venture with an engine manufacturer to assure a supply of low volume engines.

There are a wide variety of activities aimed at improving the use of human resources in managing low volume parts. These activities included:

- ?? Pushing decision making down to the very experienced people on the line and in the office, giving these people the authority to make decisions, including taking orders, checking inventory, and making commitment to customer for price and delivery.

- ?? Using technical experts within the company to assess customer buying patterns. These experts determined that a $300K investment in critical inventory would greatly improve fill rate.
- ?? Using cross-functional teaming to support analysis and decision-making. The result of one such cross-functional team was to reorganize purchasing into 5 groups, each with all the experts needed to manage its "commodity."

Innovative business models are the result of companies recognizing that the competitive environment is changing and that business offerings have to change with it.

- ?? Guaranteeing up time: The OEM promises that their equipment will be available a certain percentage of the time. For the low volume parts function, guaranteed up time means minimizing ALT and PLT.
- ?? Sharing inventory with suppliers: The OEM can reach into their suppliers inventory and vice versa. This requires a great deal of trust and cooperation and therefore is difficult to implement.
- ?? Moving from providing spares to inventory management services: The OEM becomes responsible for inventory management of its equipment for its customers. Related to this practice is the sharing of information related to the spare parts function between customer and parts supplier.

How companies acquire and use data and information a very important enabler. Practices we found include:

- ?? Maintaining extensive, detailed technical data on even very old equipment. These data varied from old drawings to electronic data, but all of the companies were very careful to maintain data on all of their parts, no matter how old. In one company there was a major effort to consolidate part numbers and to get design personnel to use existing parts rather than creating new numbers for existing parts.
- ?? Sharing of information about parts. In one company there is an attempt to share information between the low volume parts function and all other potential sources of parts, such as production, central and regional warehouses, dealers, suppliers, and even used and salvage sources.

6 High Level Implication to DLA

In all the companies we visited there is an evident strong low volume parts culture. First and foremost here is a deep, pervasive commitment to customer satisfaction as priority number one. This commitment is evident in the culture of the larger organization, the resources devoted to low volume parts, the structure of the low volume parts function and its place in the overall organization structure, the processes and procedures employed and incentives for achieving customer satisfaction.

All the companies we visited treat low volume parts differently. Some have separate low volume parts functions; all have special processes and procedures. Some provide direct incentives for low volume parts; all devote more resources to low volume parts than to other spare parts. The

result is a relatively minuscule ALT and significant pressure to reduce further reduce ALT, reduce PLT and to keep both of them short. There are also efforts to:

- ?? Shift ALT & PLT to life cycle times that decrease customer's wait time.
- ?? Problem solve based on motivated personnel, deep knowledge, and access to good data.
- ?? Special procedures to quickly respond to equipment down conditions.

In contrast, DLA appears to follow the same processes for all parts, regardless of volume. These processes result in fast delivery to customers when parts are in stock. Unfortunately, they often result in very long customer wait times when adequate numbers are not in stock, which is most often the case for low volume parts.

The clear implication is that DLA should adopt the philosophy of treating low volume parts differently from high volume parts for the express purpose of shortening customer wait times for those parts as much as possible. While DLA is not free to adopt some of the identified commercial practices because of Public Law and regulatory restrictions, the striking performance of many of the commercial companies interviewed implies that DLA could significantly improve its low volume parts delivery performance by actively seeking ways to change its stocking and order fulfillment policies and processes within these restrictions. As a minimum, DLA might conduct a marketing analysis to determine whether its customers would be willing to pay premium prices for expedited LVP service.

The remainder of this section suggests potential approaches to change that DLA might wish to explore further.

6.1 Establish Different Processes for LVP

An important lesson learned from the private sector is that low volume parts require special treatment in order to get parts to customers quickly without the expense of carrying inventory. In essence, the companies interviewed substitute fast reaction for inventory. DLA's order fulfillment processes should be examined closely to see how far DLA could realistically move in this direction. Current processes are built around efficient supply of higher volume, replenishment items which, for aviation items, comprise around 90 percent of DLA's business. As the results of the study indicate, these processes are incompatible with a goal of quick response to customer needs for low volume parts.

Satisfying customer demands for replenishment items is relatively insensitive to ALT and PLT. As long as they are predictable with relative accuracy, re-order points can be adjusted to accommodate virtually any lead time. At the expense of inventory, customer orders can be quickly filled from stock. Conversely, customer wait time is a direct function of ALT and PLT for most LVP. Not stocked, non-DVD items cannot be filled from stock, by definition. NSO items frequently cannot be filled from stock either if the order is for more than the NSO quantity or if the quantity on hand has fallen below the NSO quantity, as often happens. Within the BSM focus on Customer Relations Management, and its attendant emphasis on customer satisfaction, it would appear that the time may be right for DLA to take action to reduce the length of time customers wait for LVP.

6.2 Manage LVPs as a Separate Function

As an important step beyond refining processes within the current organization, DLA should further investigate the feasibility and potential value of a separate organizational function to manage LVP. Such an approach would not be to assume the Emergency Support Operation Center (ESOC) function, but rather to conduct routine order fulfillment and supply planning functions for LVP in ways focused on getting parts to customers much more quickly than current processes can. A separate organizational function would also allow DLA to better focus expertise on low volume issues. Identified best commercial practice suggests that a culture of customer support, a stable supply base, short ALT, and attention to PLT are critical to the cost-effective delivery of low volume parts. We do not feel that these practices could be introduced into the current DLA organizational structure as effectively as would be possible via the establishment of a separate organizational function.

Establishing a separate organizational function would also allow DLA to act differently to respond to customer requests for low volume parts. One important change would be to shift from a business case based solely on price to one that also considers part availability. While price is important in the private sector, companies are willing to pay a premium for fast service because of the prohibitive cost of equipment or production downtime. Of particular interest is the case of guaranteed up time, where the cost of downtime is shifted to the parts supplier, providing even more of an incentive to emphasize availability over price. This also suggests some interesting parallels to DLA's current focus on engaging in Performance Based Logistics (PBL) agreements.

Establishing low volume parts in a separate function (organizational unit) likely would require the implementing the following practices:

1. Enhancing the range of Sustaining Engineering capability, and thereby confirming the importance DLA has put on Sustaining Engineering practice and on product technical expertise and management commitment to low volume parts.
2. Stabilizing a low volume parts specific supply base, including long-term contracts, for low volume parts that cannot be pre-priced. This would include the definition of premium pricing for expedited service.
3. Treating Equipment Down situations differently throughout the entire system: DLA, customer, supplier, and/or middlemen, in recognition that good customer service ultimately equates to good business.

6.3 Out-Source Management of Not-Stocked, Non-DVD Items

This approach would go further than the establishment of a separate organization for management of a subset of LVP. DLA's processes have evolved to manage high volume commodity items, or at least, items for which demand can be forecasted.. Low volume parts do not fit this paradigm. As our interviews indicate, low volume parts are considerably different than commodity spares, requiring a different organizational mindset, special expertise, and different perspectives on both forecasting and supply chain responsiveness. While it may be possible to establish a function within DLA that can introduce some of the best practices from the private sector and make meaningful improvements, some of the more important practices are simply not possible to implement within the public sector and others are difficult because of the

prevailing culture, structure, style of operation and personnel assignments in DLA. Accordingly, one potential, viable solution is to out-source the management and procurement of not–stocked items.

It is our view that the most efficient way of introducing many of the identified best practices would be to outsource all aspects of the supply of non-stocked items. A contractor function would have the flexibility to implement most, if not all best practices listed above. This would allow far faster response to customer needs. Reductions of ALT by a factor of 20 times are possible, as well as significant reductions in PLT. Service customers increasingly look to see if DLA has a part in stock or due in before placing a requisition. If the part is not available or due in, they often simply buy around DLA. Outsourced management of not stocked items conceivably could respond to needs more rapidly than the Services can, and therefore would help recoup some of the business that is currently lost.

6.4 Continue Developing Peak Demand Approach to Stocking Policy

Our interviews produced solid evidence that some commercial firms are effectively using the peak demand approach, often coupled with strong human expertise. This result provides additional support and rationale for on-going Aging Aircraft Program efforts to develop this approach and validate it for deployment across DLA. The companies we interviewed who use this approach believe it provides substantial benefit.

7 Appendix A: Interview Protocol

Background: "Low Volume Parts Order Fulfillment Benchmarking"

Thank you for agreeing to participate in this project. Altarum (www.altarum.org) is a not-for-profit R&D company in Ann Arbor, Michigan. We are conducting this project for the Department of Defense's Defense Logistics Agency, and in cooperation with the Defense Sustainment Consortium (http://dsc.aticorp.org/). Our objective is to show the DLA how the commercial world supplies low volume parts for aging equipment. We value your input, and thank you for your cooperation. In return for your assistance, we will provide an organized copy of the information you gave us, and a copy of the final report. All responses are confidential. Reports will be sanitized, and identities of participating companies will not be revealed.

Below is a summary of the topics we will cover during our visit. Please regard it as an interview guide rather than a questionnaire that you have to fill out in advance. If you feel that any of your colleagues should be included in our discussions, please feel free to invite them. If you have any questions about this project, please contact Jonny Morell, 734/302-4668, jon.morell@altarum.org.

1 – Personal Information on Respondent/s

- Descriptive title
- Role in company
- Personal involvement in low volume parts (LVP)

2 – Business Profile for LVP

- Why is managing LVP important to your company (e.g., $, customer loyalty, tradition)?
- How significant is LVP business in sales per year for the company or division?
- What is the selling unit price range for LVPs (lowest, highest, typical)?
- How many LVP parts do you process annually?
- How many LVP part numbers do you process annually?
- How does LVP business vary from year to year (e.g., sales, part types)?
- If some LVPs are manufactured in-house and some outsourced:
- What % do you and your suppliers do?
  - How do you decide the allocation?

3 – Organization Profile for LVP

- Is LVP a separate organization?
- How does LVP relate to other spares management functions?

3 – Organization Profile for LVP

- ?? To whom does the LVP function report?
- ?? Is there a relationship between LVP and supply chain management for current production?

4 – Nature of LVP— Parts Description

- ?? What volumes do you consider "low volume?
- ?? What kinds of parts do you consider LVP (e.g., function, mechanical, electronic)?
- ?? Besides supply, do you provide other LVP services (e.g., manufacturing or engineering)?

5 – Process Overview for In-house LVP Management

If all your LVP management is outsourced, we will skip this section.

- ?? Describe a high-level process description of the order fulfillment process.
- ?? Does the technical complexity of an LVP make its management more difficult? If so, why?
- ?? How is technical data maintained, accessed, and delivered?
  - ✍ Different for in-house and outsourced production?
  - ✍ Are there any problematic tech data problems?
- ?? What kind of quality control and test requirements do you apply?
  - ✍ For in-house production
  - ✍ For outsourced parts
- ?? What kind of records are kept to track administrative and production lead time?

6 – Process Overview for Outsourced LVP Management

If you handle all this function solely in-house, we will skip this section.

- ?? Do you outsource the *management* of LVPs (e.g., demand forecasting, order fulfillment)?
- ?? What are the LVP's whose management you outsource? Why those?
- ?? What are the key features of outsourcing agreements (e.g., duration, responsibilities)?
- ?? What are the procedures to reach new agreements when old ones expire?
- ?? What are the quality requirements, and how are they enforced?
- ?? Are parts delivered to you or directly to the customer?
- ?? What are your performance metrics and oversight practices?
- ?? Do you outsource LVP management to single or multiple sources? How are responsibilities decided?

7 – Demand Forecasting

- ?? How do you do demand forecasting for LVPs(e.g., human analysis, ERP)?
- ?? Is it particularly hard to predict demand for particular parts or customers? Please explain.
- ?? How is the forecasting data used?
  - ✍ In-house
  - ✍ With suppliers

8 – LVP Tactics – General Safety Stock Issues

?? Do you maintain safety stock for any LVPs?
- ✍ What % orders filled from stock?
- ✍ What kinds of parts stocked?
- ✍ What are the stocking and replenishment policies, and rational for them?
- ✍ What is the re-order point calculation?

?? For LVPs that are not stocked:
- ✍ What size administrative and production lead-times do you have?
- ✍ Will customers pay a premium for accelerated delivery?

9 – LVP Tactics – Production Issues for Outsourced Production

If you handle all LVPs in-house, we will skip this section.

?? What parts are outsourced?

?? Why these parts and not others?

?? Do parts tend to have single or multiple suppliers?

?? How do you choose suppliers (e.g., supplier qualification, cost, quality)?

?? Do you use long-term agreements? If so, what are their key features?
- ✍ % produced under long term agreements?
- ✍ How do long and short term agreements differ? (e.g., contractor responsibility, price, type of parts)
- ✍ What are the quality requirements and how are they enforced?

?? Are parts delivered to company or direct to customers?
- ✍ When is each tactic used?
- ✍ Why?

?? How do you manage supplier relationships (e.g., performance metrics, oversight practices)?

?? What are the procedures to reach new agreements when existing ones expire?

?? Do you do supplier development specifically with respect to LVPs?

?? Do you monitor your supplier base for changes that may affect LVPs (e.g., supplier going out of business or being acquired?)?
- ✍ How do you do the monitoring?
- ✍ What problems have you found, and how have you dealt with them?

?? How would you characterize production lead time? Shortest, longest, typical

?? Have you made any special efforts to reduce production lead time?
- ✍ What have you done?
- ✍ How has it worked out?

?? How would you characterize administrative lead time? Shortest, longest, typical

?? Have you made any special efforts to reduce administrative lead time?
- ✍ What have you done?
- ✍ How has it worked out?

?? For the topics discussed in this section, are there any important differences in tactics or problems with respect to items that you stock as opposed to those you do not?

10 – LVP Tactics – Production Issues for In-house Production

This section is only for companies who do some in-house LVP production.

- ?? What parts are produced in-house?
- ?? Why these and not others?
- ?? How would you characterize production lead time? Shortest, longest, typical
- ?? Have you made any special efforts to reduce production lead time?
  - ✍ What have you done?
  - ✍ How has it worked out?
- ?? How would you characterize administrative lead time (shortest, longest, typical)?
- ?? Have you made any special efforts to reduce administrative lead time?
  - ✍ What have you done?
  - ✍ How has it worked out?
- ?? What agreements do you have in place with Manufacturing with respect to:
  - ✍ Quoting
  - ✍ Deliver
  - ✍ Quality
  - ✍ Invoicing
  - ✍ Payment
  - ✍ Production scheduling
  - ✍ Award/go-ahead notification
- ?? For the topics discussed in this section, are there any important differences in tactics or problems with respect to items that you stock as opposed to those you do not?

11 – LVP Performance

- ?? What measures are important (e.g., revenue, response to customers)?
- ?? Are there any elements of your LVP performance that you think are particularly successful?
  - ✍ What are they?
  - ✍ What indicators tell you they are successful
  - ✍ Any particular problems you had to overcome? How did you do it?
- ?? Are there any elements of your LVP performance that you think are particularly problematic?
  - ✍ What are they?
  - ✍ What metrics indicated the problem (e.g., lead time, cost, impact on routine business)
  - ✍ What were the problems (e.g., tech data, suppliers, obsolescence)?
  - ✍ What actions would you like to solve these problems?