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TECHNOLOGY INSERTION-ENGINEERING SERVICES PROCESS CHARACTERIZATION TASK ORDER NO. 1

VOLUME III
OC-ALC
BOOK 2 OF 2

A-1

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Technology Insertion (TI)/Industrial Process Improvement (IPI) Summary Report for OC-ALC. This document contains Focus Study and Quick Fix Recommendations for 8 Resource Control Centers (RCC's). These RCC's are: MATPFF, MATPHA, MATPHB, MATPHE, MATPIA, MATPIM, MATPIN, MATPIW

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6.13 MATPFF ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

The MATPFF RCC is responsible for those processes involved in the repair, overhaul, modification, alignment, calibration, and testing of airborne automatic pilot system components, computer systems, and navigation system components. MATPFF also is involved in the testing of airborne radomes. A detailed description of the activities that take place in MATPFF are described in paragraph 6.13.1 of this document.

The MATPFF RCC has a number of assets which allow it to meet the demands placed upon it. The workers in this RCC are well trained, and most have been working in the area for a long time. This high experience level results in the workers getting to know the repair procedures extremely well, and, because of this, high quality items are produced. The workers as a whole display good skills and motivation. The workers appear to enjoy the type of work that they do and are conscientious in seeing that the items repaired have no defects. The workers seem to enjoy their environment, and a good relationship exists between the workers and supervisors. The supervisors in MATPFF do a good job of monitoring the activities within the RCC, and providing the workers with assistance, as needed.

The RCC benefits from having a relatively small percentage of one-of-a-kind equipment. Most processes have backup equipment that can be used when the primary equipment is not available. The combination of a highly skilled work force with adequate equipment results in good throughput. The RCC is capable of maintaining good throughput under wartime surge conditions, provided that more specialized equipment and additional manpower is made available (refer to paragraph 6.13.2 of this document). Two AFCS Electro-mechanical Test Sets would be required, as would an additional four workers.

One main problem of MATPFF is a high turnover in the work force because of discontent with the current compensation rates. This problem is compounded by a lack of cross-training among the workers. Aside from the manpower problem, the RCC is hurt by the long troubleshooting time required on certain items. The use of ATE has substantially reduced the time that was once needed to locate the defect in an item, although the software is limited in the types of problems which it can find. There is still room for improvement in the ATE as bottlenecks still develop due to the time which an item must spend on the ATE and the volume of items that must be tested on it.

The process of electronic repair in the RCC is very similar to the process used in private industry, although private companies usually benefit from economies of scale, since they repair large volumes of like items. Some of the automated equipment in MATPFF is as state-of-the-art as anything which the MDMSC team has seen in use in private industry. The workers in the RCC are highly aware that the quality of their work has an effect on aircraft safety, and this awareness contributes to a very low defect rate on repaired items. Because of this emphasis on quality, MDMSC would rate the quality of the electronic repair work in MATPFF superior to that in private industry.

During initial characterization of the MATPFF RCC, a total of 16 improvement opportunities were identified (reference MATPFF Database Document Book (DDB), Improvements section). After review of the original set of opportunities by the MDMSC/Air Force team, three improvement opportunities were selected to be pursued as the focus of the TI-ES program activities related to MATPFF.

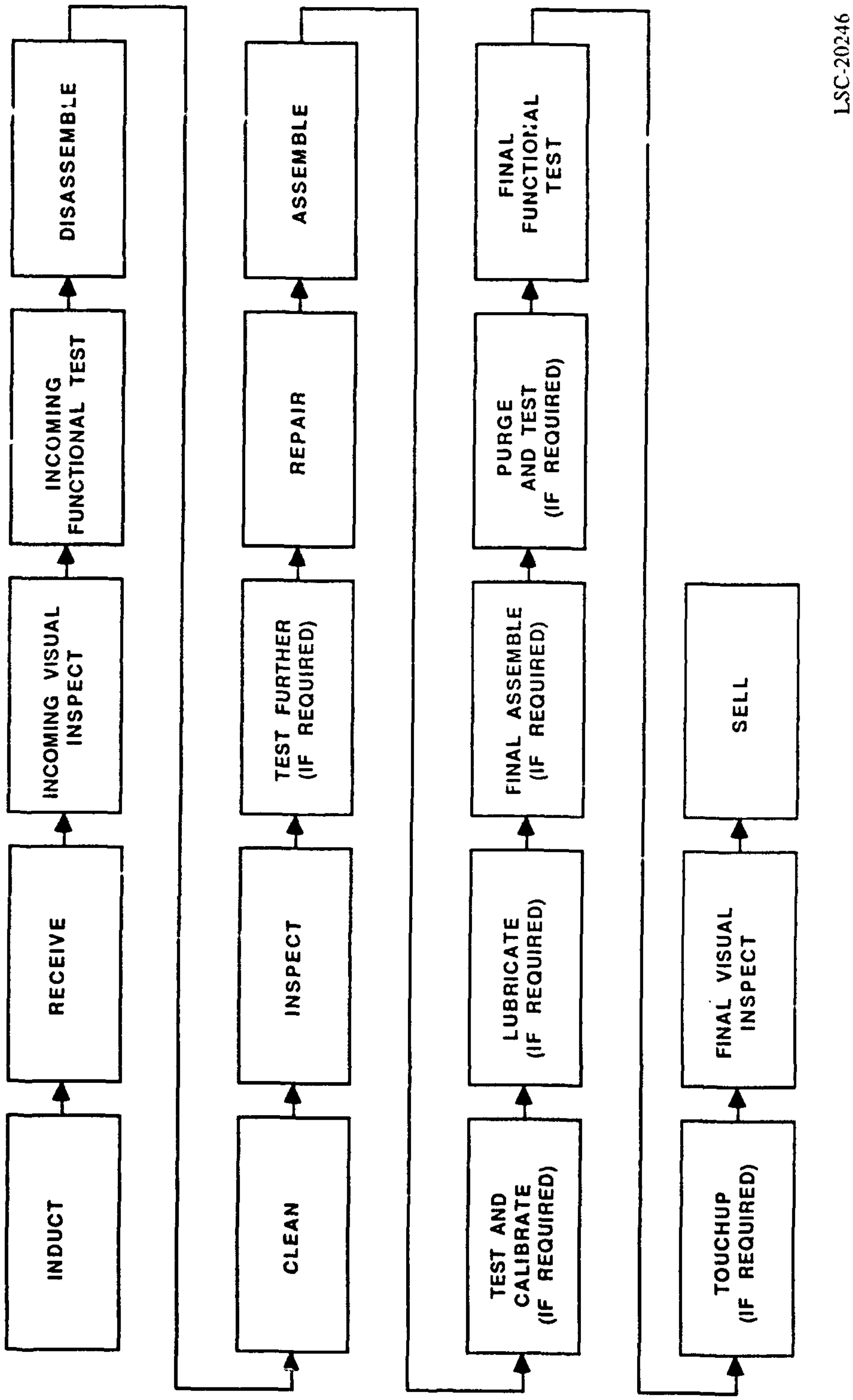
The focus study opportunity, Refinement of ATE Software, recommends improving the testing capabilities of the software to reduce the time spent on troubleshooting items and is detailed in paragraph 6.13.4 of this document. The remaining two improvement opportunities deal with reducing the flow time of items repaired in MATPFF by reducing the turnover in skilled mechanics, and by utilizing a work leader. They are described in detail under separate cover. Refer to the Quick Fix Plan for MATPFA for their descriptions.

The balance of the original MATPFF improvement opportunities are described in paragraph 6.13.5 of this document.

6.13.1 Description of Current Operation

The operations in MATPFF are typical of those used in commercial electronics repair, except that the repair procedure at OC-ALC usually calls out for only one person to be involved in the repair process from beginning to end. The basic flow of an item going through the repair process consists of testing the incoming item to determine what is wrong with it, repairing the item, and testing the repaired item to see that it functions properly. The items that are repaired in flight control unit (MATPFF) vary widely in their size and complexity. A generic process flow diagram showing the flow of a typical item through MATPFF is shown in Figure 6.13.1-1. In addition, the workload in this RCC is highly variable, with significant changes in the quarterly requirements for a PCN fairly common. It is the nature of the electronics industry to continuously make improvement and design changes; therefore, the workload in the MATPFF RCC is constantly in a state of change as new items are introduced and old items become obsolete.

Many of the items that are worked in this RCC require a lengthy troubleshooting procedure to identify which component items are malfunctioning. The flow of an item is sometimes impacted because the mechanic doing the repair encounters a problem that he can not solve. When this situation arises, a lengthy delay often occurs as the mechanic attempts to define the cause of the problem and what action can be taken to correct it. The mechanic often has to call over his supervisor or another mechanic for assistance, which adds to the delay. Because of the unpredictable condition the items are in when brought into the RCC, there are numerous instances where unique problems arise that nobody has dealt with before. These out-of-the-ordinary problems lengthen the time that it takes to repair an item, which inflates the repair cost for that item. The MDMSC team believes that it would be beneficial to promote a mechanic in each RCC to the position of work leader, where this leader can help the other mechanics troubleshoot and repair items that do not respond when worked using the established repair procedures. This idea is addressed in paragraph 6.11.1 of the Quick Fix Plan for MATPFA.



OC-ALC MATPFF PROCESS FLOW
FIGURE 6.13.1-1

The electronics RCCs sometimes suffer a productivity loss when a mechanic transfers out because there is usually not another mechanic available who can step in and do the job. The supervisors in MATPFF operate under the theory that the greatest productivity can be achieved by assigning a mechanic to work a limited number of items, which allows him to become very proficient at repairing them. This system has a major drawback in that when a mechanic leaves the RCC, there is a drop in productivity while another mechanic learns the job. Unfortunately, the MATPFF RCC has a history of high turnover in manpower, which usually takes place because the mechanic can transfer out of the RCC to a higher paying position. The MDMSC team believes that a thorough evaluation of the labor grades specified for the jobs in the MATPFF RCC needs to be undertaken to insure that the mechanics are being adequately compensated for the work that they are doing relative to what the workers in other RCCs are getting for what they do. It is our belief that a substantial investment has been made by OC-ALC to train the mechanics in the analysis techniques and repair processes used and that this investment should be protected by seeing that the mechanics receive a rate of pay that is compatible to that which is received in other RCCs. This idea is developed further in paragraph 6.11.2 of the Quick Fix Plan for MATPFA.

The MDMSC team believes that the operations within the RCC are successful in that high quality items are being produced on schedule. A main reason for this success is that the workers are trained well. They are sent to classes to insure that they remain current on the repair procedures to be used on the items processed through the RCC. The ever-changing nature of electronics demands a highly skilled work force that is knowledgeable and the MDMSC team believes that OC-ALC does an excellent job in keeping its workers trained in the state-of-the-art repair methods that have been developed.

The success of the RCC can also be contributed in part to the relaxed working atmosphere within the RCC. The MDMSC team observed that the workers were not pressured by the supervisors. The supervisors made sure that the workers under them knew their assignments and then they left the workers on their own to complete those assignments. The workers were free to consult with other workers or the supervisor if they ran into problems. The workers are self-motivated and seem to like the challenge of troubleshooting and repairing an item on their own. The supervisors make themselves readily available to the workers, but the supervisors are often called away to meetings or are unavailable to the workers because of other reasons. The MDMSC team believes that a work leader is needed in the RCC and this situation is described in paragraph 6.11.1 of the Quick Fix Plan for MATPFA.

The success of the RCC's operations is also due to the commitment of the workers to turn out nothing less than a high-quality item. The workers that were interviewed by the MDMSC team showed a great deal of pride in what they do and emphasized the amount of care that they use to guarantee that the items which they work go out defect-free. The workers' pride and feeling of ownership are contributing factors to why the RCC has proven they are capable of getting high-quality items which they repair out in a timely manner, despite a constantly changing workload.

The equipment being used in the MATPFF RCC varies in age, but much of it is over 15 years old. The MATPFA, FE, & FF RCCs have a lot of common test equipment, such as voltmeters and oscilloscopes, as well as pieces of specialized test equipment that can only handle a family of like items, or in some cases, just a single item. The MDMSC team observed instances where bottlenecks were occurring because a piece of specialized equipment lacked a backup and this was causing queues to develop at the equipment. The MDMSC team will address those operations where we believe that additional equipment will reduce the repair flow time during the model experimentation process. The MDMSC team was impressed with some of the automatic testing equipment which we saw in operation, though we were informed that some of the equipment is limited by the software that is presently being used. We were informed that some software is unable to pinpoint the specific component in an end item that is bad or is unable to detect certain types of problems, such as defective wiring. Despite the great time savings which resulted from the use of ATE, there is still a substantial amount of time required to troubleshoot most items after they come off the test equipment.The MDMSC team believes that an investigation should be undertaken to determine whether refinement of the ATE software is a project to which OC-ALC should devote its efforts. This idea is further defined in paragraphs 6.13.4 and 6.13.4.1 of this report.

The MATPFF RCC has good storage capacity and many cabinets and racks are available for storage of items. The present method of manually transporting parts works well, given the fairly small size of the items and the short distances involved. The MATPFF RCC is scheduled to be moved out of Building 230 in the future.

A comparison of the existing RCC layout to the ALC -supplied blueprints was made by MDMSC. The blueprints were found to be outdated. The prints were marked up to reflect the As-Is floor layout and these corrected prints can be found in the brown folder included in the General Information section of the DDB. The items worked in the RCC are generally small which reduces the importance of utilizing the space within the RCC efficiently. The MDMSC team believes that the area allocated to the RCC is too big for its needs. In particular, the aisles in the RCC are much wider than they need to be. The workbench area given to each worker also appears to be excessive in most cases. The utility islands that exist between workbenches could be largely eliminated by running the utilities up form the floor or down from the ceiling for each individual workbench. The poor utilization of space in the RCC does not negatively affect its productivity, but the MDMSC team believes that when the RCC is moved out of Building 320, it can be moved into a substantially smaller area than what is allowed for it now.

Aside from the use of racks and shelves, very little utilization of vertical space takes place in the RCC. There does not appear to be a need to make more use of vertical storage given the present workload conditions within the RCC. Many mechanics have been supplied with storage bins which they use to store small, frequently used items. The RCC should wait until the workload becomes fairly stable before making any decisions concerning the purchasing of equipment to allow better utilization of vertical space.

All of the work which is assigned to MATPFF takes place in Building 230 except for the radome testing, which is done at Building 3507, a facility specifically designed for that purpose. These facilities are adequate for the work that is being done.

The management structure used in the RCC during first shift seems to work well, with a section chief overseeing the activities taking place in MATPFF, as well as those in MATPFA and MATPFE. The RCC has a unit chief assigned to it, who supervises the three first-line supervisors who are assigned to each of the 3 subunits within each RCC.The MDMSC team believes that this structure is ideal for handling the day-to-day activities of the RCC because it allows the first-line supervisors to keep in close contact with the mechanics working under them and to assist them when it is required. There is also a section chief assigned to the swing shift who is responsible for overseeing the activities in MATPFF (as well as in MATPFA and MATPFE).

In addition to the supervision within the RCC, there are personnel assigned to support the RCC's operations in such areas as planning, scheduling, and engineering. The MDMSC team came away with the following impressions concerning the effectiveness of the support groups' activities relative to the operations in the RCC.

The planners seemed very involved in the day-to-day activities in the RCCs, but more interaction needs to take place between the planners and the workers to insure incorrect or redundant information does not get out to the floor. The workers as a whole felt that they would benefit from the WCDs being more detailed. The workers also complained about the wordiness of some of the

Technical Orders and the MDMSC team believes that more extensive use should be made of schematics and iogic flow diagrams (refer to paragraph 6.13.4 for more information).

Scheduling appeared very good and most items are inducted in a manner which maintains a smooth flow of items through the repair process. The items come through the repair process in fairly consistent intervals and this helps to cut down on the amount of storage space that is needed in the RCC.

Engineering needs to improve their responsiveness to the workers' requests for changes. The workers that MDMSC interviewed pointed out several instances where improvements could be made in the methods used to repair an item, yet engineering had not yet responded to their requests for a review. There were also cases where worker suggestions to implement a design change on a component or an end item in order to make the repair process easier or quicker were not being acted upon in a timely manner. These delays may be due in part to the number of steps that have to be gone through to get a design change approved.

Material support in the RCC causes numerous process delays. There are delays being caused by components not being available when they are needed. but a much more common problem is that vendor supplied items are found to be defective after the repair process has been completed. The problem that plagues the RCC is not so much that items are not on hand when needed, but that good items are not available. The reworking of an item in order to get the repair activity completed is commonplace and results in increased flow times for the items in the RCC. This situation is addressed further in paragraph 6.13.4 of this document.

The tracking of items in the RCC is simplified by the fact that on most items, a single worker will work on the item from start to finish to repair it. The tracking of items is also made easier because the items do not leave the general area where the repair work is done. The items do sometimes leave the worker's control to have processes such as sealing or painting performed, but everything which is done to the items during repair takes place within a confined area of Building 230. This situation greatly enhances the ability of the supervisors to keep track of the progress of the items that are being repaired.

The tracking of items in the RCC is complicated by the use of supplementary WCDs which enables some work a worker would normally do to be assigned to another worker. The use of supplementary WCDs fluctuates depending upon the demand for certain items and the workers usually are allowed to make the decision as to whether they will work an item solely by themselves or send some of the component work out to be performed by others. The use of supplementary WCDs not only makes the tracking of an item more difficult, but also compounds the difficulty of entering archive WCD data into a simulation program such as the one developed by MDMSC. This is because the code used to identify the component work is often the same as that used for the end item work, resulting in the intermingling of the data. The supplementary WCD system gives the RCC flexibility in adapting its manpower to the work needing to be done, but more emphasis must be placed upon getting the workers to fill out the paperwork correctly so that the RCC's ability to track the processing of items accurately is not sacrificed.

6.13.2 Statistical System Performance Measures

The OC-ALC Technology Insertion Team met with ALC representatives during the week of 17 July 1989 to perform a statistical comparison of the UDOS 2.0 Model Simulation Outputs for RCC MATPFF to the historical throughputs and flow times for FY 88. Other criteria, such as the utilization of manpower and equipment, were also used to assess the validity of the database. A detailed discussion of this validation process for the RCC is included in the Model Validation section of the DDB. The joint validation team concluded that the statistics generated by the simulation model were within an acceptable range when compared to the As-Is condition. This model database represents the as-is condition for FY 88 and can be used as a baseline for comparison purposes.

The throughput of items in MATPFF under the FY 88 workload averages 96%. The only PCNs that showed less than 90% throughput (PCNs 41206A, 41352A, and 49856A) were items which had heavy fourth quarter inductions.

The utilization of the equipment in MATPFF varies widely. Some pieces of equipment show very low utilization, such as the 312G1 breakout cable (2%), the A0800 pressure generator test set (2%), the P47675 roll integrator amplifier test station (2%), the P48722 Bendix parameter scheduling test set (1%), the P92174 environmental chamber (2%), and the PR0146 test set computer (2%). Only two pieces of equipment, the P48432 autopilot amp test station (68%) and the PG0013 Martron 1200 ATE (72%), were utilized above the 60% level.

The manpower within MATPFF is well utilized. If the manpower which is dedicated to the PG0013 Martron is not considered, the average utilization of manpower of all skill codes during the first shift is approximately 65%, with the manpower on second shift coming close to being fully utilized.

The large queues evident on the testing operations (op. nos. 040 and 110) for PCN 41207A are due to the fact that the P48957 Bendix test set unit is not always available when the item is ready for testing. This results in 75% of the items being held up at the incoming functional test, while half of them are delayed at the final functional test. A similar situation exists for PCN 41352A because of bottlenecks again developing at the testing operations (op. nos. 040 and 100) due to the lack of availability of P48957. The large queue on op. no. 110 of PCN 44327A occurs because two highly utilized pieces of equipment (the P48432 test station and the PG0013 Martron) are required to complete this operation, and these two pieces are seldom available when an item is sent to them. The ALC informed MDMSC that the workload on PCN 44327A was eliminated in 1989, so no further investigation to pinpoint how the process flow on this item could be improved was requested.

During the brainstorming process, ALC personnel expressed a desire to see what effect changes in the amount of equipment and the scheduling of manpower would have upon the flow of items in MATPFF under the FY 90 workload. The P48957 Bendix test set was used during the testing operations for PCNs 41207A and 41352A. As shown in the model outputs, the repair times on these PCNs were inflated because of queues developing at the test set. MDMSC was asked to conduct an experiment where each of these PCNs had its own test set. The manpower on MATPFF is presently assigned so that most of the workers are on first shift, with skeleton crews present on second and third shifts. It was requested that the assignment of manpower be used as an experimental factor, with an equal division of manpower between the three shifts being the level. The brainstorming session did not produce a third factor, so the third column of the array was left open, allowing the interaction between the other two factors to be tested.

The L_4 Taguchi array constructed for the factors and levels chosen is shown in Table 6.13.2-1. The table also shows the overall throughput percentages for the PCNs that were profiled (refer to the Experimentation section of the MATPFF DDB for a detailed report of the results produced for the individual PCNs). The table also lists the individual PCNs which showed the best and worst throughput under each condition.

The results produced by experimentation showed that all experimental runs produced 100% throughput. The runs also showed the same PCN producing the best throughput, though two different PCNs produced the worst throughput, depending upon which experimental run is being looked at. The high throughput on PCN 41033A and the low throughput on 41206A can be explained by the way items were inducted during the two quarter experimental simulation period. The low throughput on PCN 49374A is attributable to the low probability of an item arriving at the P92951 Honeywell 1505 tester when it is free. This situation causes items to queue at the tester, reducing the throughput.

MATPFF $L_4(2^3)$ TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS - FY 90

TABLE 6.13.2-1

EXP #	EQUIPMENT QUANTITY*	MANPOWER ASSIGNED	INTER-ACTION	NORMAL WORKLOAD**		
				AVG	BEST	WORST
1	SHARED	AS-IS		100 %	41033A / 112%	41206A / 89%
2	SHARED	LEVELED OVER 3 SHIFTS		100 %	41033A / 112%	49374A / 91%
3	UNIQUE	AS-IS		99 %	41033A / 114%	41206A / 93%
4	UNIQUE	LEVELED OVER 3 SHIFTS		100 %	41033A / 112%	49374A / 91%
RECOMMENDED	SHARED	LEVELED OVER 3 SHIFTS				

NOTE:
- * TWO PCNs (41207A & 41352A) ARE PRESENTLY RUN ON A BENDIX TEST SET (IDENTIFIED ON PME LIST AS P48957). DURING BRAINSTORMING, ASSIGNMENT OF A PCN UNIQUE TEST SET WAS IDENTIFIED FOR EXPERIMENTATION.
- ** ONLY PCNs WITH A QUARTERLY INDUCTIONS OF AT LEAST TEN (10) WERE CONSIDERED IN THE BEST/WORST ANALYSIS

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Because of the uniform throughput during experimentation, a further analysis was performed to determine how each factor affected the average flow time. Reference Table 6.13.2-2 for the array showing the flow time values for each run. The use of two Bendix test sets to process PCNs 41207A and 41352A produced little improvement in item flow time over the use of a single test set. The spreading of the manpower over three shifts produced a substantial improvement in flow times. The division of manpower between the shifts increased the chances of the needed manpower and equipment being available when the item needs them. Because the effect produced by the reassignment of manpower is so large relative to the effect of the other factor, MDMSC recommends that the work force in the RCC be spread equally over three shifts. The RCC management needs to decide if it is worthwhile to add more shifts to meet the current production demands. The supervisors must weigh the benefits that would occur from spreading manpower across shifts against the tangible and intangible costs of doing so. The expense involved in buying another Bendix test set would not justify the slight decrease in the flow time per item that would occur. MDMSC recommends that the equipment in MATPFF be left at existing levels. The levels of the experimental factors that MDMSC recommends to yield the best results for the investment involved are as follows:

<u>Recommended Configuration</u>

Factor:	Equipment (P48957)	Assignment of Manpower
Level:	As-Is (shared by PCNs)	Levelled over three shifts

To evaluate the RCC's ability to respond to surge conditions, the resource usage report was analyzed to determine whether the present levels of manpower and equipment were sufficient to meet the additional demands. Around-the-clock coverage was provided by putting the workers on 12-hour shifts and working them seven days a week to simulate surge conditions. In

MATPFF $L_4(2^3)$ TAGUCHI ORTHOGONAL ARRAY FLOW HOURS EXPERIMENTAL RESULTS - FY 90

TABLE 6.13.2-2

EXP #	EQUIPMENT QUANTITY*	MANPOWER ASSIGNED	INTER-ACTION	NORMAL WORKLOAD**
				AVERAGE FLOW HOURS
1	SHARED	AS-IS		263.4
2	SHARED	LEVELED OVER 3 SHIFTS		240.9
3	UNIQUE	AS-IS		259.8
4	UNIQUE	LEVELED OVER 3 SHIFTS		241.0

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order for MATPFF to meet the repair requirements which a surge condition would place upon its FY 90 workload, the following increases would have to be made in the RCC's resources:

Resource	Current Amount	Required Amount
945808 or 945804 AFCS Electro-mechanical Test Set	2	4
Manpower (skill codes AN, BN, and CN interchangeable)	30	34

To meet surge requirements, the entire work force will have to work 12 hour shifts and seven days a week.

6.13.3 Description of Process Problems

The present software being used with the automatic test equipment (ATE) is limited in its diagnostic capabilities. It aids the mechanic by informing him of the potential causes of a malfunction, but it does not tell the mechanic what specific component is defective. The present software is also incapable of detecting a wiring or a chassis problem. The mechanic still is forced to go through a lengthy troubleshooting procedure to pinpoint the specific cause of a problem after the testing is completed on the item. This results in increased flow times for the items being repaired. A focus study designed to alleviate this problem is described in paragraph 6.13.4.

6.13.4 Recommended Focus Study: Refinement of ATE Software

This paragraph covers the only improvement opportunity categorized as a focus study exclusively for RCC MATPFF. Before the repair on an item can begin, it is necessary to locate the specific component of an item that is malfunctioning. The shorter the amount of time required to do this, the quicker the flow time for the repair process. The focus study describes the development of improved diagnostic software to provide greater automated troubleshooting capability.

Table 6.13.4-1 details the areas that will be affected by the focus study. The table shows the MDMSC assessment of the level of effort required in the focus study to evaluate individual areas of analysis. This focus study recommends that improvements be made in the software currently being used to allow it to identify those specific components of an item which are defective. MDMSC believes that a major productivity gain can be made if the software can be sufficiently improved.

6.13.4.1 Rationale Leading to Change

During the characterization process in MATPFF, it became clear that the overall repair process flow time could be reduced significantly if the software were improved. By shortening the time required for the mechanic to further troubleshoot an item after it comes off the test equipment, more items can be processed in a given time period, improving the utilization of both the mechanic and the equipment.

The following discussion develops the benefits of the recommended idea.

Process Definition

The software presently being used is written in the Atlas language, which is commonly used in testing programs. Generally, the items that run across the ATE have long flow times relative to the other items repaired in MATPFF, with the vast majority of the repair time being taken up by the testing and troubleshooting of the item. MDMSC believes that by modifying the existing test program, or rewriting it as necessary, the repair time can be reduced substantially. Based on information gathered during the interviewing process, MDMSC believes that an average of four hours is being spent to troubleshoot an item after it comes off of the ATE.

Material Flow and Process Delays

Presently, a queue of items waiting to be tested can be found at the ATE. By improving the software, items will flow through the testing operation much quicker and smoother, resulting in fewer items being delayed.

IMPROVED ATE SOFTWARE FOCUS STUDY CRITERIA CHECKLIST
TABLE 6.13.4-1 (SHEET 1 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)	LEVEL OF EFFORT		
		MIN	AVG	MAX
Process/Material Flow	Study existing test procedure to see how items flow through the operation so that the impact of the testing operation relative to the entire process can be assessed.		X	
Equipment/Work Place Layout	Review to see what limitations are placed on the software by the hardware being used.	X		
Facility Requirements	Insure that current facilities are sufficient for needs.	X		
Labor Standards	Evaluate existing standards to see what changes might occur as a result of various degrees of improvement in the ATE software.		X	
Manpower	Review current manpower assigned to testing and evaluate possible changes that could result from changes in the software.	X		
Task Assignments	Review current assignments to see whether changes should be made as a result of reduction in the testing time.	X		
Material Requirements	No action required.	X		
Scrap Rates	Review present rates for comparison with rates that develop after implementation.	X		

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IMPROVED ATE SOFTWARE FOCUS STUDY CRITERIA CHECKLIST

TABLE 6.13.4-1 (SHEET 2 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)	LEVEL OF EFFORT		
		MIN	AVG	MAX
Material Handling & Storage Methods	Review present storage for items awaiting test to see if reductions can be made when testing operation is expedited.	X		
Inspection Techniques	Evaluate problems that presently have to be found through manual troubleshooting for a comparison to a list made after the software is improved to see if a change in the amount and type of inspection should be made.		X	
Equipment/Tools/Fixtures	No action required.	X		
Process Delays	Study the queues which exist at the ATE to evaluate the delays resulting from the existing testing operation, and predict what the impact on process flow will be at various levels of software improvement.		X	
Part Identification	No action required.	X		
Quality	Review the quality level of items being repaired using the existing software for a comparison in the future against the quality level of items repaired with the new software.	X		
Personnel Safety	No action required.	X		
Environmental Assessments	No action required.	X		

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Manpower Realignment

The implementation of the MDMSC proposal will result in significant labor savings. While MDMSC believes that the RCC will keep the same mechanics running the test equipment as are doing it now, the productivity of these mechanics will increase because of the streamlining of the testing.

Facilities and Equipment

No changes will be required in the hardware currently being used.

Materials, Inspection, and Scrap Rates

MDMSC believes that the software can be improved without sacrificing the accuracy of the testing operation. In fact, the improved software, with its expanded capabilities, should increase the ability of the mechanic to detect everything that is wrong with an item and this will insure that an item goes out with all of the defects corrected.

Flexibility and Expandability

When writing the software, MDMSC will try to structure the computer language in such a way that future revisions designed to allow the testing of additional items can be made without radical changes being required.

6.13.4.2 Potential Cost Benefit

An annual recurring cost savings of $243,739 occurs from the implementation of the recommended improvements as shown in Table 6.13.4-2.

The investment cost of the recommendation is estimated at $470,000. This cost includes the focus study effort and the implementation cost.

The Cost Benefit Analysis (CBA) shows an Internal Rate of Return (IRR) of 37% and a savings of $413,778 in terms of Net Present Value (NPV) using constant FY 89 dollars, see Figure 6.13.4-1. The CBA is in compliance with regulation AFR173-15, cost analysis procedures, dated 4 Mar 88 and rates per AFLCR 78-3.

SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS (CONSTANT FY89 DOLLARS)

TABLE 6.13.4-2 (SHEET 1 OF 2)

	CURRENT ANNUAL COSTS	PROPOSED CHANGE INVESTMENT COSTS	PROPOSED CHANGE ANNUAL COSTS
NONRECURRING COSTS (1)			
FOCUS STUDY	$0	$220,000 (2)	$0
FACILITIES			
LAND	$0	$0	$0
BUILDINGS	$0	$0	$0
SUPPORT EQUIPMENT			
DEVELOPMENT	$0	$250,000 (3)	$0
ACQUISITION	$0	$0	$0
INSTALL & CHECKOUT	$0	$0	$0
LOGISTICS SUPPORT			
INITIAL SPARES	$0	$0	$0
INITIAL TRAINING (DEV & PRESENTATION)	$0	$0	$0
TECHNICAL DATA	$0	$0	$0
TOTAL NONRECURRING COST	$0	$470,000	$0
RECURRING CCSTS (1)			
TOUCH LABOR	$487,478 (4)	$0	$243,739 (5)
SUPPORT EQUIP MAINT	$0	$0	$0
SPARES AND SPARES MGMT	$0	$0	$0
TECHNICAL DATA	$0	$0	$0
MOD KITS	$0	$0	$0
CONFIGURATION DATA MGMT	$0	$0	$0
UTILITIES	$0	$0	$0
TOTAL RECURRING COSTS	$487,478	$0	$243,739
TOTAL COSTS	$487,478	$470,000	$243,739
ANNUAL COST SAVINGS	$243,739		

NUMBER OF MONTHS FOR FOCUS STUDY	5
NUMBER OF MONTHS TO IMPLEMENT CHANGES	12

SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS (CONSTANT FY89 DOLLARS)
TABLE 6.13.4-2 (SHEET 2 OF 2)

NOTES:

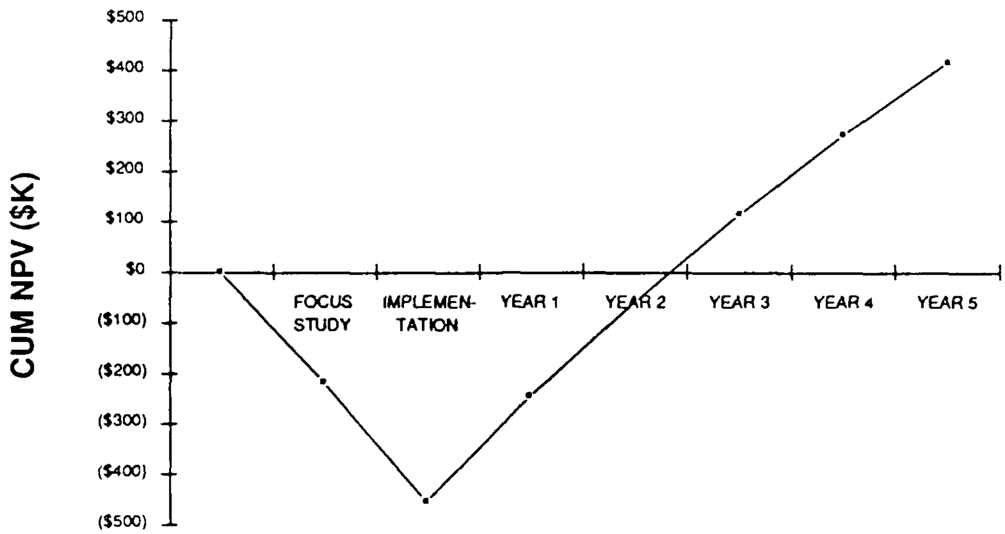
(1) ONLY ITEMS THAT ARE SIGNIFICANTLY AFFECTED BY THE PROPOSED CHANGE HAVE BEEN ESTIMATED

(2) ENGINEERING ESTIMATE FOR USE IN ENGINEERING TRADE STUDIES ONLY, DOES NOT REPRESENT FIRM PRICING

(3) SOFTWARE CHANGES FOR THE ATE INCLUDING DEBUGGING (ESTIMATE)

(4) BASED ON ITEMS PER YEAR THAT USE ATE (PROVIDED BY RCC SCHEDULERS) AND AN AVERAGE OF 4 HOURS FOR TROUBLESHOOTING EACH ITEM AFTER TESTING
4,080 ITEMS/YEAR X 4 HOURS/ITEM X $29.87/HOUR

(5) BASED ON 2 HOUR REDUCTION IN TROUBLESHOOTING TIME (ESTIMATED HOURS SAVED PER RCC INTERVIEWS)
4,080 ITEMS/YEAR X 2 HOURS/ITEM X $29.87/HOUR



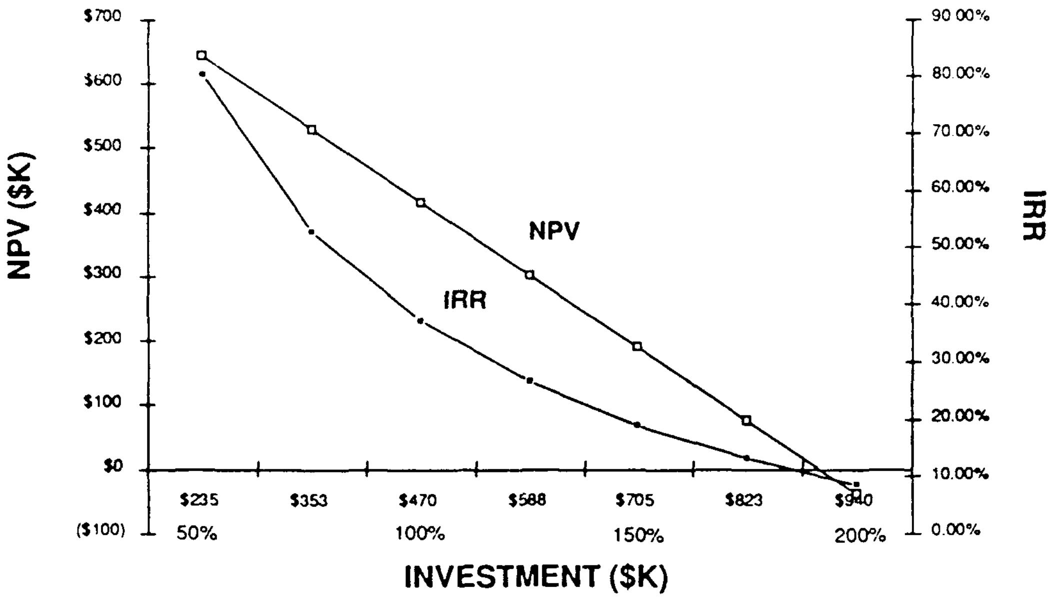
CUM NPV IN CONSTANT FY89 DOLLARS
FIGURE 6.13.4-1

The CBA covers the time frame starting with the focus study through five years after the completion of implementation. The recurring cost savings was assumed to start at the end of implementation.

The NPV takes into account the time value of money and is calculated by discounting a cash flow. The focus study cost, implementation cost, and the recurring savings were spread by fiscal year quarters and discounted back to the first quarter by using a mid-quarter discounting factor equivalent to an annual discount factor of 10%. Basically, this means a dollar that is earned in FY 90 is worth $.91 in FY 89 terms ($1.00/1.1), due to the ability to borrow or lend at a positive interest rate.

A sensitivity analysis was performed in which the investment cost varied between 50% and 200% of the estimated costs, see Figure 6.13.4-2.

To evaluate the effect that improving the ATE software would have upon the flow of items in MATPFF, PCN 44327A was chosen as a candidate for the evaluation of our focus study recommendations. The assumption that MDMSC is going to



CBA SENSITIVITY ANALYSIS
FIGURE 6.13.4-2

make is that the effect which occurs on 44327A will be representative of the changes which will occur for the other items which would be effected by the proposal. An experiment was run where time required on an operation where the Martron 1200 automatic testing equipment is used (op. no. 110) was reduced by two hours (from 9.8 to 7.8 hours). The ATE had already been identified during validation as a tight resource, so the reduction in process time for the ATE was expected to reduce the queuing of items waiting to be checked.

The result of the experiment showed a very large reduction (57%) in the average simulated flow hours. In addition, the average amount of work in process dropped 58%. This would result in a substantial savings to the ALC because lower WIP levels would reduce the inventory carrying cost on these items. The reduction in the ATE processing time also helped to relieve some of the load on the machine, reducing the utilization on it by 17%.

The actual touch labor savings are only a part of the benefits that the improvement of the ATE software will produce for MATPFF. The reduction of queues will eliminate the problem of the RCC having so many items in process, but not completed. This will allow the RCC better control over the tracking and scheduling of items. The inventory of the items which are processed across the ATE would drop significantly and this would free up storage space with the RCC, which could then be used for other items or eliminated. The decreased load on the ATE would improve the RCC's ability to process the additional workload that would come in under surge conditions.

6.13.4.3 Risk Assessment of Achieving Goals

Several elements affect the overall achievement of meeting the goal of this recommendation. MDMSC views the following as factors which could impact the implementation of our proposal.

- It may be discovered after investigation that it is not possible to detect certain types of problems. Presently, the degree of difficulty involved in modifying the software to isolate a specific defect is not known.
- Future changes in the workload mix may make it difficult to keep the software current to the needs of MATPFF.
- MATPFF may face a problem in freeing up the ATE long enough to allow software debugging without impacting the normal production flow.
- There may be legalities involved in having MDMSC modify software that was developed by someone else.
- It may be difficult to make OC-ALC personnel available to work with the MDMSC team to help define the requirements for the software and assist with the debugging of it. It is also important that OC-ALC personnel be freed from their normal duties for a time in order to be trained in the operation and maintenance of the software.
- It is possible that the improved software, because it is doing a more thorough analysis of the item, may require a longer test cycle than the existing software.

Notwithstanding the above, MDMSC recommends pursuing this focus study as it believes that the benefits outweigh the risks.

6.13.4.4 Duration and Level of Effort

MDMSC believes that the improvement of the software is a three phase process, where the phases are: (1) examination of the items to be tested and determination of the requirements for the software; (2) revision of the existing software or creation of new software to meet these requirements; and (3) debugging of the software to insure its proper functioning.

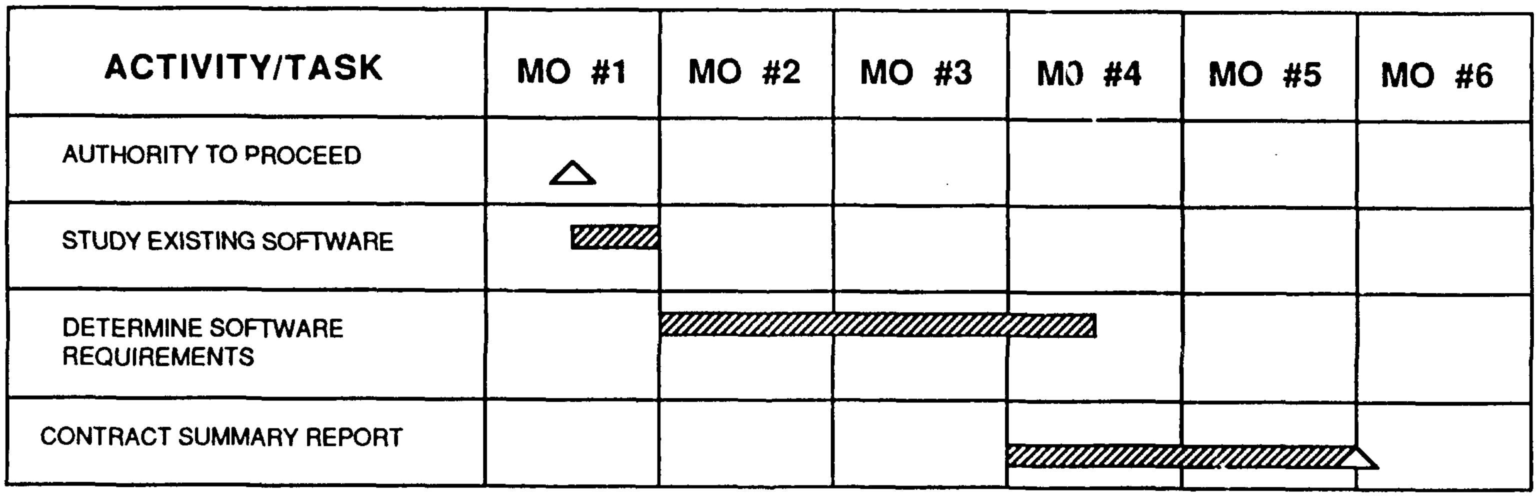
MDMSC proposes creating a team consisting of electrical engineers and computer programmers to accomplish the tasks outlined above. Program sequence and rough approximation of project timing is shown in Table 6.13.4-3.

6.13.5 Other Observations

The other observations described in this section were not considered as focus studies or quick fixes because they had a less significant impact in the areas of time, quality, or cost. These observations are recorded to assist OC-ALC in developing ideas that will further enhance their repair operations.

The following observations were originally identified as Quick Fixes and Focus Study improvement opportunities and can be found in the DDB. After review by the MDMSC/Air Force team, it was mutually agreed they should be presented as other observations.

PROPOSED FSR NO. 1 SCHEDULE
TABLE 6.13.4-3



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Environmental Improvement Opportunities

- Noise Abatement
  - Current Condition: Constant background noise makes it hard for mechanics to concentrate on their work.
  - MDMSC Recommendation: Use damping materials to cut down on the noise levels.

General Area Improvements

- Space Consolidation
  - Current Condition: The layout of the RCC takes up more space than is necessary.
  - MDMSC Recommendation: Allow the mechanics only as much workbench area as is necessary to do the job. Eliminate the island between workbenches if possible and reduce the width of the aisles.

- Ergonomic Seating
  - Current Condition: Mechanics are working while seated in desk-type swivel chairs, which usually results in the mechanic being too low relative to the height of the workbench. Many mechanics have used cushions to try to raise themselves up, but this seldom resolves the problem of the mechanics being in an uncomfortable working position.
  - MDMSC Recommendation: Purchase adjustable-height stools like those commonly used in the commercial electronics industry.

Operational Improvements

- Accuracy of Floor Documents
  - Current Condition: The Work Control Documents (WCDs) do not always accurately reflect the operations that are being performed on an item to repair it.
  - MDMSC Recommendation: Review the WCDs on all items currently being repaired and correct them until they are true representations of how the items are being processed.

- Improvement of Repair Procedure Documentations
  - Current Condition: Many of the Technical Orders related to the repair of electronic components are very wordy, which often makes it difficult for a mechanic to find a specific repair procedure.
  - MDMSC Recommendation: Check all Technical Orders to see that they contain schematic diagrams. On complicated repair procedures, utilize logic flow diagrams similar to those used in computer programming to make the steps involved in the repair process easier to follow.

- Equipment Study
  - Current Condition: The RCC contains equipment that is not being utilized very much.
  - MDMSC Recommendation: Do a study of the equipment in the RCC to see if it is possible to eliminate some of it by modifying certain pieces so that more than a single part can be run on them. Examine whether it would be worthwhile to replace some of the older equipment with more modern equipment.

- Tooling Study
  - Current Condition: Some mechanics lack the best tools to do the job, which inflates the flow time needed to repair the item.
  - MDMSC Recommendation: Study the RCC and determine what the tooling requirements are for the jobs that are in it. Make sure that the proper tools in sufficient amounts are provided to the mechanics. Examine whether the tools currently being used are the best suited to the task, paying particular attention to areas where power tools can be used in place of hand tools.

- Utilization of Board Turners
  - Current Condition: Mechanics who work on circuit boards position them manually during the repair process. The flipping and rotating of the board sometimes results in damage being done to some of the components on the board. The mechanic also requires extra time during the repair process because he has to hold onto the board with one hand while he works with his free hand.
  - MDMSC Recommendation: Supply the workers with board turners that will allow the worker to have freer use of his hands during the repair process. The turners should also reduce of damage done to the components on the board and reduce the time needed to repair the board.

- Eliminate the Reworking of Vendor Items
  - Current Condition: Mechanics who, during the course of their repair work, run into a defective vendor item sometimes rework these items in order to avoid an interruption in the repair process. The workers that we interviewed often stated that it took more time to go through the process of getting an item condemned and to get a replacement item in than what it took to rework the item to get it into an acceptable condition. The workers gave the MDMSC team the impression that two reasons why the existing procedures are not being used is that too much paperwork is required and replacement items are usually not readily available. The workers complained that there is often such a time lag in getting a replacement item in for one that has been rejected that the item under repair has to be stored. Upon the receiving of the needed component, the mechanic has to take time to retrieve the stored item and remember what point he was at in the repair process.
  - MDMSC Recommendation: The ALC must get tough with its vendors and be willing to drop them if they are unable to prove that they can consistently provide a high-quality product. The present willingness to rework a vendor's items must be changed to a hard-nosed attitude where the ALC refuses to accept any items that are outside of the

specifications that have been given to the vendor. The ALC can achieve major savings by simply refusing to devote its time and manpower to reworking nonconforming items that are sent in by vendors.

- <u>Testing Procedure Reviews</u>
  - Current Condition: On certain items, the mechanics feel that unnecessary testing is being done or that the degree to which the part is being tested is excessive.
  - MDMSC Recommendation: Periodically review the testing parameters called out in the Technical Orders to ensure that the parameters are still valid and that changes in the item have not taken place which would allow a change in the testing procedure that could expedite the repair time. It is extremely important that the tests be set up to guarantee that no defects go undetected, but care must be taken to pare the test time to the minimum that will still allow the test to be done effectively.

Quality Improvements

- <u>Improve the Packaging of Vendor Items so that more information Concerning the Manufacture of Each Item is Included</u>
  - Current Condition: Usually, only the outer packaging of new parts has the supplier's contract number, vendor code, and date of manufacture. This identification may be lost if the part is removed from its outer packaging in order to be staged for installation. If, during installation, a part is found to be discrepant, a QDR may not result in supplier corrective action due to the lack of any of this I.D. information on the QDR.
  - MDMSC Recommendation: Mandate a general contract P.O. requirements that the above three pieces of I.D. be affixed to each part by the supplier per an acceptable method. The P.O. should also stipulate that the part(s) may be returned to the supplier whenever the outer package is opened and the noted I.D. information is missing. Implementation of this idea will produce the following benefits.

- Suppliers will be required to take corrective action for every supplier related QDR.
- All supplier related QDRs will be answered in a timely manner.
- No parts still under warranty will be scrapped or repaired at the expense of the ALC.
- There will be less down time from recurring discrepancies for new parts as suppliers are required to accept the responsibility for corrective action on QDRs with properly documented part identification.

- <u>Improve the Recordkeeping of the RCC on Items Which are Condemned</u>
  - Current Condition: Production operations generate scrap through a variety of causes. This scrap is ordinarily removed from the RCC for disposal, along with the accompanying WCDs.
  - MDMSC Recommendation: Each RCC should maintain a scrap logbook that lists each part as it is scrapped and the cause for scrapping the part. A periodic review of an RCC's scrap logbook could be used to determine how to reduce excessive scrap by implementing methods to eliminate, or reduce, the repetitive causes for scrapping parts. By cutting down on the amount of items presently being scrapped, the RCC will increase the productivity of its manpower and equipment and reduce the amount of material being wasted.

- <u>Develop a "First In - First Out" (FIFO) Inventory System</u>
  - Current Condition: Supply receives and stores new supplier parts for subsequent distribution and usage by ALC shops. No stock rotation method is being used to assure a "first in - first out" distribution of these parts. New parts have a warranty that is valid for a specified period of time. This warranty becomes void when discrepant new parts are not discovered within this time period.

- MDMSC Recommendation: Supply should date stamp every part, or the outer package of every part, as it is received. Supply should then store and rotate the new parts stock so that the oldest date stamped part is issued to the production shop first. Implementation of this idea would produce the following benefits:
  - Suppliers of discrepant parts under warranty will be required to replace or repair them at no cost to the ALC.
  - The discovery of numerous discrepant parts within a contract lot usually allows the ALC to return that entire lot to the supplier for parts screening and subsequent replacement or repair at the supplier's expense.
  - Supplier corrective action becomes more timely, responsive, and effective.
  - Unreliable suppliers are eliminated early-on.
  - Flow times on items will decrease because fewer discrepant parts will find their way to the production floor.

6.14 MATPHA ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MATPHA is an RCC in the Accessories Division (MAT) and is responsible for the overhaul and testing of constant speed drive (CSD) transmissions and their associated gear boxes and components. Transmissions from the following weapon systems are repaired at MATPHA: F-15, F-16, KC-135, C-141, and F-111. A breakdown of the different types of CSDs repaired can be found in Figures 6.14-1.through 6.14-5.

The current resources within MATPHA are capable of processing all of the items under surge conditions. Throughput could be improved considerably by reducing non value-added activities, such as processing excessive paperwork which is required for obtaining replacement parts that are no longer kitted. Depending on the transmission in overhaul, time for such indirect activity may range from two to seven hours. However, from a simulation viewpoint, throughput is acceptable because the model generated an average of 2,125 end items versus 2,132 end items for FY 88 production. Deviations by PCN ranged from 1.8% to -2.0%.

Initial characterization of the RCC resulted in 15 improvement opportunities. None of the opportunities were classified as focus studies. One was classified by the MDMSC/ALC team as a quick fix and is detailed in the OC-ALC Quick Fix Plan MATPHA section. The remaining 14 were classified as other observations and are described in paragraph 6.14.4 of this document.

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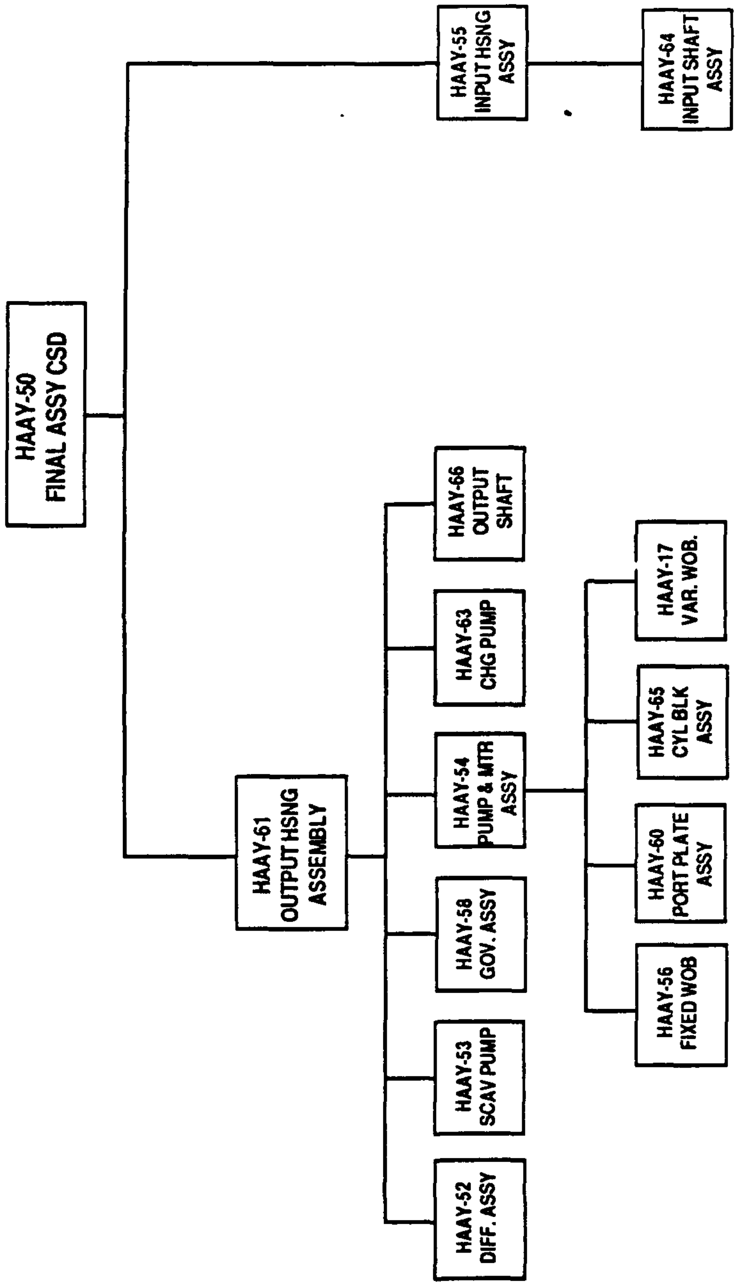

PCN # 30033A
SS C-141 CONSTANT SPEED DRIVE BREAKDOWN
FIGURE 6.14-1

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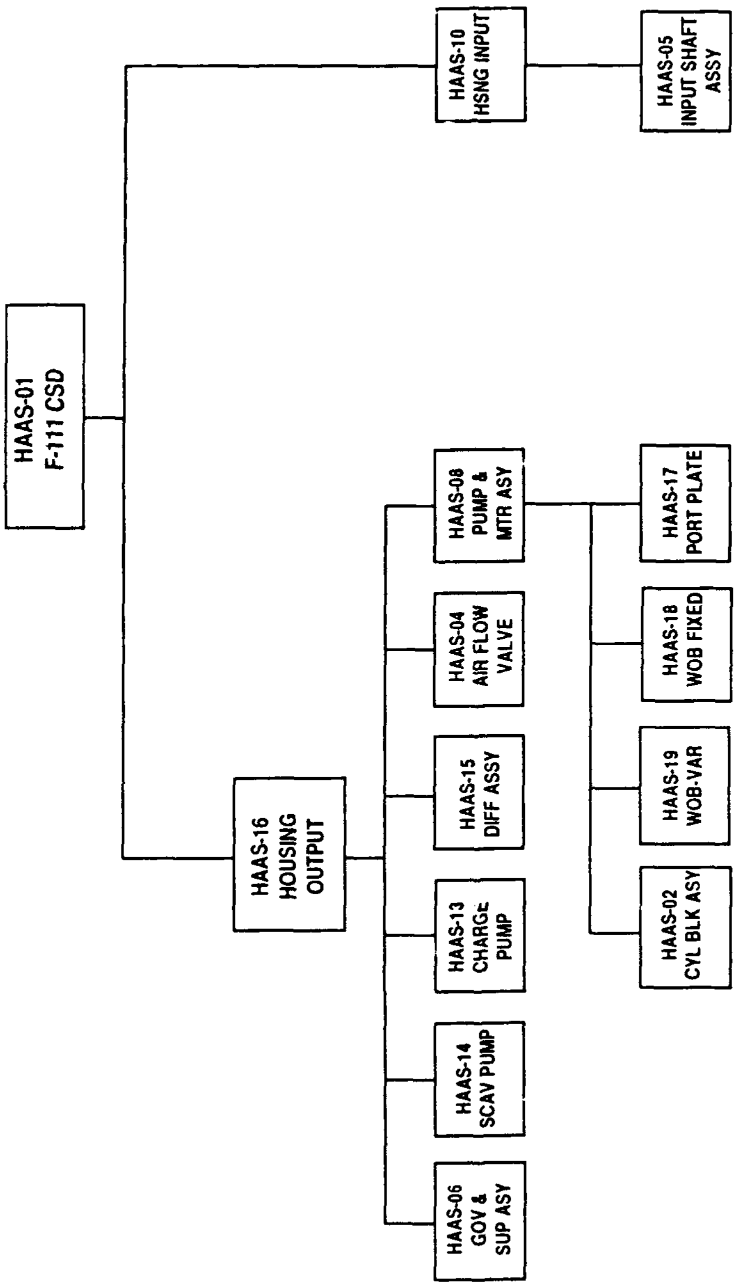

PCN # 30046A

F-111 CONSTANT SPEED DRIVE TRANSMISSION BREAKDOWN

FIGURE 6.14-2

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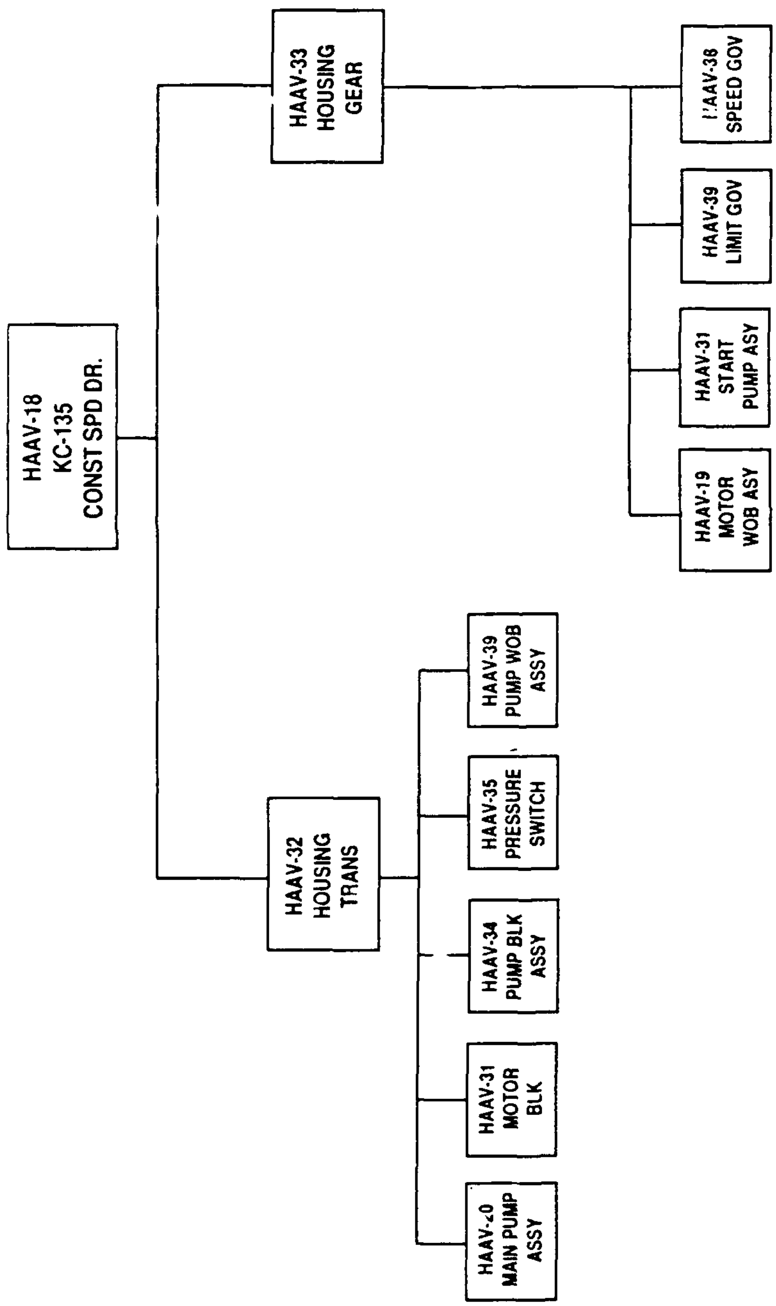

PCN # 31151A
KC-135 CONSTANT SPEED DRIVE BREAKDOWN
FIGURE 6.14-3

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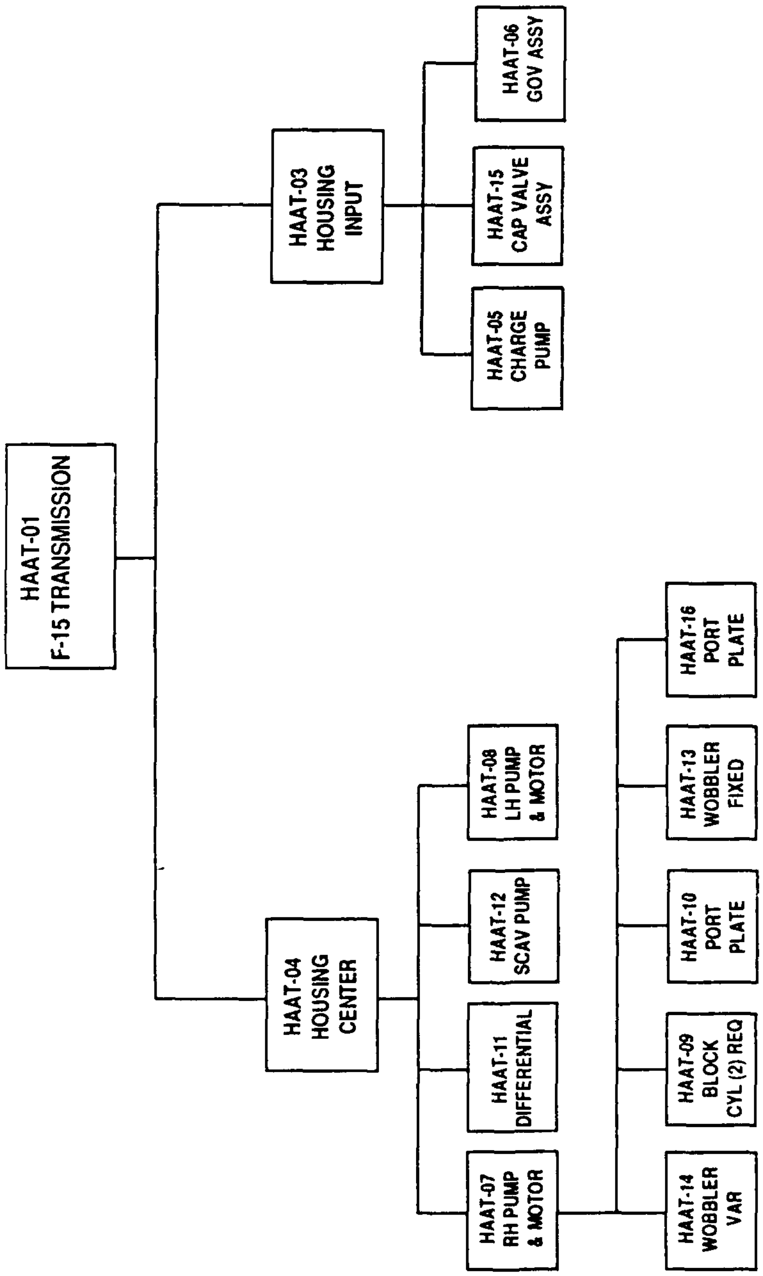
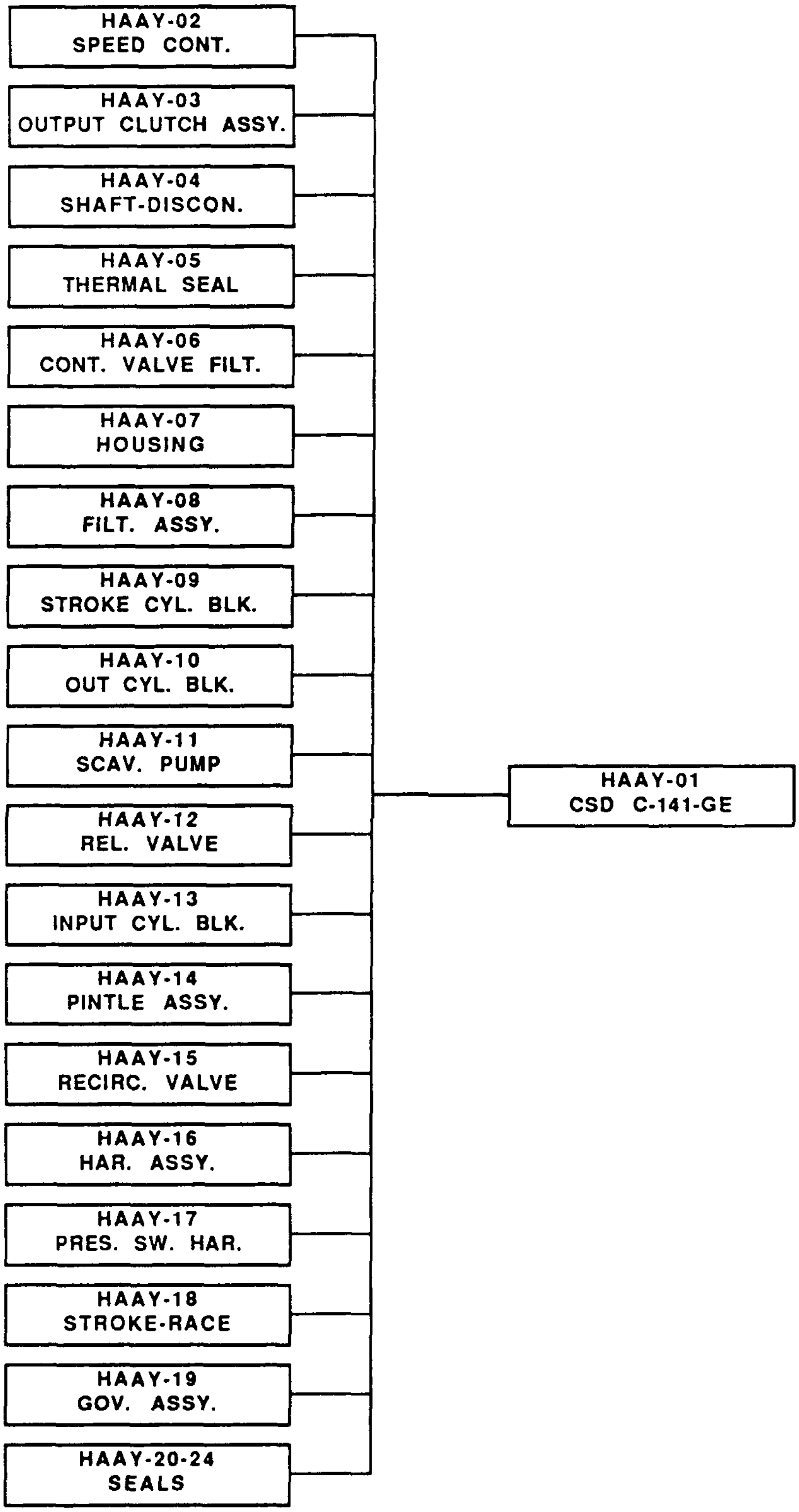


PCN # 49840
F-15 CONSTANT SPEED DRIVE BREAKDOWN
FIGURE 6.14-4



GE C-141 CONSTANT SPEED DRIVE (PCN 30011A) BREAKDOWN

FIGURE 6.14-5

The quick fix which recommends a procedural change to eliminate the testing of various pumps during disassembly will reduce repair time by an estimated one hour per CSD. These tests have shown a failure rate of less than 1%. Associated defects detected can be repaired at final test. A detailed analysis of the quick fix can be found in the Quick Fix Plan for MATPHA.

6.14.1 Description of Current Operations

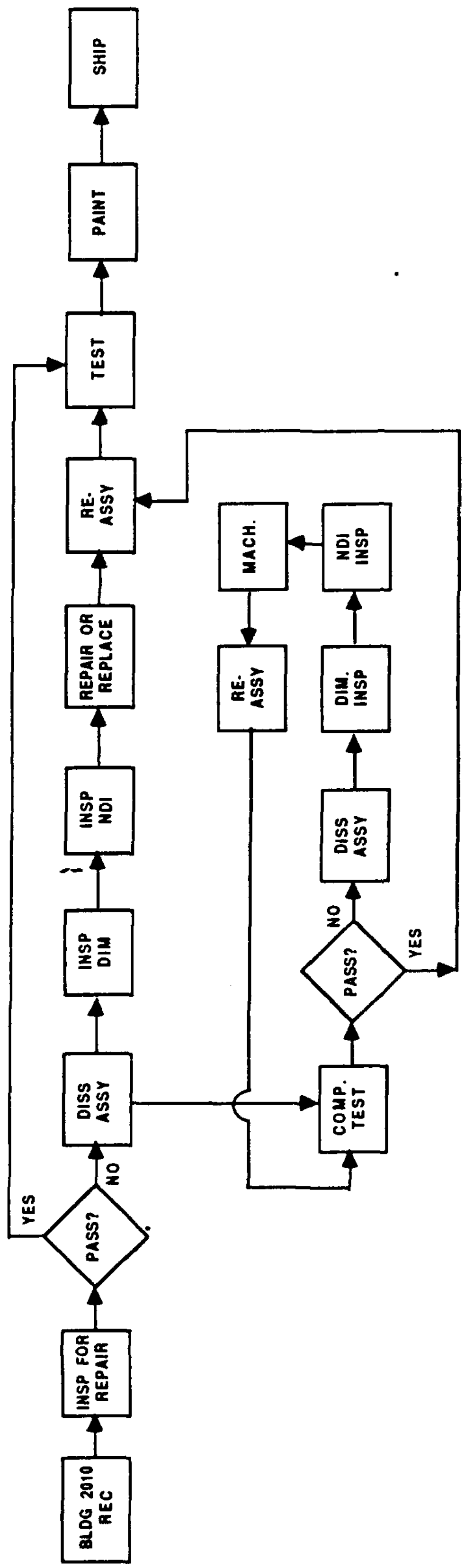
MATPHA is a general overhaul unit; however, it has the same capabilities as MATPHB (a specialized CSD overhaul unit). The CSDs repaired are used in conjunction with an aircraft generator to convert a varying mechanical input to a constant electrical output. Primarily, MATPHA takes units rejected in the field and repairs or overhauls them as required. The process flow chart for the repair of CSDs is shown in Figure 6.14.1-1. MATPHA is basically identical to MATPHB. The only difference is the different models of CSDs worked in each area. Both RCCs are located in the same building and share facilities, including the machine shop, MATPHE. MATPHA is separated into the following three distinct sections:

- Assembly
- Disassembly
- CSD Component Test Cells

The assembly area is close to Class 3000 clean room standards, with excellent lighting and working conditions. Equipment requirements are minimal, but adequate for the "bucket" tear-down and reassembly operations performed.

The disassembly area is inherently less clean because of the nature of the operations performed, with both hydraulic oil and grease being present on the tear-down benches. Drip pans are provided to minimize oil spillage. It should be noted that, nonetheless, this area is well maintained; however, lighting is somewhat sub-standard in this area.

The MATPHA area appears well organized, with good work flow, and having no areas of congestion. Personnel appear knowledgeable, and the overall impression was favorable for this RCC.



PROCESS FLOW CHART CONSTANT SPEED DRIVES
FIGURE 6.14.1-1

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Equipment presently used in MATPHA consists of several CSD component test stands, common electrical testing equipment, such as multimeters, etc., and other common and specialized hand tools.

A detailed listing of the equipment used in MATPHA is included in the Equipment Profile section of the Database Documentation Book (DDB) for this RCC.

MATPHA has a relatively stable work force with little variance. Workloads are well defined and personnel appear knowledgeable regarding their tasks. The work force is comprised of 35 journeyman technicians, seven of whom are assigned to the component test cells.

MATPHA is supported by one back shop, MATPHE, which is a general machine shop.

The workload in this RCC is relatively stable. CSDs are a common engine accessory, and new aircraft coming into the inventory use these items with little or no changes in the internal mechanisms. The present procedure for repair and overhaul utilizes the "bucket" tear-down and reassembly method. It is suggested that a "Belt Line" assembly/disassembly system would be far more cost-effective. As previously stated in paragraph 6.14, private industry has found the use of a "belt line" assembly/disassembly process to be cost effective. To achieve these benefits at OC-ALC, the present system of supply and distribution needs to be enhanced as this process is dependent on a ready supply of parts upon demand. Using the same rationale, it would be necessary to expedite rework turnaround time in MATPHE, which supports this RCC as a back shop. The average rework time for this back shop is three days, which is inadequate for the demands of a belt line system. It also is necessary to restructure the existing quality control and a labor tracking system to meet the special needs of an automated belt line. Since the feasibility of these changes must be left to the judgement of personnel at OC-ALC, this improvement opportunity is listed as an other observation in paragraph 6.14.4.

MATPHA workload consists of MISTR items, which are variable and depend on Air Force inventory needs.

The CSDs are checked for time in service, and then tested for functional and specification requirements. Overhaul and modifications are performed, as required, by Technical Order changes in order to upgrade to present requirements.

When applicable, repairs or replacements are made to defective internal components of the CSD, and inspections are performed for problems requiring back shop support.

Engineering and Planning personnel, who presently release the Work Control Documents (WCDs), should provide more detail in their methods for performing the various operations. Problem Request Forms (AFLC Form 103) are not always processed in a timely manner. In addition, the replies are often inconclusive. This leaves shop supervision with unresolved problems or requires shop supervision to work the problems through trial and error. It should be noted that replies often address the symptoms, rather than the causes of these problems.

Material handling in MATPHA is mostly manual, with the use of hand carts being the predominant means of transporting items from one area to another. Gantry cranes are often used in lifting and manipulating the larger CSDs. Technicians are routinely sent to the receiving area to uncrate delivered items and place them on pallets. A forklift is then used to place the pallets on one of several pallet racks in the area. These pallet racks are not designed to support the amount of weight placed on them, and several show signs of structural failure (see Other Observation regarding this situation, paragraph 6.14.4 of this report).

Storage capabilities in the MATPHA area consist of 62 cabinets that are 6x3x2 feet in size. These cabinets are located throughout the MATPHA/HB shop area. Other storage capability includes two pallet racks at 12x16x5 feet each, one pallet rack measuring 12x24x5 feet in size, and several cage areas. The total floor space of MATPHA is approximately 5,866 sq. ft. This is considered adequate.

6.14.2 Statistical System Performance Measures

Validation of the UDOS 2.0 model simulation outputs for MATPHA was initiated on 9 August 1989. The FY 88 80/20 list for MATPHA consisted of six end items and 103 subassemblies. The criteria used to validate the UDOS 2.0 model simulation output was: 1) throughput, 2) simulated flow versus G019C estimated flow days, and 3) resources utilization (queues). These results are presented in detail in the Experimentation section of the DDB. Other criteria, such as utilization of manpower and equipment, were also used to assess the validity of the model results.

Several assumptions were made at the time of validation. These assumptions were considered to be both necessary and reasonable in interpreting model validity. The assumptions made were as follows:

- The 80/20 workload analysis was accurate and represented 80% of the workload. The workload may vary from 80% in cases where the MDMSC/OC-ALC team has decided on, and jointly authorized, deviations from the original 80/20 listing.
- Mechanics' estimates of process times are to be considered as statistically accurate.
- Induction quantity distributions are accurate and can influence throughput.
- Historical data, collected from the WCDs, are not accurate. Some causes for these inaccuracies are:
  - WCD release practices (batch print)
  - Stamping practices on WCDs
  - Work schedules (priorities)
  - Lack of parts or high workloads in process
- Validation will be accomplished against engineering estimates.

The throughput statistical analysis performed at the time of validation was to ascertain that the model simulated FY 88 production levels were representative of actual conditions. As can be seen in the DDB, Experimentation Section, the variance analysis for simulated throughput versus actual throughput for this RCC shows a 34% difference. On the average, the model generated 37,708 inducted versus 37,838 actual end items and component parts produced. A more detailed discussion by PCN number may be found in the DDB Experimentation Section.

The flow hours statistical comparison was performed against the G019C report. The data examined contained too many inaccuracies for any meaningful analysis to be performed, mainly due to the incorrect tracking of subassemblies. The DDB contains the variance analysis for simulated flow hours versus G019C flow hours. On the average, the simulated flow hours are 17% higher than the G019C. A detailed discussion by PCN for this comparison is available in the DDB.

The brainstorming process for experimentation on MATPHA followed model validation. The prepositioning step is identification of the problem statement which is the objective of the brainstorming process. In the case of MATPHA, the problem statement read: "What would be the effect of 1) improving Mean Time Between Failures (MTBF) by installing a new computer control system, 2) improving MTBF of computerized testing equipment by making the new system independent and interchangeable, and 3) improving MTBF and Mean Time To Repair (MTTR) by 55% by the addition of a new calibration card."

An orthogonal array was developed using the Taguchi process. The team identified three factors and established two levels for each factor. An L_4 (2^3) array is depicted in Table 6.14.2-1, with throughput (Δ) being selected as a quality characteristic. Table 6.14.2-1 also shows the average throughput of all experimental runs performed as being approximately 100%. This precludes the use of throughput as an analysis factor for experimental results. It can also be seen that best and worst case analysis by PCN for each run shows little

L_4 TAGUCHI ORTHOGONAL ARRAY EXPERIMENTAL RESULTS

TABLE 6.14.2-1

	FACTORS			FY 88 THROUGHPUT% (END ITEM ONLY)		
				NORMAL WORKLOAD		
EXP #	NEW COMP. CONTROLLER	INTER-CHANGEABILITY	NEW CALIBRA-TION CARD	AVG	BEST	WORST
1	AS-IS	AS-IS	AS-IS	100%	50261A / 101%	30046A / 99%
2	AS-IS	40% IMPROVED MTBF	55% IMPROVED MTBF & MTTR	99%	49840A / 100%	31151A / 97%
3	55% IMPROVED MTBF	AS-IS	55% IMPROVED MTBF & MTTR	99%	50261A / 100%	31151A / 97%
4	55% IMPROVED MTBF	40% IMPROVED MTBF	AS-IS	99%	50261A / 100%	31151A / 98%

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variance between end items worked. MATPHA appears very efficient across its entire workload.

Table 6.14.2-2 was developed using the simulated flow time averages from each experiment and performing a Taguchi analysis using this data. By selecting the Taguchi optimum level for each factor, the most effective combinations of equipment, manpower, and skill were selected. It revealed that the optimum configuration was the As-Is condition.

The FY 90 workload was used to determine the surge capabilities of MATPHA. Surge information was supplied by the AFLC. Analysis of surge capacity, as discussed in the DDB Experimentation section of this RCC, indicates that a throughput of 100% can be achieved.

6.14.3 Description of Process Problems

The intent of this paragraph is to provide detailed description of major process problems for which there are focus study recommendations. Since none of the observed MATPHA improvement opportunities were classified as a focus study, they are addressed as quick fixes or other observations.

6.14.4 Other Observations

The process improvement opportunities described in this section were not considered as focus studies or quick fixes, but as other observations, because they had a less significant impact on the areas of time, quality, or cost. These observations are recorded to assist OC-ALC in developing ideas that will further enhance their repair operations.

Operational Improvement Opportunities

- Develop and/or Strengthen Inner Office Procedures for Processing Problem Request Forms. (Form 103)
  - Current Condition: Shop personnel do not rely upon AFLC Form 103 replies for proper support. Loss of control on technical issues may develop into a larger problem. Replies are not always processed in a timely manner and are often inconclusive.

ANALYSIS OF EXPERIMENTAL FLOW TIME AVERAGES USING TAGUCHI METHOD (L_4)

TABLE 6.14.2-2

EXPERIMENTAL FLOW TIME AVERAGES -

EXP. 1	237.12
EXP. 2	230.27
EXP. 3	230.70
EXP. 4	230.30

FACTOR	LEVEL	
1	1	233.70
	2	230.50
2	1	233.91
	2	230.29
3	1	233.71
	2	230.49

$L_4 (2^3)$

NO	1	2	3
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

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- MDMSC Recommendations: Include a time limitation for support response to all Form 103s. Limitations may be determined by the severity of the problem. Example: 1) Line stoppage - immediate response, 2) Tooling - 24 hours, 3) Other - not more than three days. Also, relocate planners and other significant support personnel to work within their RCC of responsibility.

- <u>Perform an Analysis For Selected and Total Overhauls to Determine the Most Cost Effective Procedure</u>
  - Current Condition: The four processes which are performed on CSDs are total overhaul, selected overhaul, evaluated overhaul, and minor repairs. The criteria for selected overhaul are more detailed and time consuming then for a total overhaul process.
  - MDMSC Recommendations: Evaluate the current selected overhaul criteria and procedures to determine whether an abbreviated version of the criteria would jeopardize quality and longevity of a transmission. If less complex criteria and processing can not be developed, eliminate selected overhaul and replace with a total overhaul process.
- <u>Remanufactured Parts Versus New Parts</u>
  - Current Condition: Overhaul mechanics use a combination of new and remanufactured parts to overhaul CSDs without any discipline in the decision making process. Not being able to get remanufactured parts from the machine shop (MATPHE) without delay results in the use of new items.
  - MDMSC Recommendations: Develop and implement a method, discipline, system, or criteria to determine whether a remanufactured or a new part should be used. This will result in higher productivity and increased increased utilization of shop capacity.
- <u>Variations in Overhaul Procedures</u>
  - Current Condition: There are excessive inconsistencies among mechanics in various levels of overhaul and repair procedures.
  - MDMSC Recommendation: Develop a method data card to provide pertinent data and instructions for a given operation. This document

will remain in the unit and will have relevant drawings associated with each operation.

- Excessive Time Expended Ordering Parts
  - Current Condition: Technicians prepare a request card for each item required to overhaul or repair the CSD.
  - MDMSC Recommendation: Analyze part requirements for the overhaul and order them in kits.
- Productivity Improvement Through Installation of a Beltline Process
  - Current Condition: Bucket type process are used to teardown, overhaul, and reassemble CSD(s).
  - MDMSC Recommendation: Install a "U" shaped line to 1) teardown, 2) inspect and repair, and 3) reassemble.
- Remove Inherent Bureaucracy for Returning Nonconforming Vendor Items.
  - Current Condition: A complex system has been imposed on manufacturing which impedes effective action in returning nonconforming vendor items; for example, requirements include sending an engineering drawing with the material defect report.
  - MDMSC Recommendation: Require only the signatures of a manufacturing engineer and resident quality assurance engineer to return a vendor part. Also, a QDR should be issued for all supplier discrepant parts in order to implement supplier corrective action.
- Improve Resource Utilization for Low Skill Requirements
  - Current Condition: Technicians hired at labor grade five, progress to labor grade ten automatically within six years. (There are only W.G. 10s currently used for CSD operations.)
  - MDMSC Recommendation: Use "temps" or contract labor for low skill requirements in order to release skilled technicians for higher skilled tasks.
- Copy Machine Replacement
  - Current Condition: Employees use an antiquated copy machine that requires 16.4 seconds per copy. Estimated monthly use is 45.75 manhours.

- MDMSC Recommendation: Install a modern copy machine (Pitney Bowes D 750) that requires .519 second per copy. Estimated monthly use is 1.44 manhours.

- Reduce Time Lost Waiting for WCD Printer
  - Current Condition: One printer is operational in the CSD facility. Delays of up to 4.0 hours can be expected.
  - MDMSC Recommendation: Provide two printers, one in MATPHA and one in MATPHB, strategically located in the shops.
- Improve Part Handling by Using Plastic Bins
  - Current Condition: At disassembly, parts are stored in flat pans on top of work benches, cluttering the area. Nonproductive time is expended searching through pans for a specific part during reassembly.
  - MDMSC Recommendation: Install organized plastic part bins on the back of work benches with a snap on and off feature to enable rapid part location during reassembly.
- Revise Procedures for Obtaining Miscellaneous Hardware
  - Current Condition: IBM cards are filled out to obtain every nut, bolt, and washer.
  - MDMSC Recommendation: Use rotary bins for miscellaneous hardware and install them between MATPHA and MATPHB for easy access by both groups.
- Procurement Verification for Alternative Purchases
  - Current Condition: Procurement substitutes parts that are requested by engineering/manufacturing with little or no knowledge of the requested item.
  - MDMSC Recommendation: Implement guidelines for purchasing to obtain the requestor's approval before any alternative purchases are made.
- Redesign Storage Racks to Improve Safety and Storage Utilization
  - Current Condition: CSDs are placed on pallets, then stored on storage racks four levels high. The total weight stored on these racks appears to exceed the weight limitation recommended by the manufacturer.

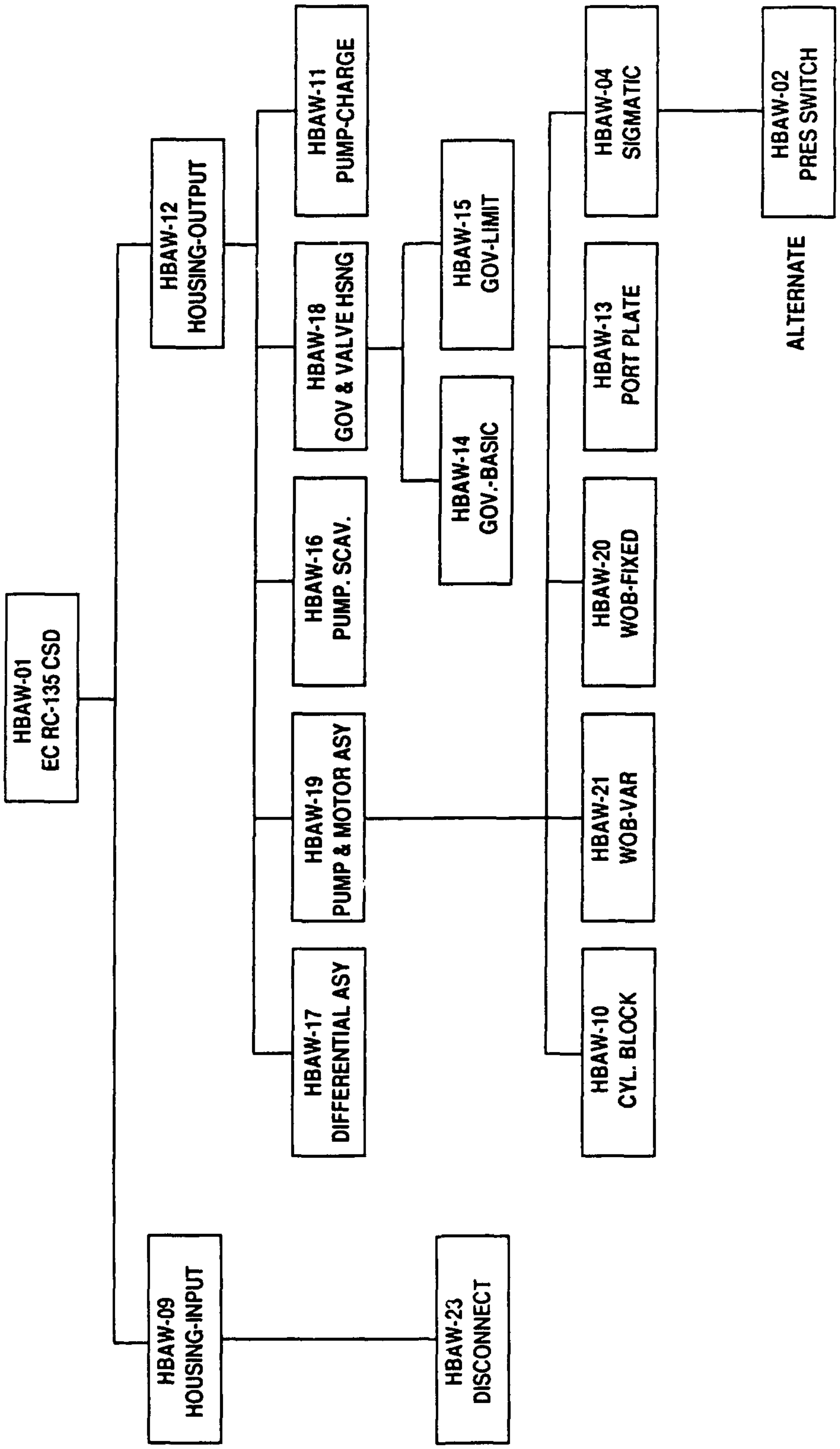
- MDMSC Recommendation: Redesign the storage area utilizing a gravity fed conveyor storage system, allowing the maximum pallet storage capacity. This will improve safety and allow more effective use of the storage area.

6.15 MATPHB ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

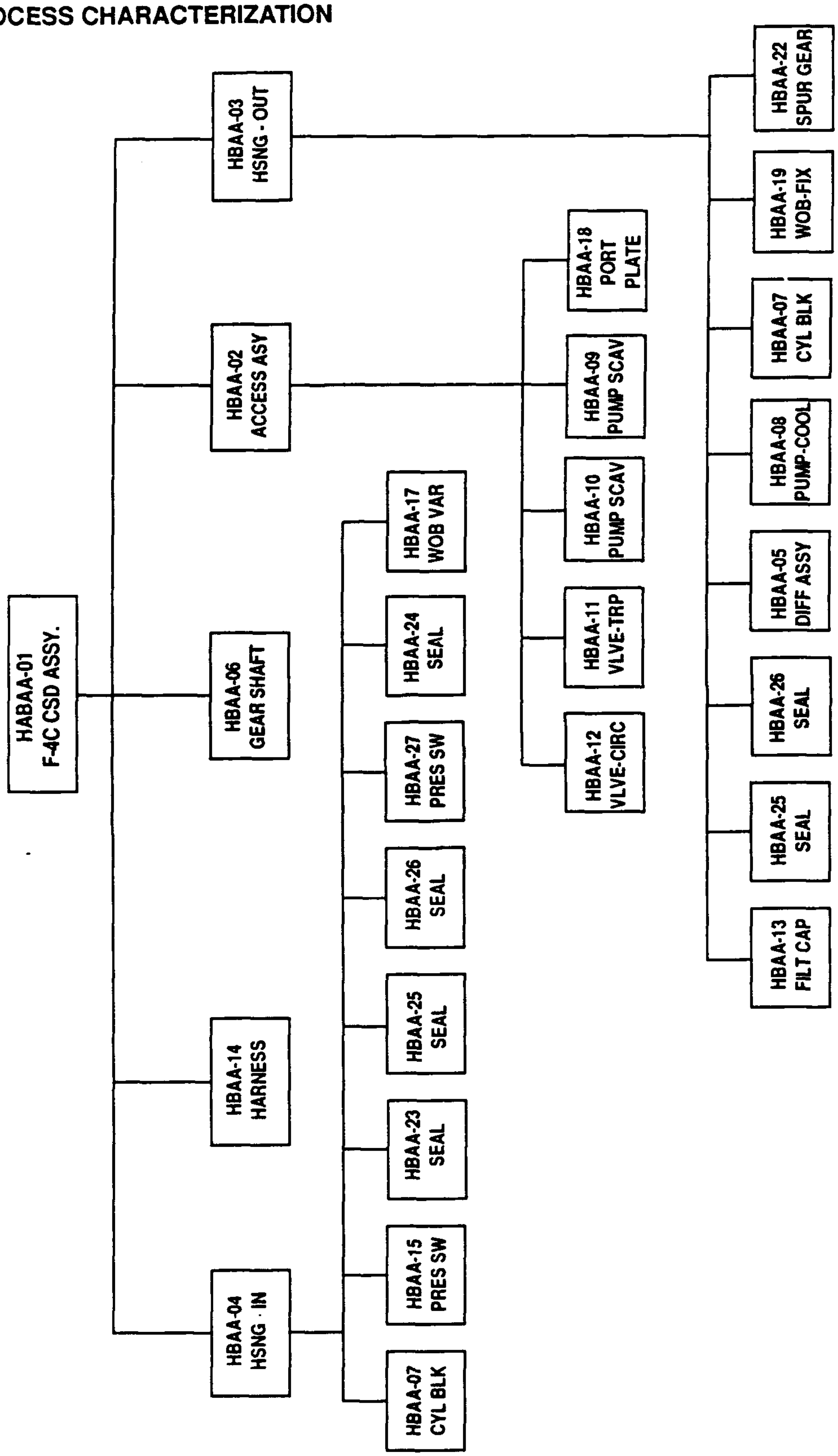
MATPHB is an RCC in the Accessories Division (MAT) and is responsible for the overhaul and testing of constant speed drive (CSD) transmissions, and their associated gear boxes and components. Transmissions from the following weapon systems are repaired in MATPHB: F-4, A-10, and EC/RC-135. A breakdown of the different types of CSDs repaired can be found in Figures 6.15-1 through 6.15-3.

The current resources within MATPHB are capable of processing all of the items under surge conditions. Throughput could be improved considerably by reducing non value-added activities, such as processing excessive paperwork. This is required for obtaining replacement parts that are no longer kitted. Depending on the transmission in overhaul, time for such indirect activity may range from two to seven hours. However, from a simulation viewpoint, throughput is acceptable because the model generated an average of 1,316 end items versus 1,319 end items for FY 88 production. Deviations by PCN ranged from 0.2% to -0.8%.

Initial characterization of the RCC resulted in 15 improvement opportunities. None of the opportunities were classified as focus studies. One was classified by the MDMSC/ALC team as a quick fix and is detailed in the OC-ALC Quick Fix Plan, MATPHB section. The remaining 14 were classified as other observations, and are described in paragraph 6.15.4 of this document.



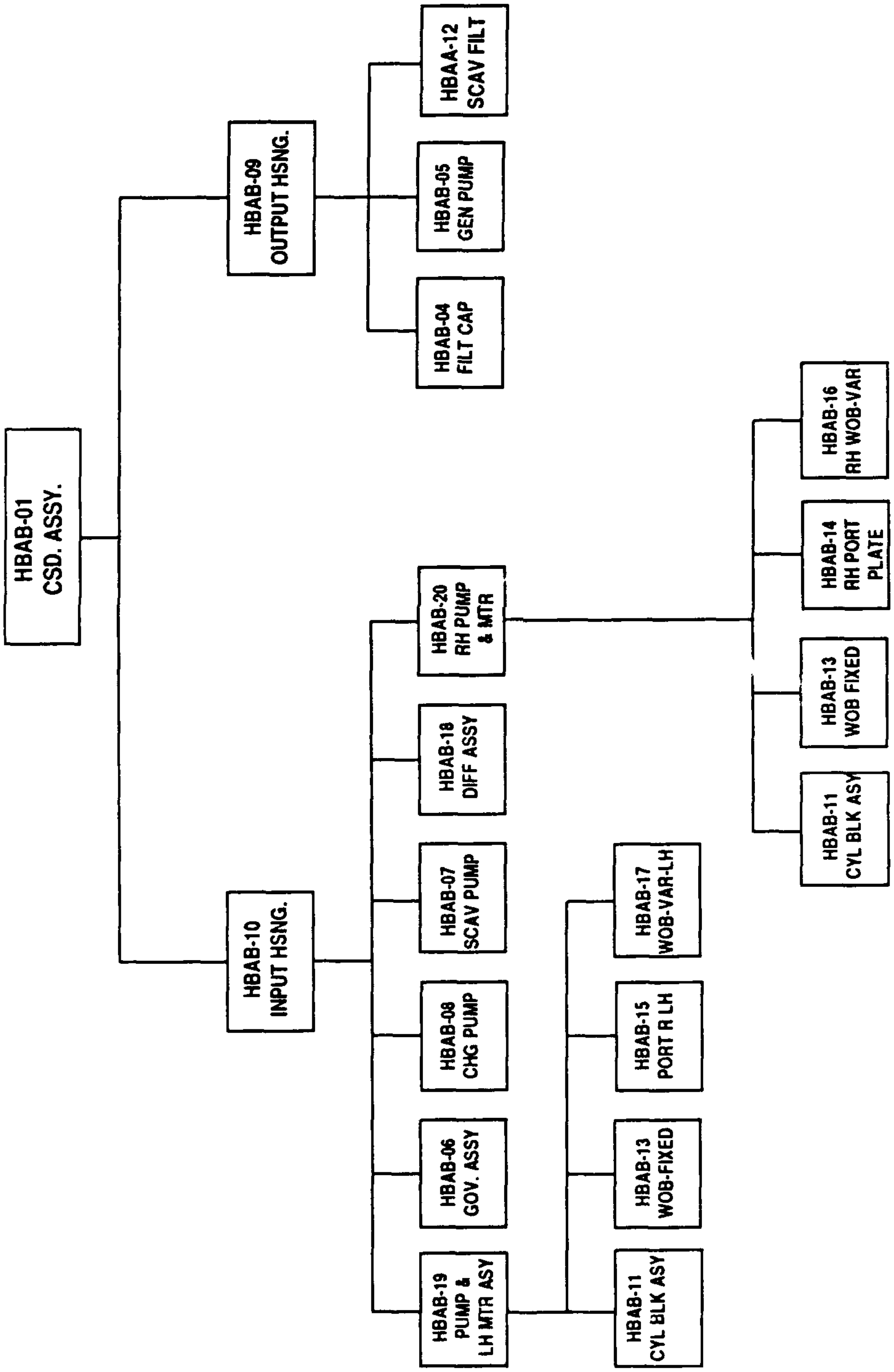
PCN # 30059A
EC/RC-135 CONSTANT SPEED DRIVE BREAKDOWN
FIGURE 6.15-1



PCN # 49720
F-4C CONSTANT SPEED DRIVE BREAKDOWN
FIGURE 6.15-2

LSC-20548

LSC-20549A



PCN # 49835A
A-10 CONSTANT SPEED DRIVE BREAKDOWN
FIGURE 6.15-3

The quick fix recommending a procedural change to eliminate the testing of various pumps during disassembly which will reduce repair time by an estimated one hour per CSD. These tests have shown a failure rate of less than 1%. Associated defects detected can be repaired at final test. A detailed analysis of the quick fix can be found in the Quick Fix Plan for MATPHB.

6.15.1 Description of Current Operations

MATPHB is a general overhaul unit; however, it has the same capabilities as MATPHA (a specialized CSD overhaul unit). The CSDs repaired are used in conjunction with an aircraft generator to convert a varying mechanical input to a constant electrical output. Primarily, MATPHB takes units rejected in the field and repairs or overhauls them as required. The process flow chart for the repair of CSDs is shown in Figure 6.15.1-1. MATPHB is basically identical to MATPHA. The only difference is the different models of CSDs worked in each area. Both RCCs are located in the same building and share facilities, including the machine shop, MATPHE. MATPHB is separated into the following three distinct sections:

- Assembly
- Disassembly
- CSD Component Test Cells

The assembly area is close to Class 3000 clean room standards, with excellent lighting and working conditions. Equipment requirements are minimal, but adequate for the "bucket" tear-down and reassembly operations performed.

The disassembly area is inherently less clean because of the nature of the operations performed, with both hydraulic oil and grease being present on the tear-down benches. Drip pans are provided to minimize oil spillage. It should be noted that, none the less, this area is well maintained; however, lighting is somewhat sub-standard in this area.

The MATPHB area appears well organized, with good work flow, and having no areas of congestion. Personnel appear knowledgeable, and the overall impression was favorable for this RCC.

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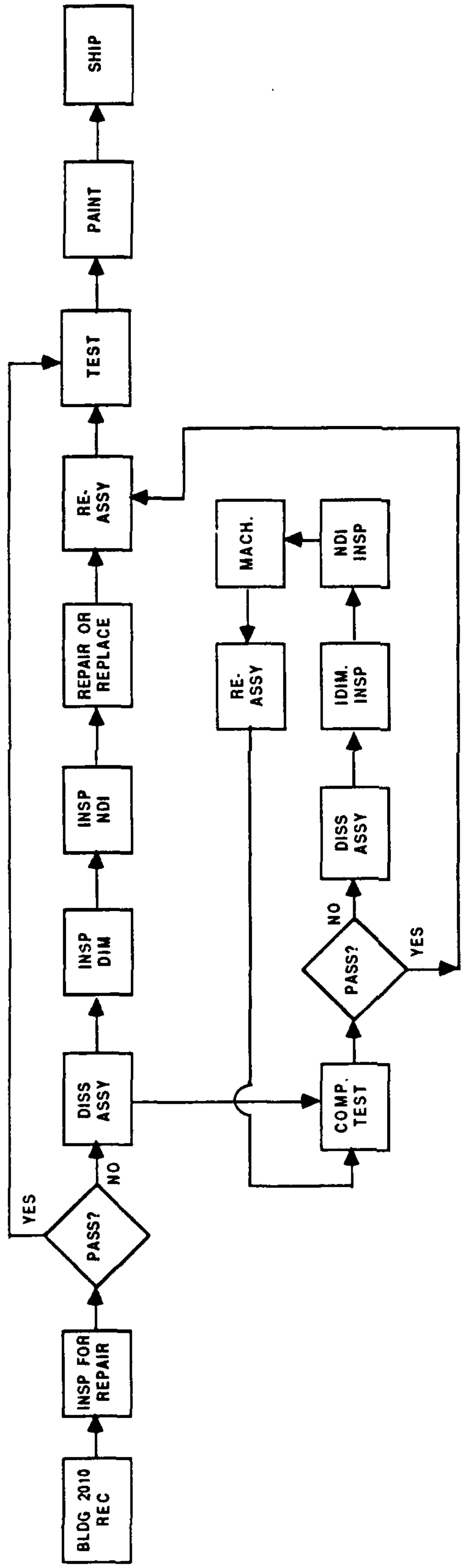

PROCESS FLOW CHART CONSTANT SPEED DRIVES
FIGURE 6.15.1-1

Equipment presently used in MATPHB consists of several CSD component test stands, common electrical testing equipment such as multimeters, etc., and other common and specialized hand tools.

A detailed listing of the equipment used in MATPHB is included in the Equipment Profile section of the Database Documentation Book (DDB) for this RCC.

MATPHB has a relatively stable work force with little variance. Workloads are well defined and personnel appear knowledgeable regarding their tasks. The work force is comprised of 29 journeyman technicians, 14 of whom are assigned to the component test cells.

MATPHB is supported by one back shop, MATPHE, which is a general machine shop.

The workload in this RCC is relatively stable. CSDs are a common engine accessory, and new aircraft coming into the inventory use these items with little or no changes in the internal mechanisms. The presently used procedure for repair and overhaul utilizes the "bucket" tear-down and reassembly method. It is suggested that a "Belt Line" assembly/disassembly system would be more cost-effective. As previously stated in paragraph 6.15, private industry has found the use of a "belt line" assembly/disassembly process to be cost effective. To achieve these benefits at OC-ALC, the present system of supply and distribution needs to be enhanced as this process is dependent on a ready supply of parts upon demand. Using the same rationale, it would be necessary to expedite rework turnaround time in MATPHE, which supports this RCC as a back shop. The average rework time for this back shop is three days. This is inadequate for the demands of a belt line system. It also is necessary to restructure the existing quality control and labor tracking system to meet the special needs of an automated belt line. Since the feasibility of these changes must be left to the judgement of personnel at OC-ALC, this improvement opportunity is listed as an other observation in paragraph 6.15.4 of this report.

MATPHB workload consists of MISTR items which are variable and depend on Air Force inventory needs.

The CSDs are checked for time in service, and then tested for functional and specification requirements. Overhaul is performed when required. Modifications are performed, as required by technical order changes, to upgrade targeted aircraft to present requirements.

When applicable, repairs or replacements are made to defective internal components of the CSD, and inspections are performed to identify problems requiring back shop support.

Engineering and Planning personnel, who presently release the Work Control Documents (WCDs) should provide more detail in their methods for performing the various operations. Problem Request Forms (AFLC Form 103) are not always processed in a timely manner. In addition, replies are often inconclusive. This leaves shop supervision with unresolved problems or requires shop supervision to work the problems through trial and error. It should be noted that replies often address symptoms rather than causes of their problems.

Material handling in MATPHB is mostly manual, with the use of hand carts being the predominant means of transporting items from one area to another. Gantry cranes are often used in lifting and manipulating the larger CSDs. Technicians are routinely sent to the receiving area to uncrate delivered items and place them on pallets. A forklift is then used to place the pallets on one of several pallet racks in the area. These pallet racks are not designed to support the amount of weight placed on them, and several show signs of structural failure. See other observation regarding this situation, paragraph 6.15.4 of this report.

Storage capabilities in MATPHB consist of 62 cabinets that are 6x3x2 feet in size. These cabinets are located throughout the MATPHA/HB shop area. Other storage capability includes two pallet racks at 12x16x5 feet each, one pallet rack measuring 12x24x5 feet in size, and several cage areas. The total floor space of MATPHB is approximately 5,866 sq. ft. This is considered adequate.

6.15.2 Statistical System Performance Measures

Validation of the UDOS 2.0 model simulation outputs for MATPHB was initiated on 9 August 1989. The FY 88 80/20 list for MATPHB consisted of three end items and 52 subassemblies. As previously stated, the criteria used to validate the UDOS 2.0 model simulation outputs was: 1) throughput, 2) simulated flow versus G019C estimated flow days, and 3) resources utilization (queues). These results are presented in detail in the Experimentation section of the DDB. Other criteria, such as utilization of manpower and equipment, were also used to assess the validity of the model results.

Several assumptions were made at the time of validation. These assumptions were considered to be both necessary and reasonable in interpreting model validity. The assumptions made were as follows:

- The 80/20 workload analysis was accurate and represented 80% of the workload. The workload may vary from 80% in cases where the MDMSC/OC-ALC team has decided on, and jointly authorized, deviations from the original 80/20 listing.
- Mechanics' estimates of process times are to be considered as statistically accurate.
- Induction quantity distributions are accurate and can influence throughput.
- Historical data, collected from the WCDs are not accurate. Some causes for these inaccuracies are:
  - WCD release practices (batch print)
  - Stamping practices on WCDs
  - Work schedules (priorities)
  - Lack of parts or high workloads in process
- Validation will be accomplished against engineering estimates.

The throughput statistical analysis performed at the time of validation was to ascertain that the model simulated FY 88 production levels were representative of actual conditions. As can be seen in the DDB, Experimentation Section, the variance analysis for simulated throughput versus actual throughput for this RCC shows a 22% difference. On the average, the model generated 24,950 inducted versus 25,004 actual end items and component parts produced. A more detailed discussion by PCN number may be found in the DDB Experimentation Section.

The flow hours statistical comparison was performed against the G019C report. The data examined contained too many inaccuracies for any meaningful analysis to be performed, mainly due to the incorrect tracking of subassemblies. The DDB contains the variance analysis for simulated flow hours versus G019C flow hours. On the average, the simulated flow hours are 23% higher than the G019C. A detailed discussion by PCN for this comparison is available in the DDB.

The brainstorming process for experimentation on MATPHB followed model validation. The prepositioning step is identification of the problem statement which is the objective of the brainstorming process. In the case of MATPHB, the problem statement read: "What would be the effect of 1) improving Mean Time Between Failure (MTBF) by installing a new computer control system, 2) improving MTBF of computerized testing equipment by making the new system independent and interchangeable, and 3) improving MTBF and Mean Time To Repair (MTTR) by 55% by the addition of a new calibration card."

An orthogonal array was developed using the Taguchi process. The team identified three factors and established two levels for each factor. An L_4 (2^3) array is depicted in Table 6.15.2-1, with throughput (Δ) being selected as a quality characteristic. Table 6.15.2-1 also shows the average throughput of all experimental runs performed as being approximately 100%. This precludes the use of throughput as an analysis factor for experimental results. It can also be shown that best and worst case analysis by PCN for each run has little

L_4 TAGUCHI ORTHOGONAL ARRAY EXPERIMENTAL RESULTS

TABLE 6.15.2-1

EXP #	FACTORS: NEW COMP. CONTROLLER	FACTORS: INTER-CHANGEABILITY	FACTORS: NEW CALIBRA-TION CARD	FY 88 THROUGHPUT% (END ITEM ONLY) NORMAL WORKLOAD: AVG	FY 88 THROUGHPUT% (END ITEM ONLY) NORMAL WORKLOAD: BEST	FY 88 THROUGHPUT% (END ITEM ONLY) NORMAL WORKLOAD: WORST
1	AS-IS	AS-IS	AS-IS	100%	49720A / 100%	30059A / 99%
2	AS-IS	40% IMPROVED MTBF	55% IMPROVED MTBF & MTTR	100%	30059A / 101%	49720A / 99%
3	55% IMPROVED MTBF	AS-IS	55% IMPROVED MTBF & MTTR	100%	30059A / 101%	49720A / 99%
4	55% IMPROVED MTBF	40% IMPROVED MTBF	AS-IS	100%	30059A / 101%	49720A / 99%

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variance between end items worked. MATPHB appears very efficient across its entire workload.

Table 6.15.2-2 was developed using the simulated flow time averages from each experiment and performing a Taguchi analysis using this data. By selecting the Taguchi optimum level for each factor, the most effective combinations of equipment, manpower, and skill were selected. It was seen that the optimum configuration was the As-Is condition.

The FY 90 workload was used to determine the surge capabilities of MATPHB. Surge information was supplied by the AFLC. Analysis of surge capacity, as discussed in the DDB Experimentation section of this RCC, indicates that a throughput of 100% can be achieved.

6.15.3 Description of Process Problems

The intent of this paragraph is to provide detailed description of major process problems for which there are focus study recommendations. Since none of the observed MATPHB improvement opportunities were classified as a focus study, they are addressed as quick fixes or other observations.

6.15.4 Other Observations

The process improvement opportunities described in this section were not considered as focus studies or quick fixes, but as other observations because they had a less significant impact in the areas of time, quality, or cost. These observations are recorded to assist OC-ALC in developing ideas that will further enhance their repair operations.

Operational Improvement Opportunities

- Develop and/or Strengthen Inner Office Procedures for Processing Problem Request Forms. (Form 103)
  - Current Condition: Shop personnel do not rely upon AFLC Form 103 replies for proper support. Loss of control on technical issues may develop into a larger problem. Replies are not always processed in a timely manner and are often inconclusive.

ANALYSIS OF EXPERIMENTAL FLOW TIME AVERAGES USING TAGUCHI METHOD (L_4)

TABLE 6.15.2-2

EXPERIMENTAL FLOW TIME AVERAGES -

EXP. 1	256.2
EXP. 2	256.39
EXP. 3	256.36
EXP. 4	256.36

FACTOR	LEVEL	
1	1	256.30
	2	256.36
2	1	256.28
	2	256.38
3	1	256.28
	2	256.38

$L_4\ (2^3)$

NO	1	2	3
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

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- MDMSC Recommendations: Include a time limitation for support response to all Form 103s. Limitations may be determined by the severity of the problem. Example: 1) Line stoppage - immediate response, 2) Tooling - 24 hours, 3) Other - not more than three days. Also, relocate planners and other significant support personnel to work within their RCC of responsibility.

- <u>Perform an Analysis For Selected and Total Overhauls to Determine the Most Cost Effective Procedure</u>
  - Current Condition: The four processes which are performed on CSDs are total overhaul, selected overhaul, evaluated overhaul, and minor repairs. The criteria for selected overhaul are more detailed and time consuming then for a total overhaul process.
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- <u>Remanufactured Parts Versus New Parts</u>
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- Variations in Overhaul Procedures
  - Current Condition: There are excessive inconsistencies among mechanics in various levels of overhaul and repair procedures.
  - MDMSC Recommendation: Develop a method data card to provide specific data and instructions on how to perform a given operation. This document will remain in the unit and have relevant drawings for each operation.
- Excessive Time Expended Ordering Parts
  - Current Condition: Technicians prepare a request card for each item required to overhaul or repair the CSD.
  - MDMSC Recommendation: Analyze part requirements for the overhaul and order them in kits.
- Productivity Improvement Through Installation of a Beltline Process
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  - MDMSC Recommendation: Install a "U" shaped line to: 1) teardown, 2) inspect and repair, and 3) reassemble.
- Remove Inherent Bureaucracy for Returning Nonconforming Vendor Items
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- Improve Resource Utilization for Low Skill Requirements
  - Current Condition: Technicians hired at labor grade five, progress to labor grade ten automatically within six years. (There are only W.G. 10s currently used for CSD operations.)
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  - Current Condition: Employees use an antiquated copy machine that requires 16.4 seconds per copy. Estimated monthly use is 45.75 manhours.
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  - Current Condition: At disassembly, parts are stored in flat pans on top of work benches, cluttering the area. Nonproductive time is expended searching through pans for a specific part during reassembly.
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  - Current Condition: IBM cards are filled out to obtain every nut, bolt, and washer.
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  - Current Condition: Procurement substitutes parts that are requested by engineering/manufacturing with little or no knowledge of the requested item.
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- <u>Redesign Storage Racks to Improve Safety and Storage Utilization</u>
  - Current Condition: CSDs are placed on pallets, then stored on racks four levels high. The total weight stored on these racks appears to exceed the weight limitation recommended by the manufacturer.
  - MDMSC Recommendation: Redesign the storage area utilizing a gravity fed conveyor storage system, allowing the maximum pallet storage capacity. This will improve safety and allow more effective use of the storage area.

6.16 MATPHE ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MATPHE is the machine shop assigned to support Constant Speed Drive (CSD) overhaul. This RCC directly supports MATPHA and MATPHB in the inspection and rework of CSD component parts routed from these areas. MATPHE is a crucial part of the repair and overhaul process of these items, many of which have critical tolerances and surface finish characteristics. The repair responsibilities of MATPHE are more fully described in paragraph 6.16.1.

Initial characterization of this RCC yielded a total of four potential improvement opportunities. After review by MDMSC/OC-ALC site personnel, one quick fix proposal was found to provide the most significant savings. All remaining improvement opportunities are briefly discussed in paragraph 6.16.4 as other observations.

The improvement opportunity identified as a quick fix item involved the use of compartmentalized trays for disassembled parts. The use of these trays would reduce the relatively high scrap rates of certain parts, which MATPHE supervision believes is due to handling damage. This quick fix opportunity is described in detail under separate cover. Refer to TI-ES Task Order No. 1, Volume III Quick Fix Plan OC-ALC MATPHE, Quick Fix Opportunities section for details.

6.16.1 Description of Current Operations

MATPHE is located in Building 2210, which also houses MATPHA and MATPHB. It is contained in its own enclosed area, and has 5,546 sq. ft. of floor space. The primary responsibility of this RCC is the inspection and rework of components used in various CSDs. These parts are routed to MATPHE from the CSD disassembly area. The parts are delivered to a centralized receiving rack, which reduces traffic through the RCC and prevents skilled machine operators from being interrupted during operations. The general operations performed by MATPHE are similar to those found in other OC-ALC machine shops, and consist of machining operations such as drilling, boring, milling, grinding, lapping, etc. It should be mentioned that the tolerances and surface finish requirements of many of the component parts worked by MATPHE are quite critical, requiring skill and precision in the performance of machining operations.

Also included in this RCC's responsibilities is the performance of Nondestructive Inspection (NDI) on CSD component parts, which mainly consists of Fluorescent Penetrant Inspection (FPI) and Magnetic Particle Inspection (MPI). The inspections require the use of a designated skill and grade level different from those of the machine operators, specifically an AI09 skill. These operations are performed in an adjoining area.

The TI-ES team assigned to study and profile MATPHE was impressed by several aspects of this RCC's operations. This machine shop annually processes a large volume of component parts, and does so in a safe and efficient manner. Personnel appear very knowledgeable about their assigned tasks, which in many cases requires a high degree of precision. Supervision in this area appeared extremely effective, an important asset given the large volume of work and existing manpower constraints. The TI-ES team received excellent support and cooperation in its evaluation of this area, which was of great importance in developing the database for this RCC.

It is important to understand that machine shops have several factors unique to their operations. Since most machines require specific set ups and/or fixtures to work any given part, it is necessary to identify an economic lot size for that part. The machine will not be set up and used for a specific part until a predetermined number of these parts has accumulated. This is an important consideration, since many set ups are time consuming and labor intensive. The economic lot size becomes even more critical as the total volume of parts processed increases. Add manpower constraints to these factors, and it becomes clear why a "first in-first out" system is unacceptable for machine shop work. This is a daily consideration of MATPHE supervision, and one which appears to be handled reasonably well. It is also a difficult concept to explain to the primary RCCs needing specific reworked parts, with their own requirements and deadlines. All too often supervision in MATPHE must instruct machine tool operators to stop operations on one item to set up and run another. While a certain amount of this is to be expected, it must be the exception rather than the rule. For this reason, it may be beneficial for management to consider the possibility of maintaining buffer stock, which could then be used to prevent work stoppage due to unavailability of parts. While this suggestion has both pros and cons, it should be evaluated in terms of the benefits gained versus the cost of implementing.

Manpower constraints have been mentioned several times in relation to this RCC. In 1988, this machine shop has 12 AJ09 machine tool operators, one AJ10 machinist, and one AI09 inspector. For that same year, the total number of parts inducted (and used in model development) was reported as 40,418. It must be remembered that this represents only 80% of this RCC's workload, and only applies to direct labor tasks. Model results show that manpower shift utilization averaged 81%. This indicates that while there was sufficient manpower to accomplish most tasks, significant delays could occur due to manpower unavailability. This was indeed seen for certain items, and is probably reflected as increased average flow hours. Since that time, there have been two machine tool operators retire, and the death of the NDI inspector. As of the date of this report, management of this area was attempting to fill these positions. Given the negative effect that reduced manpower would have on operations performed in this shop, management's effort is to be commended. It is to be hoped that budget considerations will allow these positions to be filled in a timely manner.

It was observed that personnel in MATPHE had several indirect labor tasks that they were assigned to perform. These included scrap metal processing, hazardous waste monitoring, precious metal accountability, as well as several others. These tasks can require several hours per week of a work force already stressed to meet production schedules. While necessary tasks, these might be better assigned to other areas or personnel having lower utilization potential.

The equipment used in MATPHE consists of machines used for grinding, lapping, boring, milling, etc. The equipment appears to be well maintained, although some equipment is dated and was reported to cause difficulty when performing precision machining operations. While model results showed several pieces of equipment highly utilized most queue formation can be attributed to the high manpower utilization. These observations are discussed in more detail in the Statistical Performance section of this report, paragraph 6.16.2.

One task assigned to the TI-ES team was comparing operations and processes performed in the RCCs observed with similar practices in outside industry. While there are certain companies performing overhaul and repair of aerospace products, comparisons are difficult make. Few privately owned companies would be willing or able to take on the highly variable and diverse workload found in the MATPHE. While there are certainly some operations and processes that could be performed at less expense by private industry, the vast majority of the tasks performed in MATPHE would be of little interest to outside machine shops. The demand for quick turnaround of several dissimilar components requires frequent machine tear down and set up, which is not economically feasible for many companies. In any case, it is perhaps unwise to lose control of critical operations and processes which are necessary for meeting overall mission responsibilities.

Support functions for this RCC, including planning, scheduling, and engineering, were discussed with MATPHE supervision and directly observed when possible. The overall impression of these groups was favorable. One area of possible improvement would be the manner in which planners document operations on the WCDs. There is a great deal of similarity in how the various CSDs are processed, including the machining work that is performed on similar parts. The practice of having individual planners track items related to particular weapon systems causes significant variation in WCD format. While there are advantages to having planners follow the flow of particular items through various RCCs, there are advantages in having continuity in WCD format and emphasis, as well as having planners familiar with overall shop operations. It is also easier for shop supervision to have one point of contact when questions regarding time standards and WCD format occur. While the suggestion of having one planner responsible for an entire RCC might not be feasible for areas working a large number of dissimilar parts, it would be relatively simple to implement in the CSD overhaul and repair units given the similarities between the various CSDs.

The CSD overhaul and repair RCCs, which consist of MATPHA, MATPHB, and MATPHE are unique in several respects. These RCCs are responsible for items that are very similar in their processing characteristics even though they belong to different weapon systems. They are located in a single facility, which is for the most part dedicated solely to their use. Management in these RCCs appears dedicated to producing high quality products, and for the most part displays an excellent grasp of the needs and processes involved in realizing that goal. Despite recent changes in budget, management appears to have coped very well in adapting operations in the RCCs to maintain schedule. Still, it may be difficult for management to realize the importance that MATPHE plays in the production process. This machine shop has a much lower visibility than the two assembly/disassembly areas. MATPHA and MATPHB are the entry and exit points of the end item product, and naturally appear to be the areas of greatest concern. However, given the critical tolerances and specifications of the internal components of the various CSDs, the machine shop occupies a crucial position in the production process. Given the inherent physical limitations of machining processes, MATPHE has the potential to be a definite limiting factor for production. For this reason, management should carefully monitor the needs and production capability of this RCC. Problems occurring in MATPHE production will quickly affect the ability of MATPHA and MATPHB to produce quality products in a timely manner.

This concept of viewing the three RCCs responsible for CSD repair and overhaul as integrally related is very important. As an interesting exercise for future consideration, it may be productive for OC-ALC to run all three RCCs interactively using UDOS 2.0 model simulation. This would allow the interactions that occur between these areas to be examined, and might prove an important planning tool. While this is beyond the scope of Task Order No. 1, it would be beneficial to see the effects that simulated changes in MATPHE procedures would have on end item flow hours.

In summary, all three RCCs responsible for CSD overhaul and repair appeared proficient in their assigned tasks. TI-ES observers in these areas were very impressed by both personnel and management, and while improvement opportunities exist, the overall opinion of these RCCs was very positive. These RCCs were also felt to be representative of the many interactions that can occur between related production areas and their critical support back shops. OC-ALC management might find areas such as these to be important test sites for implementation of new technologies and procedures, which could then be applied to other areas if successful.

6.16.2 Statistical System Performance Measures

Validation of the UDOS 2.0 model simulation outputs for MATPHE was initiated on 11 August 1989. The validation process for this RCC was somewhat complicated by the lack of historical data regarding throughput and flow times for components worked in MATPHE. This deficiency occurred because historical tracking procedures mainly relate to the end item CSD. Since MATPHE is concerned with inspecting and reworking specific CSD component parts, the existing historical data does not apply. This necessitated a close review of the model simulations of throughput and flow hours for items worked in this RCC. Working in cooperation with OC-ALC personnel, an item by item review of these factors was performed. The final validated model run is felt to approximate actual conditions of MATPHE production in FY 88.

Several assumptions were made at the time of validation. These assumptions were considered to be both necessary and reasonable in interpreting model validity. The assumptions were as follows:

- The 80/20 workload analysis was accurate and represented 80% of the workload. The workload may vary from 80% in cases where the MDMSC/OC-ALC team has decided on and jointly authorized deviations from the original 80/20 listing.
- Mechanics' estimates of process times are to be considered as statistically accurate.

- Induction quantity distributions are accurate and can influence throughput.
- Historical data collected from the WCDs are not accurate. The reasons for the inaccuracies are influenced by the following:
  - WCD release practices (batch printing)
  - Stamping practices on WCDs
  - Work schedules (priorities)
  - Lack of parts/high work in process
  - RCC in question handles only component parts, not end items
- Validation to be accomplished using the experience of the RCC's supervision to judge the accuracy of model generated simulations concerning flow time and throughput for MATPHE.

When the average simulated flow time for this shop was calculated, it was found to be 92.21 hours. This was the average of all items represented in the model inputs, some of which had flow hours considerably in excess of three days. Those items having a significant deviation from the average will be discussed individually later in this paragraph.

The throughput statistical analysis was performed during validation to ascertain that the model simulated FY 88 production levels. As can be seen in the DDB Experimentation Section, Table 1, the variance analysis for simulated versus actual throughput for all profiled PCNs showed a difference of only 0.25%. The model generated 40,318 items versus 40,420 actual items produced. A more detailed analysis by PCN number may be found in the DDB Experimental Section. As previously mentioned, a statistical comparison of the flow hours for individual items against historical records was not possible for this RCC.

Certain items worked in MATPHE are seen to have significantly higher flow hours than the average rework item of three days, which was given by the shop foreman as a rough estimate. Some of these items use specific equipment which is in high demand (hones, jig grinder, etc.). They may also be worked in larger quantities with relation to other items inducted. Finally, all of these factors may be further complicated by high manpower utilization. The following is a list of the items that exhibit large deviations from the norm, along with reasons for the deviations:

- 31151A34 (182.17 Hr) Pump block assy. Uses OC3193 (58% util.)
- 31151A38 (137.02 Hr) Governor. Uses OC3193
- 31151A39 (200.58 Hr) Wobbler. Part worked in high volume. Manpower constraints
- 49720A02 (140.90 Hr) Accessories assy. Uses OC3527 (59% util.)
- 49720A05 (131.45 Hr) Differential assy. Uses OC3193
- 49720A17 (111.51 Hr) Wobbler. Uses OC2666 (53% util.)
- 49720A18 (194.91 Hr) Port plate. Part worked in high volume. Manpower constraints
- 49835A09 (375.28 Hr) Output housing. 30 day back shop flow time
- 49835A10 (366.43 Hr) Input housing. 30 day back shop flow time
- 49840A05 (118.05 Hr) Charge pump. Uses OC2666
- 49840A09 (323.44 Hr) Cylinder block. Worked in very high volume. Significant manpower constraints
- 49840A12 (123.02 Hr) Scavanage pump. Uses OC2666
- 50261A11 (351.57 Hr) Cylinder block. Worked in very high volume. Significant manpower constraints
- 50261A16 (117.91 Hr) Wobbler. Part worked in high volume. Manpower constraints

The above parts may display some elevation in flow time due to the economic lot size required for their efficient processing. MATPHE supervision will not normally run these items in small batches due to the time required for machine set-up.

The brainstorming process for experimentation on MATPHE followed model validation. The predisposing step is identification of the problem statement or objective of the brainstorming process. Since it was felt that certain items exhibited excessive flow time due to specific factors, the following problem statement was generated for MATPHE: "What effect would be seen on flow time and throughput in MATPHE if (1) manpower were increased in those skill areas showing high utilization, (2) there is addition of extra jig grinders (one versus three additional) and (3) welding operations on CSD housings were brought in-house, as opposed to the present back shop rework they now receive."

An orthogonal array was developed using the Taguchi experimental process. The team identified three factors and established two levels for each factor. An L_4 (2^3) array is depicted in Table 6.16.2-1, with throughput (Δ) being selected as a quality characteristic. A discussion of the results of the model experimentation follows. It should be noted that since the average throughput of all experimental runs is shown to be approximately 100%, the use of throughput as an analysis factor for experimentation is not possible. It can also be seen that best and worst case analysis by PCN for each run exhibit a narrow range of variation.

Table 6.16.2-2 was developed using the simulated flow time averages from each experiment and performing a Taguchi analysis using this data. By selecting the Taguchi optimal level for each factor, the most effective combination of equipment, manpower, and production process was selected. In examining Table 6.16.2-2, it is easily seen that each of the experiments produced substantially lower average flow times than the As-Is condition of 92.21 hours. The Taguchi optimal configuration can be interpreted as follows:

- The addition of manpower is clearly advantageous.
- The addition of one jig grinder is sufficient to increase production.
- Bringing welding operations performed on CSD housings in-house is of benefit to production capabilities in MATPHE.

The addition of one jig grinder had significant effect on reducing flow time. This was expected since this equipment was identified as a bottleneck under present conditions. Experiment three, which contains all of the optimal conditions, exhibits the best average flow hours for this RCC. It is important to remember that benefits obtained from addition of equipment in this shop will not be fully realized without sufficient staffing of appropriate skilled personnel. The effect of bringing in-house welding capability to this shop is probably even greater than shown by experimental results. Welding operations performed in outside back

L_4 TAGUCHI ORTHOGONAL ARRAY EXPERIMENTAL RESULTS

TABLE 6.16.2-1

	FACTORS			FYXX THROUGHPUT %		
				NORMAL WORKLOAD		
EXP #	MANPOWER	JIG GRINDER	WELDING	AVG	BEST	WORST
1	AS-IS	ADD ONE OC2666	AS-IS	100%	30011A02 / 104%	49835A10 / ?2%
2	AS-IS	*ADD THREE* OC2666	IN-HOUSE	100%	30011A07 / 104%	50261A. / 93%
3	ADD: AI09 (X1) AJ09 (X8) AJ10 (X1)	ADD ONE OC2666	IN-HOUSE	100%	30011A02 / 104%	49720AA22 / 97%
4	ADD: AI09 (X1) AJ09 (X8) AJ10 (X1)	ADD THREE OC2666	AS-IS	100%	30011A02 / 104%	49835A10 / 92%

LSC-20651

ANALYSIS OF EXPERIMENTAL FLOW TIME AVERAGES USING TAGUCHI METHOD (L_4)

TABLE 6.16.2-2

EXPERIMENTAL FLOW TIME AVERAGES

EXP. 1	57.68
EXP. 2	53.18
EXP. 3	45.98
EXP. 4	53.96

FACTOR	LEVEL	
1	1	55.43
	2	49.97
2	1	51.83
	2	53.57
3	1	55.82
	2	49.58

$L_4\ (2^3)$

NO	1	2	3
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

LSC-20643

shops presently require an average of 720 flow hours to complete. Since only one paired set of the CSD housings modeled (49835A) exhibits a relatively high percentage of parts requiring welding operations, the full effect of this change is not seen. It is interesting to note that the model shows the in-house welding operation to be 70% utilized, which would indicate that there is sufficient work to justify this change. Supervision in this machine shop expressed a great need for these changes, which appears justified based on experimental results. OC-ALC management may wish to study these suggested changes and, if feasible given existing budget constraints, implement them as soon as possible.

In order to determine if this RCC was capable of meeting surge requirements, an experimentation run was performed using FY 90 workloads at surge capacity as provided by the AFLC. Given the experimental design used, it appears that MATPHE is capable of meeting present surge requirements. Several facts are worthy of consideration in this regard. First, it is assumed that under surge conditions, manpower will be divided between two twelve hour shifts to allow continuous production. This would naturally benefit MATPHE, given its presently high manpower utilization. Given the larger workloads under surge conditions, those parts having specific economic lot sizes will reach these quantities sooner, which may actually lower flow times for certain items. It must be remembered that the experimentation runs were performed using FY 88 manpower levels, which have now changed. It is important to staff a machine shop with this volume of work at sufficient levels. This is especially true given the critical position that MATPHE occupies in the CSD repair and overhaul process.

Further statistical comparison regarding this RCC may be found in the DDB under the Experimentation Section. Also included is a brief description of Taguchi analysis and procedures.

6.16.3 Description of Process Problems

The intent of this paragraph is to expound on major process problems for which there are focus study recommendations. Since there are no major process problems identified for MATPHE at this time, the potential improvement opportunities mentioned in paragraph 6.16 are classified as other observations in this report or as quick fixes in the Quick Fix Plan.

6.16.4 Other Observations

The observations described in this section were not considered as focus studies or quick fixes because they had a less significant impact in the areas of time, quality, or cost. These observations are recorded to assist OC-ALC in developing ideas that will further enhance their operations.

The observations which follow were originally identified as quick fix and focus study improvement opportunities, and are documented as such in the MATPHE DDB. After review by the OC-ALC site personnel and the TI-ES team, it was agreed that they should be presented as other observations for future reference.

- Mishandling of Parts
  - Current Condition: It was observed that personnel in the CSD disassembly areas stack component parts into metal baskets, which are then sent to MATPHE for inspection or rework. In some cases, parts having critical surface characteristics are thrown atop other components, with subsequent damage occurring to mating surfaces. Even when care was taken in placing components into the baskets, the basket design caused parts to be stacked upon each other which, in turn, caused surface damage.
  - MDMSC Recommendation: It is possible that much of the problem has to do with personnel being unfamiliar with the critical tolerances and surface characteristics of the parts they handle. Personnel in this area appeared concerned with producing quality products. Without training and careful monitoring of parts handling procedures, they may well be unaware of the damage potential to these critical parts. Given the reported high costs of scrapped parts, management should closely monitor this situation, correcting mishandling when encountered. It would also be very useful to begin keeping a parts scrap log, noting those parts which indicate damage due to mishandling (which show unique damage patterns). Design of

compartment trays is the focus of the previously mentioned quick fix in this area.

- Utilization of Skilled Labor for Indirect Activities
  - Current Condition: Personnel in MATPHE are responsible for a number of duties other than their primary task of machining and inspection of CSD component parts. These can include such things as scrap material processing, hazardous waste monitoring, precious metal monitoring and distribution, as well as several others. While these are necessary tasks, they require several hours per week of an already heavily utilized work force.
  - MDMSC Recommendation: If possible, these tasks should be assigned to personnel having a lower utilization. Since these and similar tasks are performed by skilled personnel in a number of RCCs, a workpool dedicated to these types of activities might be a practical solution. These personnel could then be assigned responsibility for several areas needing their services. Skilled technicians would then be free to perform tasks directly related to production in their assigned areas.
- Overtime Versus Addition of New Manpower
  - Current Condition: MATPHE appears to have a shortage of skilled machine tool operators, as well as NDI personnel. This shortage could adversely affect the production capability of this RCC for both normal and surge conditions.
  - MDMSC Recommendation: As a temporary measure, personnel in this area could be asked to maintain production quotas by working set amounts of planned overtime. This practice could be curtailed as soon as budget considerations allow hiring of sufficient skilled personnel. It would be necessary to carefully plan overtime requirements in advance where possible. This would avoid loss of efficiency due to fatigue.

6.17 MATPIA ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MATPIA is primarily a support area for Engine Division (MAE) RCCs. MATPIA work involves manufacturing/repair of tubing and sheet metal, testing/manufacture of springs, and manufacture of cabling. It has its own painting, degreasing, and NDI (fluorescent penetrant and magnetic particle) capabilities, as well as having a foundry for the production of sheet metal tooling and heat treating. However, this foundry is not presently operating due to the impending shop move.

The throughput on items processed through MATPIA is very good. The majority of items which were profiled as part of the 80/20 list for the FY 88 workload went through the required repair operations without delays. Even under the increased demand that would occur under war time surge, the RCC would still be capable of attaining full throughput with its current resources.

During characterization of this RCC, 17 opportunities for improvement were identified (refer to MATPIA Database *Documentation* Book). Eleven of these opportunities were jointly selected by the MDMSC/OC-ALC team to be pursued as other observations. One of these other observations addresses the substitution of an environmentally acceptable cleaning compound for the chlorinated solvents currently used. In particular, a product known as Bio-Act® has been highlighted as a candidate for use in many cleaning situations (see paragraphs 6.0 and 6.17.4 for additional information on biodegradable solvents). It should be noted that the Occupational Safety and Health Administration has analyzed several such products and judged them to be non-hazardous. This solvent has various surface active agents and is miscible with cutting oils in all proportions. After dissolving the oily film, the Bio-Act®/oil mixture can be rinsed from the metal with water to leave the surface ready for welding, painting, coating, or further processing. Bio-Act® has very low toxicity, and does not contribute to the depletion of stratospheric ozone. Furthermore, it will not corrode metal surfaces and is an excellent cleaner for manually removing grease and dirt from large surfaces prior to parts fabrication and assembly. The following are examples of benefits and features that OC-ALC/AFLC can realize from the Bio-Act® product line:

- Safe for employees and the environment
- Biodegradable, non-toxic, non-reactive, non-corrosive, no chlorine, no heavy metals, no petroleum solvents
- Rinses completely with water--leaves no oily residue
- Safe flash point
- Does not deplete stratospheric ozone
- Cold cleaning--removes oils, greases, asphalt, and resins at ambient and room temperatures
- Low vapor pressure
- Pleasing odor

The MDMSC TI-ES team strongly recommends that the change over to a biodegradable solvent be implemented as soon as possible in order for OC-ALC to be ready to do business in the 1990's and beyond. An additional five opportunities were developed during analysis of collected MATPIA data in St. Louis. All of these other observations are discussed in paragraph 6.17.4.

6.17.1 Description of Current Operations

MATPIA operations consist of sheet metal manufacturing and repair, cable manufacturing and repair, tubing manufacturing and repair, and spring testing and manufacturing. The RCC is located in four distinct areas in Building 3001: W-63 for tube, cable, and spring operations; W-55 for sheet metal manufacturing; P-53 for NDI and paint; and W-35 for sheet metal repair. The sheet metal sections have been separated temporarily while the RCC is being relocated. The proposed layout for the sheet metal subunit has been included with the other prints for MATPIA in the Database Documentation Book.

The RCC is a support shop for other RCCs in MAT and MAE (the Engine Division). Its support functions consist of both manufacturing and repair tasks.

The work performed within MATPIA is extremely diverse. The work is classified as either MISTR, Manufacturing or Temporary. MATPIA work can be grouped into five categories with the following responsibilities:

- Tube Manufacturing, Spring Manufacturing, Cable Manufacturing and Repair - Any type of tubing, cable, or spring manufacturing or repair for MAT, MAE, or MAB is performed in this area. If a cable requires rework and can be salvaged, the necessary repair work will be completed in this sub-unit of MATPIA.
- Tubing Repair - Rework and repair of the tubes, duct assemblies and certain manifolds from the TF30, TF33, TF41 or J79 engines will be performed here.
- NDI, Sheet Metal Manufacturing and Paint - If a sheet metal item cannot be salvaged from an aircraft, a manufacturing work order will be generated by the respective work group and sent to planning. Planning will issue the specific manufacturing requirements and route a bill of material to supply. Supply will retrieve the appropriate material and move it to the sheet metal manufacturing group. The sheet metal mechanics will have a AFLC Form 206, an L3A Statement of Work, and an installation blueprint to aid in completion of the job. The NDI section performs fluorescent penetrant and magnetic particle inspection for tubes, hoses, manifolds, housing and other miscellaneous parts of engine assemblies. The paint group performs its operations on manufactured sheet metal items and other specific parts.
- Foundry - This subunit was not in operation and is not specifically addressed as a part of this process characterization effort. When in operation, the foundry is a part of the sheet metal manufacturing subunit.
- Sheet Metal Repair - The sheet metal repair group performs repair and rework operations on small sheet metal assembly items. The P-100 ejector nozzle, the P-103 and P-107 tail feathers, the sonic suppressor, and the KC-135 frame thrust reverser constitute approximately 95% of the sheet metal repair workload. The operation process is primarily controlled by one mechanic with certain operations being performed by specific mechanics (one for rivet replacement, two for inspection). The current location of the sheet metal shop is designated as temporary.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

Plans have been developed to integrate the sheet metal repair, manufacturing, and foundry units at the W-35 location. There are tentative plans to move the NDI sub-unit of MATPIA into a new area which combines all NDI units of MAT. In view of the low utilization rates on Fluorescent Penetrant Inspection (FPI) equipment, this is a desirable move. However, additional travel and queue times may result if this is not carefully planned.

A significant issue which caused great difficulty during the data collection effort, and consequently model validation, was the proper approach to take regarding T jobs and M jobs. A large portion of the 80/20 list consists of the T jobs and M jobs. Manufactured items are typically worked only once or twice during the year and very little data exists concerning the control numbers. There have been many problems with scheduling and planning due to the lack of control data. It is recommended that some type of procedure be established whereby production controls for T and M jobs will be implemented in MATPIA. The quality of scheduling, planning, and engineering support can be improved. The personnel involved are, for the most part, willing workers with adequate background and training, some of whom have become demotivated by the lack of properly documented data and other tools necessary to do their job. This lack of data impacts the quality of the planning/scheduling support and makes calculations of shop efficiency and capabilities very difficult and inexact.

For purposes of data collection and modeling of MATPIA manufacturing jobs (M-coded work), a statistical approach was implemented which involved a Taguchi simulation based upon average M jobs in various manufacturing families. This method identifies the causes and relative values of variations from the mean, through a Taguchi sensitivity analysis. A sampling of historical M jobs is used to estimate the frequency of occurrence for each Taguchi factor (source of variance), resulting in a probability model that includes data for both the process required and operation time for each M job. This method generated a generic average for M jobs as well as a distribution of the deviation from this average.

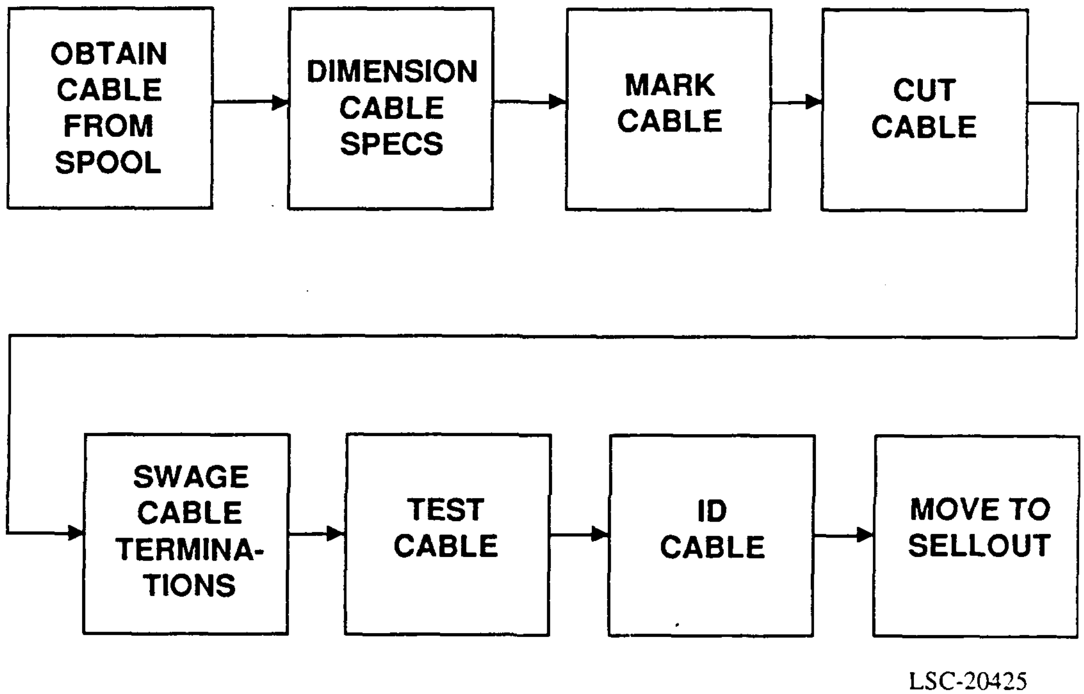
The equipment and machinery used in this RCC varies widely in age and condition. Shop personnel identified the need for a stretch forming machine.

MDMSC understands that management is receptive to the purchase of such equipment if the justification and purchase paperwork can be accomplished. (The need has been recognized for a year or more, yet the paperwork has not been initiated.)

Each item (cable, spring or tubing) has particular equipment designated for the necessary operations required for item completion. The wire stretcher (OC1870) and cable tester (OC1865) are the two main pieces of equipment used for cable manufacturing operations. The general process flow for cable manufacturing operations is shown in Figure 6.17.1-1.

The main machinery which is utilized in the tubing manufacture area consists of the band saws, flare machines, NC tube benders and the data center for them, manual tube benders and swaging machines. There are two Pines NC bending machines and one fully automated Eaton Leonard NC bending machine. The Eaton Leonard machine (which is by far the most expensive machine) is only utilized ten percent of the time because of significant limitations. The collet on the carriage does not release the tube for repositioning. The portion of the tube held by the collet must be cropped after the bending operation, contributing to higher material costs than necessary. Many of the manual machines (such as the tube benders) are approaching the end of their useful lives, where the cost of maintaining the equipment is greater than the financial value obtained from the use of the equipment. Overall equipment age ranges from three years to 40 years.

The buffing machines and the pressure testers are the primary pieces of equipment used in the tubing repair sub-unit. Hose cutters, swagers, and drill presses are located in the RCC, but are used to a lesser extent. Dust collectors in the unit are attached to a specific buffing machine. The equipment is aging but is still able to function at a reasonable level. As indicated on the equipment profile, only five of the ten buffers have experienced breakdowns within the last three years. However, the testers tend to break down more frequently and should be evaluated for possible replacement. General equipment age ranges from five to thirty years.



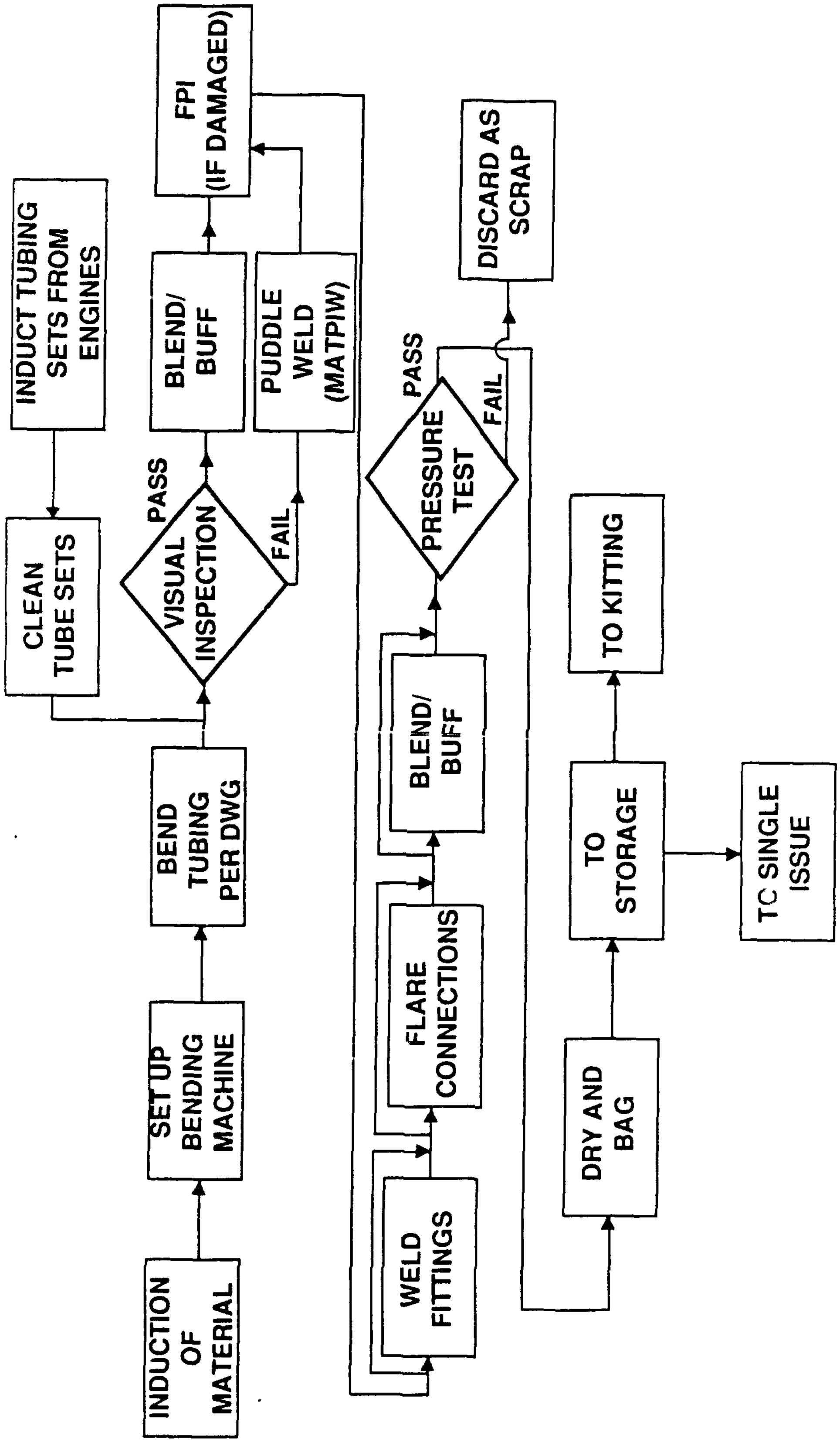
CABLE MANUFACTURING PROCESS FLOW CHART
FIGURE 6.17.1-1

A flow chart incorporating all major operations performed in the manufacture and repair of tubing is presented in Figure 6.17.1-2. This is a generic process flow diagram which identifies the paths that the vast majority of inducted items presently take through the tubing subunit. The equipment used in these operations has been identified above. Note that the flow diagram incorporates the buffing/blending prior to FPI testing, which is addressed as a quality observation later in this report. The NDI equipment is discussed below and is also identified in Figure 6.17.1-3, which is a further illustration of the NDI area process flow.

An engine lathe (OC1673) and two spring testers are the major pieces of equipment utilized in the spring manufacturing and testing area. Any work order for spring manufacturing will require material to be wound on the engine lathe. The spring testers are used extensively and should be monitored closely to ensure calibration requirements are met. Springs inducted into this subunit are first tested. As shown in Figure 6.17.1-4, if they fail the test sequence, they are discarded and new springs manufactured. No springs are repaired. MDMSC believes that this is the most advantageous approach because the cost to repair springs and an expected low yield of acceptable springs from repairing would outweigh any advantages.

Band saws, metal shears, formers, stretchers, punches, brakes, and drill presses are the primary major equipment used in the sheet metal manufacturing area. As with tube manufacturing much of the equipment is old and should be evaluated to determine what the remaining useful life is for each item. The metal roller (OC800369) and metal former (OC2449) experience breakdowns at least once every 90 days and require much maintenance. The degreaser (OC3129) also breaks down and is serviced approximately every 30 days. Downtime for this degreaser is approximately eight hours for each breakdown. The equipment age in this area ranges from five to 45 years.

The sheet metal repair unit has drill presses, dimplers (automatic and manual), and punches which serve as the primary equipment. Figure 6.17.1-5 shows the generic manufacturing flow for this subunit. Most of the other equipment



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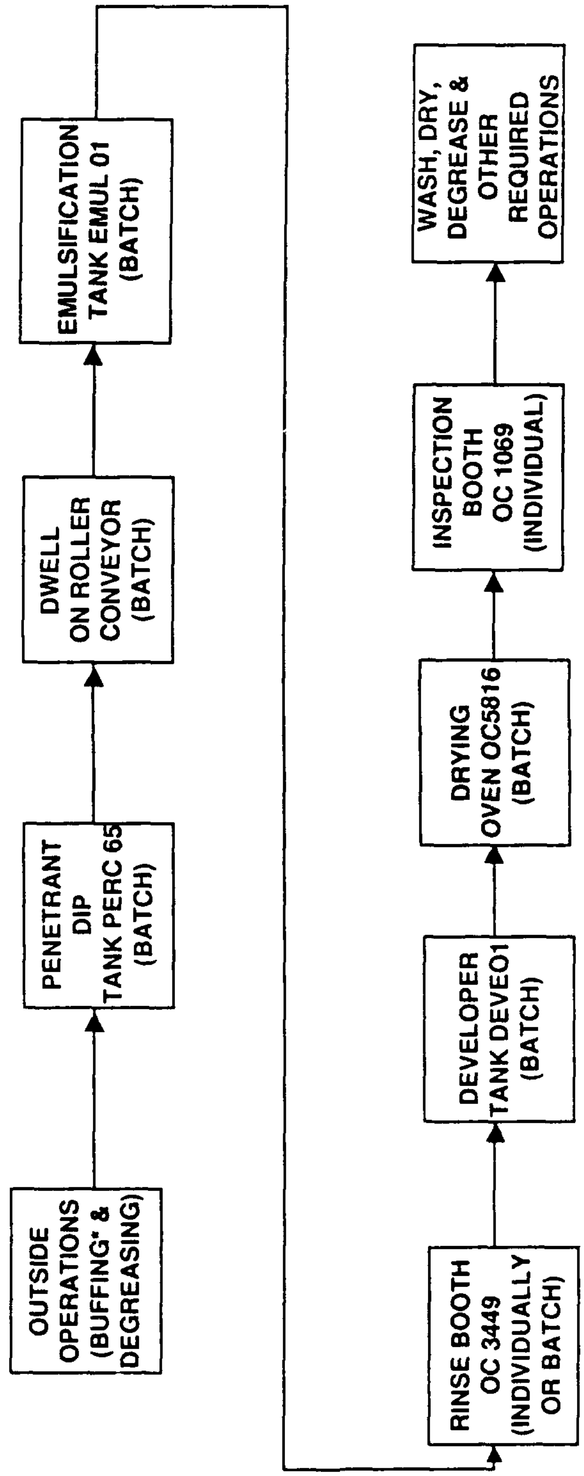
MATPIA TUBING MANUFACTURE AND REPAIR FLOW CHART

FIGURE 6.17.1-2

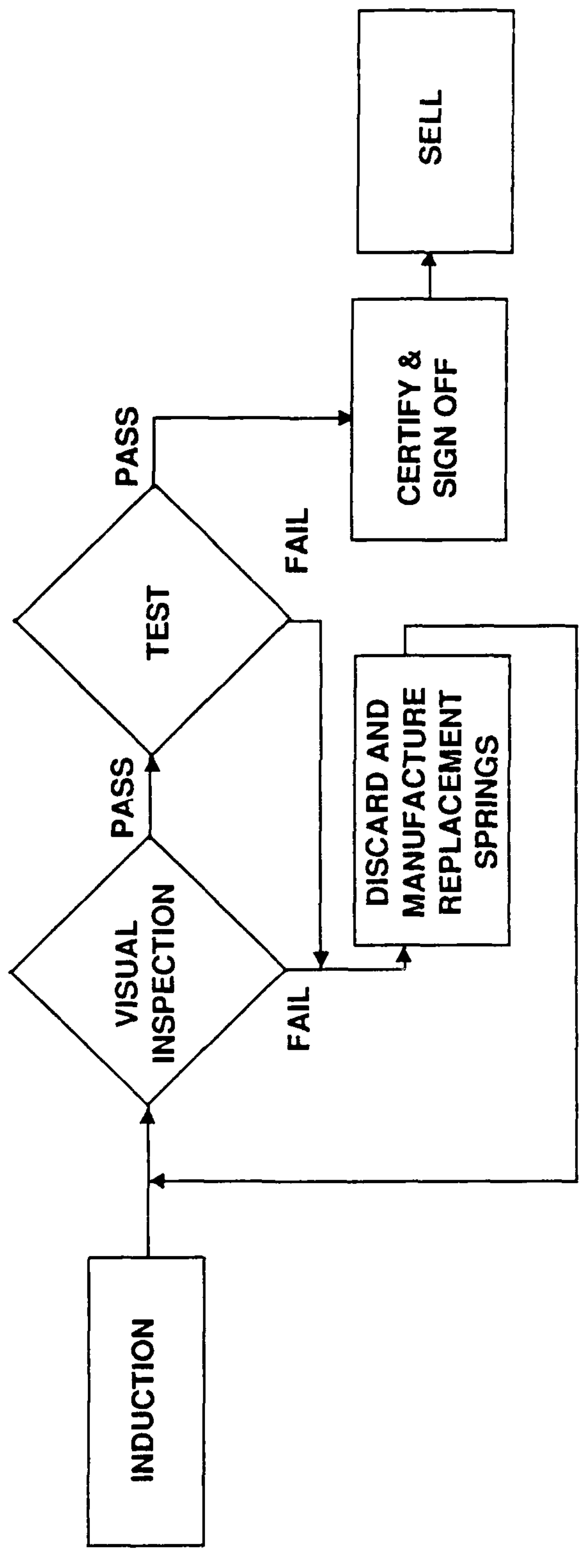
LSC-20390



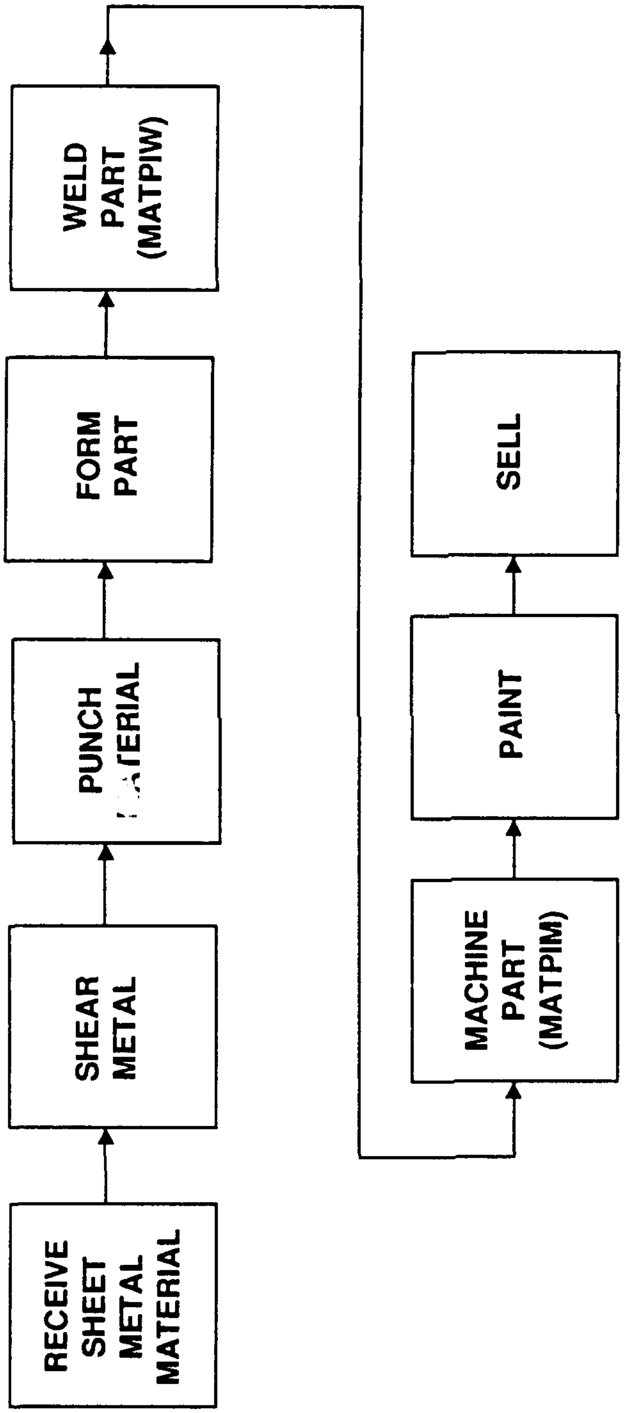
* NOTE THAT BUFFING IMMEDIATELY PRIOR TO PENETRANT INSPECTION VIOLATES INDUSTRY PRACTICE

FLUORESCENT PENETRANT INSPECTION PROCESS FLOW (MATPIA)

FIGURE 6.17.1-3



MATPIA SPRING TESTING AND MANUFACTURE FLOW CHART
FIGURE 6.17.1-4



(THIS PROCESS FLOW REPRESENTS ONE TYPICAL M JOB)

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SHEET METAL MANUFACTURING PROCESS FLOW CHART
FIGURE 6.17.1-5

consists of small hand tools. However, there are some major hand tools which must be allocated to all 25 mechanics of the unit. There is only one pneumatic squeeze gun and only one hi-shear gun currently available, but apparently several more have been ordered. Smaller hand tools are more readily available.

In the NDI section, the tanks, wash rack booth, inspection booth, and magnetic particle booth generally require very little maintenance. The paint booth area and the paint oven also require little or no maintenance. Foundry equipment is currently dismantled and was not evaluated.

The work force in MATPIA is fairly stable with a majority of the workers having five to ten years of experience. The workers are specialized in the skill requirements for their respective subunits (tube, cable, sheet metal, and NDI) and will typically not be used interchangeably with other units within MATPIA. The work force morale appears to be generally good.

In the tube manufacturing and cable area, there are 14 direct mechanics and one indirect supervisor. There is one skill code (CY) and two levels (08, 09). Tube makers and spring makers have the same skill code/level (CY09) but the workers are not interchangeable. A tubemaker can do springmaking work but a springmaker cannot do tubemaking work.

The tubing repair area has 14 direct operators and one indirect supervisor. There is only one skill code and one skill level.

There are 17 direct operators and one indirect supervisor in the sheet metal manufacturing area. The direct operators are comprised of four skill codes (AS, AI, A3, and AZ). In addition to the direct operators permanently assigned, nine "loan-in" operators are currently manning this shop.

The repair and manufacturing processes present in MATPIA employ standard technologies. Each sub-unit and manufacturing area has its own emphasis as discussed below.

The processes involved with manufacturing cable are fairly simple. A mechanic obtains raw cable material from the northeast section of the cable unit and cuts the cable to its proper dimensions. The proper end forms are then applied to the cable, usually by swaging. The cable is then tested on the cable testing equipment, identified as serviceable, and then moved to sellout.

Tubing components are both repaired and manufactured in this RCC. Repair involves more sophisticated processes than the average manufacturing job. Repair operations for tubing consist of visually inspecting the tubing to determine what repairs are needed; buffing, expandable ball operation (internal swaging) for dents, puddlewelding (done by MATPIW), facing operations (primarily for manifolds), pressure testing in water tanks, and then capping or bagging the tubes for storage. If required, the tubes will also be put through the zyglo process in the MATPIA NDI subunit.

In the tubing manufacturing area, once raw material for the job arrives at the unit, the mechanic determines the processes and respective equipment needed relative to M job specification (usually from an L3A form). The lot size (quantity), the size of the tube, and the radius of bend are critical factors in setting up a job. When the process and equipment have been determined, the tubing is cut on a band saw, worked on a flaring machine, deburred, and bent to specifications on an NC or manual bending machine. Approximately 50% of all tubing is bent on an NC machine due to the complexity of the required bends. The tube is then swaged, degreased, pressure tested, and kitted or moved out to the conveyor line.

Sheet metal manufacturing jobs begin with delivered sheet stock, a form L3A, and an installation drawing. The main processes a part goes through are typically shearing, bending (or forming), degreasing, heat treating, assembly processes (if necessary), finishing, and painting (see Figure 6.17.1-5.) Many parts are worked on the Raskin NC punch machines. Processing parameters are determined by the type of alloy being fabricated as well as the dimensions of the part being fabricated. Frequently worked materials are aluminum, steels, Waspalloy, and titanium alloys.

The operations for sheet metal repair are standard for sheet metal assembly work. These operations include such activities as the installation of all rivet types, drilling, hole sizing, shim installation, grinding, dimpling, and punching. The primary items worked are afterburner nozzles which utilize the above mentioned operations.

All parts requiring fluorescent penetrant inspection go through the following operational sequence: (1) penetrant; (2) emulsifier; (3) wash booth; (4) developer; (5) oven; (6) black light inspection; (7) wash booth; and (8) oven. Process times range anywhere from two to eight hours. Fluorescent magnetic particle inspection is also performed in the NDI area for parts fabricated from ferrous alloys. Currently, a kerosene (or similar solvent) suspension of particles is used. A degreasing sequence usually precedes and follows the NDI procedure.

The paint process basically involves masking, painting, and oven bake.

The volume and mix of workload varies considerably within MATPIA, but the overall mix consists of approximately 48% manufacturing and temporary jobs, 13% MISTR, and 39% PDM. This is further detailed as follows.

The primary requests on work orders are tube and cable manufacturing requests. The tubes requested are needed for engine shops replacement items for a kitting board. The cables are generally requested for engine assemblies. Additionally, many of the lifting cables and slings used by the aircraft lines are manufactured here. The main engines worked by this unit are the TF30, TF33, TF41, and the J-79 models. The work is allocated according to these given estimated percentages: 20% PDM, 5% temporary, and 75% manufacture.

Tubes, manifolds, and duct assemblies are the main components worked in tube repair with tubes constituting the vast majority of the work. The components come from the J-79, TF-30, TF-33 and TF-41 engines. The workload is allocated by the following percentages: 1% MISTR, 85% PDM, 4%

temporary, and 10% manufacture. These estimated percentages correspond with the control numbers and WCDs profiled in this unit.

The sheet metal manufacturing unit includes the NDI, paint and foundry units, and covers a variety of programs, engines and aircraft. The actual sheet metal manufacturing operations primarily work manufacturing jobs. Aircraft parts are manufactured for the B-52, C-135, A-7, B-1B and E-3A AWACS. Work is also done for the J-79, TF-30, TF-33 and TF-41 engines. The NDI and paint units will serve as back shops to sheet metal manufacturing, sheet metal repair, tubing, and the engine shops. The workload for the entire section is allocated according to the following percentages: 5% PDM, 5% temporary, and 90% manufacturing.

Approximately 95% of the 80/20 workload for sheet metal repair consists of assembly rework and repair for the P-100, P-103, and P-107 ejector nozzles and tailfeathers on the TF-30 engine. The remaining work is allocated among the KC-135 frame thrust reverser assembly and the sonic suppressor. The allocation of the work by type is approximately 50% MISTR and 50% PDM.

Raw materials for fabrication/manufacturing operations in MATPIA arrive by the same process as in other RCCs. Once within the RCC, the mechanics manually move material either to storage or directly to a workbench to begin the manufacturing or repair processes.

Both tubing and cable raw material arrive at the unit from the supply building. The cable is placed on spools for storage while the tubing is carried to a work bench for operations to begin. The tubes and cables are manually handled throughout the entire process in the area.

Tubes for repair arrive at the tubing repair unit from the engine shop via two methods; movement of tube bins on a trailer or transport by the engine conveyor line. Approximately 95% of all tubes are delivered by a trailer. The bins are checked for completeness of engine sets and placed in the storage cabinet until the mechanics are able to work them. Tubes which require zyglo inspection or puddleweld are manually transported in a bin to those areas.

Parts requiring degrease, zyglo, or magnetic particle inspection generally are placed into a basket. An overhead sling aids the mechanic in positioning the basket. Transport of some bins of parts in and out of zyglo is either by cart or hand carrying.

Nozzles and tailfeathers inducted into sheet metal repair are stored in crates and placed outside the storage area. The parts are uncrated and moved into the storage area on a pallet. They are placed in shelf compartments on the pallet, which is moved by a pallet jack. A mechanic will then manually transport a nozzle or tail feather to his workbench to begin operations. If an assembly requires movement to another shop for work, the mechanic places the assembly on a pallet designated for that shop. When a pallet is loaded to capacity (typically 20 parts), the mechanic responsible for transport moves the pallet outside the unit with a pallet jack. He will then use a forklift to move the pallet to the shop performing the necessary remaining operations. When the assemblies are completed by sheet metal repair, they are placed outside the unit for pick-up by the engine shop.

Incoming material for cable is stored on different spools (according to type of material) in the northeast section of the unit. Raw material for tubing is temporarily stored in tubing cabinets located within the unit. There are several cabinets for small tools, parts, and fixtures.

The tubes requiring repair are sent to the tubing repair unit by trailer or conveyor. Almost 95% of all tubes arrive by trailer. When the tubes arrive at the storage cabinet, a mechanic checks to ensure the completeness of each bin according to engine type. All incoming tubes remain in the cabinet until a mechanic is ready to work them. Several cabinets in the unit are used for storing tools, small parts or fixtures, and work in process. The moving storage shelves (OC5725) contain bin locations for every tube of every engine. Small accessories are stored in the vertical spacesavers. Both storage systems are automated and save both time and space.

When a kitting board has been depleted, a mechanic kits the board with the tubes stored in the moving storage system and the vertical spacesavers. At least one kitting board exists for every engine and model type.

Incoming raw material for sheet metal operations is stored in cabinets located in the center of the area. Sheets of all types of metal required for parts manufactured in the unit are kept in partitioned sections of the cabinet by mechanic name. When the mechanic needs a certain type of material he will obtain it from his section. When a mechanic must work a job requiring a particular sheet or block of metal, the mechanic obtains the material and manually transports it to the area of the first designated operation. The mechanic's workbench contains small bins for miscellaneous parts, templates, and tools. Two large spacesavers exist which store punches, dies, and various tools and fixtures. The NDI and paint units have storage areas used primarily for incoming and outgoing work.

6.17.2 Statistical System Performance Measures

The MDMSC/OC-ALC Technology Insertion team met with ALC representatives starting on 7 August 1989 to perform a statistical comparison of the UDOS 2.0 model simulation outputs for RCC MATPIA. The outputs were compared to the throughputs and flow times that the supervisory personnel felt were representative for the profiled PCNs for FY 88. The reasons why the opinions of the supervisors were used rather than historical throughput and flow time figures is discussed in paragraph 6.0 of this document. Aside from throughput and flow times, criteria such as the utilization of manpower and equipment was used to asses the validity of the model database. The minutes of the validation sessions that were held for MATPIA are included in the Experimentation Section of the DDB. The joint validation team concluded that the statistics generated by the simulation model were within an acceptable range when compared to the As-Is condition. The validated model database represents the As-Is condition for FY 88 and can be used as a baseline for comparison purposes.

The throughputs of all items (MISTR, as well as temporary and manufacturing jobs) for FY 88 averaged 100%. The PCNs profiled for MISTR items all showed high througnput. The one T-job and seven M-jobs all showed throughput of 100%.

A large amount of equipment was profiled for MATPIA during the data collection process. The majority of equipment shows utilization percentages of less than 25%. However, there are certain pieces of equipment which seem to be utilized well. These include the OC5816 dye penetrant drying oven (47%), the 38413 fixture (46%), and the OC4866 electric oven (40%).

Overall, the utilization of the profiled equipment in MATPIA is low primarily because the process times for most of the equipment are low. The majority of equipment takes less than one hour to process an item. In addition, most of the equipment is specialized and processes a relatively low number of different items. Out of all of the equipment that was profiled, only 14 pieces of equipment could be used in the processing of at least ten different items. These pieces are OC1069, OC1956, OC3129, OC3449, OC3917, OC3924, OC5725, OC5816, PACBEN, PERC65, BENA01, DEVE01, and EMUL01. MDMSC believes that an equipment study should be undertaken in MATPIA (refer to paragraph 6.17.4). The bottom line is that the RCC contains too much equipment relative to the amount of work that is being done. An effort needs to be made to improve the capabilities of some pieces of equipment so that other pieces can be removed from the RCC. This would free up a significant amount of floor space and would allow a better layout of the RCC's equipment to be established.

The utilization of the manpower in MATPIA varies widely depending on the skill code and labor grade of the workers. In fact, three classifications of workers that are in the RCC were not required to perform the repair work on those items which were profiled. These workers include two molders (AZ10), one rubber molder (BV10), and two springmakers (CY09A). Of the workers who were utilized on the profiled items, the first shift utilization ranged from a low of 5% for the nine tubemakers (CY09) to a high of 75% for the two NDI testers (AI09).

Aside from the testing personnel, no other classifications of workers showed a first shift utilization of greater than 44%.

The main reason behind the generally low utilization of workers in MATPIA is the specialization of workers. Ten unique classifications of workers were profiled in MATPIA and each classification is limited in the type of work that it can do. The limitations that specialization places on the flow of items could be eliminated if a cross-training program were set up (refer to paragraph 6.17.4). Under the existing conditions, the utilization of the different classifications of workers will vary widely simply because of the nature of the repair work. Certain classifications are needed during the repair processes more than others and the utilization statistics provided by the model bear this out.

The utilization statistics are somewhat misleading in that they are based upon the workers only doing the amount of work that is called out in the operation profiles. Actually, a significant amount of work goes on in MATPIA which is "hidden" in that it was not covered on any operation profiles. This problem is most apparent on manufacturing jobs, where the lack of clearly defined engineering processes and tooling problems caused certain items to be reworked. Some items in MATPIA had to go through numerous rework cycles before the repairs on them were done satisfactorily. This reworking of items has become part of the operating philosophy of the RCC, so that it is second nature for the workers to do whatever they feel is necessary to complete the repair on an item, even if this involves performing tasks that are not part of the established repair procedure. Because the amount of rework currently being done is largely undocumented, it is difficult to estimate how much the manpower utilization percentages would increase if the time devoted to rework was considered.

The utilization statistics must also be evaluated in light of the fact that the 80/20 philosophy was not strictly adhered to in MATPIA. Because of the difficulties which MDMSC encountered in profiling certain items (refer to paragraph 6.0 for more details), the profiling process in MATPIA covered slightly less than 70% of the total FY 88 hours. The utilization statistics should be analyzed in a manner which takes into account that the total workload was not profiled.

In general, the PCNs profiled in MATPIA flowed smoothly through the RCC with relatively few delays. The items that queued the most during their processing are 38805A, 38804A, and 74525A. An examination of the individual operations on these PCNs indicated that most of the delays occurred because a worker of the proper classification was not available when needed. This problem was compounded because of the items being sent out to back shops. Some of the queuing on PCNs 38804A and 38805A was caused by the 38413 fixture being tied up when an item was ready to use it. The 38413 fixture was modeled as being 46% utilized under the FY 88 workload, but this figure is somewhat deceiving because the fixture does act as a bottleneck, resulting in almost 70% of the items being delayed. Even though the average time in queue for an item waiting for the fixture was less than a day, the cumulative effect of these delays was significant, especially on PCN 38805A because of the high number of items inducted. MDMSC recommends that the ALC use the model to experiment with the quantity of fixtures. Experimentation would show what effect an additional fixture similar to the 38413 would have on the repair processes.

During the brainstorming for experimentation, the ALC personnel brought up a number of factors in the areas of equipment and manpower that they wished to have evaluated. During the discussions that took place during the validation process, it was brought up that the long flow times on certain items (such as PCNs 74525A, 38804A, 38805A, 21361A, and 21128A) were caused by the items being sent out to another RCC (MATPIW) for repair work. The ALC requested that one of the factors considered in experimentation be the addition of sufficient manpower and equipment to allow the welding operations to be performed in MATPIA. In addition to changing the welding step in the operation profile, the mandatory flow time that was put in to compensate for the current time delay (from when an item returns from MATPIW to when the worker in MATPIA start repair work upon it again) was also eliminated.

The MDMSC team was confronted with the problem that on the profiles for the five PCNs mentioned above, a series of back shop operations where the item is processed back and forth between MAESHA and MATPIW were profiled as a single back shop operation. Since the proposed in-house welding of items would only affect that portion of the back shop time that is attributed to MATPIW, MDMSC assumed that the time currently taken to perform the required heat treat operations in MAESHA would remain unchanged. The transfer of the welding operations to MATPIA was projected to reduce the cumulative time needed to weld repair the items to two hours. This projection was based on the profile that was written on PCN 74525A during the data collection process for MATPIW, which showed 1.94 hours being needed to make the repairs on the items.

To estimate the amount of time that an item would spend in the back shop RCC MAESHA, a phone conversation was held on 4 October 1989 with Larry Lasater, the foreman in the sheet metal repair subunit of MATPIA. Larry, based upon his experience in MATPIA, was able to help the MDMSC team estimate what percent of the time presently shown on the profiles for the back shop operation was due to operations being done in MAESHA. A joint consensus was reached that 48% of the back shop time currently shown on the profiles should be allocated to MAESHA. To simulate the experimental condition of welding items in MATPIA instead of sending them to MATPIW, the following changes were made in the operation profiles for the affected PCNs:

- The time shown for the back shop operation covering the welding and heat treat operations was reduced by 52%.
- An operation was added to the profile after the back shop to show a worker in MATPIA spending two hours to weld repair the item. For convenience, the identification codes which were established in MATPIW for manpower and equipment were carried over for use in MATPIA. To cut down on the amount of welding equipment that would be needed, the experimental condition was set up to man the equipment during both first and second shifts.

Because of the similarity between the five PCNs being examined, the MDMSC team and ALC personnel agreed that the PCNs could be changed in a like manner. The only difference between PCNs with regard to the experimental condition is that the back shop time for PCN 74525A is lower than that shown for the other four PCNs.

The items which go through a dye penetrant inspection process often have to make multiple trips through a drying oven. After the inspection operation, it is necessary to clean the item using a hot water rinse to remove the dye. Unfortunately, the item often has to backtrack to the oven to eliminate water picked up during the cleaning process. The ALC personnel expressed a desire to use the elimination of this secondary drying cycle as an experimental factor. The items currently processed through the OC5816 oven were chosen as the sample group and to simulate the new condition, all operations on the profiles which dealt with drying the item after the dye has been removed were eliminated. The validation group knew of equipment presently on the market which would prevent duplicate drying operations by using a water displacing rust inhibitor. The inhibitor would force moisture out of the part chemically, eliminating the need to do it through physical means.

When the projected workload for FY 90 was used to run the model, a sharp increase in the utilization of the manpower within the RCC was noted. The workers of the classification BS10 became fully utilized and increased queuing was noticed on the repair processes requiring these workers. Because MDMSC was concerned that the effect of having limited manpower available to process the FY 90 workload would mask the effect of the Taguchi factors picked for experimentation, it was decided to make the amount of manpower an experimental factor. Doing this allowed MDMSC to study the effect of manpower quantity directly and kept this factor from masking the impact caused by the other factors. Because the BS10s were in such high demand, experimentation was performed with four additional BS10s being added to the existing work force.

The general foreman of MATPIA, Glenn Berglan, requested that experimentation be performed where the downtime on two degreasers (OC3129 and its alternate, OC1705) would be changed. A summary of the changes is given below:

Equipment Code	Mean Time Between Failures (As-Is)	Mean Time to Repair (As-Is)	Mean Time Between Failures (Projected)	Mean Time to Repair (Projected)
OC3129	30 days	8 hours	15 days	72 hours
OC1705	45 days	1 hour	30 days	72 hours

The decision was made to treat the degreaser downtime experiment by itself, where a comparison would be made between the As-Is condition and the As-Is condition with the downtime on the degreasers being changed to what Glen suggested. This traditional, one-factor experiment was used because an L_4 Taguchi array had already been completely filled with the factors discussed previously. Refer to Table 6.17.2-1 for a graphic representation of the array, which shows the factors and levels determined during brainstorming. The use of this L_4 array reduced the number of experimental runs needed to evaluate the three factors from eight to four. The table gives the overall throughput percentages for the PCNs that were profiled and shows the PCNs which produced the best and worst throughput under each experimental run. The Experimentation section of the MATPIA DDB gives a detailed report of the experimental results produced for the individual PCNs and contains level average diagrams that were drawn up using throughput and average flow time as the quality characteristics being measured.

The experimentation showed that acceptable throughput (94% or better) is achieved under all of the experimental run conditions. The PCN which showed the best throughput in two of the four runs (38804AR1) had such a short flow time that even with most of the inductions coming late, all of the items which were inducted were completed. The two other PCNs which showed the best throughput during experimentation (PCNs 93008A2 and 21361A) benefitted from having most of the inductions occurring during the first quarter. The PCN

MATPIA L_4 TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS - FY 90

TABLE 6.17.2-1

EXP #	WELDING OPERATIONS	AMOUNT OF MANPOWER	DRYING TIME	NORMAL WORKLOAD		
				AVG*	BEST**	WORST**
1	AS-IS	AS-IS	AS-IS	96%	38804AR1 / 106%	38804A / 72%
2	AS-IS	AS-IS AND 4 MORE BS10s	ELIMINATE DUPLICATE DRYING OPERATIONS	97%	38804AR1 / 103%	38804A / 74%
3	DONE WITHIN RCC	AS-IS	ELIMINATE DUPLICATE DRYING OPERATIONS	94%	93008AZ / 103%	38804A / 62%
4	DONE WITHIN RCC	AS-IS AND 4 MORE BS10s	AS-IS	96%	21361A / 109%	38804A / 71%
RECOM-MENDED	DONE WITHIN RCC	AS-IS AND 4 MORE BS10s	AS-IS			

* ONLY MISTR ITEMS WERE CONSIDERED
** ONLY PCNS WITH AVERAGE QUARTERLY INDUCTIONS OF AT LEAST 10 WERE CONSIDERED FOR THE BEST AND WORST CONDITIONS.

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that showed the worst throughput (38804A) was impacted by queues developing at an operation where a worker of a classification which is highly utilized (BS10) is needed, along with a heavily utilized fixture (38413). The probability of both resources being free when an item initially needs them is small and this caused delays in processing, which in turn caused low throughput. This item was also hurt because it usually has to wait for manpower when it returns to MATPIA from back shop RCCs. Because of the small differences between the throughput produced in the experimental runs, a comparison of the average flow times to repair an item under the different experimental conditions was made and is depicted in Table 6.17.2-2.

The results of experimentation were surprising, especially the decreased throughput noted on those experimental runs where the welding of items was done in MATPIA. A comparison of the throughput achieved under the existing condition (where items are sent to MATPIW to have the welding performed) to that achieved with in-house welding showed the back shop condition to produce 1.5% more throughput. A comparison of average flow times indicated a 10% increase occurring when the welding operations were performed in MATPIA. The general consensus during brainstorming had been that the creation of a welding area within MATPIA would substantially reduce the amount of time needed to repair the five items affected by the change (PCN 21361A, 21128A, 38804A, 38805A, and 74525A). The negative results produced by experimentation did not seem logical, so MDMSC did an in-depth analysis on these five PCNs.

During the experimentation, two welders plus the equipment which they need were added to the resources available on the first and second shifts. This set-up satisfied the experimental conditions that had been decided upon during brainstorming. The MDMSC team discovered that this level of equipment and manpower was not sufficient to meet the demand of items requiring welding. The welders are utilized 100%, indicating that additional resources are required to keep items from queuing up at the welding operation. The extent to which the inadequate welding resources hurt the flow of these five PCNs during experimentation became obvious when the resource queue statistics were

L_4 TAGUCHI ORTHOGONAL ARRAY FOR MATPIA FLOW TIMES EXPERIMENTAL RESULTS - FY 90

TABLE 6.17.2-2

EXP #	WELDING OPERATIONS	AMOUNT OF MANPOWER	DRYING TIME	AVG*
1	AS-IS	AS-IS	AS-IS	401.0
2	AS-IS	AS-IS AND 4 MORE BS10s	ELIMINATE DUPLICATE DRYING OPERATIONS	383.8
3	DONE WITHIN RCC	AS-IS	ELIMINATE DUPLICATE DRYING OPERATIONS	436.5
4	DONE WITHIN RCC	AS-IS AND 4 MORE BS10s	AS-IS	437.4

* ONLY MISTR ITEMS WERE CONSIDERED

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analyzed. This analysis showed that when items are processed to have the welding done in MATPIA, queues quickly develop at the welding operation. On average, 1.7 items end up waiting to be welded and they wait an average of 228.4 hours. The amount of queuing that takes place was reflected in the average amount of work in process for these five PCNs, which increased by 18% when in-house welding was modeled.

The MDMSC team is convinced that the suggestion to perform the welding operations within MATPIA is a good one. However, the amount of welding equipment and manpower should be increased beyond the levels used during experimentation. MDMSC recommends that further experimentation with the model be done to determine the levels of manpower and equipment required to perform the welding within the RCC without serious queues forming. Once these levels have been determined, the ALC must consider such factors as the degree to which the layout of the RCC would have to be changed, the training that will need to be done to provide the RCC with skilled manpower, etc. Studies would have to be conducted to determine whether the reduction in flow time that could be achieved would justify the expense that would be involved in setting up a welding area in MATPIA. The MDMSC team believes that the equipment needed to implement the in-house welding concept could be transferred from MATPIW without impacting production there.

The addition of four BS10s to the existing first shift manpower increased the RCC's ability to get items completed. The additional workers increased the throughput by 1.5% and reduced the average number of items that have to wait on a worker of this classification by 14%, though the average amount of time spent in the queue did increase slightly. When analyzed as a group, the MISTR items which were profiled showed a 2% reduction in the average flow time. The additional workers also reduced the first shift utilization of the BS10s from a very high 83% to a more acceptable 71%.

The RCC needs to examine whether its work force is comprised of a sufficient number of workers of each classification. The model should be utilized by MATPIA to determine the ideal number of workers of each classification to assign to repair items in the RCC. The present distribution of manpower appears ineffective in that certain classifications of workers do not seem to have enough work to keep them busy, while other classifications seem to be overloaded with too much work. The RCC should strive to attain a fair distribution of work among classifications and the model can be a valuable tool in accomplishing this.

The elimination of the duplicate drying operations had little effect on throughput or the average flow time. The effect on the average flow time of the MISTR PCNs as a whole was only a 1% reduction. Even when just those PCNs which were affected by the change (PCNs 68159A, 38805A, 50280A, 97205A, and 38675A) were examined, this effect only increased to 3%. The experimental condition would have affected 20 PCNs under the FY 88 workload, but all of these PCNs except the six previously mentioned dropped out when the FY 90 workload was used. This reduced the potential benefits to be gained by implementation of the idea significantly. The model indicated that the elimination of the drying operations that are currently done after the dye penetrant has been washed off of the item would reduce the utilization of the OC5816 oven from 47% to 39%. Because the oven is not a bottleneck, the elimination of the drying operations had no effect on the average number of items that queue at the oven or the average time that they wait.

Based on the results of the experimentation performed by MDMSC, the recommended levels of the experimental factors that yield the best results are:

<u>Recommended Configuration</u>

Factor:	Welding Operations	Amount of Manpower	Drying Time
Level:	As-Is	Four moie BS10s	As-Is

Because the improvement shown when the duplicate drying operations were eliminated was so slight, MDMSC believes that, unless the investment needed to implement this change is very small, the RCC should stay at the As-Is condition. MDMSC also wants to emphasize that the above recommendation only applies to the single experiment that was performed. More experimental runs should be made at different levels for the factors to evaluate the feasibility of potential changes.

The results produced from the experiment where all factors except degreaser downtime were kept constant are summarized in Table 6.17.2-3. The changes in the downtime for the two degreasers produced flat responses in both the throughput percentage and the average flow time per item. No significant productivity improvements will be experienced in MATPIA as a result of the altered downtimes. MDMSC believes that the experimentation did not produce results that were significantly different from the As-Is conditions because the degreasers were only lightly utilized, so very few items ever got delayed at the degreasing process. The effect of degreaser downtime on the productivity of the RCC was minimized by a number of factors. The degreasers showed low utilization, so it was unlikely that an item was sent to one of them when it was broken. Even if one degreaser broke down, the presence of the back-up degreaser prevented items from queuing. The probability of both degreasers being unavailable because of breakdowns was very low.

The degreasers are batch processing equipment and can handle up to 50 items at a time. This helped to keep queues to a minimum because items that did start to queue because of the degreasers being unavailable were still usually processed as soon as the degreasers become available. Because of this and the other reasons previously stated, MDMSC does not believe that it is good use of the RCC's resources to work on ways to reduce degreaser downtime. The model showed that the RCC will not receive any significant benefits from working on the degreasers to increase their productive time.

To evaluate the RCC's ability to respond to war time surge conditions, the FY 90 workload was increased by the surge percentages provided to MDMSC by AFLC Headquarters. Around-the-clock coverage was simulated by assigning the workers to two 12-hour shifts and working them seven days a week. The model showed that under this work schedule MATPIA currently has sufficient manpower and equipment to meet the increased repair demands that would be placed on it in war time. However, the high first-shift utilization rates for the NDI

EXPERIMENTAL RESULTS FOR EVALUATION OF DEGREASE DOWNTIME REDUCTION

TABLE 6.17.2-3

EXP #	DEGREASER DOWNTIME*	THROUGHPUT%***	BEST**	WORST**	FLOW TIME AVG.***
1	AS-IS	96%	38804AR1 / 106%	38804A / 76%	400.8
5	REDUCED	95%	38804AR1 / 106%	38804A / 75%	401.3

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* FOR THE VAPOR DEGREASERS, THE NEW DOWNTIME DATA IS AS FOLLOWS:

CODE	MTBF	MTTR
OC3129	15 DAYS	72 HRS.
OC1705	30 DAYS	72 HRS.

** ONLY PCNs WITH AVERAGE QUARTERLY INDUCTIONS OF AT LEAST TEN WERE CONSIDERED FOR THE BEST AND WORST CONDITIONS.

*** ONLY MISTR ITEMS WERE CONSIDERED.

inspectors (80%) and the sheet metal mechanics (87%) indicate that it might be advantageous to add workers of these classifications to prevent items from queuing. Because of the extremely high utilization of the OC4866 oven (92%), the RCC should consider installing a backup unit in case problems occur with the primary unit. The model showed that under surge, the amount of equipment and manpower available kept the average queue wait very low, even on those resources which were heavily utilized.

6.17.3 Description of Process Problems

The intent of this paragraph is to expound on major process problems for which there are a focus study recommendations. Since there are no major process problems identified for MATPIA RCC at this time, potential improvement opportunities discussed in paragraph 6.17.4 are classified as other observations in this report.

6.17.4 Other Observations

The other observations described in this section were not considered as focus studies or quick fixes because they had a less significant impact on the areas of time, quality, or cost. These observations are recorded to assist OC-ALC in developing ideas that will further enhance their operations.

The observations which follow were originally identified as Quick Fix and Focus Study improvement opportunities and are detailed as such in the MATPIA Database Documentation Book. After review by the MDMSC/OC-ALC TI-ES team, it was mutually agreed that they should be presented as other observations for future reference.

Operational Improvement Observations

- Replacement of Chlorinated Solvents as Degreasing/Cleaning Agents
  - Current Condition: Parts are cleaned/degreased in solvent dip tanks and in vapor degreasers. Release of chlorinated solvent vapors from such equipment is a health and environmental concern.
  - MDMSC Recommendation: Coordinate with the Engineering and Services Support Center at Tyndall AFB in Florida, which has an ongoing study related to replacement of chlorinated solvents. The OC-ALC point of contact for this coordination effort will probably be able to input implementation concerns to these studies, such as modification of present capital equipment (degreasers, soak tanks, etc.) to use the new process and the impact of the new process on manufacturing operations.
- Improvement of M and T Job Procedure Documentation
  - Current Condition: Manufacturing (M) and Temporary (T) jobs are currently processed with only minimal information and without sufficient time standards to assure that they are worked efficiently.
  - MDMSC Recommendation: Provide more detailed working instructions to the workers so that they are not forced to work up repair procedures on their own.
- Tooling for Raskin NC Punch Press
  - Current Condition: Punches and dies were lasting fewer than two sheets (of A-286 stainless steel) before needing replacement. At the time this observation was made, they were being replaced when they began to bind on the withdrawal stroke. Since that time, conversations with the operator indicate that he first switched to a punch-die set with more clearance which improved operation considerably. He next checked the level on the table. Leveling the table further improved performance.

- MDMSC Recommendation: MDMSC recommends that: (1) tool set clearances be specified and posted for different types of work performed; and (2) that periodic checking of table levelness be added to either the preventive maintenance procedure or the operators' routine. (Performance improvement at last check had increased to over six sheets of A-286 steel with no trouble.) A further recommendation is the use of carbide tool sets in lieu of the presently used tool steel.

• <u>Penetrant Inspection Procedure</u>
  - Current Condition: Tubes inducted for repair are buffed ("blended") and then inspected. Tubes obviously in need of repair are sent for welding, while suspect tubes are sent to NDI for fluorescent penetrant inspection. Performing a buffing operation before penetrant inspection is in violation of inspection procedure as adopted by the American Society for Nondestructive Testing (ASNT) and accepted by the aerospace industry.
  - MDMSC Recommendation: In accordance with accepted procedures, the following sequence should be followed: clean/degrease tubing, give it a light etch, and then penetrant inspect. The cleaning should be done by a method which does not smear surface metal over possible cracks. A solvent soak with ultrasonic agitation is acceptable for very soiled tubes; otherwise a simple vapor degreasing should be sufficient.

• <u>Excessive Workflow to Penetrant Inspection</u>
  - Current Condition: Incoming tubing for repair is given an initial visual inspection which determines whether they are sent to welding, to penetrant inspection, or to buffing. Approximately 10% are sent to NDI for fluorescent penetrant inspection. (The flow time for those sent to penetrant inspection is 24 hours.) The penetrant operators report that they perform an additional visual inspection, this time under a 10x magnifier. and that they actually perform penetrant inspection on only 2% of the tubes received. The penetrant inspection step is stamped as completed on all of the received items whether it is actually performed or not.

  - MDMSC Recommendation: The personnel performing the initial visual inspection should be issued 10x magnifiers in order to do a more complete visual inspection of those tubes which would be sent to penetrant inspection. Only those tubes still identified as being in questionable condition would then be sent to the NDI subunit.

- Fluorescent Penetrant vs Visual Inspection
  - Current Condition: All tubes required by the technical order to be penetrant inspected are moved to the NDI subunit. Several Engineering Requests (AFLC Form 103, Nonconforming Technical Assistance Request and Reply) are in force which supercede the technical order and state that visual inspection is adequate. These parts are still moved to NDI.
  - MDMSC Recommendation: (1) Determine which parts require only visual inspection on a permanent basis, (2) post this list of parts in the work area, (3) provide visual inspection facility (10x glass at inspection workstations), and (4) apply for change in technical order to document procedural change.
- Tailfeather Shingle Drill Bits
  - Current Condition: Tool steel and nitrided drill bits are used to drill holes in Waspalloy shingles. These bits do not last long and are expensive on a yearly basis due to replacement costs.
  - MDMSC Recommendation: Use carbide drill bits at a machining speed of 200-250 surface feet. This should provide correct feed and speed to make bits last longer and result in tool cost savings.
- Purchase of Stretch-Forming Machine
  - Current Condition: Skins and other sheet metal parts for B-52, C-130, and KC-135 aircraft are currently sent to Kelly AFB for stretch forming. Purchase of a stretch-forming machine has been justified for over a year at OC-ALC, yet the paperwork has not been accomplished.
  - MDMSC Recommendation: In view of the decreased flow time and increased productivity available through stretch forming capability, the purchase of this equipment should be expedited; i.e. a higher priority should be assigned.

- Frame Thrust Reversers
  - Current Condition: Frame thrust reversers purchased from commercial airlines require modification before use on KC-135 aircraft.
  - MDMSC Recommendation: Study processing and develop a standard WCD to detail the modification process to reduce flow time (presently in excess of ten work days).
- Tag Printing
  - Current Condition: Presently, a tag printing operation consists of calling up the appropriate tag format on a computer terminal and tailoring. The terminal cannot be used for another tag order until the current one is finished because the program resides in the terminal itself.
  - MDMSC Recommendation: Purchase additional one or two printers and a buffer memory for each so that after set up (tailoring) the program could be down loaded to a buffer memory to drive the printer. This would allow the operator to set up a second job while the first was printing.
- Equipment Study
  - Current Condition: The RCC contains equipment that is not utilized very much.
  - MDMSC Recommendation: Perform an analysis of the equipment in the RCC to see if it is possible to eliminate some of it by modifying certain pieces of equipment so that they can process a larger variety of parts. The analysis would also evaluate whether some of the older equipment should be replaced with more modern equipment.
- Establishment of Spring-Making Procedures and Creation of a Training Program
  - Current Condition: Presently, only two workers are skilled in the fabrication of springs and both are expected to retire within the next five years. The spring-making process is undocumented and is an "art" because it is so dependent upon the skill and experience of the worker doing the job.

- MDMSC Recommendation: The RCC should take steps to document the process to the point that it becomes a "science." The establishment of procedures and the detailed documentation of them will free the RCC from its dependence upon certain workers to do the job. Once procedures have been set up, a training program should be established to insure a constant supply of trained manpower to cover situations where experienced spring-makers leave the RCC.

• Establishment of Cross-Training Programs Within the RCC
  - Current Condition: MATPIA has a work force consisting of specialized workers who are assigned to perform only a relatively small range of tasks. This specialization results in the fairly low utilization of many of the workers in this RCC and increases the impact that is felt upon production when a worker is absent. The existing system also makes it difficult for a supervisor to coordinate his manpower to expedite the processing of items.
  - MDMSC Recommendation: The RCC should train its workers to do a variety of tasks. This cross-training would enhance the ability of MATPIA to control the flow of items through it by allowing more flexibility in the way in which workers are assigned. The cross-training would provide job enrichment by expanding the workers' abilities and allowing them to do more than just a limited number of tasks. Cross-training would also cut down significantly on the amount of handling being done by reducing the number of times that items have to be passed between operators. The reduction in handling wouid decrease the chances of an item being damaged while in transit, and also improve the RCC's ability to track an item.

• Improvement of Staff Support
  - Current Condition: MDMSC believes that too much design work is currently being done by the workers in MATPIA. While these workers are experienced, they lack the necessary educational background to perform design functions effectively. As a consequence, many pieces of tooling and fixturing are designed on a trial and error basis, which results in additional time and manpower being used.

- MDMSC Recommendation: More support needs to be provided, especially in the areas of sheet metal fabrication and tooling design, by qualified individuals within the ALC. Those people whose job responsibilities include supporting the activities in MATPIA should be made to fulfill these responsibilities, which will leave the workers in the RCC free to do the repair work that they were hired in to do.

• Improvement of Tooling Storage

- Current Condition: There is currently no organized method of storing the tooling used in MATPIA. The workers store tooling in the available cabinets in a haphazard fashion, making it very difficult to retrieve a particular piece of tooling should the need to use it again arise. The RCC lacks a system to identify a piece of tooling and pair it up with the job where it is used. This makes it almost impossible for a worker to know what particular job the tooling was designed for unless he happened to have run the job before and remembers it. Because of the "trial and error" method used to design some of the tooling in MATPIA, some obsolete tooling ends up getting stored.
- MDMSC Recommendation: The existing problems regarding tooling storage could be resolved if the RCC would undertake the following steps:

  (1) Go through all of the tooling currently being stored and eliminate any that is judged to be obsolete. It might prove worthwhile to establish a secondary storage area for the tooling that is expected to be needed again, but is not used often enough to justify taking up space in one of the primary storage cabinets.

  (2) Establish a method for identifying a piece of tooling so that workers can readily determine which jobs require that piece. The stamping of an identification number on the tooling should be investigated as a possible solution.

  (3) Set up a defined storage area for each piece of tooling identified in step two and establish procedures to see that each piece of tooling is returned to its assigned spot after use. This storage area should be laid out so that the most frequently needed tooling is the easiest to get at.

Inventory/Sourcing

- In-House vs Contract Manufacturing of Tubing
  - Current Condition: Many tubing parts which are manufactured by outside contractors which are well within the production capabilities of this RCC. Outside manufacture lowers utilization of RCC resources and increases lead time required for parts.
  - MDMSC Recommendation: Many of these parts can be returned to in-house manufacture to decrease response/lead times for needed hardware and to increase shop resource utilization.

6.18 MATPIM ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MATPIM is a Resource Control Center (RCC) within the Accessories Division (MAT) of OC-ALC and is located in Building 3001. MATPIM is responsible for machining parts on conventional machines. This RCC is a general machining unit which processes both newly manufactured parts and items that require machining repairs. Sixty items, representing 80% of the FY 88 workload, were selected for process characterization. The tasks are mostly temporary (T) and manufacturing (M) and do not include items classified as general maintenance shop repairs.

MDMSC team members were well received by the supervisor and the machinists. Much of the information in this report was jointly developed by MDMSC and OC-ALC personnel. The clarity of purpose and viability of recommendations is, in good part, due to the openness and cooperation given by MATPIM personnel, staff functions, and supervision.

The machinists in MATPIM are highly trained and very experienced in machining processes. The success of the operations that take place in this RCC can be largely attributed to the dedication and quality consciousness of the machinists. The MDMSC team observed a high degree of expertise among the machinists, as evidenced by the fact that they were capable of maintaining tight tolerances during machining operations despite the condition of some of the equipment that they work with. Much of the equipment in MATPIA is at least 15 years old and it requires a highly skilled worker to maintain the dimensional accuracy that is demanded on many of the items machined in the RCC. The machinists not only have to contend with old equipment, but also have to be capable of establishing the repair procedures on an item. The machinists often have to work from blueprints to determine exactly what must be done to an item. Much of the paperwork which accompanies items being processed through MATPIM contains little more than routing information. If machining instructions are given, they are often expressed in generic terminology using phrases such as "repair as necessary," "machine as required," etc. The machinists' experience allows them to carry out repair procedures even when lacking detailed instructions.

The throughput in MATPIM is very good and would continue to be so even under war time surge. The RCC appeared to have an excess of equipment, as evidenced by the fact that even under a surge workload, some pieces of equipment still showed very low utilization. The current level of manpower within the RCC is sufficient to meet the additional demands that the RCC would face under surge conditions.

MDMSC evaluated the equipment layout to be as efficient as most of private industry. The main difference in private industry is that tool fabrication, equipment parts, etc. are not sent to be worked in production machine shops, but are usually worked in general maintenance or tool shops where they will not precipitate any interruptions in production flow.

The nature of the work performed in RCCs caused unique problems. Because of the amount of temporary and manufacturing work which takes place in MATPIM (as well as in MATPIA, MANPIN, and MATPIW), many of the operations which take place in these RCCs are not documented. The T and M jobs are for the most part one-of-a-kind repairs that will not be repeated. The ALC believes that it is not worthwhile to devote the time and effort to create detailed documentation for repair work that is probably only going to occur once. Because of this, the paperwork that accompanies T and M jobs is usually very simplistic. Therefore, in the absence of operation sequences, it was impossible to track the items. It was extremely difficult to obtain profile information from the operators who may have worked the job only once in the past year.

The 55% T and M jobs posed a major problem in the characterization of MATPIM. They varied enormously from job to job in such areas as batch sizes and processes used. The jobs are very seldom repeated as the U.S. Air Force can manufacture on a one-time only basis. To facilitate characterization under these circumstances, representative groups of parts were sampled and the history of various part types was noted. Utilizing a Taguchi orthogonal array and sensitivity analysis, a statistical distribution of part process and process times was generated. The use of the Taguchi array enhanced the quality of data derived from the samples and provides OC-ALC planners with a more effective tool for estimating new manufacturing jobs.

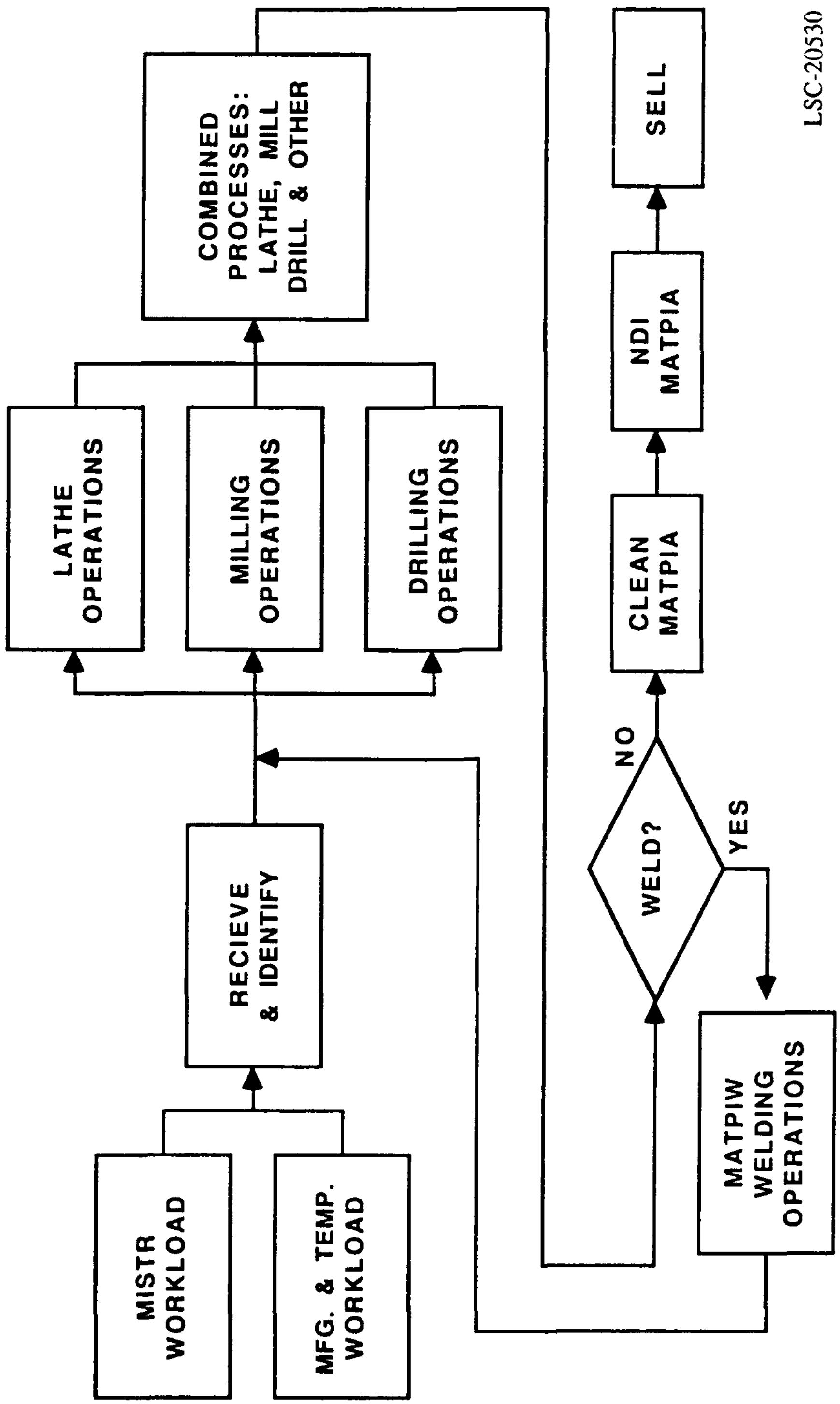
During the initial characterization of MATPIM, a total of five improvement opportunities were identified (reference DDB, Potential Improvements section). After review of this original set of opportunities by MDMSC and OC-ALC personnel, it was mutually agreed that they should be noted as other observations due to the difficulties in quantification.

The process improvement opportunities, classified as other observations in this report, are as follows and are detailed in paragraph 6.18.4.

- Replace the single grade of carbide inserts with multiple grades based on the type of material processed to increase tool life and optimize feed/speeds.
- Transfer those parts that prove adaptable from conventional machining equipment to numerically controlled machines, to increase effectiveness in quality, set-up, and machine process times.
- Review temporary and manufacturing jobs for the segregation of production machining from general maintenance or tooling jobs.
- Remove three unused screw machines that will release 200 sq. ft. of floor space.
- Replace/recondition old machines for improved productivity and quality.

6.18.1 Description of Current Operation

The repair/manufacturing processes within MATPIM consist mainly of milling, drilling, and lathework. A typical repair process is to machine the damaged areas of a part, send to welding to build it up, and then finish machining the welded areas. A typical manufacturing process is to completely machine a part from the raw material. A detailed description of the MATPIM repair/manufacturing process is available in the MATPIM DDB, paragraph 2.4 (Repair Process Technologies). A MATPIM repair/manufacturing process flow diagram is included in this document (see Figure 6.18.1-1).



MATPIM GENERIC PROCESS FLOW DIAGRAM
FIGURE 6.18.1-1

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

The workload in MATPIM consists of 45% Management of Items Subject to Repair (MISTR), 50% Manufacturing, and 5% Temporary work.

MATPIM has a stable work force. The direct work force consists of 58 general machine operators. The indirect work force consists of three supervisors, one tool room mechanic, one cleaner, and one training instructor. The experience level of the general machine operators is very high and they turn out high quality items on schedule.

The bulk of equipment in MATPIM consists of conventional machines such as engine lathes, turret lathes, horizontal/vertical/universal/rotary head mills, drill presses, gang drills, radial drills, automatic screw machines, jig bores, a jig mill, a slotter, a band saw, and a cut-off saw. Other equipment in MATPIM consists of a sleeve cutter, a belt sander, an oven, etc. The equipment within MATPIM is 15 to 25 years old; 30% is in good condition, 30% is in workable condition, and 40% is in bad condition. Proper grades of carbide inserts are not being used in machining operations. Some equipment, such as the automatic screw machines, are not utilized and unnecessarily occupy floor space. Some parts, which should be economically machined on NC machines in MATPIN, are presently machined on conventional machines in MATPIM.

The main machining area of MATPIM is generally clean and well lighted. Machines are arranged on the basis of the process type of layout; i.e., similar types of machines are grouped together and arranged within the RCC for the optimum process flow.

Material handling in MATPIM involves the use of carts, pallet jacks, jib cranes, and manpower. Baskets, totes, and pallets are used to hold the items.

The storage areas in MATPIM consist of a tool crib and a designated drop zone for incoming items. The ALC provided facility layout drawings have not been maintained and are not representative of MATPIM.

6.18.2 Statistical System Performance Measures

During the brainstorming session for MATPIM, the ALC personnel expressed a desire to add workers to the second shift to work specific types of items. The addition of three workers to repair housings, two to work actuators, and four to work nozzles were examined during experimentation. The ALC personnel wanted to know what improvements, if any, would occur from having dedicated manpower working these items on the later shift.

The L_4 Taguchi array constructed for the factors and levels chosen is shown in Table 6.18.2-1. This array reduced the number of experimental runs needed from eight to four. The table also shows the overall throughput percentages for the PCNs that were profiled (refer to the Experimentation section of the MATPIM DDB for a detailed report of the results produced for the individual PCNs). The table also lists the individual PCNs which showed the best and worst throughput under each condition.

The throughput achieved under the different experimental conditions shows a large variance. The PCNs which produced the worst throughput (31151A-MCZ11 and 50346A-MCZ10) were items which had very large second quarter inductions relative to those in the first quarter. The PCNs which showed the highest throughput (97148A-MCZ10 and 49196A-MCZ10) had all of their inductions occurring during the first quarter. Except for those PCNs where there was a substantial difference between the number of items inducted per quarter, the output was close to the number of items inducted.

The experimentation showed that the addition of second shift manpower did not improve the throughput on any of the types of items which were reviewed during experimentation. To further analyze the effect that the additional manpower had upon the flow of items in MATPIM, a comparison of average flow times (refer to Table 6.18.2-2) was made. This table shows some values which at first glance seem odd, in that the additional manpower actually resulted in longer average flow times. To determine the reason for this occurrence, a more detailed breakdown of flow times was made to focus on just those types of items which had manpower dedicated to them during experimentation.

L_4 TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS FOR MATPIM

TABLE 6.18.2-1

EXP #	FACTORS: MANPOWER TO WORK HOUSINGS **	FACTORS: MANPOWER TO WORK ACTUATORS ***	FACTORS: MANPOWER TO WORK NOZZLE SEGMENTS****	NORMAL WORKLOAD: AVG	NORMAL WORKLOAD: BEST*	NORMAL WORKLOAD: WORST*
1	AS-IS	AS-IS	AS-IS	99%	97148A, MCZ10 / 139%	3151A, MCZ11 / 80%
2	AS-IS	ADD 2 TO 2ND SHIFT	ADD 4 TO 2ND SHIFT	99%	97148A, MCE10 / 141%	31151A, MCZ11 / 80%
3	ADD 3 TO 2ND SHIFT	AS-IS	ADD 4 TO 2ND SHIFT	99%	97148A, MCZ10 / 139%	31151A, MCZ11 / 80%
4	ADD 3 TO 2ND SHIFT	ADD 2 TO 2ND SHIFT	AS-IS	99%	49196A, MCZ10 / 136%	50346A, MCZ10 / 72%
RECOM-MENDED	AS-IS	AS-IS	AS-IS	----		

* ONLY PCNs WITH AVERAGE QUARTERLY INDUCIONS OF AT LEAST TEN WERE CONSIDERED FOR THE BEST AND WORST CONDITIONS.
** AFFECTS PCNs 23111A, 30010A, 30033A, 30046A, 30059A, 30060A, 31151A, 49720A, 49835A, 50197A, 50214A, AND 50215A.
*** AFFECTS PCNs 49196A, 49730A, 50279A, 50280A, 97148A, 50281A, 50282A, 50283A, 50346A, 97168A, 97175A, 98013A, 98035A, 98071A, AND T4873.
**** AFFECTS PCN 67509A.

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L_4 TAGUCHI ORTHOGONAL ARRAY FOR MATPIM FLOW TIMES EXPERIMENTAL RESULTS

TABLE 6.18.2-2

EXP #	MANPOWER TO WORK HOUSINGS	MANPOWER TO WORK ACTUATORS	MANPOWER TO WORK NOZZLE SEGMENTS	AVG
1	AS-IS	AS-IS	AS-IS	386.3
2	AS-IS	ADD 2 TO SECOND SHIFT	ADD 4 TO SECOND SHIFT	402.3
3	ADD 3 TO SECOND SHIFT	AS-IS	ADD 4 TO SECOND SHIFT	386.1
4	ADD 3 TO SECOND SHIFT	ADD 2 TO SECOND SHIFT	AS-IS	406.5

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An analysis of the flow times that resulted from each experimental run on each PCN is shown in Table 1 of the MATPIM DDB. The flow times produced under each experimental run were compared to the times produced under the As-Is condition. These PCNs, which are highlighted in yellow, represent items where the experimental flow time varied from the As-Is flow time by 10% or more. All but one of these PCNs (T4873A) was affected by the experimental condition where two workers dedicated to working actuators were added to the second shift. On the average, the flow times on these PCNs increased 19% as a result of the dedication of two second-shift workers to work actuators (this is based on a comparison between the average flow time for the affected PCNs in the two runs where the two actuator workers were added and the two runs where no workers were dedicated to the actuators).

To investigate the cause of this increase, the WIP levels for the affected PCNs were looked at. This examination revealed that approximately 15% more WIP is present when the two workers dedicated to actuators are added to second shift (note: only the 12 PCNs which were highlighted in Table 1 were used to make this calculation). This increase in WIP was probably due to the dedicated workers on second shift starting to work on actuators, but not finishing them. This work is then passed on to the first shift workers to process, which produced the higher WIP levels.

The two actuator workers were fully utilized, indicating that they are continually busy doing actuator-related work. Unfortunately, the actuators have extensive back shop work done to them and this compounds the problem of items being held up during the repair process. The average simulated flow time for an actuator profiled in MATPIM is over 20 days. The items flow time suffers not only because of the transports to and from the back shops, but also because of the shift changes. The shift changes hurt the flow of an actuator because the workers on second shift are dedicated to actuators and will always work on one if it is available, which causes a high number of them to be in process. However, the workers on first shift are modeled so that they will repair any item that comes to them and this lack of priority on actuators forces many actuators to be delayed simply because they have to "wait their turn." A first-shift worker is usually going to be found working an item other than an actuator just because the probability is higher that the model will induct a non-actuator item for repair.

To further investigate why the additional second-shift workers produced such negative results for the actuators, MDMSC did a calculation where for each skill code of worker, the average queue quantity was multiplied by the average queue wait. These numbers were then totaled and divided by the total number of workers (ignoring any overtime manpower) to get a weighted average. A comparison was made between the numbers produced in the two runs with dedicated actuator workers and the numbers produced in the other two runs. The average value of this calculation for the runs with the dedicated actuator workers was twice as high as the value for the other runs. This indicates that the net effect of adding the two actuator workers to second shift is negative because more items queue up and the average time that they wait for resources goes up.

The experimentation showed that the addition of the actuator workers created a bottleneck in the process rather than improving the flow. Because of the absence of any WIP limits on the actuators, the model indicated that the dedicated workers "flood" the system with actuators and even with a larger number of workers available who can work them, the actuators end up taking longer to repair. MDMSC recommends that the ALC perform further experimentation to determine if limiting the number of actuators in process at one time would help to eliminate the bottlenecks caused by having a large number of actuators in work at one time. The model should also be utilized to evaluate the effects of changing the amount of manpower available on the different shifts. The RCC should also consider using the model to see what advantages and disadvantages result from dedicating workers to repair selected items.

The effect of experimentation on items other than actuators was insignificant. The addition of manpower to second shift to work housings and nozzles produced flat responses. Unless changes are made in the way in which items are brought into the RCC or in the assignment or amount of manpower in the

RCC, no benefits will come to the RCC from the assignment of manpower to second shift in the manner in which it was done during experimentation. Given the experimental conditions, MDMSC recommends that the RCC stay at the As-Is condition. The levels of the experimental factors that yielded the best result are as follows:

<u>Recommended Configuration</u>

Factor:	Manpower to repair housings	Manpower to repair actuators	Manpower to repair nozzle segments
Level:	As-Is	As-Is	As-Is

To evaluate MATPIM's ability to respond to surge conditions, the resource usage report was analyzed to determine whether the current levels of manpower and equipment were sufficient to meet the demands of war time surge. To simulate surge conditions, around-the-clock coverage was modeled by assigning the workers to 12-hour shifts and working them seven days a week. The surge workload was calculated by increasing the FY 90 workload by the surge percentages that were provided by AFLC Headquarters.

The model showed that the RCC is capable of repairing all of the items that would come in under war time surge with its current level of equipment and manpower. Even at surge, many pieces of equipment show low utilization figures, indicating that the RCC has excess equipment capacity.

The model output when the surge workload was used showed the following equipment with a utilization percentage of zero:

Equipment Code	Equipment Description
357290	Warner and Swasey Turret Lathe
386015	Gang Drill Press
414551	Warner and Swasey Turret Lathe
800718	Monarch Engine Lathe
800733	Bardom and Oliver Turret Lathe
800785	Warner and Swasey Automatic Bar Machine
800927	Monarch Engine Lathe

Equipment Code	Equipment Description
801262	Porter-Cable Belt Sander
837826	Edlund Drill Press
851104	Slotter
OC2230	Jones and Lamson Turret Lathe
OC2445	Lablonde Lathe
OC2719	Cincinnati Hydrashaft Lathe
OC3135	Jones and Lamson Turret Lathe
OC3355	Lablonde Lathe
OC3983	Drill Press
OC3987	Drill Press
OC4735	B&S Automatic Screw Machine
OC4736	B&S Automatic Screw Machine
OC6546	Darex Grinder

The above 20 machines include many pieces of equipment which are kept within the RCC to act as back-up units in case the primary equipment breaks down. It reveals that these machines are not needed even under the surge workload and indicates that the RCC could remove them without impacting its ability to meet the surge requirements. There is a possibility that some of the items which were not profiled would require the use of one of the listed machines, but the 80/20 concept states that the items which were profiled are representative of the entire workload. This would imply that any equipment that was not used to process the profiled items is unlikely to be used for the remaining items.

MATPIM could greatly reduce its floor space requirements if those pieces of equipment which are used very infrequently or not at all were removed. The RCC would benefit from an in-depth equipment study to determine exactly what types of equipment (and the quantity of each) are needed to perform the required repair work. It may end up that the RCC might find it effective to develop alternate processes for those items which are processed on pieces of equipment with low utilization so that these pieces can be moved out of the RCC, which may permit a more efficient RCC layout to be implemented. These alternate processes could require more time than the existing processes, but might end up saving money for the RCC by allowing a consolidation of its resources. This consolidation would allow the RCC to focus its efforts on a smaller number of machines, which should make it easier to keep all of the machines in peak running condition.

6.18.3 Description of Process Problems

The intent of this paragraph is to expound on major process problems for which there are focus study recommendations. Since there are no major process problems identified for MATPIM at this time, five potential improvement opportunities identified during initial characterization of the MATPIM are classified as other observations in this report.

6.18.4 Other Observations

The other observations described in this section were not considered as quick fixes because they were difficult to quantify or had a less significant impact in the areas of time, quality, or cost. These observations are recorded to assist OC-ALC in developing ideas that will further enhance their operations.

The observations which follow were originally identified as quick fix improvement opportunities and are detailed as such in the MATPIM DDB. After review by the MDMSC/OC-ALC TI-ES team, it was mutually agreed that they should be presented as other observations for future reference.

General Area Improvement Opportunities

- Remove the Automatic Screw Machines from the Machine Shop
  - Current Condition: There is no workload on the automatic screw machines per the workload profile. The automatic screw machines are not utilized and they unnecessarily occupy approximately 200 square feet of valuable floor space.
  - MDMSC Recommendation: Remove the automatic screw machines from the machine shop. Approximately 200 square feet of valuable floor space will become available.

- Replace/Recondition Old Machines for Improved Productivity and Quality
  - Current Condition: Forty percent of the machines in the machine shop are old and in bad condition and cannot machine to close tolerances. They are not run at optimum feeds/speeds, are frequently down for maintenance, and produce poor quality parts.
  - MDMSC Recommendation: Old machines in bad condition should be replaced or reconditioned. This will result in improved productivity and quality.
- Review the Manufactured Parts Presently being Machined on the Conventional Machines fur Machining on the NC Machines to Reduce the Set-Up and Process Times
  - Current Condition: Parts suitable for machining on the NC machines because of the part configuration and lot size are being machined on the conventional machines in the machine shop.
  - MDMSC Recommendation: Review the manufactured parts in the machine shop for machining on the NC machines to reduce the set-up and process times. The part configuration and lot size should be taken into account while reviewing the manufactured parts for NC machining.
- Review Temporary and Manufacturing Jobs for the Segregation of Production Machining from General Maintenance or Tooling Jobs
  - Current Condition: The requirements for temporary and manufacturing items are on the increase. The basic assumption behind the increase is that the aging of aircraft, and subsequent overhauls required, now require replacing "core" parts such as housings, shafts, pulleys, etc., that were not normally replaced in the past. Procurement of these items is becoming more difficult as time passes because vendors have discarded their tooling or are faced with the high cost of reinstalling the processes for limited orders.

- MDMSC Recommendation: Segregate the production processes from the abstract items such as equipment parts, tooling, desk parts, bicycle pedals, etc. which would be relegated to a general maintenance repair department. In addition, engineered planning should be established for all production items.

• The Grade of Carbide Inserts Should Suit the Material in Machining Operations for Optimum Speed, Feed, and Insert Life
  - Current Condition: One general grade of carbide inserts is being used to machine all materials. As a result, machines are not run at the optimum speeds and feeds. Life of inserts is also shortened.
  - MDMSC Recommendation: The appropriate grade of carbide inserts should be used in machining operations to suit the material to achieve optimum speed, feed, and insert life. This would reduce tooling cost and machine cycle time.

6.19 MATPIN ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MATPIN is a Resource Control Center (RCC) within the accessories division (MAT) and is located at the north end of Building 3001. This RCC is responsible for Numerical Control and Computer Numerical Control (NC/CNC) machining requirements. MATPIN support lends itself to the more difficult operations where precision and schedule needs are of upmost importance. In addition, the newly installed flexible machining center is a remote subunit of MATPIN, located near the south end of Building 3001. Although this system was not characterized, MDMSC is of the opinion that (upon complete installation) an enhancement in all turning operations will be realized. A study should be conducted to determine if any outside turning work can be redirected to MATPIN in order to fully utilize the capacity of this system. The extent of MATPIN tasks is more fully addressed in paragraph 6.19.1.

MDMSC team members were well received by supervision and the machinists. The resultant recommendations and conclusion were due to the openness and cooperation given by MATPIN personnel.

During the initial characterization of MATPIN, a total of 11 improvement opportunities were identified (reference DDB, Potential Improvements section). After review of this original set of opportunities by MDMSC and OC-ALC personnel, it was mutually agreed that they should be noted as other observations due to the difficulties in quantification.

Throughput in MATPIN is excellent and would remain so even under a war time surge condition. The RCC appeared to have an excess of equipment. As evidenced by the surge workload, some pieces of equipment showed extremely low utilization. An enhancement in throughput, as well as operating costs, can be realized if a reduction in set-up time can be achieved (reference Other Observations, paragraph 6.19.4 for more information).

One of the tasks assigned to the TI-ES team was to compare operations and technology in MATPIN to those of private industry. A comparison with MDMSC and other major aerospace companies will show a more efficient operation by private industry in the utilization of numerical and/or computer numerical controlled resources. The current layout of the RCC is not conducive to multi-machine operations. It should be noted that one advantage of using NC/CNC type equipment is the reduction in machine attention time. This allows an operator more free time to perform additional tasks internal to a given machining cycle. The equipment technology was judged by MDMSC to be state-of-the-art.

6.19.1 Description of Current Operation

MATPIN is responsible for manufacturing and reworking of engine accessories and aircraft components. The total RCC area covers approximately 27,000 sq. ft. and is staffed with one chief supervisor, three first line supervisors, 46 NC machinists, and one tool crib attendant. The workload consists of a 70-30 mix, with "M" or manufactured work accounting for 70% of the workload and MISTR items accounting for the remainder. Also, MATPIN is responsible for building/manufacturing many of their fixtures and tools. Programming and tape tryout are additional functions required of the machinists.

This RCC can be viewed as a critical support NC/CNC machine shop which performs many operations that cannot be done by other sources. Types of equipment used in this area are three, four, and five axis horizontal and vertical mills, lathes, and a laser machining center. These machines perform such operations as milling, profiling, turning, boring, grinding, drilling, and cutting. Manufacturing and/or rework is performed on such parts as diffuser cases, shafts, stators, spacers, housing (oil and gearbox) and gear box covers. Equipment ranges in age of approximately five to 20 years, with much of the equipment having been retrofitted within the last ten years. Material and/or parts are received for manufacture or rework from various RCCs throughout the site. To complete a part, back shop operations such as welding, heat treating, etc., often have to be performed. Parts that require back shop work have processing delays caused by the need to move the parts between RCCs and many of the PCNs profiled during characterization of MATPIN suffered delays because of this. The nature of machine shop work is that parts often have to be sent out between the machining operations for metal treatment operations and MATPIN was no exception.

The process technologies in MATPIN consist of manufacture/remanufacture of component parts. These parts are processed to incorporate and comply with all current aircraft modifications and technical order changes. A typical repair process is to machine the damaged areas of a part, send to welding to build material, and then finish machining the welded areas. A typical manufacturing process is to completely machine a part per engineering drawing from raw material. A repair/manufacturing process flow diagram is included in this document (see Figures 6.19.1-1 and 6.19.1-2).

Engineering and planning should be more attentive to the Work Control Documents (WCD) and provide more detail for the methods of performing the various operations. Also, problem request forms (AFLC Form 103) are not always processed in a timely manner. Scheduling needs to develop a systematic approach to tracking and maintaining records for parts that come into the department. Records should provide data on completed work and time between delivery.

Material handling in MATPIN is accomplished by the machinists, who move work from machine to machine. Parts exit and return to the NC area several times within the remanufacturing cycle. There are no overhead cranes in the area, so large items (mostly fixtures) are handled with a fork lift truck. Set-up can be hampered when a truck is used, but can be achieved. This often causes delays in the set-up process. Note, fork lift trucks are not assigned to MATPIN, so a request must be made for their services.

There is no designated parts storage area. The workload is such that no storage area is necessary. A limited storage for fixtures/tools is available. This space limitation creates a need for constant development and manufacture of new fixtures, for the previous ones are no longer available. In most cases, a fixture is kept in MATPIN for a short time before being sent out to be scrapped or for other use outside the RCC. Currently, it is necessary to do this to free up space for incoming parts.

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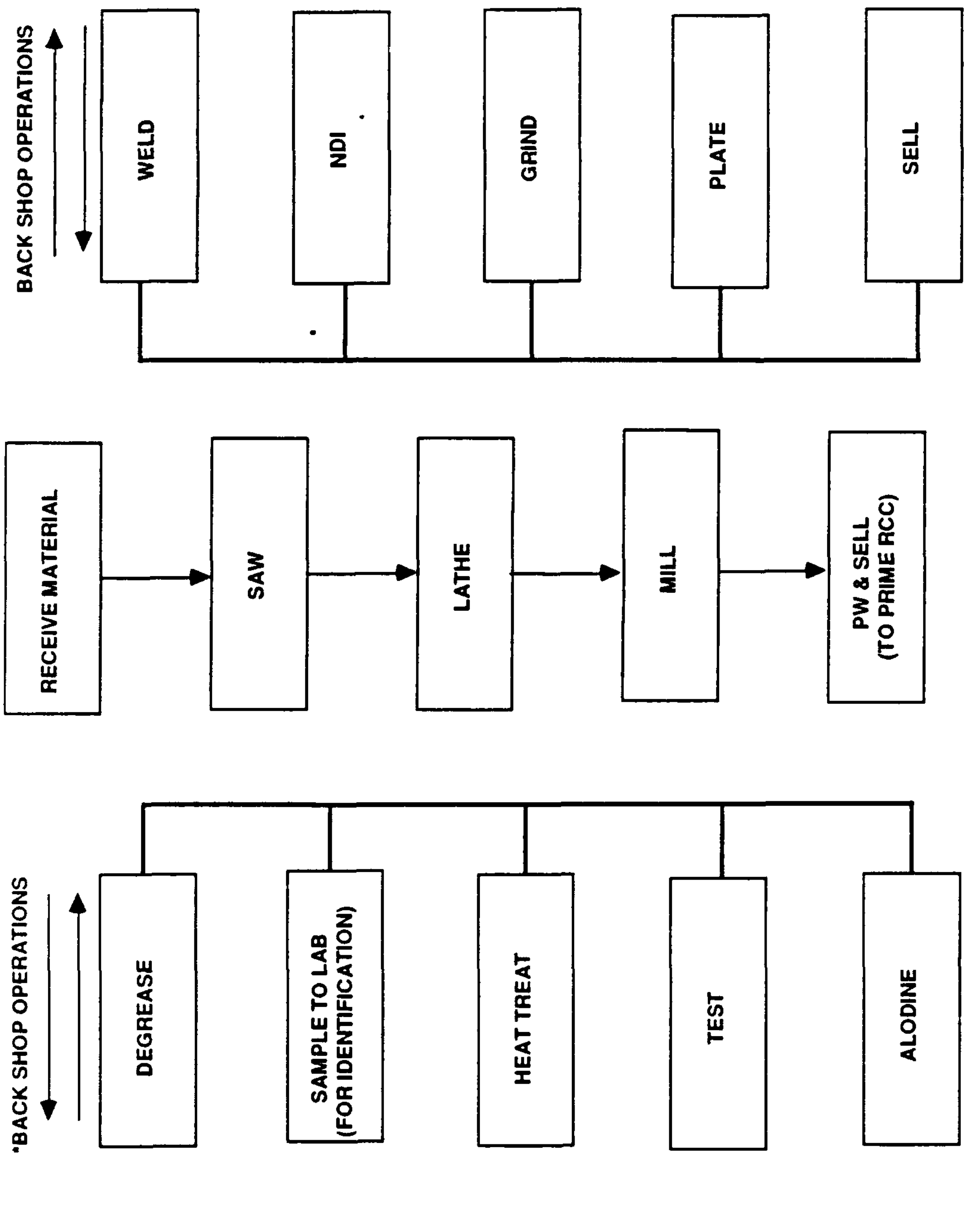

*VARIOUS BACK SHOP ACTIVITIES (TRANSPORTED OUT OF MATPIN AND RETURNED) IN SUPPORT OF RCC OPERATIONS.

TYPICAL PROCESS FLOW FOR MANUFACTURED ITEMS (MATPIN)

FIGURE 6.19.1-1

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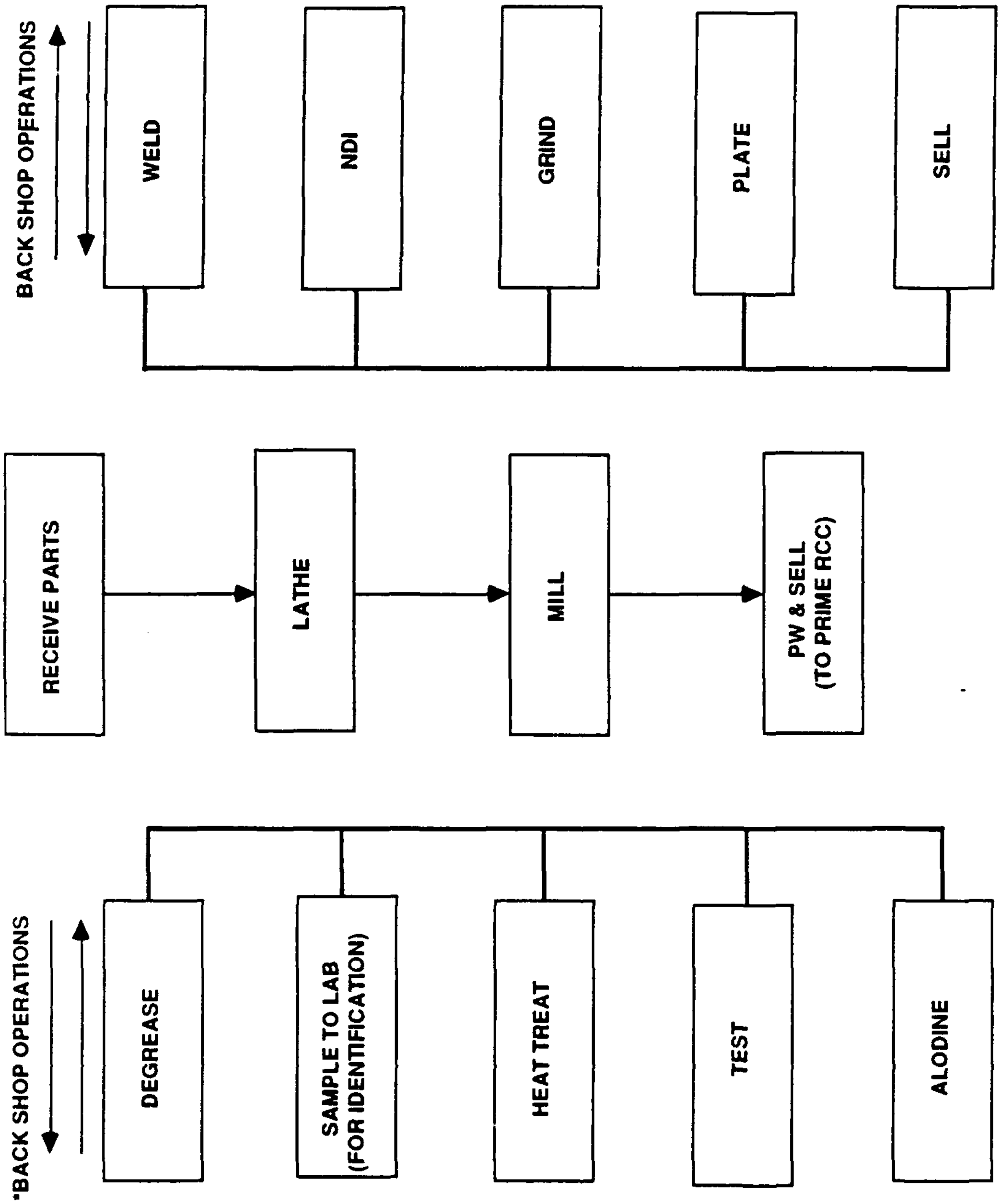

*VARIOUS BACK SHOP ACTIVITIES (TRANSPORTED OUT OF MATPIN AND RETURNED) IN SUPPORT OF RCC OPERATIONS.

TYPICAL PROCESS FLOW FOR REPAIR ITEMS (MATPIN)

FIGURE 6.19.1-2

6.19.2 Statistical System Performance Measures

Validation of the UDOS 2.0 model simulation outputs for MATPIN was initiated on 7 August 1989. The validation process consisted of a statistical analysis of throughput (simulated versus actual) for the validated model run. It was necessary to rely on the experience of the supervisors to provide an estimated flow time by PCN because of a lack of historical data. A detailed explanation regarding history and associated problems can be found in paragraph 6.0 of this document. Additional criteria for validation included the analysis of average flow times and utilization of manpower and equipment. These items ascertained the validity of the database. The MDMSC/OC-ALC validation team agreed on the following assumptions for interpreting the model's validity.

- The 80/20 workload analysis was accurate and represented 80% of the workload. The workload may vary from 80% in cases where MDMSC/AFLC jointly authorized deviations from the original 80/20 listing
- Mechanics' estimates of process time are considered accurate.
- Induction quantity distributions are accurate and can influence throughput.
- Historical data, collected from WCDs are not accurate. The reasons for inaccuracies are:
  - WCD release practices (batch print)
  - Stamping practices on WCDs
  - Work schedules (priorities)
  - Lack of parts/high work in process

The validation team concluded that the statistics generated by the model were within an acceptable range when compared to the As-Is condition. This model database represents an As-Is condition for FY 88 and can be used as a baseline for comparison.

Throughput of items in MATPIN for the FY 88 workload averaged 100%. All PCNs showed at least 95% throughput, which is excellent.

Equipment for this RCC showed low utilization. For example, equipment such as the OC3042-lathe, OC4953-horizontal mill, and OC5610-lathe were almost never used for processing the FY 88 workload. However, the most utilized equipment were OC2877-vertical mill (53%), OC2883-vertical mill (56%) and OC2878-vertical mill at 57% shift utilization. Manpower was found to have an average utilization of 40.5% between first and second shifts. This indicates that indirect activities consumes much of the available hours in MATPIN.

The brainstorming process for experimentation on MATPIN followed model validation. Several "what if" scenarios to improve productivity and surge conditions were discussed. It was concluded that a problem with excessive processing and downtime for equipment OC2878 and OC2879 should be used for experimentation. Problem statement is as follows: What changes in throughput and/or process flow times will occur from (1) replacing OC2878 and OC2879 with one new machine, (2) reducing downtime by 75%, and (3) shortening operations by 25%?

An orthogonal array was developed using the Taguchi process. The team identified two factors and established two levels for each factor, with an interaction between those factors. An L_4 (2^3) array is depicted in Table 6.19.2-1, with throughput (Δ) being selected as a quality characteristic. The results of these experiments are as follows:

- Four experimental runs indicated that average throughput was 100% for each. The PCN which showed the best throughput on three of the four experimental runs (PCN 26236A) benefitted from having the vast majority of the experimental inductions occurring in the first quarter. The PCN which showed the best throughput on the remaining run (PCN 73433A) benefitted from having a very low number of inductions. On the other hand, the PCN which produced the worst throughput in all experimental runs (PCN 29251A) was hurt by having an operation where a piece of equipment is needed for a longer period of time than the worker. This situation allows the worker to be pulled off onto other jobs and then the part waits because the worker is not around when the machine-controlled operation is completed. These delays inflate the repair flow time and lower throughput. A contrast between As-Is and 75% reduction in downtime if a new machine replaced two old machines showed that both

L_4 TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS

TABLE 6.19.2-1

FACTORS

EXP #	REDUCE DOWNTIME	REPLACE MACHINES	INTER-ACTION	NORMAL WORKLOAD		
				AVG	BEST	WORST
1	AS-IS	AS-IS 2 OLD MACHINES	AS-IS	100%	26236A N0Z11 / 103%	29251A N0Z10 / 86%
2	AS-IS	REPLACE W/ ONE NEW MACH. 25% RED.	AS-IS	100%	26236A N0Z11 / 103%	29251A N0Z10 / 86%
3	75% REDUC-TION IN DOWNTIME	AS-IS 2 OLD MACHINES	AS-IS	100%	26236A N0Z11 / 103%	292518 N0Z10 / 86%
4	75% REDUC-TION IN DOWNTIME	REPLACE W/ ONE NEW MACH. 25% RED.	AS-IS	100%	73433A / 108%	29251A N0Z10 / 86%

NOTE: - ONLY MISTR ITEMS WERE CONSIDERED.
- ONLY PCNs WITH AVERAGE QUARTERLY INDUCTIONS OF AT LEAST TEN WERE CONSIDERED FOR THE BEST AND WORST CONDITIONS.

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conditions produced 100% throughput. The reason is that the old machines are under utilized, and to replace tnem with one new (faster) machine would not bring any significant improvements to the current throughput capabilities of the RCC.

- Average flow times increased by 6.5 hours and processing time increased by 1.2 hours. As shown in Tables 6.19.2-2 and 6.19.2-3, experiments 1 and 2 were very close in flow times and experiments 3 and 4 showed a minor variation.
- One reason for the under utilized equipment was found to be of common practice with MATPIN. Investigations revealed that the old machines are not capable of running at full capacity. To run these machines at 100% feed rate 100% of the time would create excessive repairs. RCC management has selected to run these machines less often to reduce downtime.
- The Taguchi array was set-up to allow MDMSC to examine the interaction of the two factors brainstormed. The results shows there were no interaction between these factors.
- To evaluate the RCC's ability to respond to war time surge condition, the FY 90 workload was increased by the surge percentages provided to MDMSC by AFLC. Around-the-clock coverage was simulated by assigning the workers to two 12 hour shifts and working them seven days a week. The model showed that under this work schedule MATPIN currently has sufficient resources to meet a surge condition.

6.19.3 <u>Description of Process Problems</u>

The intent of this paragraph is to expound on major process problems for which there are focus study recommendations. As there are no focus study recommendations identified for MATPIN, Potential Improvement Opportunities can be found in paragraph 6.19.4 as Other Observations.

L_4 TAGUCHI ORTHOGONAL ARRAY FLOW TIME EXPERIMENTAL RESULTS

TABLE 6.19.2-2

EXP #	REDUCE DOWNTIME	REPLACE MACHINES	INTER-ACTION	AVG
1	AS-IS	AS-IS 2 OLD MACHINES	AS-IS	161.2
2	AS-IS	REPLACE WITH ONE NEW MACHINE 25% REDUCTION	AS-IS	162.3
3	75% REDUC-TION IN DOWNTIME	AS-IS 2 OLD MACHINES	AS-IS	167.7
4	75% REDUC-TION IN DOWNTIME	REPLACE WITH ONE NEW MACHINE 25% REDUCTION	AS-IS	168.8

• ONLY MISTR ITEMS WERE CONSIDERED

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ANALYSIS OF EXPERIMENTAL FLOW TIME AVERAGES USING TAGUCHI METHOD (L_4)

TABLE 6.19.2-3

EXPERIMENTAL FLOW TIME AVERAGES

EXP. 1	161.2
EXP. 2	162.3
EXP. 3	167.7
EXP. 4	168.8

FACTOR	LEVEL	
1	1	161.8
	2	168.3
2	1	164.5
	2	165.6

$L_4\ (2^3)$

NO	1	2	3
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

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6.19.4 Other Observations

The other observations described in this section were not considered as focus studies or quick fixes because they had a less significant impact in the areas of quality, time, or cost. These observations are recorded to assist OC-ALC in developing ideas that will further enhance their repair operations.

Environmental Improvement Opportunities

- Improve "Climate Control" Conditions
  - Current Condition: Ambient temperature conditions around the machines are not stable enough to guarantee accurate measurement readings on close tolerance parts.
  - MDMSC Recommendation: Install a climate control system dedicated to the numerical control area, independent of the primary system, to maintain a controlled environment eliminating the possibility of inaccurate inspection readings.

Sourcing/Inventory

- Purchase Better Quality Tooling
  - Current Condition: Some of the tooling being used in MATPIN displays poor tool wear characteristics, resulting in short tool life.
  - MDMSC Recommendation: The supervisors in the RCC should provide feedback to Purchasing regarding any tooling which is felt to be substandard. This information would help Purchasing to identify cases where it would prove cost effective to pay more for more expensive tooling that would last longer and produce better quality parts.

Operational Improvement Opportunities

- Machine Repair
  - Current Condition: The Cincinnati Lathe, machine #L10 (OC 3419), is inoperable and has been since February 1988. Parts normally scheduled across this machine are having to be routed across the conventional lathes in MATPIM. This results in process delay time and limits the NC capability.
  - MDMSC Recommendation: Assess the condition of the piece of equipment and repair or replace as found appropriate..
- "In House" Repair Parts Inventory
  - Current Condition: Number L21 lathe (OC 2366) is inoperable and has been for three months. The machine is down because of the "power supply" being robbed to repair another machine.
  - MDMSC Recommendation: Establish a small inventory of shelf or replacement items. These would be low cost items that are replaced with some degree of frequency determined by past history. This will reduce downtime and increase productivity.

Material Handling

- Jib Cranes
  - Current Condition: There is a need for more jib cranes within the department. Machine operators currently require tow motors to come in and out of the department to load and unload heavy blocks of material at machines.
  - MDMSC Recommendation: Install additional jibs at locations or machines where most needed. This should eliminate most tow motor traffic and reduce the possibility of operator injury.
- Overhead Crane
  - Current Condition: An overhead crane system is not available in the department. This condition has existed since 1984. Without an overhead system, it is virtually impossible to move large batches of parts or large blocks of material without the aid of a tow motor. Use of a tow motor is difficult in this area because of the congestion.

- MDMSC Recommendation: Install overhead gantry-type crane system. This should provide the capability of moving material and other heavy items in, out, and about shop.

Quality Assurance

- Control of Scrap Parts
  - Current Condition: It has been noted that some machined parts resurface in the system after having failed inspection. After parts fail inspection they are identified with dyeco coloring and designated as scrap. Parts sometimes inadvertently resurface at a later date having been wiped clean of dyeco and ready for use.
  - MDMSC Recommendation: To eliminate the possibility of scrap parts mistakenly re-entering the system, have parts altered or deformed. One method would be to saw discrepant parts in half. Other means would be to notch or cut off one small corner. This would permanently identify the part as being scrap.

General Area Improvement Opportunities

- Equipment Upkeep
  - Current Condition: Currently some machines are in need of minor repair. The machines are experiencing problems such as malfunctioning on/off switches, control panel indicator lights not working, etc. These are types of problems that could possibly result in downtime if not corrected. There is the possibility that things of this nature could also be considered a safety hazard.
  - MDMSC Recommendation: Maintenance should be made aware of problems as they occur, no matter how minor (minor being items that do not result in immediate downtime). This could be done by a simple log book program. When an operator is experiencing any type of minor malfunctioning of his/her machine, he/she would log in the problem. This log would be reviewed daily by a member of the maintenance team. This effort would work in conjunction with the PM program.

- Improve Set-Up Techniques to Enhance Productivity
  - Current Condition: Set-up techniques are based on an individuals background and experience. Operators may improvise as necessary which will vary from person to person. Set-up times are excessive and may create bottlenecks when several operations are required on the same machine.
  - MDMSC Recommendation: Provide a method data card or operation sheets for set-up. Break set-up activities into three basic operations: pre-set, prime set-up, and post set-up. Provide incoming and outgoing space for parts and tools at or near machine. Have industrial engineering study each set-up and provide engineered standards. This will work in conjunction with the method data card. Measure set-up performance and efficiency. The goal should be to reduce set-up costs.
- Drill Press Holding Fixture
  - Current Condition: Some parts require a drilling operation on the manual drill press before being placed on the numerical control equipment. Currently, there are no holding fixtures or holding devices for securing parts while drilling.
  - MDMSC Recommendation: Because of the limited storage space available, the NC department has limitations on the number of fixtures they can store. Because of this and the limited number of parts that may require a fixture, some universal fixtures should be designed and built to accommodate all parts needing drilling.
- Double Plating
  - Current Condition: After parts have been rough machined, they are sent to the plating shop for plating. Parts on occasion return from plating without proper plating. Before parts can be finish machined, they are sent back to the plating shop for rework.
  - MDMSC Recommendation: Plating mechanics should be monitored to make sure the Technical Order or specifications are adhered to. By doing so, the quality of all parts will be realized the first time.

6.20 MATPIW ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

The MATPIW RCC is responsible for performing gas and resistance welding required in the manufacture, repair, and modification of aircraft parts, accessories, structures, and equipment. Oxygraph and plasma cutting processes are also performed in MATPIW. A detailed description of the activities that take place in MATPIW is given in paragraph 6.20.1 of this document.

The RCC operates smoothly and MDMSC rates the RCC highly, both in terms of the quality of the items which they produce and the efficiency of their repair processes. The personnel in MATPIW are committed to producing high quality items. This is a key factor in the success of the RCC. The support organizations connected with MATPIW do an excellent job of ensuring that the RCC has everything that it needs to produce items on schedule. All planning, scheduling, and engineering support personnel who work with the supervisors in MATPIW are dedicated to making sure that the RCC is prepared for any workload changes that might occur.

RCC operations can be improved by reducing the time necessary to switch workers to new work; however, the MDMSC team did not observe many delays actually occurring once the work was in process. It would benefit the ALC to improve the documentation on non-MISTR items, such as manufacturing and temporary work. Non-MISTR items currently lack detailed floor documentation, which sometimes makes it difficult for a worker to know exactly what is to be done with the item that he is assigned to repair or fabricate. The lack of documentation in the RCC also severely reduces its ability to determine the percent of resources being occupied in handling non-MISTR items. This lack of documentation also limits the ability to plan activities accurately in order to make the most efficient use of resources.

MDMSC believes that the operations in MATPIW are as effective as those in private industry. When considering the wide variation in the conditions of the items repaired in the RCC, it is not feasible to implement mass-production welding technology. MATPIW operates in much the same way a welding job shop in private industry does. MDMSC believes that the high degree of quality consciousness shown by the workers in MATPIW is a significant reason for its current success.

The throughput in MATPIW for the FY88 workload was very good. To maintain high throughput under the FY 90 workload, additional manpower must be added to the work force. This situation is explained in detail in paragraph 6.20.2. The additional workers would provide MATPIW with the capability of processing the FY 90 workload and handling the predicted war time surge provided that the workers are assigned to twelve-hour shifts, seven days a week. The RCC has excess equipment, even at surge. Under war time surge, the 28 TIG welding booths in the north shop and the 11 booths in the south shop all showed an average utilization of 19%. The items that were profiled in MATPIW covered 73.1% of the total hours attributed to this RCC in FY 88 (refer to the "80/20 Workload" section of the DDB). Therefore, the number of welding booths theoretically needed to process the surge workload in each of the welding shops could be calculated as shown below.

Shop	Existing No. of Booths	No. of Booths Needed Under Surge
North	28	(28 x .19)/.73 = 8
South	11	(11 x .19)/.73 = 3

The model showed that with the around-the-clock coverage which would be provided during surge, many of the welding booths in MATPIW would not be needed. MDMSC must stress that the above numbers are only approximations. Certain basic assumptions were made, such as that all of the welding booths are identical, and that full utilization of the booths can be obtained. Also, the increased operation of the welding booths during surge would probably increase the percentage of time a booth is unavailable due to preventative maintenance or breakdown repair activities. The RCC should perform a detailed study before any equipment changes are made, but it is clear that the number of welding booths in MATPIA could be reduced without reducing the RCC's ability to process the items that would come in under surge.

During the initial characterization of MATPIW, a total of 22 opportunities were identified (reference the Potential Improvements section of the Database Documentation Book (DDB) for MATPIW). After review of the original set of opportunities by the MDMSC/Air Force team, two opportunities were selected to be pursued as the focus of the TI-ES program activities relating to MATPIW.

The two major improvement opportunities, "Elimination of the Lid from the Cleaning Tank" and "Creation of a Tube Repair Area within MATPIA," are quick fix opportunities and are described in detail under separate cover. Refer to the Quick Fix Plan for MATPIW for their descriptions.

The balance of the improvement opportunities are described in paragraph 6.20.4 under Other Observations.

6.20.1 Description of Current Operation

RCC MATPIW is in the Industrial Services Section (MATPI) of the Accessories Division (MAT) at OC-ALC. It is located in Building 3001 and is presently divided into two main areas which are commonly referred to as the north shop and the south shop. The south shop primarily has work related to the fuel manifolds, such as the welding and brazing of manifolds, nozzles, etc. The north shop has a variety of jobs which involve both the cutting and welding of metals. The non-MISTR workload (prototype work, temporary and manufacturing jobs, etc.) is normally performed in the north shop. A worker out of MATPIW is assigned to Building 2121 to do welding for the Aircraft Division (MAB). Future plans call for the north and south shops to be consolidated into one area, but during the time that the MDMSC team was at Tinker AFB, the two shops largely operated independently of each other.

A wide variety of items are sent to MATPIW to be weld repaired. These items vary greatly in their size and configuration, but the basic processes to repair them are similar. An item enters the shop, is prepared for welding, is weld repaired, has some post-welding activities performed on it, and is moved out of the shop. Usually the items to be repaired have been inspected in another RCC and defects have been marked. The most common pre-welding activities consist of cleaning and brushing the areas around the defects to prepare the items for welding and loading into a fixture. Some items also require pre-heating prior to the repair process. The most common post-welding activities are removing the items from the holding device, grinding and/or sanding of the welds to improve their appearance, and inspecting of the items to insure that all needed repairs have been made. If the electron beam welding machine is used to do the repairs, the worker performs additional activities, such as warming up the machine, pumping air into and out of the machine, changing fixtures, changing filaments, etc. For items which go through the various types of welding processes, generic process flow diagrams are presented in Figures 6.20.1-1 and 6.20.1-2.

The majority of items that are sent to MATPIW are repaired using the Tungsten-Inert Gas (TIG) process. Only a few items are welded using the Metal-Inert Gas (MIG) or spot welding processes. The RCC has four electron beam welders at its disposal, and the ALC is trying to expand the capabilities of these machines in order to increase their workload. The workload going through MATPIW varies considerably from quarter to quarter because of shifts in the quantity of non-MISTR items requiring repair or manufacture.

The work force in MATPIW is highly skilled, and the vast majority of workers have been in the RCC for a long time. The average experience level of the workers in this RCC averages 15 years. This experience level is a major factor in its smooth operation. The workers are dedicated and highly experienced in all aspects of welding. They are very conscientious and closely inspect the items they weld, so that very few items leave the RCC with defects.

The operations in MATPIW are well supported by the planning, scheduling, and engineering groups. The MDMSC team was impressed with the close interaction of the groups supporting the operations in MATPIW. All of the support personnel make an effort to maintain a close working relationship with the supervisors in MATPIW, and this contributes to the RCC's ability to produce high quality parts on schedule. This close working relationship also makes the RCC very adaptable to changes in the types and quantities of items in work.

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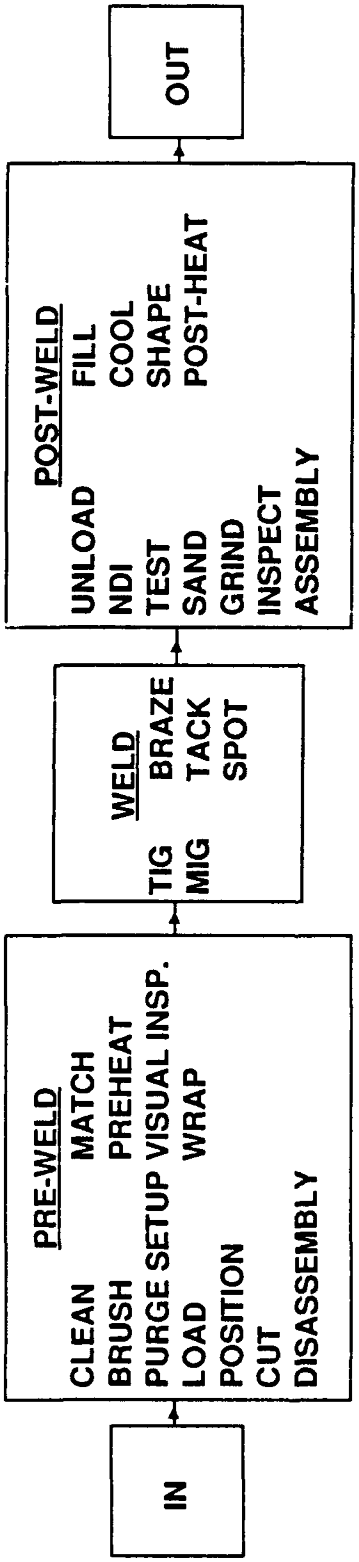
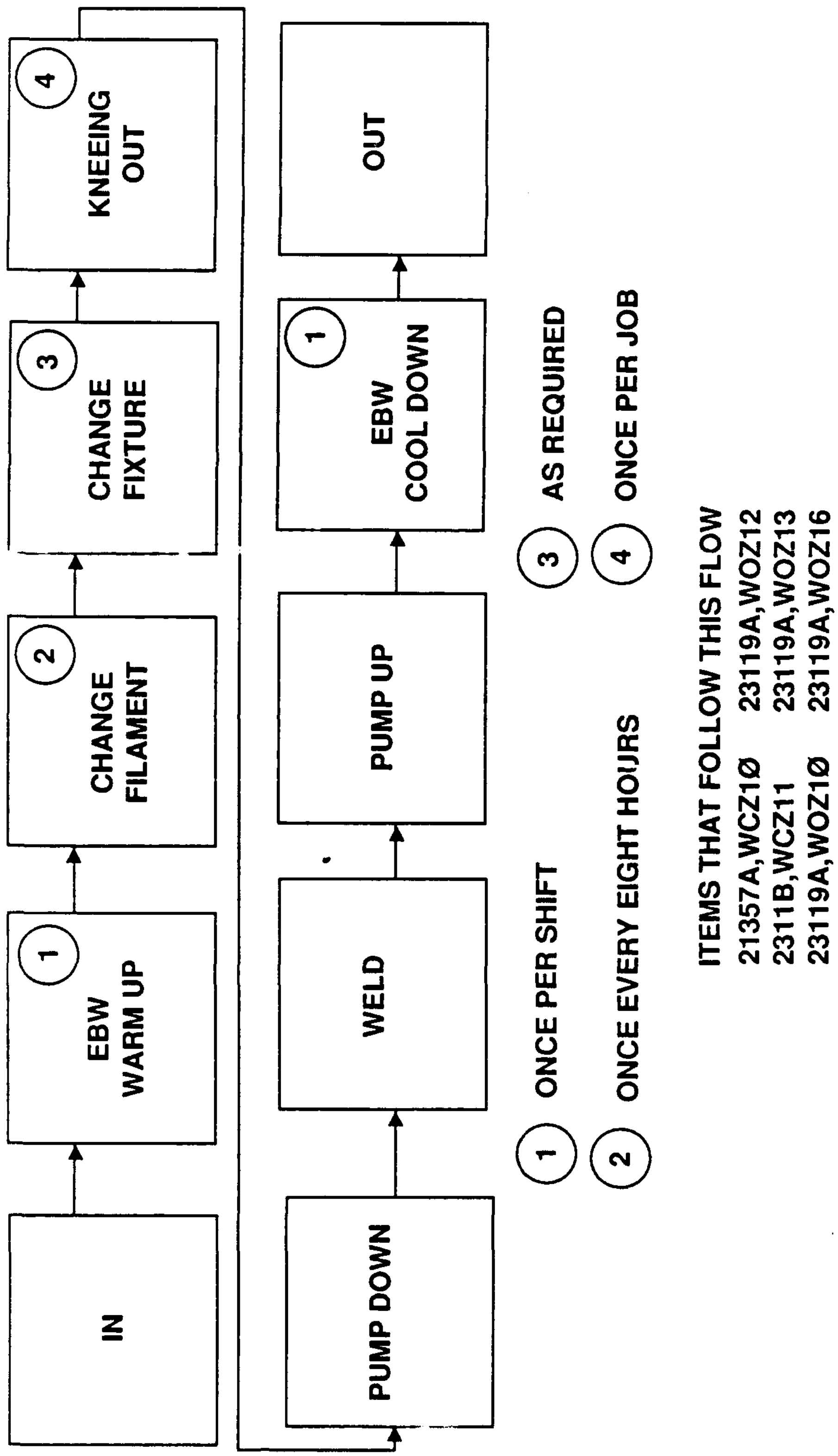


MATPIW PROCESS FLOW CHART
FIGURE 6.20.1-1



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MATPIW ELECTRON BEAM WELDING MACHINES PROCESS FLOW CHART

FIGURE 6.20.1-2

The day-to-day involvement of planning, scheduling, and engineering in the activities in MATPIW keep to a minimum the number of problems, such as parts shortages, outdated paperwork, etc., which interrupt the repair processes. MATPIW personnel should be commended for properly analyzing both their forecasted workload changes and their work methods to insure that the RCC is adequately prepared ahead of time.

The only flow problems in the MATPIW operations are occasional delays in the changeover of workers from job to job. MDMSC believes that action should be taken to insure that the supervisor is ready ahead of time to assign a worker a new job. This will require closer monitoring of the progress of the welders on their jobs and better coordination with the material handlers to move out completed items quickly and replace them with the next items scheduled for welding. The large sizes of the items processed through MATPIW and their long repair times make parts tracking an easier task than in most RCCs. However, some items (fuel nozzles in particular) are small and are batch processed, which complicates their tracking. The scheduler assigned to MATPIW made frequent trips to view the floor operations to keep informed on the status of the jobs in process.

The use of a minimum number of calculated flow days for items processed through MATPIW created problems for the MDMSC team. This subject is addressed further in paragraph 6.20.2.

The ALC provided the MDMSC team with blueprints of the RCC, but these prints did not accurately reflect the actual floor layout. The prints were corrected, and the marked-up copies are included in the MATPIW Database Documentation Book.

The layout of the welding areas is good, with most of the available area occupied by welding booths. The booths are identical, in that each usually contains a welding machine, one or two work tables, and a roll-around tool cart. As stated before, most of the workers use the TIG welding process, and the machines being used for this were either manufactured by Miller or Lincoln.

The Miller welders account for over 60% of the available machines and were purchased within the past three years, while the Lincolns are much older, most being 15 to 20 years old. Because of wiring differences among the welding machines, thicker materials must be welded only on designated machines. Aside from the welding machines, there are ovens in each shop to pre-heat and post-heat items. Each shop also has an inspection booth, where a dye penetrant inspection process is used to detect cracks and other defects. The north shop has various small pieces of equipment located throughout the area, such as grinders, belt sanders, etc. The north shop is somewhat congested but this situation could be improved by adopting a just-in-time system where an item is not moved into MATPIW until the equipment to be used is available and the prior job is moved out. Items are presently being stored on the floor, which occupies valuable floor space and sometimes causes safety concerns when items are stacked on top of each other.

An area in the north shop is devoted to the repair of the tubes for the tubing kit boards. A hot water cleaning tank is available for cleaning the tubes after repair, but this cleaning process is hampered by a lid on the tank. This situation will be discussed in detail in paragraph 6.20.1 of the Quick Fix Plan for MATPIW. There is a large room in the north shop which contains a plasma arc cutting machine. It is used to cut iron based alloys, but is also capable of switching to oxy-acetylene for cutting non-ferrous materials. Another room has been set aside for prototype work. The MDMSC team has safety concerns in the north shop, the roof has areas where water leaks through. The electron beam welders are also unsafe because the railing does not extend completely around the platform. This leaves a gap where a worker could possibly fall off the platform.

The storage capability in MATPIW is adequate, with the area around the electron beam welders containing large cabinets which are used primarily for the storage of component parts which are used in the repair process. There are also large sliding drawers by the electron beam welders where fixtures are stored, but the larger fixtures are usually set on the floor by the machines when not in use. Equipment and tools are often stored in unoccupied welding booths.

A primary storage area exists in the middle of the north shop, where large items are put onto pallets for storage and smaller items are often stored in one of the several cabinets available.

The items which are processed through MATPIW vary considerably in size, but the bulk of the material is moved by either hand carrying or by using push carts for all sizes of parts. The majority of items are transported into and out of MATPIW using forklifts, and are handled manually during the repair process. A pallet jack is available in the RCC for the movement of loaded pallets within the RCC. The MDMSC team noticed that in most cases, the workers use protective materials, such as brown paper or plastic netting, to insure that items do not get damaged. To transport the tubes for the tubing kit boards, the workers use special wooden boxes that have slots cut into the sides and ends to provide hand-holds These boxes are very helpful in allowing a quantity of tubes of different sizes and configurations to be moved all at one time.

In areas where heavy items are routinely handled, special material handling equipment has been installed. For example, a crane system is located in the cutting room for handling sheets of steel and other materials, and a hoist is available in the electron beam welding area for the installation and removal of the large fixtures. An adjustable-height, movable table is also utilized during the changeover of fixtures.

The MDMSC team believes that the operations in MATPIW run as well as those in most welding shops in private industry. The management structure in MATPIW is arranged so that a Unit Chief oversees the activities in both the north and south shops, with a welding training leader assigned full-time to help with the training and certification of the workers. This RCC has a two-tier certification system where a worker has to be certified to weld a specific type of metal, as well as being certified to weld a specific item. A supervisor is assigned to each of the three subunits in MATPIW (the gas and electron beam subunit, the general welding subunit, and the accessories welding subunit). This management system seems to work well because the first-line supervisors are usually available to help troubleshoot problems out on the floor. However, the supervisors were sometimes not around when a worker had completed one job and needed to be assigned to a new job. The RCC runs on a one-shift basis, with overtime being worked as needed to meet demand.

6.20.2 Statistical System Performance Measures

The MDMSC/OC-ALC Technology Insertion team met with ALC representatives during the week of 7 August 1989. They performed a statistical comparison of the UDOS 2.0 model simulation outputs for RCC MATPIW to the historical throughputs and flow times for FY 88. Other criteria, such as the utilization of manpower and equipment, were also used to assess the validity of the database. A detailed discussion of the validation process used for MATPIW is included in the Experimentation section of the DDB. The joint validation team concluded that the statistics generated by the simulation model were within an acceptable range when compared to the As-Is condition. The As-Is condition was determined by discussions with the supervisory personnel in the RCC. This was done because the planner for MATPIW uses a minimum of seven flow days when calculating the flow time for an item being processed through the RCC. The consensus of the MDMSC/ALC validation group was that because of this, there would be too much variance between the model times and the calculated flow days. Therefore, the model outputs were validated against the knowledge of the supervisors in MATPIW, all of whom have a great deal of experience. The model database represents the As-Is condition for FY 88 and can be used as a baseline for comparison purposes.

The throughput of MISTR items under the FY 88 workload averages 100%. All of the PCNs profiled showed at least 98% throughput except for 70522A-WCZ10, which only showed 84% throughput because of large late quarter inductions and a long simulated flow time per item.

A comparison of the simulated flow hours for the MISTR items against the actual hours, taking into account the workload weight, revealed a difference of 78% when the PCNs are treated as a group. If the top three variances (due to PCNs 68622A-WOZ10, 70521A-WCZ10, and 70522A-WCZ10) are excluded from the calculation, the difference drops to 57%. This difference is attributable to the nature of the work; the amount of work that must be done to an individual item varies widely, based on the condition of that item when it is received.

The utilization of the equipment in MATPIW was generally low. Some of the most infrequently used equipment in this RCC included the OC 5333 spotwelder (2%), the Dake hand press (1%), and the fixture used for the welding of the APU duct (6%). As the MDMSC team expected, the TIG welding booths showed the highest utilization factor, but even they were not utilized more than 50%. This statistic bore out the observations of the MDMSC team, who saw empty booths being used for temporary storage. The utilization of the 28 TIG welding booths in the north shop only averaged 44% for processing those items which were profiled. The items that were profiled in MATPIW covered 73.1% of the total hours attributed to this RCC in FY 88 (refer to the 80/20 Workload section of the DDB), so theoretically, the processing of the workload in the north shop could be done using only (28 x .44)/.73 = 17 booths. This calculation shows that 11 booths could be removed from the north shop without impacting the capability of the RCC to repair items. However, this may not prove true in reality because each booth is unique and is affected by a variety of factors, such as downtime, etc. During modeling, all welding booths were treated as identical units for convenience.

Following the same line of reasoning as was used above, the processing of the workload in the south shop could be done using only (11 x .28)/.73 = 5 booths, a reduction of six booths from the existing level. MDMSC wants to stress that the above numbers are only approximations and that further studies should be done before any equipment is removed from the RCC. The calculations also assume that full utilization of the booths can be obtained. Though the numbers above are just estimates, it is obvious from analyzing the model results that the number of welding booths available in MATPIA is more than what was necessary to process the FY 88 workload. The number of booths could have been reduced in FY 88 without impacting the RCC's ability to process all of the items received for repair.

One possible use for the equipment which could be removed from MATPIW would be to set up work cells in some RCCs which presently must send items to MATPIW for welding. The experimentation in RCCs such as MATPHE (refer to paragraph 6.16.2) shows that the performance of welding operations in-house rather than in back shops creates significant improvements in the process flow. The excess equipment in MATPIW could be put to good use in other RCCs, and the ALC should seriously consider setting up welding areas in some of the other RCCs, rather than having a centralized area.

The manpower in MATPIW is heavily utilized. The average utilization of the workers assigned to the first shift was 82%, and the workers who were loaned into MATPIW showed an average utilization of 68%. The workers who were called in for weekend work were utilized 100%. The large order that came through in FY 88 for oxygen racks (M2613K) demanded that a great deal of overtime be worked and is responsible for the high utilization of the weekend workers.

The two items which seem most affected by queues (PCNs 70521A-WCZ10 and 70522A-WCZ10) have numerous back shop operations and the queues are caused by the lack of a worker to handle the item when it comes back into MATPIW.

Using the UDOS 2.0 model, MDMSC determined that the FY 88 manpower levels used in the validated model were inadequate to meet the FY 90 workload forecasted by OC-ALC. To adequately meet FY 90 requirements during experimentation, MDMSC elected to add additional manpower. The figures below describe the changes made in the FY 88 baseline to reach the FY 90 baseline:

Skill Code/Grade	Quarter	Current Amount	Increased Amount
AW10C	1	14	16
	2	14	16
	3	13	15
	4	15	17

Skill Code/Grade	Quarter	Current Amount	Increased Amount
BW10A	1	7	9
	2	7	9
	3	7	9
	4	8	11

The MDMSC team assumed that the number of loan-in workers available in FY 88 will also be available in FY 90, both under the normal workload and under wartime surge. The MDMSC team also assumed that the non-MISTR workload (M and T jobs) would increase by the same percentage from FY 88 to FY 90 that the total number of MISTR items did. Table 6.20.2-1 was constructed to show the comparison of the inductions for FY 88 versus those for FY 90 for those MISTR items profiled. This table projects the FY 90 workload (given the assumption that was made) for those non-MISTR items which were profiled because of their appearance on the 80/20 listing for MATPIW for FY 88.

PROJECTION OF WORKLOAD FOR NON-MISTR ITEMS FOR FY 90

TABLE 6.20.2-1

PCN	FY 88 WORKLOAD	FY 90 WORKLOAD
15025A,WCZ10	48	143
15113A,WCZ10	243	265
21357A,WCZ10	76	36
23111B,WCZ11	113	0
23119A,WOZ10	30	0
23119A,WOZ11	30	0
23119A,WOZ12	30	0
23119A,WOZ13	30	0
23119A,WOZ16	30	0
23119A,WOZ21	30	0
23307A,WOZ10	86	0

PCN	FY 88 WORKLOAD	FY 90 WORKLOAD
23113A,WOZ10	79	0
24101A,WCZ16	76	0
25743A,WCZ10	103	0
25743A,WCZ20	103	0
27834A,WOZ11	162	0
27914A,WCZ10	94	0
27918A,WCZ10	76	0
30241A,WCZ99	248	163
38632A,WOZ10	168	118
38644A,W9Z10	581	747
38718A,WCZ11	366	265
38805A,WOZ11	46	72
49315A,WOZ10	886	804
49711A,WCZ10	229	231
49720A,WCZ10	608	456
49777A,WCZ10	202	391
49779A,WCZ10	446	814
49802A,WCZ10	149	371
49806A,WCZ99	156	376
49808A,WCZ99	86	185
49810A,WCZ99	89	180
50067A,WCZ10	1,884	3,286
50280A,WCZ12	473	531
50281A,WCZ12	667	561
50282A,WCZ12	148	102
50326A,WCZ10	618	254
50346A,WCZ12	609	768
61138A,WOZ10	425	564
67509A,WOZ10	1,070	978
68622A,WOZ10	21	2
70521A,WCZ10	270	347
70522A,WCZ10	155	209

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

PCN	FY 88 WORKLOAD	FY 90 WORKLOAD
72996A,WCZ10	51	0
74049A,WCZ11	41	0
74525A,WCZ11	955	1,668
74525A,WCZ12	955	1,668
93008A,WOZ10	765	733
97138A,WCZ10	476	423
97138A,WCZ12	476	423
98034A,WCZ10	205	167
98042A,WCZ11	305	314
98043A,WCZ11	298	277
98057A,WCZ10	184	178
Total	16,750	19,874

Ratio of FY 90 workload to FY 88 workload = $\frac{19{,}874}{16{,}750}$ = 1.19 = ~ 1.20

Using this ratio to predict the FY 90 workload on non-MISTR items gives us the following inductions on M&T jobs:

PCN	FY 88 WORKLOAD	FY 90 WORKLOAD
M2402K	9	11
M2405K	9	11
M2613K	421	505
M4076K	75	90
M4085K	25	30
M5418K	100	120
M5425K	100	120
M5443K	100	120
M6227K	30	36
M6228K	30	36
M9234K	50	60
M9514K	50	60

PCN	FY 88 WORKLOAD	FY 90 WORKLOAD
M9541K	50	60
M9545K	50	60
T4027A	30	36
T4147A	34	41
T4978A	40	48
T6411A	30	36
T6880A	30	36

During the brainstorming for experimentation, the ALC personnel asked that the operations involved in filling the fuel manifolds with silicone be examined. It was requested that the tasks involved in filling the manifolds be treated as back shop operations. The ALC personnel wanted to use manpower changes as factors in experimentation, altering the levels of the manpower in both the north and south shops. The manpower in the south shop was increased while that in the north shop was decreased.

The L_4 Taguchi array constructed for the factors and levels chosen is shown in Table 6.20.2-2. The use of this array reduced the number of experimental runs required from eight to four. The table also shows the overall throughput percentages for the PCNs that were profiled (refer to the Experimentation section of the MATPIW DDB for a detailed report of the results produced for the individual PCNs) and those individual PCNs which showed the best and worst throughput under each condition.

The experimentation showed that full throughput was achieved under all of the experimental run conditions. The PCNs which showed the best throughput in the experimental runs (PCN 70521-WCZ10 and PCN 21357A-WCZ10) benefited from having high first quarter inductions relative to those in the second quarter. On the other hand, PCN 70522A-WCZ10 showed the worst throughput on all runs because of a large increase in the number of inductions from the first to the second quarter (from six to 55). For all other PCNs, the output was very close to the number of items inducted. To further investigate the effect of each

L_4 TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS FOR MATPIW

TABLE 6.20.2-2

EXP #	SILICONE FILL OF MANIFOLDS	SOUTH SHOP MANPOWER	NORTH SHOP MANPOWER	NORMAL WORKLOAD		
				AVG	BEST	WORST
1	AS-IS	FY 90 + 2 BW10A	FY 90	100%	70521A, WCZ10 / 104%	70522A, WCZ10 / 72%
2	AS-IS	FY 90 + 4 BW10A	FY 90 -2 AWEB	100%	21357A, WCZ10 / 109%	70522A, WCZ10 / 72%
3	ELIMINATE FILL AND ADD TRANSIT OF .2 HRS.	FY 90 + 2 BW10A	FY 90 - 2 AWEB	100%	21357A, WCZ10 / 105%	70522A, WCZ10 / 72%
4	ELIMINATE FILL AND ADD TRANSIT OF .2 HRS	FY 90 + 4 BW10A	FY 90	100%	21357A, WCZ10 / 105%	70522A, WCZ10 / 70%
RECOMMENDED	ELIMINATE FILL AND ADD TRANSIT OF .2 HRS.	FY 90 + 4 BW10A	FY 90			

*ONLY PCNs WITH AVERAGE QUARTERLY INDUCTIONS OF AT LEAST 10 WERE CONSIDED FOR THE BEST AND WORST CONDITIONS.

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factor level, MDMSC did an analysis of the average flow time produced under each condition (refer to Table 6.20.2-3). The results of the throughput and flow time analysis are shown in graph form in the Experimentation section of the DDB for MATPIW.

The results of experimentation show a significant reduction in flow time can be achieved by performing the silicon fill operation outside of MATPIW. This operation involves injecting the silicone into the manifolds, baking the manifold, allowing the manifold to cool, and trimming off the excess. The two experimental runs in which the silicon fill operation was treated as a back shop showed a 19% reduction in the average flow time for the manifolds (PCNs 49802A, 49806A, 49808A, 49810A, 98034A, 98042A, 98043A, and 98057A) when compared to two runs where the operation was left in MATPIW.

The addition of workers into the south shop showed that the addition of workers of the classification BW10A helped to reduce the flow time needed to repair items. The PCNs which require a BW10A to work them (30241A, 38644A, 38718A, 49777A, 49779A, 49802A, 49806A, 49808A, 49810A, 50067A, 50326A, 61138A, 97138A, 98034A, 98042A, 98043A, and 98057A) required an average flow time of 74.8 hours to repair when two additional workers were added to the work force needed to handle the FY 90 workload. The addition of four BW10As dropped the average flow time to repair these PCNs to 61 hours, an 18% improvement. This improvement occurred because the BW10As are in high demand and items end up queuing because workers are not available to work them. The utilization of the BW10As was very heavy even with the additional workers being added. The average utilization of the BW10As during the regular work week in the experimental runs where the work force was at level FY 90 + 2 BW10As was 81%, but dropped to 70% in the runs where the work force was at level (FY 90 + 4 BW10As). The experiment indicated a need for more workers of skill code BW10A to be assigned to the south shop.

The manpower situation in the north shop is different from that in the south. MATPIW supervision believes that there is an excessive number of workers assigned to process the items which go across the electron beam welders

L_4 TAGUCHI ORTHOGONAL ARRAY FLOW TIMES EXPERIMENTAL RESULTS

TABLE 6.20.2-3

EXP #	SILICONE FILL OF MANIFOLDS	SOUTH SHOP MANPOWER	NORTH SHOP MANPOWER	AVG
1	AS-IS	FY 90 + 2 BW10A	FY 90	97.0%
2	AS-IS	FY 90 + 4 BW10A	FY 90 -2 AWEB	96.0%
3	ELIMINATE FILL AND ADD TRAN-SIT OF .2 HRS.	FY 90 + 2 BW10A	FY 90 - 2 AWEB	93.6%
4	ELIMINATE FILL AND ADD TRAN-SIT OF .2 HRS	FY 90 + 4 BW10A	FY 90	91.4%

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(PCNs 21357A, 38632A, and 74094A). The experimentation indicated that two of the workers presently assigned to the electron beam welders could be reassigned without affecting the throughput of items through MATPIW. This reduction of two workers of the skill code AWEB raised the utilization of this group of workers during the regular work week from 66% to 72%, though the average flow time needed to repair the PCNs mentioned increased by 11%. The welding engineer is presently investigating ways of increasing the number of items run across the electron beam welders, so MDMSC recommends that further experimentation be conducted taking into consideration the workload changes that are predicted to occur in the future.

Based upon our analysis, the levels of the experimental factors that MDMSC believes will yield the best results when considering the investment involved are:

<u>Recommended Configuration</u>

Factor:	Silicone Fill of Manifolds	South Shop Manpower	North Shop Manpower
Level:	Eliminate in IW + allow .2 hr. transit time	FY 90 + 4 BW10As	FY 90 - 2 AWEB

Under the recommended configuration, the number of workers that the RCC would need to assign to first shift under each skill code would be:

Skill Code:	AW10A	AW10B	AW10C	AW10D	AW11	AWEB	BW10A	BW10B
No. of workers:	1	3	16	1	2	4	13	1

The numbers above were calculated assuming that the manpower loaned into the RCC during FY 88 is also available in equal amounts in FY 90.

To evaluate the RCC's ability to handle the increased repair demands of wartime surge, the resource usage report was analyzed to determine whether the current level of equipment and the FY 90 manpower would be sufficient to meet the additional demands. Around-the-clock coverage was provided by assigning the workers to 12-hour shifts and working them seven days a week to simulate surge conditions. The FY 90 workload was increased by the surge percentages provided by AFLC Headquarters. The UDOS 2.0 model shows that the existing equipment is capable of handling the number of items that would be inducted into the RCC under wartime surge. MDMSC also discovered that the FY 90 manpower (which is equivalent to the FY 88 manpower plus two AW10Cs and two BW10As) is capable of handling surge, even without workers being loaned into MATPIW from other RCCs.

6.20.3 Description of Process Problems

The intent of this paragraph is to expound on major process problems for which there are focus study recommendations. Since there are no major process problems identified for the MATPIW RCC at this time, improvement opportunities discussed in paragraph 6.20.4 are classified as other observations in this report or quick fixes in the Quick Fix Plan.

6.20.4 Other Observations

The other observations in this section were not considered as focus studies or quick fixes because they had a less significant impact on the areas of time, quality, or cost. These observations are recorded to assist OC-ALC in developing ideas that will further enhance their repair operations.

The following observations were originally identified as Quick Fix and Focus Study improvement opportunities, but after review by the MDMSC/ALC team, it was agreed that they should be presented as other observations.

Environmental Improvement Opportunities

- Improve Air Quality
  - Current Condition: The current vacuuming system does not appear to filter out the fine particles of metal produced during grinding operations.
  - MDMSC Recommendation: Evaluate the seriousness of the problem and take the corrective action that is appropriate (improve the vacuum system, have the workers wear masks, etc.)

Health/Safety Opportunities

- Install a Complete Railing Around the Platforms of the Electron Beam Welders
  - Current Condition: The platform railings for the electron beam welding machines do not completely enclose the platform due to interference problems with the doors of the welders. This leaves a dangerous gap through which a worker could fall off the platform.
  - MDMSC Recommendation: Modify the platforms to allow the railings to completely enclose the platform area.
- Repair the Roof Over the Welding Area
  - Current Condition: Water leaks through the roof into the welding shop area. This is an extremely dangerous condition, considering the high power equipment that is in use.
  - MDMSC Recommendation: Inspect and repair the roof, as required, to insure that no water leaks remain to jeopardize worker safety.

General Area Improvements

- Better Packaging of Incoming Items
  - Current Condition: The bellows that are used on the APU duct do not receive adequate preservation packaging. Consequently, the bellows are periodically damaged in shipping.
  - MDMSC Recommendation: Strictly enforce the packaging requirements established by OC-ALC for incoming bellows.
- Creation of a Just-In-Time (JIT) System
  - Current Condition: Valuable floor space is being used in MATPIW to store items to be repaired, and items that have been repaired but are awaiting shipment to another RCC or to supply. This creates a congested and unsafe working area.
  - MDMSC Recommendation: Do not allow an item to come into MATPIW unless a welding booth is available for the repair. Also, make arrangements to move the item out as soon as repairs are completed.

Operational Improvements

- Study the Process Used to Line-Up the No. Four Seal Ring to the Seal Holder to Determine Where Improvements Can Be Made
  - Current Condition: The alignment of the ring to the holder is a lengthy process (1.5 hrs.) resulting in a long repair flow time.
  - MDMSC Recommendation: Examine the process in detail to determine where method or design changes can streamline the alignment process.
- Establish Guidelines to Allow the Safe Handling of the Sonic Suppressor Injector Nozzles (PCNs 70521A and 70522A)
  - Current Condition: The nozzles are stacked on top of each other for storage. This is dangerous because some of the stacks get high enough that there is the chance of them tipping over if they are bumped. As the stacks grow, workers actually toss the nozzles on the top, which sometimes damages the nozzles.
  - MDMSC Recommendation: Develop a good method for handling the nozzles and build the appropriate storage facilities (racks, shelves, etc.). Investigate the use of protective materials, such as foam or bubble wrap.
- Train Workers in the Proper Repair Procedure to Use on the Combustion Chamber Liners (Nicknamed "Cans" By the Workers)

Note: This item was on the 80/20 listing for MATPIW for FY 88, but has since been moved to RCC MAEPCB.

  - Current Condition: To repair certain individual liners of the cans, it is sometimes necessary to cut tubes off of the can. Some liners can be repaired without the tubes being cut off and there are some workers who are apparently not aware of this procedure because they are cutting off tubes unnecessarily, creating extra work.
  - MDMSC Recommendation: Train the mechanics thoroughly in the repair procedure on the cans so that only the minimum necessary work is done.

- <u>Improve Fixturing for Assembling the Can Liners and Dome</u>
  - Current Condition: The fixture that Pratt-Whitney built for assembling the liners and domes together is very complex, with many hand screws and slides used to hold the items in place.
  - MDMSC Recommendation: Analyze the assembly process to determine if improvements can be made in the fixture that would improve the repair flow time.
- <u>Build More Fixtures to Make the Welding Repairs on the Bleed Valve Housing (PCN 97138A) Easier to Do</u>
  - Current Condition: When a fixture is not used, the item is welded on top of a workbench. The housing is difficult to handle and to get into the proper position for welding. Some workers burn their hands handling this item during the repair process.
  - MDMSC Recommendation: A fixture has been built by one of the workers in MATPIW which has significantly increased the safety and speed of the welding process. Build as many fixtures as the demand for the item requires (using the existing fixture as a model) to reduce the manual handling of the housing during the repair.
- <u>Study the Repair Process on the Injector Nozzle Tail-Feathers (PCNs 74325A and 38805A) to See Where Improvements Can Be Made</u>
  - Current Condition: The purging on these items requires the maneuvering of purging rods and blocks in and out of the many holes in the tail-feathers, which is a very awkward, time consuming , and unsafe task.
  - MDMSC Recommendation: Examine the repair process in detail to determine where process improvements can be made to streamline the process and make it safer.
- <u>Improve the Training of the Flight Line Mechanics on the Disassembly/ Assembly Procedure for the Jet Engine Tubing</u>
  - Current Condition: The MDMSC team was informed during our interviews that the tubes sent in to MATPIW sometimes have damaged or twisted ends that would appear to have been damaged because of the way in which they were disassembled from the aircraft (or later reassembled).

- MDMSC Recommendation: Teach the proper technique to remove and install the tubes to the flight line mechanics who do this job. Provide the mechanics with the proper tools so that excessive force is not used to break the tubes loose or tighten them down.

- Improve the Hand-Held Fixture that is Used When Welding the Nuts Onto the Tube Shields of the "Cans"
  - Current Condition: The fixture utilizes bolts which are screwed in to hold the nuts into position for welding.
  - MDMSC Recommendation: Use tight-fitting pins rather than bolts to speed up the alignment process. Consider attaching these pins to the fixture to reduce the risk of losing the pins.

Inventory/Sourcing

- To Make Repairs on the "Cans" Use a Male Tube End (P/N 677481) Rather Than an Interconnector Tube Stub (P/N 677523)
  - Current Condition: The Technical Order for the "can" repair specifies that either the end or the stub may be used.
  - MDMSC Recommendation: Because so many repairs can be accomplished using the male tube end, specify this in the Technical Order to cut down on inventory costs.
- Mandate a First-In, First-Out (FIFO) System for Those Items Being Stored in the Electron Beam Welding Area
  - Current Condition: The area around the electron beam welders contains many cabinets where items that are used in the repair process are stored. Some items tend to get pushed to the back of the cabinets, where they sit unused until the inventory level falls very low. Because the newer items brought in are usually put in front of the older items, some suffer age damage and must be scrapped.
  - MDMSC Recommendation: Rotate the items so that the older items will be used first. This will greatly reduce the number of items that must be scrapped because of rust, etc.

- Standardize the Types and Sizes of Materials Used to Construct Racks in MATPIW
  - Current Condition: Many different types and sizes of materials are used to construct racks each year in MATPIW. Even though these racks have certain characteristics in common, there is no consistency in the way that they are designed. Many clever design techniques used on some racks are not carried over to other racks. Excessive maintenance work is being done on some racks simply because they are not properly designed.
  - MDMSC Recommendation: When discussing the above problem with the planner and engineer for MATPIW, it was suggested that rather than establishing strict design guidelines for the racks, it would be better to establish a common "pot" of materials for the engineers to use when designing racks. The rack design will standardize naturally if the engineers work with the same sizes and types of materials.
- Find A New Supplier for the JT-3D Engine Frame Assembly (PCN 68622A)
  - Current Condition: The weld repair process on this assembly which is used on the KC-135 is lengthy because the assemblies are old. This results in a very high number of defects requiring weld repairs. The number of cracks found is usually so great that multiple trips must be made to a back shop for a dye penetrant inspection process to insure that all defects are found and repaired.
  - MDMSC Recommendation: The time that it takes to repair this assembly is so long that it is not economical to do this process at OC-ALC. An attempt should be made to locate a vendor who is willing to manufacture the frame assembly in order to replace the old ones being sent in for repair. Finding a manufacturer will allow the Air Force to replace those assemblies that are in the worst condition, thus improving the reliability of the item. A new item is less likely to suffer stress damage than one that has been repaired multiple times.

Quality Improvements

- Improve the Packaging of Vendor Items so that More Information Concerning the Manufacture of Each Item is Included
  - Current Condition: Usually, only the outer packaging of new parts has the supplier's contract number, vendor code, and date of manufacture. This identification may be lost if the part is removed from its outer packaging in order to be staged for installation. If, during installation, a part is found to be discrepant, a QDR may not result in supplier corrective action due to the lack of any of this I.D. information on the QDR.
  - MDMSC Recommendation: Mandate general contract P.O. requirements that the above three pieces of I.D. be affixed to each part by the supplier per an acceptable method. The P.O. should also stipulate that the part(s) may be returned to the supplier whenever the outer package is opened and/or the noted I.D. information is missing. Implementation of this idea will produce the following benefits.
    - Suppliers will be required to take corrective action for every supplier related QDR.
    - All supplier related QDRs will be answered in a timely manner.
    - No parts still under warranty will be scrapped or repaired at the expense of the ALC.
    - There will be less down time from recurring discrepancies for new parts as suppliers are required to accept the responsibility for corrective action on QDRs with properly documented part identification.

- Improve the Record Keeping of the RCC on Items Which are Condemned
  - Current Condition: Production operations generate scrap through a variety of causes. This scrap is ordinarily removed from the RCC for disposal, along with the accompanying WCDs.

- MDMSC Recommendation: Each RCC should maintain a scrap logbook that lists each part as it is scrapped and the cause for scrapping the part. A periodic review of an RCC's scrap logbook could be used to determine how to reduce excessive scrap by implementing methods to eliminate, or reduce, the repetitive causes for scrapping parts. By cutting down on the amount of items presently being scrapped, the RCC will increase the productivity of its manpower and equipment and reduce the amount of material being wasted.

TECHNOLOGY INSERTION-ENGINEERING SERVICES
PROCESS CHARACTERIZATION
TASK ORDER NO. 1

VOLUME III
OC-ALC

QUICK FIX PLAN
23 OCTOBER 1989
REVISION A
15 DECEMBER 1989

CONTRACT NO. F33600-88-D-0567
CDRL SEQUENCE NO. B007

MCDONNELL DOUGLAS
McDonnell Douglas Missile Systems Company
St. Louis, Missouri 63166-0516 (314) 232-0232

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LIST OF ACRONYMS AND ABBREVIATIONS

AFLC	AIR FORCE LOGISTICS COMMAND
ALC	AIR LOGISTICS CENTER
CSD	CONSTANT SPEED DRIVE
CSR	CONTRACT SUMMARY REPORT
DDB	DATABASE DOCUMENTATION BOOK
FSN	FEDERAL STOCK NUMBER
FY	FISCAL YEAR
MDMSC	MCDONNELL DOUGLAS MISSILE SYSTEMS COMPANY
OC-ALC	OKLAHOMA CITY AIR LOGISTICS CENTER
PCN	PRODUCTION CONTROL NUMBER OR PART CONTROL NUMBER
RCC	RESOURCE CONTROL CENTER
TI-ES	TECHNOLOGY INSERTION-ENGINEERING SERVICES
WCD	WORK CONTROL DOCUMENT

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OC-ALC QF

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LSC-20695

OC-ALC QUICK FIX PLAN

6.0 OKLAHOMA CITY AIR LOGISTICS CENTER (OC-ALC)

During the third quarter 1989, McDonnell Douglas Missile Systems Company (MDMSC) completed the process characterization of 20 Resource Control Centers (RCCs) at OC-ALC in Oklahoma City, Oklahoma. The process characterization was performed as a part of the Technology Insertion-Engineering Services (TI-ES) Program. The sections which follow present remedial action recommendations to repair processes observed during the conduct of the TI-ES program and are limited to improvement opportunities defined as quick fixes.

The quick fix opportunities presented in this report represent the total 20 RCCs at OC-ALC. Table 6.0-1 shows the RCC applicability for each quick fix addressed in the body of this report.

There is a total of 24 unique quick fixes which represent a projected annual savings of over $2 million. Some quick fixes apply to multiple RCCs.

		Quick Fixes	
RCC	Function	No.	Savings
MABPAB	C-135 Sheet Metal	1	(1) flow day
MABPFF	B-52 Sheet Metal	2	$1,792
MATPAA	Pneudraulic Accessories	4	$303,155
MATPAB	Pneudraulic Accessories	4	$240,581
MATPAT	Pneudraulic Accessories	1	$9,725
MATPFA	Electronic Accessories	2	$618,163
MATPFE	Electronic Accessories	1	$4,803
MATPFF	Electronic Accessories	0	
MATPCC	Elec-Mech Accessories	3	$142,633
MATPCA	Elec-Mech Accessories	1	$98,700

OC-ALC QUICK FIX APPLICABILITY MATRIX

TABLE 6.0-1 (SHEET 1 OF 3)

QUICK FIX TITLE	SCOPE (RCC AFFECTED)						
	MABPAB	MABPFF	MATPAA	MATPAB	MATPAT	MATPCA	MATPCB
INCREASE SHEET METAL REPAIR CAPACITY	6.1.1						
NOSE COWL BUY OFF		6.2.1					
BOMB BAY DOOR CART		6.2.2					
DAILY SUPPLY FROM CAGE			6.3.1	6.4.1			
ELIMINATE SOLENOID REJECTION			6.3.2				
PORTABLE POWER TOOLS			6.3.3	6.4.2			
WORKBENCH SPACE ORGANIZATION			6.3.4	6.4.3			
REPAIR CYLINDER INSTEAD OF REPLACE				6.4.4			
REDUCE MANUAL LIFTING					6.5.1		
REPAIR CONTROL RELAY BOX						6.6.1	
IMPROVE HOOD DESIGN							6.7.1

LSC-20656A

OC-ALC QUICK FIX APPLICABILITY MATRIX
TABLE 6.0-1 (SHEET 2 OF 3)

QUICK FIX TITLE	SCOPE (RCC AFFECTED)					
	MATPCC	MATPCD	MATPCM	MATPFA	MATPFE	MATPFF
BETTER LABOR UTILIZATION	6.8.1					
IMPELLER UNIT REPAIR	6.8.2					
REDUCE TESTING MANPOWER	6.8.3					
REWORKING CONTROL ASSY COMPONENTS		6.9.1				
DIGITAL READOUTS			6.10.1			
WORK LEADER				6.11.1	6.11.1	6.11.1
RETAIN EXPERIENCED WORKERS				6.11.2	6.11.2	6.11.2
REPAIR PRESSURE RATIO TRANSDUCER					6.12.1	

LSC-20656

OC-ALC QUICK FIX APPLICABILITY MATRIX

TABLE 6.0-1 (SHEET 3 OF 3)

QUICK FIX TITLE	SCOPE (RCC AFFECTED)						
	MATPHA	MATPHB	MATPHE	MATPIA	MATPIM	MATPIN	MATPIW
ELIMINATE UNNECESSARY TESTING	6.14.1	6.15.1					
REDUCE PARTS SCRAP RATE			6.16.1				
DECREASE TUBING FLOW TIME							6.20.1
DECREASE TRANSPORT OF TUBING							6.20.2

LSC-20656

RCC	Function	Quick Fixes No.	Quick Fixes Savings
MATPCB	Elec-Mech Accessories	1	Safety
MATPCD	Elec-Mech Accessories	1	$99,938
MATPCM	Machine Unit	1	$37,098
MATPHA	General Transmission Overhaul	1	$74,300
MATPHB	Specialized Transmission Overhaul	1	$45,500
MATPHE	Machine Shop Unit (CSD)	1	$373,120
MATPIW	General Welding Unit	2	$18,872
	Total	27	$2,068,380

MABPAB Implementing A Mobile Tagging Unit Concept is proposed as all tagging and conditioning operations may be performed at the paint shop. A reduction of one flow day is projected. An annual savings is not applicable for this improvement (reference paragraph 6.1.1).

MABPFF Performing the Inspection and Buy-off of the Nose Cowls Repaired at the Paint Shop is recommended to eliminate returning the cowls back to MABPAB after painting. A reduction of one flow day is projected. An annual savings is not applicable for this improvement (reference paragraph 6.2.1).

MABPFF Utilizing a Second Transport Fixture for the Bomb Bay Doors is proposed by constructing a fixture similar to one already in use. Once the doors are loaded onto a cart, they then will not have to be unloaded until they are delivered to supply. A yearly savings of $1,792 may be realized.

MATPAA Transporting a Full Day's Supply of Items from the Supply Cage at the Start of the Shift is recommended so that one worker may be assigned to bring over a day's work to the RCC in one trip. This would prevent each individual worker from having to leave the work area to bring over single units. A yearly savings of $174,554 may be realized.

MATPAA Eliminating High Reject Solenoids may be achieved by purchasing solenoids from Consolidated Controls rather than Kaiser Ekel. Kaiser Ekel's defect rate is 40%. A yearly savings of $10,604 per year may be realized.

MATPAA Using Power Tools for Assembly/Disassembly recommended to provide a more efficient means of unfastening and fastening nuts, screws, and bolts. A yearly savings of $88,498 may be realized.

MATPAA Organizing Work Benches is recommended to create more working space through the use of rotating bins. A yearly savings of $29,499 may be realized.

MATPAB Transporting A Full Day's Supply of Items from the Supply Cage at the Start of the Shift would have one worker supply the entire area rather than individual trips by the mechanic. Estimated savings $119,233.

MATPAB Using Power Tools for Assembly/Disassembly provides a more efficient means of unfastening and fastening nuts, screws, and bolts. Savings estimate $82.125.

MATPAB Organizing Work Benches would create more working space through the use of rotating bins. Estimated savings $27,373 per year.

MATPAB Repairing Rather than Replacing (Purchasing) Cylinder Assemblies is proposed by varnish recoating of in-cylinder bores. A yearly savings of $11,850 may be realized.

MATPAT Reduction of Manual Lifting of Heavy Fixtures is provided by using a jib crane which would require less labor and increase safety. A yearly savings of $9,725 may be realized.

MATPCC Repairing Rather than Replacing Impellers is proposed to eliminate the need to purchase new ones. A yearly savings of $90,360 may be realized.

MATPCC Automating the Testing of the Harness Cables is recommended by automation of the tester. This will free up the mechanic who currently runs the test. A yearly savings of $20,909 may be realized.

MATPCC Using a Bulk Handling System for the Items is recommended to eliminate the movement of individual items by the mechanics. A yearly savings of $31,364 may be realized.

MATPFA Decreasing the Repair Time on Problem Parts by Utilizing a Work Leader proposes the creation of a leader position to prevent repair operations from being delayed because of mechanics running into problems that they do not know how to handle. Estimated savings = $253,230 per year (evaluated in conjunction with MATPFE and MATPFF).

MATPFA Decreasing the Repair Time by Retaining Experienced Workers proposes a review of the compensation rates to insure that workers feel that they are being paid fairly for the work which they do. Estimated savings = $364,933 per year (evaluated in conjunction with MATPFE and MATPFF).

MATPFE Decreasing Flow Time to Repair Pressure Ratio Transducer by deletion of test prior to repair. Estimated savings of approximately $4,803 annually.

MATPFF Refer to MATPFA

MATPCA Control Relay Box (PCN 35113A) amplifier assembly is repairable in many cases. As this item is not presently being repaired, the control relay box is replaced at a cost of $2,700/item. Repair of this subassembly would result in a savings of approximately $98,700 annually.

MATPCB Hood Design on Manifold/Nozzle Test Stations (OC 1202 and 1132) is inadequate and unsafe. Fuel spray is escaping the chamber, collecting on floor and equipment. A redesigned hood using neoprene seals and metal tongue in groove mating would alleviate this. (Safety concern, not readily quantifiable.)

MATPCD Replacement versus Repair of Muscle Valve Housing and Cover (PCN 965711A) concerns the replacement of these items when repair processes are documented. The muscle valve housing can be reworked by plug welding and redrill of holes. The cover can be repaired by replating. Total savings of $99,938 annually are possible.

MATPCM Installation of Digital Readouts on various milling machines and lathes would result in increased accuracy and reducing set-up times. Total annual savings possible is $37,098.

MATPHA Eliminate unnecessary testing of CSD pumps after disassembly since the failure rate is less than 1%. Test pumps at final test. Estimated savings of $74,300 per year.

MATPHB Same as MATPHA with an estimated savings of $45,500 per year.

MATPHE Reduce scrap rate by providing compartment trays for disassembled parts. These trays will eliminate various types of nicks and scratches caused by handling. An estimated savings of $373,120 per year.

MATPIW To Decrease the Flow Time on Tubing Repair recommends the removal of a lid from a cleaning tank to streamline the process of putting the tubes into the tank and removing them later. Savings are estimated to be $8334.

MATPIW To Decrease Flow Time by Eliminating the Transporting of Tubes recommends that a tubing repair area be set up in RCC MATPIA to eliminate the need to move tubes to and from MATPIW. Savings are estimated to be $10,538.

6.1 MABPAB QUICK FIX OPPORTUNITY

During the expedited process characterization of the MABPAB sheet metal repair shop, MDMSC identified, through observation, a potential improvement opportunity. This section presents and develops one quick fix opportunity to assist MABPAB management to meet two of their objectives; the reduction of flow days and the increase of shop capacity.

6.1.1 Quick Fix Opportunity to Reduce Flow Days and Increase Shop Capacity of the Sheet Metal Repair Process

6.1.1.1 Description of Current Operations

After the end item is repaired in Building 95, it is moved three miles across the base to Building 2122 for painting. Once the item is painted and cured, it is moved three miles back across the base to Building 95 for tag and conditioning. It is then taken to storage or the repair line, as required.

6.1.1.2 Description of Current Process Problems

Each completed end item is brought back to Building 95, across the base, only to be tag and conditioning processed. This is not efficient. The tag and conditioning operation should be performed at the paint shop in Building 2122.

6.1.1.3 Description of New Process

MDMSC recommends implementing the mobile-tagging unit concept and performing all tag and conditioning operations at the paint shop. However, it is even more efficient if the final operation of tag and conditioning is considered an inspection, whereby MDMSC would then recommend allowing the paint operator to do the inspection.

6.1.1.4 Rationale Leading to Change

This opportunity will reduce handling time, improve flow days, and reduce the labor requirements for the sheet metal mechanics.

To tag and condition the end item after the painting operation in Building 2122 would definitively reduce the flow days. Also, if this final operation of tag and conditioning is considered to be an inspection operation for the painting process, this would then allow the painting operator to inspect this job. This approach would completely free the sheet metal mechanic from the tag and conditioning operation.

6.1.1.5 Estimated Cost/Savings

MDMSC does not anticipate cost savings associated with this recommendation. The savings would be reflected as a cost avoidance in terms of flow days and an increase in the shop's capacity.

Conservatively, if we use the engineering estimates based on the G019C report, we could reduce flow time by one day. The engineering estimates allow 24 hours (one day) to move an end item between buildings. With a mobile tagging unit we do not have to move the end item back to Building 95.

However, if allowed, it would be even more efficient for the painter, rather than the sheet metal mechanic, to inspect and tag the end item in Building 2122. This would increase the repair capacity of the MABPAB RCC.

6.1.1.6 Implementation Cost/Schedule

No cost is associated with this quick fix recommendation, and it should be implemented immediately.

6.2 MABPFF QUICK FIX OPPORTUNITIES

During the characterization of the MABPFF RCC, MDMSC noted several potential opportunities to improve the performance of the MABPFF repair operation.

This section develops and presents three quick fix opportunities to assist MABPFF in meeting its objectives. The first opportunity, the construction of a transport fixture for moving the wing flaps, addresses how some of the current material handling operations may be avoided. The second opportunity, the elimination of the movement of the nose cowls back to MABPFF after inspection, shows how a process change may eliminate unnecessary material handling. The third opportunity, the construction of an additional cart for transporting the bomb bay doors to supply, also shows how the amount of material handling being done on an item may be cut by preventing the double handling of items.

6.2.1 Quick Fix Opportunity to Decrease Flow Time by Performing the Inspection and Buy-off of the Nose Cowls at the Paint Shop

6.2.1.1 Description of Current Operations

The nose cowls, as well as other items which will not be evaluated as part of this idea, are repaired in MABPFF and then transported to painting for finishing. After the painting is completed, the items return to MABPFF for buy-off and final paperwork. The cowls are especially troublesome because they have to be moved using a tractor and cart system. The cowls also have a history of being returned from supply because of defects in the paint job. The MDMSC team estimates that the extra handling and backtracking on the cowls results in an increase of one hour in the repair flow time, based upon observations made of the process by MDMSC industrial engineers.

6.2.1.2 Description of Current Process Problems

The current method of handling the cowls is extremely inefficient because it has the cowls backtrack to RCCs where the needed operations should have already been performed. The transporting of large items to an RCC for such minor tasks as inspection and tagging is a misuse of material handling equipment and manpower. The extra handling also increases the chances that a worker will be injured. The current method makes it almost impossible to maintain a consistent flow of items through MABPFF, which compounds the scheduling problem.

6.2.1.3 Description of New Process

MDMSC believes that the current flow problems can be solved easily by setting up a system whereby painting notifies MABPFF when a cowl is through the painting operation, at which time MABPFF will dispatch a worker to inspect the cowl. If it is found to be acceptable, the buy-off procedure will be completed and the necessary paperwork filled out. The cowl can then be transported from painting to supply, which will substantially streamline the repair process. The validated model showed that some of the manpower in MABPFF is not fully utilized, so it is possible that some workers could be relocated to painting to do the preparation of the cowls prior to their move to shipping.

6.2.1.4 Rationale Leading to Change

The efficiency of a process depends in large part on the ability of an item to flow through the predetermined steps without delays. An item's flow should be such that it is not processed through an RCC more than once unless the processes being used dictate that this is necessary. In the case of the cowls, excessive movement of the cowls were being made even though these extra moves are not required based upon the processing methods being used.

6.2.1.5 Estimated Cost Savings

MDMSC does not anticipate cost savings associated with this recommendation. The savings would be reflected as a cost avoidance in terms of flow days and an increase in the shops' capacity.

6.2.1.6 Implementation Cost/Schedule

The restructuring of the process to eliminate the transports of the cowls back to MABPFF after they are repaired can be done as soon as OC-ALC wishes to make the change. No cost will be incurred because existing manpower will be utilized.

6.2.2 Quick Fix Opportunity to Decrease Flow Time by Building Another Transport Cart for the Bomb Bay Doors

6.2.2.1 Description of Current Operation

The process currently used to get the doors through painting and to supply is being interrupted because of a lack of availability of the specially designed, large wheel cart that is used to move the doors across the base to supply. After being repaired in MABPFF, the doors have to be moved to painting, but if the special cart is not available, this move can be made using one of the small wheel carts in the area. However, the doors will have to be transferred from the small wheel cart to the large wheel cart to make the move to supply. If the large wheel cart is already being used, the process grinds to a halt until the cart again becomes available to move the doors to supply.

6.2.2.2 Description of Current Process Problems

The shortage of the cart forces the double-handling of the doors, which creates delays which increase the process flow time. If the doors are initially loaded onto a large wheel cart, they can be processed through painting and sent to supply with no additional material handling being required until the final unloading. If a small wheel cart is used to get the doors through painting, workers are required to transfer the doors to a large wheel cart, which increases the chance of a door being damaged and having to be reworked. It also increases the chances of a worker getting hurt. The unpredictability of not knowing when the large wheel cart will be available for use reduces the ability of MABPFF to get the doors out on a timely basis, which aggravates the scheduling of these items through the ALC.

6.2.2.3 Description of New Process

MDMSC recommends that a second large wheel cart, similar to the existing one, be built. Having a second cart available should completely eliminate the use of the small wheel cart to get the doors through the painting process. Once the doors have been loaded onto the cart, no further handling will be required until their arrival in supply.

6.2.2.4 Rationale Leading to Change

The processing of an item should not be delayed because of a shortage of material handling equipment, and this problem is compounded when items must be handled more than once because of this shortage. The second cart would result in an improvement not only in repair time, but also in quality and worker safety.

6.2.2.5 Estimated Cost Savings

The MDMSC team believes that almost all of the trips made to move the doors from painting to supply are delayed because of the need to transfer the doors to a different cart. The construction of a second cart should completely eliminate these delays, so MDMSC estimates that 60 trips each year can be shortened in the time currently needed to transfer the doors between carts (this estimate is based on the number of doors repaired during FY 88). Based on observations made by the MDMSC team, two workers are required to switch the doors from one cart to another, with an average of 30 minutes required. Using this information, MDMSC calculated the annual savings that will result from the implementation of this idea as shown below:

$$\text{Annual Savings} = \frac{60 \text{ trips}}{\text{year}} \times \frac{.5 \text{ hour} \times 2 \text{ people}}{\text{trip}} \times \frac{\$59.74}{\text{hour}} = \$1,792$$

6.2.2.6 Implementation Cost/Schedule

Because the design for the transport cart has already been proven, MDMSC believes that no design modifications will be needed. The only action which has to be taken to implement the proposal is to construct another cart identical to the existing one, which MDMSC believes can be done within a month with an investment in materials and labor of $3,000 or less.

being repaired in MABPFF, the doors have to be moved to painting, but if the special cart is not available, this move can be made using one of the small wheel carts in the area. However, the doors will have to be transferred from the small wheel cart to the large wheel cart to make the move to supply. If the large wheel cart is already being used, the process grinds to a halt until the cart again becomes available to move the doors to supply.

6.2.3.2 Description of Current Process Problems

The shortage of the cart forces the double-handling of the doors, which creates delays which increase the process flow time. If the doors are initially loaded onto a large wheel cart, they can be processed through painting and sent to supply with no additional material handling being required until the final unloading. If a small wheel cart is used to get the doors through painting, workers are required to transfer the doors to a large wheel cart, which increases the chance of a door being damaged and having to be reworked. It also increases the chances of a worker getting hurt. The unpredictability of not knowing when the large wheel cart will be available for use reduces the ability of MABPFF to get the doors out on a timely basis, which aggravates the scheduling of these items through the ALC.

6.2.3.3 Description of New Process

MDMSC recommends that a second large wheel cart, similar to the existing one, be built. Having a second cart available should completely eliminate the use of the small wheel cart to get the doors through the painting process. Once the doors have been loaded onto the cart, no further handling will be required until their arrival in supply.

6.2.3.4 Rationale Leading to Change

The processing of an item should not be delayed because of a shortage of material handling equipment, and this problem is compounded when items must be handled more than once because of this shortage. The second cart would result in an improvement not only in repair time, but also in quality and worker safety.

6.2.3.5 Estimated Cost Savings

The MDMSC team believes that almost all of the trips made to move the doors from painting to supply are delayed because of the need to transfer the doors to a different cart. The construction of a second cart should completely eliminate these delays, so MDMSC estimates that 60 trips each year can be shortened in the time currently needed to transfer the doors between carts (this estimate is based on the number of doors repaired during FY 88). Based on observations made by the MDMSC team, two workers are required to switch the doors from one cart to another, with an average of 30 minutes required. Using this information, MDMSC calculated the annual savings that will result from the implementation of this idea as shown below:

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6.2.3.6 Implementation Cost/Schedule

Because the design for the transport cart has already been proven, MDMSC believes that no design modifications will be needed. The only action which has to be taken to implement the proposal is to construct another cart identical to the existing one, which MDMSC believes can be done within a month with an investment in materials and labor of $3,000 or less.

6.3 MATPAA QUICK FIX OPPORTUNITIES

During the characterization of the MATPAA RCC, MDMSC noted several potential opportunities to improve the performance of the MATPAA repair operation.

This section develops and presents four quick fix opportunities to assist MATPAA in meeting its objectives. The first opportunity recommends moving a day's supply of units from the cage (staging area) to the work area by one operator to reduce the parts handling time, the second opportunity suggests procuring all the solenoids from Consolidated Controls to save the repair cost, the third opportunity recommends providing portable power tools to minimize the disassembly/assembly process time, and the fourth opportunity recommends better organization of workbenches in the assembly area to create more space for assembly work.

6.3.1 Quick Fix Opportunity to Move a Day's Supply of Units from the Cage to the Work Area by One Operator

6.3.1.1 Description of Current Operations

Each operator walks to the staging area (cage) to get a unit to work on.

6.3.1.2 Description of Current Process Problems

Each operator walks to the cage and selects a unit to repair. This often requires some searching as the parts are stored in disarray. The operator then carries the unit back to his work area. This same procedure is repeated each time a unit is repaired. This results in the operator spending a large amount of time moving between the cage and his work area.

6.3.1.3 Description of New Process

One operator should move a day's supply of units from the cage to the work area at the beginning of the shift.

6.3.1.4 Rational Leading to Change

Reduce the handling time now spent moving units to the work area.

6.3.1.5 Estimated Cost Savings

Current Operations $209,463

(Each operator walks to the cage to get a unit to work on.)

From 80/20 workload,

9,350	Total 80/20 workload items per year assuming above as 40% of total workload items per year.
x 2.5	Adjust from 40% to 100%.
23,375	Total workload items/units per year.
x 0.3	Estimated handling time per item (hour).
7,012.5	Total handling time per year (hours).
29.87	RCC rate ($29.87 per hour).
$209,463	Yearly cost.

New Process $34,909

(One operator should move a day's supply of items from the cage to the work area.)

23,375	Total workload items/units per year.
0.05	Estimated handling time per item (hour).
1,168.8	Total handling time per year.
29.87	RCC rate ($29.87 per hour).
$34,909	Yearly cost.

Yearly savings $174,554

6.3.1.6 Implementation Cost/Schedule

Implementation of this proposal can be accomplished, simply by assigning one operator to move a day's supply of units to the work area from the cage.

6.3.2 Quick Fix Opportunity to Eliminate Rejection of Solenoid, FSN 1660-00-677-2071 by Procuring All Solenoids from Consolidated Controls

6.3.2.1 Description of Current Operations

Solenoids are procured from two vendors; Kaiser Ekel and Consolidated Controls.

6.3.2.2 Description of Current Process Problems

Solenoids from Kaiser Ekel experience an apprcximate 40% reject rate.

6.3.2.3 Description of New Process

Procure all solenoids from Consolidated Controls.

6.3.2.4 Rationale Leading to Change

Eliminate rejection of solenoids and therefore the repair cost.

6.3.2.5 Estimated Cost Savings

Current Operations $10,604

(Solenoid, FSN 1660-00-677-2071 is procured from two vendors; Kaiser Ekel and Consolidated Controls. Solenoids from Kaiser Ekel experience approximately 40% reject rate.)

From 80/20 workload,

57	Yearly quantity, PCN 30775A.
+ 298	Yearly quantity, PCN 31179A.
355	Total yearly quantity.
x .5	Assuming 50% are procured from Ekel.
178	Yearly quantity of solenoids from Ekel.
x .4	40% of solenoids from Ekel are rejected.
71	Yearly quantity of solenoids from Ekel rejected.
x 5	Estimated repair time per solenoids (hour).
355	Total repair time per year (hours).
x 29.87	RCC rate ($29.87 per hour).
$10,604	Total repair cost.

New Process $0
(Procure all solenoids from Consolidate Control.)
$0 Total repair cost.

Yearly savings $10,604
(If all solenoids are procured from Consolidated Controls.)

6.3.2.6 Implementation Cost/Schedule

Implementation of this proposal can be accomplished simply by procuring all solenoids from Consolidated Controls, one vendor only.

6.3.3 <u>Quick Fix Opportunity to Provide Portable Power Tools (Electric/Battery) in the Disassembly/Assembly Areas.</u>

6.3.3.1 Description of Current Operations

No portable power tools (electric/battery) are available presently in the disassembly/assembly areas.

6.3.3.2 Description of Current Process Problems

Mechanics in the disassembly/assembly areas do not have portable power tools (electric/battery) and as a result it takes longer to disassemble/assemble.

6.3.3.3 Description of New Process

Provide portable power tools (electric/battery) to mechanics in the disassembly/assembly areas.

6.3.3.4 Rationale Leading to Change

Portable power tools (electric/battery) should minimize disassembly/assembly operation process time.

6.3.3.5 Estimated Cost Savings

Current Operations $884,982

(Portable power tools, electric/battery, are not available in the disassembly/assembly area.)

From 80/20 workload,

9,350	Total 80/20 workload items per year.
x 8.45	Average standard hours per item (8.45).
79,007.5	Total 80/20 workload standard hours per year (80% workload hours.
x 1.25	Adjust from 80% to 100%.
98,759.4	Total workload hours per year.
x 0.30	Assuming disassembly/assembly hours 30% of the total workload hours.
29,627.8	Total disassembly/assembly hours per year.
29.87	RCC rate ($29.87 per hour).
$884,982	Yearly cost.

New Process $796,484

(Provide portable power tools, electric/battery, in the disassembly/assembly areas.)

29,627.8	Total disassembly/assembly hours per year.
x .90	Assuming 10% improvement.
26,665.0	Total disassembly/assembly hours per year.
x 29.87	RCC rate ($29.87 per hour).
$796,484	Yearly cost.

Yearly savings $88,498

6.3.3.6 Implementation Cost/Schedule

Implementation of this proposal can be accomplished during the course of regular operations with a minimum impact on regular production.

The following represents the one time cost:

65	Quantity of portable power tools.
x 150	Estimated cost ($150.00 each).
$9,750	Total cost.

Implementation cost $9,750

6.3.4 Quick Fix Opportunity to Organize Workbenches to Create More Space for Assembly Work

6.3.4.1 Description of Current Operations

Operators work on extremely crowded workbenches.

6.3.4.2 Description of Current Process Problems

Workbenches are cluttered with large number of in-process parts and bins of bench stock, leaving inadequate space for assembly work.

6.3.4.3 Description of New Process

Provide rotating steel bench bins in the assembly areas for bench stock and small parts.

6.3.4.4 Rationale Leading to Change

More space will be created on the work benches for assembly work by replacing bins of bench stock with rotating steel bench bins. This will help to improve performance of the operators and reduce operation process time.

6.3.4.5 Estimated Cost Savings

Current Operation $589,989

(Workbenches are cluttered with large number of in-process parts and bins of bench stock, leaving inadequate space for work.)

From 80/20 workload,

9,350	Total 80/20 workload items per year.
x 8.45	Average standard hours per item (8.45)
79,007.5	Total 80/20 workload standard hours per year (80% workload hours).
x 1.25	Adjust from 80% to 100%.
98.759.4	Total workload hours per year.
x .2	Assuming assembly hours 20% of the total workload hours.
19,751.9	Total assembly hours per year.
29.87	RCC rate ($29.87 per hour).
$589,989	Yearly cost.

New Process $560,490

Provide rotating steel bench bins in the assembly area for bench stock and small parts. Doing so should reduce the annual assembly hours by 5%, based upon the estimate of an industrial engineer with over 20 years of experience.

19,751.9	Total assembly hours per year.
x .95	Assuming 5% improvement.
18,764.3	Total assembly hours per year.
x 29.87	RCC rate ($29.87 per hour).
$560,490	Yearly cost.

Yearly savings $29,499

6.3.4.6 Implementation Cost/Schedule

Implementation of this proposal can be accomplished during the course of regular operations with a minimum impact on regular production.

The following represents the one time cost:

65	Quantity of rotating steel bench bins.
x 50	Estimate cost ($50.00 each).
$3,250	Total cost.

6.4 MATPAB QUICK FIX OPPORTUNITIES

During the characterization of the MATPAB RCC, MDMSC noted several potential opportunities to improve the performance of the MATPAB repair operation.

This section develops and presents four quick fix opportunities to assist MATPAB in meeting its objectives. The first opportunity recommends moving a day's supply of units from the cage (staging area) to the work area by one operator to reduce the parts handling time, the second opportunity recommends providing portable power tools to minimize the disassembly/assembly process time, the third opportunity suggests organizing workbenches to create more space for assembly work, and the fourth opportunity suggests repairing rather than replacing a cylinder assembly.

6.4.1 Quick Fix Opportunity to Move a Day's Supply of Units from the Cage to the Work Area by One Operator

6.4.1.1 Description of Current Operations

Each operator walks to the staging area (cage) to obtain and repair a unit.

6.4.1.2 Description of Current Process Problems

Each operator walks to the cage and selects one unit to repair. This often requires some searching, because the parts are stored in a state of disarray. The operator then carries the unit back to his work area to repair it. This same procedure is repeated each time a unit is repaired. This results in the operator spending a large amount of time moving between the cage and the work area.

6.4.1.3 Description of New Process

One operator should move a full day's supply of units from the cage to the work area.

6.4.1.4 Rational Leading to Change

Reduce the handling time to move units to the work area.

6.4.1.5 Estimated Cost Savings

Current Operations $143,080

(Each operator walks to the cage to get an item to work .)

From 80/20 workload,

4,795	Total 80/20 workload items per year assuming above as 30% of total workload items per year.
x 3.33	Adjust from 30% to 100%.
15,967	Total workload items per year.
x 0.3	Estimated handling time per item (hour).
4,790.1	Total handling time per year (hours).
29.87	RCC rate ($29.87 per hour).
$143,080	Yearly cost.

New Process $23,847

(One operator should move a day's supply of items from the cage to the work area.)

15,967	Total workload items per year.
0.05	Estimated handling time per item (hour).
798.35	Total handling time per year.
29.87	RCC rate ($29.87 per hour).
$23,847	Yearly cost.

Yearly savings $119,233

6.4.1.6 Implementation Cost/Schedule

Implementation of this proposal can be accomplished, simply by assigning one operator to move a full day's supply of units from the cage to the operators in the work area.

6.4.2 Quick Fix Opportunity to Provide Portable Power Tools (Electric/Battery) in the Disassembly/Assembly Areas

6.4.2.1 Description of Current Operations

No portable power tools (electric/battery) are available presently in the disassembly/assembly areas.

6.4.2.2 Description of Current Process Problems

Mechanics in the disassembly/assembly areas do not have portable power tools (electric/battery). As a result, it takes longer to perform the disassemble/assemble operations.

6.4.2.3 Description of New Process

Provide portable power tools (electric/battery) to mechanics in the disassembly/assembly areas.

6.4.2.4 Rationale Leading to Change

Portable power tools (electric/battery) will minimize disassembly/assembly operation process time.

6.4.2.5 Estimated Cost Savings

Current Operations $821,228

(Portable power tools (electric/battery) are not available in the disassembly/assembly area)

From 80/20 workload,

4,795	Total 80/20 workload items per year.
x 15.29	Average standard hours per item (15.29).
73,315.6	Total 80/20 workload standard hours per year (80% workload hours.
x 1.25	Adjust from 80% to 100%.
91,644.5	Total workload hours per year.
x 0.30	Assuming disassembly/assembly hours 30% of the total workload hours.
27,493.4	Total disassembly/assembly hours per year.
29.87	RCC rate ($29.87 per hour).
$821,228	Yearly cost.

New Process $739,103

(Provide portable power tools (electric/battery) in the disassembly/assembly areas.)

27,493.4	Total disassembly/assembly hours per year.
x .90	Assuming 10% improvement.
24,744.0	Total disassembly/assembly hours per year.
x 29.87	RCC rate ($29.87 per hour).
$739,103	Yearly cost.

Yearly savings $82,125

6.4.2.6 Implementation Cost/Schedule

Implementation of this proposal can be accomplished during the course of regular operations with a minimum impact on regular production.

The following represents the one-time cost:

95	Quantity of portable power tools.
x 150	Estimated cost ($150.00 each).
$14,250	Total cost.

Implementation cost $14,250

6.4.3 Quick Fix Opportunity to Organize Work Benches for Creating More Space for Assembly Work

6.4.3.1 Description of Current Operations

Operators work on extremely crowded workbenches.

6.4.3.2 Description of Current Process Problems

Workbenches are cluttered with large number of in-process parts and bins of bench stock, leaving inadequate space for assembly work.

6.4.3.3 Description of New Process

Provide rotating steel bench bins in the assembly areas for bench stock and small parts.

6.4.3.4 Rationale Leading to Change

More space will be created on the work benches for assembly wcrk when the bins of bench stock are replaced with rotating steel bench bins. This will help to improve performance of the operators and reduce operation process time.

6.4.3.5 Estimated Cost Savings

Current Operations $547,484

(Operators work on extremely crowded work benches).

From 80/20 workload,

4,795	Total 80/20 workload items per year.
x 15.29	Average standard hours per item (15.29).
73,315.6	Total 80/20 workload standard hours per year (80% workload hours.
x 1.25	Adjust from 80% to 100%.
91,644.5	Total workload hours per year.
x .20	Assuming assembly hours 20% of the total workload hours.
18,328.9	Total assembly hours per year.
29.87	RCC rate ($29.87 per hour).
$547,484	Yearly cost.

New Process $520,111

(Provide rotating steel bench bins in the assembly areas for bench stock and small parts)

18,328.9	Total assembly hours per year.
x .95	Assuming 5% improvement.
17,412.5	Total assembly hours per year.
x 29.87	RCC rate ($29.87 per hour).
$520,111	Yearly cost.

Yearly savings $27,373

6.4.3.6 Implementation Cost/Schedule

Implementation of this proposal can be accomplished during the course of regular operations with a minimum impact on regular production.

The following represents the one-time cost:

95	Quantity of rotating steel bench bins.
x 50	Estimated cost ($50.00 each).
$4,750	Total cost.

Implementation cost $4,750

6.4.4 Quick Fix Opportunity to Repair Rather Than Replace, Cylinder Assembly (Part No. 363779-1) by Recoating the Damaged Varnish Coating in the Bores of Cylinder Assembly

6.4.4.1 Description of Current Operations

The cylinder assembly body is discarded if there is a damaged varnish coating within the bores of the cylinder assembly.

6.4.4.2 Description of Current Process Problems

Damaged cylinder assemblies are discarded and replaced with new assemblies. Replacing damaged assemblies is very expensive.

6.4.4.3 Description of New Process

Repair the cylinder assembly body by recoating the damaged varnish coating in the bores.

6.4.4.4 Rationale Leading to Change

In order to minimize the cost, repair, rather than replace, the cylinder assembly. The cost of replacing the damaged unit with a new one is very high.

6.4.4.5 Estimated Cost Savings

Current Operation $14,448

(Cylinder assembly is being discarded because of damaged varnish coating in the bores.)

From G019 report sheet attached to the quick fix in the DDB.

213	FY 1989 quantity.
x .11	Usage factor (repair with new assembly)
24	Quantity of cylinder assemblies repaired per year.
x 602	Cost of new assembly ($602.00) from C3771 report sheet attached to the quick fix in the DDB.
$14,448	Yearly cost.

New Process $2,598

(Repair cylinder assembly by recoating the damaged varnish coating in the bores.)

24	Quantity of cylinder assemblies repaired per year.
x 108.24	Estimated cost to repair cylinder assy ($108.24) from the cost benefit calculations sheet attached to the quick fix in the DDB.
$2,598	Yearly cost.

Yearly savings $11,850

6.4.4.6 Implementation Cost/Schedule

Implementation of this proposal can be accomplished during the course of regular operations with a minimum impact on regular production.

The following represents the one-time cost:

Implementation cost $554.40
(Refer to the quick fix
in the DDB.)

6.5 MATPAT QUICK FIX OPPORTUNITIES

In the assessment of MATPAT, MDMSC noted several potential opportunities to improve the testing of pneudraulic items.

This section develops and presents one quick fix opportunity that reduces operator fatigue while minimizing a safety hazard.

6.5.1 Quick Fix Opportunity to Reduce Manual Lifting of Heavy Fixtures and to Improve Safety Factors

6.5.1.1 Description of Current Operations

Some of the fixtures used in MATPAT are extremely heavy and require four men to move them in and out of the test cell during set-up operations.

6.5.1.2 Description of Current Process Problems

A major concern is the safety hazard in man-handling the heavy fixtures. In addition, it requires interrupting the tests of other operators to assemble these fixtures at the set-up operation.

6.5.1.3 Description of New Process

MDMSC recommends the following:

- Provide an inexpensive jib crane at an approximate price of $1,000 (reference McMaster-Carr).
- Utilize the jib crane so only two operators will be required during set-ups.

6.5.1.4 Rationale Leading to Change

Observations indicated that at least .2 hours, or .05 hours per operator, was required for the assembly when using four men to start the set-up. The set-up itself required .5 manhours.

PCNs 50294A, 92062, and 92063A require heavy test fixtures and have 296 total yearly set-up occurrences. In addition, the handling of heavy objects presents a definite safety hazard.

6.5.1.5 Estimated Cost Savings

Current Operations (four operator team)

$19,451

296	Number of yearly set-ups.
x 2.2	Set-up labor (four operators per hour x .55 hours).
651.2	Total labor hours per year.
x 29.87	RCC rate ($29.87 per hour).
$19,451	Yearly cost.

New Process (two man team)

296	Number of yearly set-ups.
x 1.1	Set-up labor (two operators per hour x .55 hours).
325.6	Total labor hours per year.
x 29.87	RCC rate ($29.87 per hour).
$9,726	Yearly cost.

$9,726

Yearly savings

$9,725

6.5.1.6 Implementation Cost/Schedule

For $1,000 or less, a standard off-the-shelf jib crane (non-motorized) can be purchased and put to use immediately.

6.6 MATPCA QUICK FIX OPPORTUNITIES

6.6.1 Quick Fix Opportunity to Repair Control Relay Box (PCN 35113A)

6.6.1.1 Description of Current Operations

When internal components cause failure of the control relay box, the entire item is replaced at a cost of $2,700/end item.

6.6.1.2 Description of Current Process Problems

Components contained in the amplifier subassembly are often responsible for the high rate of control relay box failure. These components are replaceable in many instances. No repairable time is presently assigned to this subassembly.

6.6.1.3 Description of New Process

Repair time should be assigned to the amplifier subassembly of this control relay box, and repair components provided in the existing supply and distribution system.

6.6.1.4 Rationale Leading to Change

Repair procedures for the amplifier subassembly are documented. These procedures were developed during a period when the end item (control relay box) was unavailable. Technicians report that the control relay box shows a high rate of failure. Even though the repair procedures exist, no repairable time is assigned to this item, forcing the RCC to purchase new end items.

6.6.1.5 Estimated Cost Savings

Current Operations	$113,400

An average yearly induction of these items is 150. Of these, approximately 80% are found to be inoperative upon testing. Approximately 35% of the failed items are repairable (technicians' estimates). Replacement cost of each item is $2,700.

$2,700	Cost of each item.
x 42	Number of repairable items replaced with new items. (150 x .80 x .35 = 42)
$113,400	Cost of replacing repairable items.

New Process	$14,700

Repair costs for this item are as follows:

Average replacement component cost (1) =	$200
Average repair cost of labor (1) =	+ 150
	$350

Sources: (1) floor interview data

$350	Cost of repairs per item.
x 42	Number of items being repaired.
$14,700	Annual cost of repairing control relay box.

Yearly savings	$98,700

6.6.1.6 Implementation Cost/Schedule

The cost of implementing the new process procedures would be negligible. The repair procedures are already documented, and stock listings of the amplifier assembly components needed are available in the RCC. Costs associated with stocking the needed components into existing supply and distribution system were not available to the TI-ES team.

6.7 MATPCB QUICK FIX OPPORTUNITIES

6.7.1 Quick Fix Opportunity to Improve Hood Design on OC 1202 and 1132 in Building 3108

6.7.1.1 Description of Current Operations

On manifold/nozzle test stations protective hoods are often left open during test. Fuel spray often gets outside of chamber, spilling fuel on surrounding floor and getting fuel spray into surrounding atmosphere. The hoods are left open to give operators an adequate view of the fuel spray pattern.

6.7.1.2 Description of Current Process Problems

Test stations are operated with protective hoods in raised position to enable operator to view nozzle spray patterns. This defeats the purpose of the hood and poses a potential fire/explosion hazard caused by fuel on the floor and a heavy concentrations of fuel spray/vapor in air. Fuel on floor also presents a slipping hazard.

6.7.1.3 Description of New Process

A redesigned hood with more effective provisions for viewing nozzle and manifold spray patterns would allow the test to be run with the containment hood in proper operating position. Enhancements to the hood-frame mating joint during this redesign effort can avoid the smaller problem of minor fuel leakage which was also noticed. A number of strategies, such as wiper blades, clear plastic baffles or shields, etc., are available as design elements for the new hoods.

6.7.1.4 Rationale Leading to Change

The escape of fuel and fuel vapors caused by the present mode of operating, presents a clear health and safety hazard. At the same time, it is recognized that this is an essential test, necessary to assure proper operation of the major end item (an aircraft engine). Redesign of the fuel containment hood is expected to provide the most reasonable means of eliminating the hazard.

6.7.1.5 Estimated Cost Savings

This is a significant health and safety issue. It is anticipated that a reduction in fuel usage may be realized. We are not able to quantify this fuel savings, but it is expected to be small.

6.7.1.6 Implementation Cost/Schedule

MDMSC notified the OC-ALC T.I. contact along with responsible branch chief of the problem. Tinker AFB Health and Safety department immediately responded. MDMSC reviewed proposal with them to facilitate implementation.

6.8 MATPCC QUICK FIX OPPORTUNITIES

During the characterization of the MATPCC RCC, MDMSC noted several opportunities to improve the performance of the MATPCC repair operations.

This section develops and presents three quick fix opportunities to assist MATPCC in meeting its objectives. The first improvement opportunity, the Bulk Transporting of Items, recommends the elimination of the hand-carrying of individual items by the mechanics. The second improvement opportunity, the Repairing of the Impeller Unit Rather Than Buying It, advocates the utilization of existing manpower and equipment to repair an item that is currently being purchased at a high cost. The third improvement opportunity, the Automation of the Harness Cable Thermostat Tester, suggests the complete automation of a testing procedure. The current procedure ties up a mechanic and prevents him from being used in the most efficient manner.

6.8.1 Quick Fix Opportunity to Better Utilize Labor in MATPCC

6.8.1.1 Description of Current Operations

The highly skilled mechanics in MATPCC routinely carry items to and from other RCCs and the supply area. Consequently, these mechanics are being taken away from their repair operations. The manual transporting of items creates a work environment where workers are constantly walking in and out of the area, which is distracting and negatively affects worker productivity.

6.8.1.2 Description of Current Process Problems

The use of high skill labor to do low skill tasks is wasteful and results in an unnecessary increase in the time needed to repair an item. The workers in MATPCC are in a skill classification that is required to perform complex repair procedures, and having them do such a simple task as moving items between RCCs is an extremely poor use of talent. In addition, the workers in MATPCC are not making use of the existing system of overhead conveyors and other material handling equipment.

6.8.1.3 Description of New Process

The RCC needs to establish material handling procedures that will allow the bulk transporting of items by utilizing existing equipment using lower labor grade workers. The emphasis of our plan is to cut time by moving items in bulk, instead of one part at a time, and to cut costs by using the lowest labor grade of workers possible.

6.8.1.4 Rationale Leading to Change

The RCC must utilize its workers in the most cost effective way possible. By freeing the highly skilled mechanics from the job of moving items, they will be able to concentrate their full efforts on the repair of items.

6.8.1.5 Estimated Cost Savings

MATPCC repairs approximately 10,500 items per year (based on FY 88 figures). The MDMSC team believes that the conversion to the bulk transporting of items can be done relatively soon with very little investment. To evaluate the potential savings that would result from implementation of the idea, the following assumptions were made:

- The transport of numerous items at the same time will result in an average time savings of .1 hour per item (based on the estimates of MDMSC industrial engineers who observed the process).
- The conversion to the bulk transporting of items will not require any additional equipment or manpower, so no implementation cost will be listed. Moving items in bulk will simply demand that existing equipment and manpower be utilized better. The implementation of the idea may be as easy as laying items on a pallet and moving them with a forklift.

The calculation of the estimated annual cost savings is given below:

Annual Savings = 10,500 items/yr x .1 hr/item x $29.87/hr = $31,364

6.8.1.6 Implementation Cost/Schedule

As stated above, no additional costs should be incurred by OC-ALC. If the ALC is willing to dedicate the necessary manpower to implement this improvement, the new system should be in place within two months.

6.8.2 Quick Fix Opportunity to Reduce Expenses in MATPCC by Repairing Impeller Units Rather Than Purchasing Them

6.8.2.1 Description of Current Operations

When impeller units (P/N 6620-00-463-7489) in the fuel flow transmitters (PCNs 42089A, 45362A, 48371A, 61207A, and 61264A) becomes worn or damaged, new impellers are installed into the transmitters. The impellers are presently being purchased at a cost of $481.80 each, and approximately 200 transmitters a year need impeller replacements.

6.8.2.2 Description of Current Process Problems

Excessive funds are expended each year to buy the noted impellers.

6.8.2.3 Description of New Process

An employee suggestion (#861138) has been submitted, but remains unimplemented, concerning a procedure whereby the impellers can be reworked, which would eliminate the need to purchase all but a small number of new ones. The equipment and labor that will be needed to perform the rework is already available and the rework procedure would not require any further training of the mechanics. The rework procedure could be put into effect immediately. MDMSC recommends the immediate implementation of this suggestion rather than waiting for the scheduled updating of the technical order. The costs involved in a special revision of the T.O. are minor compared to the potential savings that would result from establishing a repair procedure now.

6.8.2.4 Rationale Leading to Change

The cost of purchasing an item from an outside vendor tends to be quite expensive because the relatively low volume involved discourages the use of mass production technology in the manufacturing of the item. Doing the repairs at the ALC provides MATPCC with better control of the quality of the finished item. It also provides a margin of safety if a surge condition hits by allowing the RCC its own repair capability so that it can supplement the number of items coming in from outside to meet the increased demand.

6.8.2.5 Estimated Cost Savings

The MDMSC team estimates the cost in labor and materials needed to rework the impellers at $30 each. Assuming that 200 impellers per year will need rework (based on FY 88 figures), the potential savings that would result from the implementation of USAF Suggestion #861138 would be:

200 units/yr. x ($481.80 - $30/unit) = $90,360.

6.8.2.6 Implementation Cost/Schedule

This improvement can be implemented immediately at zero cost.

6.8.3 Quick Fix Opportunity to Reduce Manpower Needed to Test Harness Cables in MATPCC

6.8.3.1 Description of Current Operation

The thermostats on the harness cables are tested using a specially built piece of equipment (identified by the code P92418) which has a large (approximately six-quart capacity) oil reservoir. The thermostat is placed into the reservoir when the oil temperature is between 275 and 300°F, then the temperature of the oil is raised to between 300 and 350°F to cause the thermostat to activate. The oil temperature is then allowed to cool to 300°F, at which point the thermostat is supposed to deactivate. This test procedure is quite lengthy and must be repeated if the operator is unsure as to whether the specified temperature limits were attained.

6.8.3.2 Description of Current Process Problems

The existing process for testing the thermostat makes very poor use of the mechanic because he is idle during the time periods when the oil in the reservoir is heating up and cooling off. Based on the interviews that the MDMSC team conducted, it takes up to forty-five minutes to warm the oil and up to fifteen minutes to let it cool, so this is an hour of time that the mechanic is basically idle. The RCC is not utilizing its manpower efficiently when a mechanic's time is spent on such non-productive tasks.

6.8.3.3 Description of New Process

Because of the relatively simple nature of the test, MDMSC believes that the testing procedure can be completely automated. Through the use of a relay system, the manpower presently needed to perform the test can be eliminated and a printed output will be produced by the automated tester. This will not only free a mechanic from the need to watch the equipment, but it will also provide the ALC with a good method for collecting historical data on the test.

The automated test equipment will only require a mechanic to hook and unhook the cable from the tester and to analyze the test results. The mechanic's services will not be required during those periods when the temperature of the oil is changing. This will save MATPCC from paying the mechanic for an hour's worth of labor.

6.8.3.4 Rationale Leading to Change

The most effective use of a mechanic is to keep him busy on the touch repair work. The RCC will not get their best value from a mechanic if he is idle during the testing operation. Automating equipment is one way of allowing a mechanic concentrate on those tasks which will produce the greatest benefits to the ALC.

6.8.3.5 Estimated Cost Savings

The idea that MDMSC proposes is evaluated below, using the assumption that 700 cables will be tested each year (based on FY 88 figures).

Annual Savings = 700 items/yr x 1 hr./item x $29.87/hr. = $20,909

MDMSC believes that the automation of the test equipment can be accomplished for a $2500 investment in labor and material.

6.8.3.6 Implementation Cost/Schedule

MDMSC believes that a three-month time period is sufficient for the tester to be automated and debugged. As stated before, an implementation cost of $2500 is estimated.

6.9 MATPCD QUICK FIX OPPORTUNITIES

6.9.1 Quick Fix Opportunity Concerns the Reworking of Two Components, the Muscle Valve Housing and the Cover, of the 96571A Control Assembly

6.9.1.1 Description of Current Operations

The 96571A control assemblies are being disassembled for overhaul. It was noted that some repairable parts are being replaced, instead, thus increasing the cost of the overhaul operation.

6.9.1.2 Description of Current Process Problems

The muscle valve housing, and the main cover to the control assembly is being replaced with new parts when some are repairable.

6.9.1.3 Description of New Process

The recommended quick fix is to rework these original parts when possible. The muscle valve housing can be reworked by filling the bolt holes that have become oversized or out of round with weld metal and then redrilling, allowing for reassembly using the original housing. The cover can be reworked by repeating the plating process.

6.9.1.4 Rational Leading to Change

After disassembly of muscle valve housing and cover from the main control assembly, 50% of the housings and 40% of the covers are scrapped and replaced without any consideration of rework. The concept of reworking the items, when possible, should result in a per unit cost savings and an inventory reduction.

6.9.1.5 Estimated Cost Savings

This savings is calculated based upon 100% salvage of items which are currently scrapped and replaced.

Current Operation

Item A (Muscle Valve Housing)		Item B (Cover)	
$1611.00	Replacement Cost (1)	$800.00	Replacement Cost (1)
X 125.00	Item/Yr (Induction Rate) (2)	X 125.00	Items/Yr (2)
201,375.00	Projected Cost/Yr	100,000.00	Projected Cost/Yr
.50	Per Cent Replace (3)	.40	Per Cent Replace (3)
$100,688.00	Projected Cost/Yr	$40,000.00	Projected Cost/Yr

New Process (Rework)

Item A (Muscle Valve Housing)		Item B (Cover)	
$600.00	Rework Cost (4)	$65.00	Rework Cost (4)
X 125.00	Item/Yr (Induction Rate) (2)	X 125.00	Items/Yr (2)
75,000.00	Projected Cost/Yr	8,125.00	Projected Cost/Yr
.50	Per Cent Replace (3)	.40	Per Cent Replace (3)
$37,500.00	Projected Cost/Yr	$3,250.00	Projected Cost/Yr

Savings/Yr/Item

$100,688	Current Projected Cost/Yr	40,000	Current Projected Cost/Yr
37,500	Revised Projected Cost/Yr	3,250	Revised Projected Cost/Yr
$63,188	Housing Savings	$36,750	Cover Savings

$63,188	
36,750	
$99,938	Total Combined Savings/Yr

NOTES:

(1) From purchase records provided by OC-ALC.

(2) From induction quantity records provided by OC-ALC.

(3) As estimated by MATPCD personnel (R. Bussell), greater than 95% of rejected housings were successfully repaired in the past when new ones were not available.

(4) MDMSC manufacturing engineering estimate.

6.10 MATPCM QUICK FIX OPPORTUNITIES

6.10.1 Quick Fix Opportunity to Improve Machine Handling and Accuracy by Installing Digital Readouts

6.10.1.1 Description of Current Operations

Set-up, rework, repair, and production are performed on various manual and semi-automatic machines. Measurement of variation from a desired dimension is obtained by feeler gages, dial gages and sometimes subjectively by the operator.

6.10.1.2 Description of Current Process Problems

Excessive time is necessary for various machining operations. Processing time often exceeds industry standards because of the time consuming use of manual gaging and machine handling.

6.10.1.3 Description of New Process

Install Acu-Rite III digital readouts on the five three-axis milling machines and the remaining five two-axis engine lathes. This will reduce processing time by an estimated 35.6%.

6.10.1.4 Rationale Leading to Change

MDMSC observed operations on both manual, and digitally equipped lathes. The purpose was to determine what impact digital readouts would have on a typical machine shop operation. Processing time for the digitally equipped lathe was 7.4 minutes, versus 11.5 minutes for the manual lathe. This equates to a 35.6% time savings. Also, equipment would become more flexible by machining more close tolerance work that are currently done in back shop RCCs.

6.10.1.5 Estimated Cost Savings

Current Operations	$104,209

Manual and semi-automatic machines are used without digital readouts.

3,488.76	Total workload hours--provided by OC-ALC.
x $29.87	Direct labor rate.
104,209.00	

New Process	$67,111

Install five two-axis and five three-axis digital readouts.

2,246.76	Reduced workload hours.
x 29.87	Direct labor rate--provided by AFLC.
$67,111.00	

Yearly Savings	$37,098

Notes:
- 80/20 workload consisting of 26 PCNs were analyzed to determine the potential savings if digital readouts were installed.
- An average of 35.6% reduction of workload hours.

6.10.1.6 Implementation Costs

Purchase:

• Five two-axis readouts @ $1,845 =	$9,225
• Five three-axis readouts @ $2,345 =	11,725
Total Cost	$20,950

(Costs include delivery and installation per manufacturer.)

6.11 MATPFA QUICK FIX OPPORTUNITIES

During the characterization of MATPFA, MDMSC noted several potential opportunities to improve performance of the MATPFA repair operation.

This section develops two quick fix opportunities to assist MATPFA in meeting its objectives. These recommendations are also applicable to MATPFE and MATPFF and are evaluated in terms of the affect which its implementation would have in the three RCCs as a whole. The first recommendation, To Decrease Repair Flow Time by Utilizing a Work Leader, examines the advantages of creating a work leader position within each of the three RCCs. The second recommendation, To Decrease Repair Flow Time by Retaining Experienced Workers, examines the potential benefits of reducing the turnover of skilled mechanics in MATPF.

6.11.1 Quick Fix Opportunity to Decrease the Repair Flow Time by Utilizing a Work Leader in MATPF

6.11.1.1 Description of Current Operations

The flow of an item is sometimes impacted because the mechanic doing the repair experiences a problem that he is not familiar with. When this situation arises, a lengthy delay often occurs as the mechanic attempts to define the cause of the problem and what action can be taken to correct it. The mechanic often has to call over his supervisor or another mechanic for assistance, which creates another negative effect on production. Because of the unpredictability of the condition that items arrive in, there are instances when a unique problem arises that nobody has been forced to deal with before. If the mechanic lacks the knowledge to troubleshoot this out-of-the-ordinary problem, he is supposed to contact his supervisor, but there are times when a supervisor is unavailable or tied up with other tasks. The MDMSC team seeks to eliminate these delays which serve to lengthen the time which it takes to get an item repaired, which inflates the cost of making the repair.

At the present time, no system exists to record the productive time that is lost because of a mechanic running into a problem which his training has not prepared him to handle. It may be beneficial for the mechanics to record how often they are unable to repair an item on their own, for this information would help to show how pressing the need for a leader is, as well as to help pinpoint areas where the mechanics may require further training.

6.11.1.2 Description of Current Process Problems

The primary process problem is that items are being delayed during the repair operation because of mechanics hitting "snags." These delays are often lengthy and often require more than one person's assistance to resolve. To try to maintain a fairly smooth flow of production, mechanics will often store away these "dog" items and try to work on them during slack periods. This situation complicates the tracking of items and increases the chances that an item will become unsalvageable because it has been sitting around for so long.

6.11.1.3 Description of New Process

Create a work leader position, where the leader's job is to assist the other mechanic in any way possible, primarily by helping with pinpointing the specific component of an item that needs repair and deciding on the proper method to fix it, if one does not already exist. This leader would do anything he could to expedite the flow of items through the RCC and some of the activities which he might do include inspecting the work of others, locating and bringing over necessary parts and tools, helping with the preparation of WCDs and Technical Orders, etc. The leaders would also help to take some of the burden off of the first-line supervisors by doing some of the tasks currently assigned to them.

While one work leader for an RCC may seem insufficient, it must be remembered that industry experience is that the "span of control" required depends upon circumstances. In areas such as the RCCs being examined in this proposal, the span of control can be larger than what is considered normal because of the workers being so well-trained and experienced.

MDMSC believes that the implementation of the work leader proposal can be done on a trial basis, which would help to determine the best number of workers to have assigned to a work leader position. The information gained during this trial period could be used to determine whether the idea should be implemented permanently.

6.11.1.4 Rationale Leading to Change

The MDMSC team is convinced that the formation of a leader position will have a very positive affect on the operations in these RCCs. The benefits that will result from the use of a leader as a roving troubleshooter are many, but the biggest one is that items will flow through the repair process more smoothly. By not having to track down and wait on a person to get free and come over to help him, a mechanic will be able to spend a greater percentage of his time in productive activities. The fact that the mechanics will no longer have to interrupt other mechanics or their supervisor will also increase the productivity of the RCC as a whole. The quicker flow of items through the repair cycle will also improve the utilization of the mechanics.

The reliability of the items being repaired should improve because a more experienced person will be assisting in the repair process. Flexibility of the mechanics may improve if the ALC makes use of the leader to help train mechanics to fix items that they are presently unfamiliar with. The morale of the mechanics will also improve because they won't be left on their own to handle problems that they were not trained to handle. The training of those mechanics who are not leaders can also be limited to those repairs which have to be made fairly often, not those which only appear infrequently, which eliminates the need to train a mechanic in a process that he may never use.

6.11.1.5 Estimated Cost Savings

The major benefit of creating a work leader position in the RCC is that the average flow time to repair items will decrease. The following assumptions were made.

- The leader will make $2.50/hour more than he did as a mechanic.
- The volume of items going through MATPFA, MATPFE, MATPFF in an average year is (12,400 + 16,800 + 6,800) or 36,000 items/year (based on FY 88 figures).

- The annual pay of a worker or leader is based on working 2080 hours per year.
- The use of a leader will result in an average time savings of fifteen minutes on the items worked in MATPF(based on discussions with the supervisors in the area).

Current Operations

The three RCCs under analysis employ approximately 190 mechanics to perform the repair work processed through them. This would produce an annual cost to MATPF of: 190 x 2080 hrs./yr x $29.87/hr. = $11,804,624

New Process

The use of the leaders will reduce the annual repair hours needed in MATPF by the following amount:

Hours saved - 36,000 items/yr. x .25 hours./item = 9,000 hours

The new annual cost would then become:
[(395,200 - 9,000) hrs./yr. x $29.87/hr + 3 people x 2080 hrs/year
x $2.50/hr.] = $11,551,394
Yearly Savings $253,230

The potential risks involved in promoting a mechanic to a leader is that other mechanics who lost out on getting the spot may become disgruntled and decrease their work effort. There will also be a minor loss of production while the leader meets with people to learn jobs that he is presently not familiar with. A workload change, or even the variations in the number and type of defects in the items normally received, will alter the demand for the leader, but this problem can be handled by having the leader do mechanic-type work during the lulls when he does not have to function as a leader.

6.11.1.6 Implementation Cost/Schedule

The elevation of a mechanic to the position of leader will cause an increase in payroll costs because it is only fair that the leader is paid better because of the additional responsibilities which the job entails. The MDMSC team views this as the only major drawback to the idea of using a leader.

Once approval is received from the Manpower Division, it should only be a matter of three months before the idea is fully implemented. This time span allows one month for the selection of the mechanic who will become leader and two months for the training needed to get the leader versed in all aspects of his job.

6.11.2 Quick Fix Opportunity to Decrease the Repair Flow Time by Retaining Experienced Workers in MATPFA (Also Affects MATPFE and MATPFF)

6.11.2.1 Description of Current Operations

The workload in MATPF consists of a large variety of different items, with a great deal of analytical thinking required on the mechanic's part to make the repairs properly. To learn the jobs of the employees in MATPF requires a great deal of formal and on-the-job training. When a mechanic feels that he is limited in his opportunity to advance in MATPFA, MATPFE, and MATPFF, he often is able to transfer out to a higher paying position in another RCC or outside of the ALC. When a skilled mechanic leaves, the RCC very seldom has another person who can step in and do the jobs done by the departed worker without a loss in productivity occurring as a result.

6.11.2.2 Description of Current Process Problems

MATPF suffers because a significant number of people transfer out each year to RCCs which offer higher paying positions. The MDMSC team found out that the people who transfer are not unhappy with the type of work or the work environment in MATPF, but they do want the opportunity to make more money. Access to higher paying positions is presently very limited and the supervisory personnel in Building 230 estimated that the three RCCs lose an average of 40 people a year. It is expected that ten employees a year would be lost through normal attrition.

Based on conversations with the supervisors in MATPF, it was estimated that the employee who steps in to replace an experienced employee will require 18 months before he attains the productivity level of the employee who left. The supervisors also pointed out that depending upon where the employee transfers to, the training that has been provided to him at the division's expense will only be partially utilized.

6.11.2.3 Description of New Process

A job classification study should be performed to insure that the present compensation rates for jobs being done in MATPF are fair relative to the rates received by employees in other RCCs. The rates that are paid to employees who do similar types of work in private industry must also be studied to insure that the RCCs remain competitive when bidding for skilled employees.

6.11.2.4 Rationale Leading to Change

The supervisors in MATPF impressed upon the MDMSC team the extent to which their operations are impacted by the loss of experienced mechanics. They feel that they are unfairly hurt by the present classification of jobs within their areas. The level of expertise needed to repair item in MATPF is high and the supervisory personnel does not believe that this is reflected in the pay rate on certain jobs. The supervisors told the MDMSC team that this situation, in conjunction with the jobs in other RCCs being too highly rated as to the labor grade and skill code required, creates the high turnover rate.

The benefit of reducing turnover in the work force is that the same people who are used to repair an item and who have gotten to know its unique characteristics and problems are kept on the item. This keeps productivity high and insures high reliability on the repaired items. Retention of an experienced employee also insures a smoother, more reliable flow of items through the repair process and keeps the utilization of resources high. The safety level of the RCC sometimes drops when inexperienced people who are unfamiliar with their new surroundings are brought in, so there is a benefit in retaining employees who already know the standard procedures for the area. The MDMSC team feels that a substantial investment has been made by OC-ALC to train the employees in the analysis techniques and repair processes used in MATPF, and that this investment should be protected by offering the employees a rate of pay that is compatible to that which is received in other RCCs.

6.11.2.5 Estimated Cost Savings

The major benefit in raising the labor grade of some of the jobs in MATPF is that doing so will keep employees from leaving the RCC. This turnover negatively affects the productivity of the RCC while an employee masters the job that was formerly done by the employee who left. The following assumptions were made so that a cost benefit analysis could be done on the idea:

- An average of 30 employees per year leave MATPF to go to higher paying jobs in other RCCs or at the FAA.
- The employee who steps in to replace an experienced employee requires an initial training period in which he will attend many training classes to learn the basics of electronic repair. During the initial training, it is felt that the employee will only average 40% productivity. This employee will also require approximately one year of OJT before he is fully trained in all aspects of his job and will only average 80% productivity during this time span.
- The pay upgrade will raise hourly labor costs by $2.50 and will be given to the items which are worked by 30 of the approximately 200 workers in MATPF.
- A worker's annual pay covers 2,080 hours, but only 1,744 of these are considered productive hours.

<u>Current Operation</u> $690,275 loss

Based upon the supervisor's opinion of the productivity losses that occur as a result of the loss of an experienced mechanic, the loss to the RCCs that results from the turnover problem is $690,275.

- Cost of lost productivity during the first six months:
  30 x .6 x 872 hrs/yr. x $29.87/hr. = $468,840

- Cost of lost productivity during next 12 months:
  30 x .2 x 1,744 hrs/yr. x $29.87/hr. = $312,560

- Total savings over 18 months = $781,400

- Savings prorated over one year = ($781,400/18)x12 = $520,933

<u>New Process</u> $156,000

Under the MDMSC proposal, it is assumed that all turnover (except that due to normal attrition) will be eliminated, meaning that all jobs should have a skilled mechanic available to perform them, so 100% productivity should be maintained. The yearly cost can be calculated as follows:

30 x 2,080 hrs/yr. x $2.50/hr. = $156,000.

Yearly Savings $364,933

6.11.2.6 Implementation Cost/Schedule

The potential risk involved in upgrading the electronic workers is that a major increase in operating costs will occur. This increase should be offset by the increased productivity provided that there is always a supply of work to be done. The upgrading of these workers may also contribute to wage inflation if other groups of workers also insist that their jobs be upgraded.

MDMSC believes that once the idea receives the approval of the Classification Division and the Office of Personnel Management, the necessary work required to implement the idea can be done within a four month time span. It is believed that three months will be required to do a detailed job classification analysis within the three RCCs (MATPFA, MATPFE, and MATPFF) within MATPF. The additional month is allowed to cover those actions taken as a result of this analysis.

6.12 MATPFE QUICK FIX OPPORTUNITIES

During the characterization of the MATPFE RCC, MDMSC noted three potential opportunities to improve the performance of the MATPFE repair operations.

This section develops and presents two quick fix opportunities to assist MATPFE in meeting its objectives. The first opportunity, the Utilization of a Work Leader, is described in detail in paragraph 6.11.1 of the Quick Fix Plan for MATPFA. The second opportunity, to Decrease the Repair Flow Time by retaining experienced Workers, is described in detail in paragraph 6.11.2 of the Quick Fix Plan for MATPFA. The third opportunity, to Decrease the Repair Time on the Pressure Ratio Transducer (PCN 45335A), recommends an investigation into the benefits that result from the performance of the incoming functional test to determine whether the test should be eliminated or not and is described in detail in paragraph 612.1.

6.12.1 <u>Quick Fix Opportunity to Decrease the Flow Times to Repair the Pressure Ratio Transducer (PCN 45335A) in MATPFE</u>

6.12.1.1 Description of Current Operations

The incoming functional test currently being performed on the transducer does not seem to reveal to the mechanic any information other than that the item is bad, which makes the test useless in most cases because the item should not have been returned from the field unless it was bad.

6.12.1.2 Description of Current Process Problems

The mechanic is currently instructed by the WCD to perform an operation which seems to produce no useful results with regard to the repair of the part. This situation makes the flow time to repair the part longer than it needs to be.

6.12.1.3 Description of New Process

Evaluate the effectiveness of the incoming test. If the test does not produce any useful information that will help in the repair process, eliminate it and let the mechanic start in on the disassembly and troubleshooting of the transducer as soon as he receives it. This will result in an increase in productivity without affecting product quality.

6.12.1.4 Rationale Leading to Change

Under the existing conditions, .3 hr. of the mechanic's time is being taken up by an activity which does not seem to make a contribution to his work effort. This time was given to the MDMSC during the interview with the mechanic and further investigation needs to be done to determine if the incoming functional test could be eliminated without producing any negative impact on the quality of the repaired item. Elimination of the test would allow .3 hours to be saved on each item repaired.

6.12.1.5 Estimated Cost Savings

Our calculation of the savings that will be achieved if the incoming functional test is eliminated is given below:

Current process:
Annual repair cost = 536 items/yr x 8.45 hrs/item x $29.87/hr = $135,287
Proposed process:
Annual repair cost = 536 items/yr x 8.15 hrs/item x $29.87/hr = $130,484
$4,803

6.12.1.6 Implementation Cost/Schedule

The MDMSC team believes that a one-month period will be adequate for making the necessary changes in the paperwork and getting the new paperwork into use out on the floor. The changes can be made utilizing existing OC-ALC personnel. No effect on current operations should be felt.

6.13 MATPFF QUICK FIX OPPORTUNITIES

Two quick fix opportunities described in detail in paragraphs 6.11.1 and 6.11.2 for MATPFA also apply to MATPFF. All potential improvement opportunities for this RCC are classified as other observations and are described in paragraph 6.13.5 of the CSR.

6.14 MATPHA QUICK FIX OPPORTUNITY

During the process characterization of MATPHA, MDMSC noted several opportunities for improvement. One opportunity will be expanded upon in this section.

Productivity improvements will be realized upon revising the procedures from testing CSD pumps at disassembly (tear-down) to reflect only one test operation after final assembly. A reduction of end item flow hours, as well as an estimated savings of $74,372, can be realized.

6.14.1 <u>Quick Fix Opportunity to Eliminate Unnecessary Testing of Pumps After Disassembly</u>

6.14.1.1 Description of Current Operations

All CSD pumps are tested after disassembly (tear-down). Existing records show a failure rate of less than 1%. Most pumps are set aside to be reassembled before final testing of CSD(s).

6.14.1.2 Description of Current Process Problems

Empirical data reveals a 99% success rate from pump testing. An estimated 0.5 hour of direct labor is required for the testing and causes additional flow time on the end item. Pump failures (1%) can be detected at final test, where an estimated 0.5 hour would be required to disassemble and reassemble a pump to the main drive.

6.14.1.3 Description of New Process

Implement a procedural change to eliminate the pump test after CSD tear-down operation. This will reduce direct labor by an estimated 0.5 hour per pump and improve CSD flow time.

6.14.1.4 Rationale Leading to Change

MDMSC observed the test operation and reviewed the existing log book. It was determined that the low failure rate justifies not testing these pumps until final test. The estimated time to test at tear-down is equal to the estimated time to disassemble and reassemble at final test should the pumps fail. This equates to an annual savings in direct labor of an estimated 2,490 hours.

6.14.1.5 Estimated Annual Cost/Savings

Current Operations		$75,123.00
Test all pumps after tear-down.		
2,515	Total workload - provided by OC-ALC	
x 1.0	Hour required per CSD - estimated by MDMSC	
2,515	Total hours required per year	
x $29.87	Direct labor rate - provided by AFLC	
$75,123		
New Process		$751.00
Remove and replace pumps in CSD after final test at a rate of one percent.		
2,515	Total workload	
x 1%	Failure rate	
25.15	CSDs requiring repair per year	
x 1.0	Time (hour) required to remove and replace pumps after final test	
25.15	Total hours required per year	
x$ 29.87	Direct labor rate	
$751.00		
Yearly Savings		$74,372.00

Note:
- Repair time for both current and new processes will be the same.
- Two pumps per CSD.

6.15 MATPHB QUICK FIX OPPORTUNITY

During the characterization process of MATPHB, MDMSC noted several opportunities for improvement. One opportunity will be expanded upon in this section.

Productivity improvements will be realized upon revising the procedures from testing CSD pumps at disassembly (tear-down) to reflect only one test operation after final assembly. A reduction on end item flow hours, as well as an estimated savings of $45,540, can be realized.

6.15.1 Quick Fix Opportunity to Eliminate Unnecessary Testing of Pumps After Disassembly

6.15.1.1 Description of Current Operations

All CSD pumps are tested after disassembly (tear-down). Existing records show a failure rate of less than 1%. Most pumps are set aside to be reassembled before final testing of CSD(s).

6.15.1.2 Description of Current Process Problems

Empirical data reveals a 99% success rate from pump testing. An estimated 0.5 hour of direct labor is required for the testing and causes additional flow time on the end item. Pump failures (1%) can be detected at final test, where an estimated 0.5 hour would be required to disassemble and reassemble a pump to the main drive.

6.15.1.3 Description of New Process

Implement a procedural change to eliminate the pump test after CSD tear-down operation. This will reduce direct labor by an estimated 0.5 hour per pump and improve CSD flow time.

6.15.1.4 Rationale Leading to Change

MDMSC observed the test operation and reviewed the existing log book. It was determined that a low failure rate would justify not testing these pumps until final test. The estimated time to test at tear-down is equal to the estimated time to disassemble and reassemble at final test should the pumps fail. This equates to an annual savings in direct labor of an estimated 1,525 hours.

6.15.1.5 Estimated Annual Cost/Savings

Current Operations		$46,000.00
Test all pumps after tear-down.		
1,540	Total workload - provided by OC-ALC	
x 1.0	Hour required per CSD - estimated by MDMSC	
1,540	Total hours required per year	
x $29.87	Direct labor rate - provided by AFLC	
$46,000		

New Process		$460.00
Remove and replace pumps in CSD after final test at a rate of one percent.		
1,540	Total workload	
x 1%	Failure rate	
15.4	CSDs requiring repair per year	
x 1.0	Time (hour) required to remove and replace pumps after final test	
15.4	Total hours required per year	
x $ 29.87	Direct labor rate	
$460.00		

Yearly Savings $45,540.00

Note:
- Repair time for both current and new processes will be the same.
- Two pumps per CSD.

6.16 MATPHE QUICK FIX OPPORTUNITY

During the characterization of MATPHE, MDMSC noted an opportunity to improve the handling of parts in order to greatly reduce handling damage. This quick fix will result in a savings of over $370,000 per year.

6.16.1 Quick Fix Opportunity to Reduce Parts Scrap Rate

6.16.1.1 Description of Current Operations

When Constant Speed Drives (CSD) are disassembled, parts are placed into large metal baskets, and then transported to MATPHE for rework. These baskets are not compartmented and parts having critical surface finish requirements are stacked together without regard for possible damage.

6.16.1.2 Description of Current Process Problems

MATPHE supervision reports that many components delivered to the machine shop show damage characteristics of mishandling. This is due to the design of the present delivery baskets. TI-ES team members observing operations in this area reported that parts were often tossed into the baskets, with little regard for the potential damage to critical surfaces. Several of the affected parts show a high scrap rate directly attributable to handling damage.

6.16.1.3 Description of New Process

Introduction of compartmented trays, and the training of personnel in the importance of correct parts handling, should significantly reduce present scrap rates.

6.16.1.4 Rationale Leading to Change

Given the high replacement cost of the affected parts, it is obvious that a high scrap rate due to mishandling of parts is unacceptable. The present design of the metal baskets exposes component parts to damage. The baskets are not compartmented, and parts must be stacked atop each other in the baskets. Damage caused by personnel throwing parts into these baskets during CSD disassembly could easily be corrected by implementing training in correct parts handling techniques. Personnel in the CSD overhaul and repair RCCs displayed a desire to produce quality products. It is likely that many are simply unaware of the critical surfaces and tolerances of the parts they handle.

6.16.1.5 Estimated Annual Cost/Savings

Current Operations $373,120

Three items were selected for this study: cylinder blocks, port plates, and wobblers. These items were reported as being the parts most commonly seen displaying handling damage. These parts are reported below, with conservative estimates of both scrap rate and replacement cost included. It should be remembered that this does not include the costs associated with repair and/or rework of these items. MATPHE personnel are required to attempt repair on damaged parts, which are often found to be out of tolerance after machining rework. MATPHE supervision reports that this is a significant portion of this RCC's workload. It should also be noted that the following parts represent inductions from various CSDs. Due to the similarity of these parts from one another, they are reported here as a group.

ITEM	ANNUAL INDUCTIONS	% SCRAP	AVE. COST/ITEM	TOTAL COST
Cyl. Blks.	6,288	7%	$450	$198,072
Port Plate	3,266	4%	$700	$91,448
Wobbler	6,688	3%	$400	$83,600
			Total:	$373,120

6.16.1.6 Implementation Cost/Schedule

Manufacture of the compartmented trays could be accomplished by the OC-ALC wood working shop. The material chosen for construction of these trays was phenolic. This material is resistant to oil and hydraulic fluids, would not mar metal surfaces, and is readily available. It should be mentioned that several possibilities exist for obtaining compartmented trays, as well as a choice of different materials for their construction. The choice of which material and manufacturer to be selected is left to OC-ALC discretion. The following is a rough estimate of the costs of producing 100 compartmented trays using 1/4" phenolic. This information was collected by MATPHE supervision.

Estimated Cost of Material: $90/48x48 sheet of 1/4" phenolic. (est. 5 trays per sheet).

Estimated Labor Cost: ($45/manhour) x (3 hrs./5 trays) = $135/5 trays.

Total cost: [($90/5 trays) + ($135/5 trays)] x 100 trays = $4,500

NOTE: It is very important that scrap rates of various parts, and the type of damage responsible, be tracked. It would be advisable for MATPHE machine shop supervision to begin keeping a scrap log. This would help identify problem areas. Given the large expense of replacing these component parts, this is a matter of some concern.

6.17 MATPIA QUICK FIX OPPORTUNITIES

There were no quick fix opportunities identified for MATPIA. All potential improvement opportunities for the RCC are classified as other observations and are described in paragraph 6.17.4 of the CSR.

6.18 MATPIM QUICK FIX OPPORTUNITIES

There were no quick fix opportunities identified for MATPIM. All potential improvement opportunities for the RCC are classified as other observations and are described in paragraph 6.18.4 of the CSR.

6.19 MATPIN QUICK FIX OPPORTUNITIES

There were no quick fix opportunities identified for MATPIN. All potential improvement opportunities for the RCC are classified as other observations and are described in paragraph 6.19.4 of the CSR.

6.20 MATPIW QUICK FIX OPPORTUNITIES

During characterization of the MATPIW RCC, MDMSC noted two potential opportunities to improve the performance of the MATPIW repair operations.

This section develops and presents two quick fix opportunities to assist MATPIW in meeting its objectives. The first opportunity, "Decrease the Flow Time on the Tubing Repair," recommends the removal of a lid from a cleaning tank to speed up the process of setting tubes into the tank and removing them. The second opportunity, "Decrease the Flow Time by Eliminating the Transporting of Tubes," suggests establishing an area within MATPIA to do tubing repair so that tubes don't have to be moved back and forth between MATPIA and MATPIW.

6.20.1 Quick Fix Opportunity to Decrease the Flow Time on Tubing Repair in MATPIW

6.20.1.1 Description of Current Operations

The tubes that come from MATPIA are repaired in MATPIW and then cleaned in a hot water bath for approximately one-half hour to remove the flux residue. A plastic lid was added to the tank to prevent the evaporation of water, though the interviews conducted by MDMSC indicated that only half a tank of water would evaporate during an eight-hour shift.

6.20.1.2 Description of Current Process Problems

The lid on the tank has negatively impacted the productivity of the tubing repair activity in the following three ways:

- The welder must spend time opening and closing the lid.
- The welder must take time to position the tubes in the tank so the lid can be closed completely.
- The welder must fish the tubes out of the hot water with a bent wire, and then the tubes have to be allowed to cool and drain before they can be handled. Before the lid was installed, the tubes could usually be positioned in such a way that the repaired area was under water, but enough of the tube remained out of the water to provide a handhold.

6.20.1.3 Description of New Process

The tubing repair process can be improved by eliminating the lid from the hot water cleaning tank. The flow time per tube will be expedited by removal of the lid, thus improving the utilization of the cleaning tank and increase productivity.

6.20.1.4 Rationale Leading to Change

The recommended change will improve the process by increasing the percentage of value-added activities for the welder. Eliminating the lid will allow the welder more freedom of movement to better perform his operations. Because the fluid in the tank is pure water, no environmental danger would result from eliminating the lid. The area around the tank is ventilated well enough that the water vapor generated will not be a problem. Eliminating the lid will also reduce the chance of tube damage caused by the lid dropping accidentally.

6.20.1.5 Estimated Cost Savings

The assumptions which were made to do a cost/benefit analysis on this idea are given below.

- Tubes are put into and taken out of the tank in batches of ten (based on interviews with the worker who normally does the tubing repair).
- The work simplification that will result from the lid being taken off will result in a time savings of 0.5 hour per batch of tubes (based on the estimates of the MDMSC industrial engineer who observed the process).
- Approximately ten percent of the tubes on a tubing kit board have to be repaired, and a kit board covers an average of 93 tubes (based on an interview with the supervisors in MATPIA).
- An average of 600 kit boards per year come in for weld repair (based on FY 88 figures provided by scheduling).

$$600 \text{ kits/yr} \times 93 \text{ tubes/kit} \times 0.1 \text{ factor} = 5580 \text{ tubes/yr}$$

$$\frac{5580 \text{ tubes/yr}}{10 \text{ tubes/batch}} = 558 \text{ batches/yr}$$

Current Process:

Annual cost of handling tubes during cleaning process

558 batches/yr x .75 hr/batch x $29.87/hr = $12,501

Proposed Process:

Annual cost of handling tubes during cleaning process

558 batches/yr x .25 hr/batch x $29.87/hr = $4,167

Annual Savings = $8,334

6.20.1.6 Implementation Cost/Schedule

The removal of the lid can be accomplished with minimal effort by base personnel. The MDMSC team also believes that the need to replenish the water in the tank because of evaporation will only have a slight effect on the operating costs in MATPIW. No impact on operations in MATPIW is anticipated while the current tank lid is being removed. It can be done simultaneously with the change in weld repair responsibility to MATPIA, should that quick fix be implemented.

6.20.2 Quick Fix Opportunity to Decrease Flow Time by Eliminating the Transporting of Tubes in MATPIW

6.20.2.1 Description of Current Operations

The tubes that make up the tubing kit board are disassembled from the engine and sent to the tubing and cable RCC (MATPIA) to be inspected for defects. A portion of these are sent to MATPIW to have the defects repaired, and are then returned to MATPIA for fluorescent penetrant inspection (if necessary) and kitting. The shops utilize specially made boxes to move the tubes into and out of the RCCs, with two workers usually being utilized for transporting the tubes because of their length.

6.20.2.2 Description of Current Process Problems

The problem with the existing process is that the welders have to spend time doing activities that don't directly contribute to the repair process. The skill of a welder is wasted when he spends his time performing common manual tasks such as moving parts. There is also an appreciable flow time impact on MATPIA, because tubes moved to MATPIW may wait in queue with work from other RCCs.

6.20.2.3 Description of New Process

An area in MATPIA should be devoted to the tubing repairs currently being done in MATPIW. The equipment that would have to be moved into MATPIA to implement this idea can be moved without much trouble and expense, provided that suitable floor area in MATPIA can be found. Currently, MATPIA is in the process of a move. Planning for this welding capability can be integrated into the current move. The MDMSC team believes that the most difficult part of the move is the relocation of the hot water cleaning tank (and its associated plumbing). This tank is where tubes are soaked to clean off the flux after the repair process is completed. A smoother process flow will result from moving the necessary equipment into MATPIA so that the different types of weld repair can be done on the tubes. This is because the tubes will be kept in MATPIA for the entire process. The flow time on the repair process will decrease as a result of centralizing the repair tasks within a single RCC.

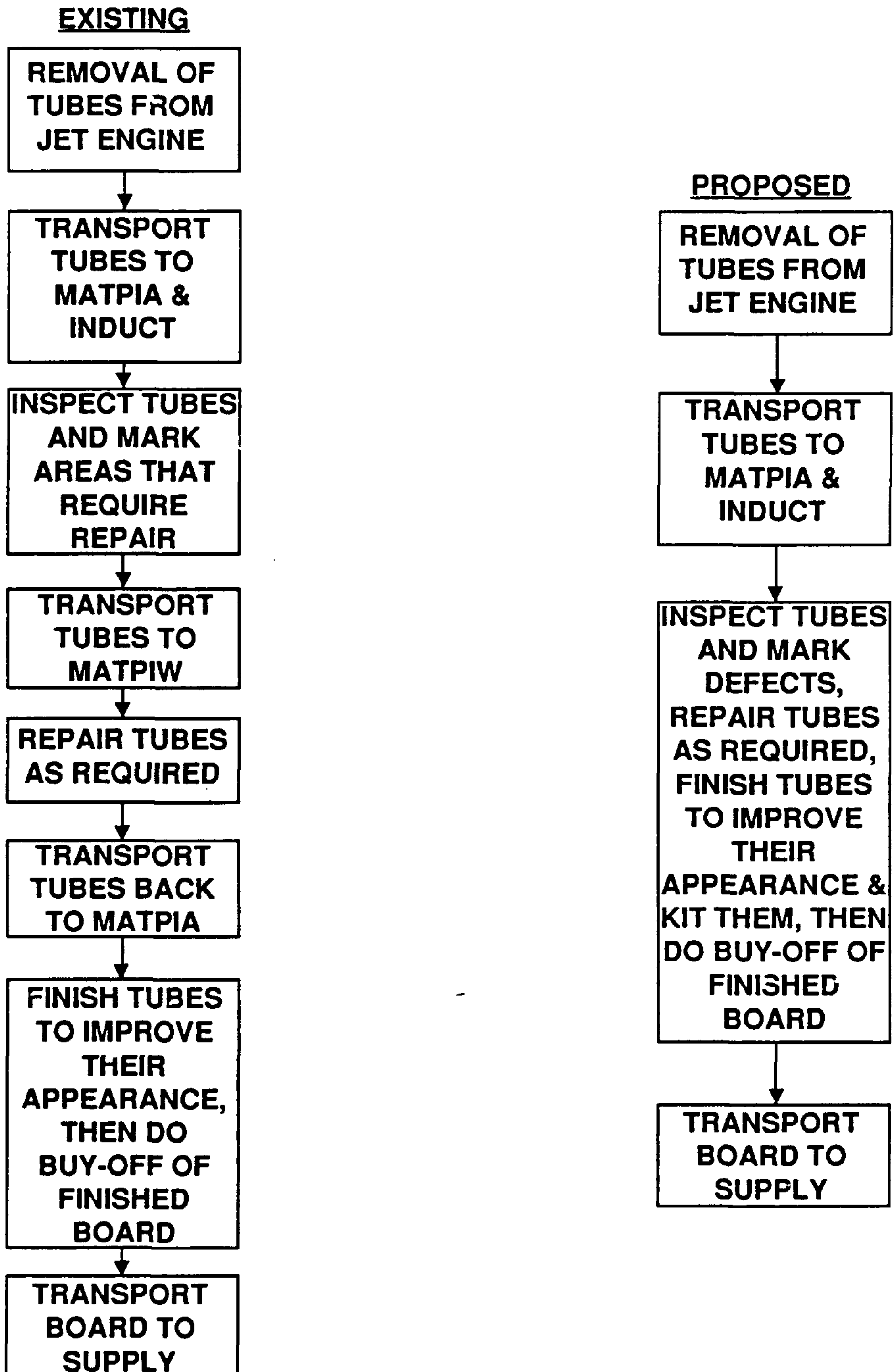
6.20.2.4 Rationale Leading to Change

Based on information gathered through our interviews, MDMSC discovered that the average number of tubes moved to and from MATPIW at one time is ten, with each move requiring two men for approximately 0.1 hour eaeh. This time will be saved by doing the weld repair in MATPIA. An unquantifiable amount of damage which presently results from the movement of tubes between MATPIA and MATPIW will also be eliminated. Refer to Figure 6.20.2-1 to see how the proposal will streamline the repair process on the tubes.

6.20.2.5 Estimated Cost Savings

This recommendation affects ten percent of the tubes in the tubing kit boards (this estimate was given to MDMSC by the workers in MATPIA and represents the number of tubes that are sent to MATPIW for repairs). To determine the quantity of tubes affected, MDMSC examined those boards which showed up on the 80/20 listing. The number of boards repaired annually and the number of

TASK ORDER NO. 1
PROCESS CHARACTERIZATION



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COMPARISON OF EXISTING VS. PROPOSED METHOD FOR REPAIR OF TUBING KIT BOARDS
FIGURE 6.20.2-1

tubes on each board was used to determine the approximate number of tubes going to the weld shop. The table below details how this number was calculated.

PCN of Tubing Kit Board	No. of Boards Inducted	No. of Tubes in Board	Total No. of Tubes
23307A	86	58	4988
23313A	30	65	1950
24101A	76	111	8436
25743A	103	61	6283
27914A	94	132	12408
27918A	76	132	10032
			TOTAL = 44097

Taking ten percent of the above total yields 4410 tubes repaired per year. As stated earlier, an average of ten tubes are moved at a time, which means 441 round trips have to be made, each requiring two men. This number covers both MATPIA workers bringing the tubes to MATPIW for repair and MATPIW workers returning tubes to MATPIA for kitting. Each round trip takes approximately .2 hour per worker.

Current Process:

Annual cost of transporting tubes to and from MATPIW.

441 trips/yr x 2 workers x $29.87/worker-hr x .2 hr/trip x 2 trips = $10,538

Proposed Process:

Cost of transporting tubes between RCCs is eliminated under the MDMSC proposal.

0

Annual Savings $10,538

An experimental run was made in which the time to transport the tubes out of MATPIW was removed from the profiles for the tubing kit boards (PCNs 23307A-WOZ10, 23313A-WOZ10, 24101A-WCZ16, 25743A-WCZ10, 27914A-WCZ10, and 27918A-WCZ10). This experiment shows that the average flow time for repairing a tubing kit board in MATPIW drops 14% when the tubes no longer have to be transported outside of the RCC. The amount of work in process also shows a decrease of 15%. This reduction in inventory will not only reduce the carrying cost to the ALC, but will reduce the chances of tubes being damaged while being transported.

6.20.2.6 Implementation Cost/Schedule

MDMSC believes that the expense of implementing this idea should be very low because the move should be completed in a relatively short time span utilizing existing ALC personnel. MDMSC believes that if no outside labor is required, the proposal can be implemented for less than $300. This should be sufficient to cover any materials and tooling needed to make the proposed move.

The repair process on the tubes would have to be halted during the time that the move is underway, but MDMSC believes that the move can be made quickly enough to prevent any serious impact on operations.