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

**VOLUME IV
OO-ALC**

**CONTRACT SUMMARY REPORT
15 DECEMBER 1989**

**CONTRACT NO. F33600-88-D-0567
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LIST OF ACRONYMS AND ABBREVIATIONS

ALC	AIR LOGISTICS CENTER
CBA	COST BENEFIT ANALYSIS
CNC	COMPUTER NUMERICAL CONTROLLED
CSR	CONTRACT SUMMARY REPORT
DDB	DATABASE DOCUMENTATION BOOK
DMMIS	DEPOT MAINTENANCE MANAGEMENT INFORMATION SYSTEM
E&I	EVALUATION AND INSPECTION
FAA	FEDERAL AVIATION ADMINISTRATION
FY	FISCAL YEAR
HQ-AFLC	HEADQUARTERS - AIR FORCE LOGISTICS COMMAND
IM	ITEM MANAGER
M	MANUFACTURING
MA	DIRECTORATE OF MAINTENANCE
MDMSC	MCDONNELL DOUGLAS MISSILE SYSTEMS COMPANY
MM	DIRECTORATE OF MATERIAL MANAGEMENT
NDI	NON DESTRUCTIVE INSPECTION
O.D.	OUTSIDE DIAMETER
OO-ALC	OGDEN AIR LOGISTICS CENTER
PAC	PRODUCTION ACCEPTANCE CERTIFICATION
PAT	PROCESS ACTION TEAM
PCN	PART CONTROL NUMBER
PDM	PROGRAMMED DEPOT MAINTENANCE
QFP	QUICK FIX PLAN
RCC	RESOURCE CONTROL CENTER
ROM	ROUGH ORDER OF MAGNITUDE
T	TEMPORARY
TI	TECHNOLOGY INSERTION
TI-ES	TECHNOLOGY INSERTION-ENGINEERING SERVICES
TO	TASK ORDER
UDOS 2.0	UNIVERSAL DEPOT OVERHAUL SIMULATOR 2.0
WCD	WORK CONTROL DOCUMENT

OO-ALC CONTRACT SUMMARY REPORT

7.0 OGDEN AIR LOGISTICS CENTER (OO-ALC)

During the fourth quarter 1989, McDonnell Douglas Missile Systems Company (MDMSC) completed process characterization of seven Resource Control Centers (RCCs) within the MANP branch of the Industrial Products and Landing Gear Division MAN at OO-ALC, Hill AFB, Ogden, Utah. The MANP branch is primarily responsible for performing repairs to aircraft landing gears, wheels, and brakes.

The process characterization was performed as part of Task Order (T.O.) No. 1 of the Technology Insertion-Engineering Services (TI-ES) program and revealed that improvements opportunities exist at all RCCs. Improvement opportunities described in this Contract Summary Report (CSR) are classified as focus studies, quick fixes, and other observations. Improvements classified as focus studies and other observations are described in paragraphs 7.1 through 7.7 of this CSR. Improvements classified as quick fixes are described in paragraphs 7.1 through 7.7 of the Quick Fix Plan.

Seven RCCs were selected to be characterized by the ALC. The seven RCCs and their responsibilities are as follows:

- MANPGP - responsible for the assembly of aircraft landing gears, aircraft wheels, and brakes, and the disassembly of the C-5 landing gears.
- MANPGW - responsible for the disassembly of aircraft landing gears, aircraft wheels, and aircraft brakes.
- MANPRA - responsible for machining operations on aircraft landing gears, aircraft wheels, and aircraft brakes.

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- MANPRC - responsible for various manufacturing and repair operations relative to metal coating/metal protective (inorganic) surface finishes.
- MANPRB - responsible for grinding operations on aircraft landing gears, aircraft wheels, and aircraft brakes.
- MANPWW - responsible for heat treatment, welding, and flame spray for all of OO-ALC.
- MANPNA - responsible for all non-destructive inspection for all of OO-ALC.

Two techniques were employed by MDMSC to evaluate the RCCs; industrial engineering assessment and process characterization. The first technique, industrial engineering assessment, allowed MDMSC to become knowledgeable of each RCC's activities by conducting on-site analysis of the RCC operation. The engineering assessment consisted of observing shop floor operations, material flow, equipment use, shop floor layout, and interviewing mechanics, foremen, supervisors, schedulers, and planners for their assessment of the RCC. MDMSC observed that the MANP is laid out functionally to support three product lines: aircraft wheels, aircraft brakes, and aircraft landing gears. MANP also supports other miscellaneous workload at OO-ALC. An example is armament end items that are plated by MANPRC.

During the engineering assessment, MDMSC identified major obstacles and problems that MANP production encounter daily.

MANP production branch is commended for their dedicated effort to meet production quotas since some of the obstacles are not within their control. The problems considered beyond control of MANP are:

- Part shortages
- Lack of raw materials
- Material Management Engineering Support

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The problems attributable to the operational process of the RCCs and considered controllable are:

- Parts robbing
- Scheduling
- Undocumented rework
- Informal batching of parts
- Training
- Loss of personnel to other RCCs
- Discontent with job
- Complex routings

One of the major problems identified is the lack of parts to assemble end items. This problem was identified through interviews with mechanics, foremen, supervisors, schedulers, and planners. This problem was confirmed during validation of the Universal Depot Overhaul Simulator (UDOS) 2.0 simulation flowtime results and the historical flowtime results. Deltas exist between simulated flowtimes and historical flowtimes of 0 to 537%. The difference says that historical flowtime is from 0 to 537% greater than simulated flowtimes. See Tables 7.1.2-7 through 7.1.2-11. MDMSC and ALC personnel investigated the differences between historical flowtimes and simulated flowtimes for each Production Control Number (PCN). MDMSC and ALC personnel found one PCN of particular interest. PCN 90101A is a C-5 main wheel. It has a history of parts shortage over a year old. Three temporary jobs were initiated by the Item Manager (IM) authorizing MANP to induct wheels into disassembly (MANPGW) to rob parts and return the stripped wheels to supply. These parts are needed by assembly (MANPGP) to meet production quota. An experiment was performed with UDOS 2.0 that inducted 377 C-5 main wheels per quarter to disassemble, clean, reassemble, and return them to supply in "x" condition. The team wished to quantify the impact of inducting wheels to rob parts on the total flow of parts through the repair cycle. It was concluded that inducting wheels to rob parts had an insignificant effect on the flow process of landing gears and brakes, but it extended the total flowtime for all wheels by 10.72%. The true cost of not having parts available for the assembly of C-5 wheels includes the

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cost of the T-job, cost of end items not available for rework (x-condition in supply), and the extended cost of work in process of all wheels.

Summary of cost for not having parts (PCN 90101A) available to assemble the C-5 wheel for a year

Cost of T-job	\$45,579/yr
Value of C-5 wheels not available for use	\$9,542,264/yr
Cost of extended work in process	\$66,807/yr

(See section 7.1.4.3 for data)

The cost of not having parts available for assembly is very expensive. MDMSC is proposing a focus study, "Investigation of Deltas Between Historical and UDOS 2.0 Simulated Flowtimes for Production Control Numbers and the Applicability of Group Technology and Cellular Organization Within MANP". This focus study would include investigating, identifying the problems, quantifying the problems, and making recommendations to reduce the flowtimes for PCNs as identified in Task Order No. 1.

Parts robbing is a significant problem for MANPG. It is an expensive workaround for not having parts available for assembly and it only delays the solution to the real problem. Another related problem is informally robbing parts. Mechanics in assembly will rob parts from disassembly to assemble end items when parts are not available. When this is done, no usage is shown by supply so supply will not order more parts. Supply may even cancel the stock number for the part. This costly method may continue until this PCN is not inducted for a quarter, cutting off the supply line of parts for assembly. A crisis develops because assembly needs parts to finish the work in process.

Scheduling within the MANP branch is difficult to achieve. Master scheduling exists for every PCN within MANP. Scheduling between the RCCs is

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accomplished with weekly and daily "hot sheets" which list the PCNs needed immediately by the next RCC. MANP is laid out functionally which makes scheduling even more difficult than if MANP was laid out using group technology and cellular organization. OO-ALC is conforming to group technology as it performs all the maintenance on aircraft and landing gears, aircraft brakes, and aircraft wheels. End items are now transported among seven RCCs to accomplish all of the repair tasks needed. Cellular organization would have one RCC responsible for all operations performed on an end item from disassembly to assembly except for a back shop operations, like plating, that may not be feasible due to environmental restrictions.

OO-ALC is the lead center for the Depot Maintenance Management Information System (DMMIS). DMMIS is a scheduling system that is designed using Manufacturing Resource Planning (MRP-II). DMMIS works on the principle of establishing an end item due date. DMMIS will then provide a start data and establish the due dates parts are needed. DMMIS will not schedule start dates of end items unless the parts needed are available. DMMIS is a long range solution to the scheduling problems that have been identified. An interim solution has been identified as a quick fix opportunity to color code parts to identify the month the part was inducted into the system. The color coding will make it easy to identify non-priority parts that are not being worked. An expeditor can then schedule these parts to be worked based on how long the parts have been in the system.

Lack of raw materials was identified as a problem that hinders production and encourages rob decisions as opposed to make decisions. A specific example is that MANPMN machine shop cannot obtain the raw material necessary to make C-5 bushings. Lack of raw materials to make C-5 bushings stops production by MANPRA which stops the flow of wheels until the bushings are robbed on T-jobs. It is not fully understood why RCCs cannot obtain the raw materials needed to make parts, but it is recognized that procurement practices within the ALC are complicated.

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Rework of end items in a functional design will always be a problem. Each RCC is responsible only for the quality of the operation the RCC performs. No RCC is responsible for the total quality of the end item. Resolution of rework problems is difficult because of delayed feedback from RCC to RCC. This is a result of the end items being in storage or queues that extend over many days, making it difficult to obtain meaningful feedback on problems.

Undocumented rework between the RCCs was identified during the validation of the simulation results. Rework was identified as a major problem by the landing gear subunit of MANPGP. The foreman estimates that five manhours are lost a week due to rework. Parts are usually returned to the supporting RCC for immediate rework because the landing gears are waiting on the parts to complete the end item. Time is not taken to identify the real nature of the defects, so the same defect can reoccur because of lack of communication. In a cellular organization the supporting function would be part of the RCC thus making communication easier for the assembler to talk to the person that is responsible for the defect. A single supervisor can correct the problem and easily monitor parts to determine if the solution worked.

Informal batching of parts was identified within the supporting RCCs. RCCs often work batches of parts making it difficult on the next RCC to schedule work on end items. The batch sizes are not coordinated between RCCs to produce a smooth flow of end items. Informal batching of parts affects the flowtime of end items in that parts are not worked until a mechanic has a specified number of parts available for processing. This practice affects the RCC that is responsible for assembling end items. For example MANPRA machine shop may set up and process eight outer cylinders of a KC-135 main landing gear without processing any inner cylinders. MANPGP landing gear subunit has Work Control Documents (WCDs) to assemble four KC-135 main landing gears. MANPGP receives eight outer cylinders and no inner cylinders from MANPRA. MANPGP has to wait on MANPRA to process four inner cylinders before starting assembly of the landing gear. MANPGP is behind schedule due to the practices of MANPRA that are not controlled by MANPGP. Supporting RCCs

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must be more aware of the impact of batching decisions. A half hour machine set-up time is a small price to pay to preclude delaying a \$50,000 landing gear.

Directorate of Material Management (MM) engineering support was identified as a problem. Material management engineers are responsible for dispositioning repairs that are beyond the limits of technical data for the PCNs. The mechanic fills out a form 103 describing the defect. Planning MANEC, submits the form to MM engineering for disposition. MM engineering may take as little as two hours or as long as two months to disposition the form 103. A form 103 stops work on an end item until the form 103 is dispositioned. The unpredictable response time for forms 103 make it difficult for MANP to schedule completion of end items. MDMSC recommends an MM engineer be assigned to MANP production branch full time to disposition form 103s or that MA and MM develop a memorandum of agreement designating a tolerable response time.

Lack of training was identified by RCC personnel. There appears to be no formal training on how to properly disassemble or assemble wheels, brakes, and landing gears. OO-ALC provides training on how to read and understand technical orders, how to read blueprints and understanding principles of sheet metal. During validation of the simulation results, An MANEP engineer was observed working in the landing gear disassembly area. The engineer was standardizing each landing gear disassembly process, and designing special tools that are needed for disassembly.

Loss of personnel to other RCCs and discontent with the job is a major problem in the functional layout. Personnel are assigned one task in an RCC to work. Some tasks are dirty and strenuous in an RCC. People will work that task until they become discontent and find another job in a different RCC to work.

Group technology and cellular organization can help to minimize discontent with the job. Group technology could be used to group the repair/rework of all aircraft wheels into a RCC. The RCC would be responsible for the disassembly to the assembly of aircraft wheels.

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Cellular operations would assign clear responsibility and authority for producing parts efficiently and with high quality to the RCC. The supervisor has the responsibility for the entire repair cycle of wheels including machines and mechanics needed for processing. Mechanics are familiar with what they are working on and their immediate "customer" is the next mechanic in the repair process; thus, they have immediate feedback on the quality of their work. Communications between mechanics and supervisor are direct, and immediate, so that quality becomes "Everyone's business". People can be assigned multiple tasks within the cell to support production. The RCC controls the process flow of parts within the cell. Job enrichment comes with self-satisfaction within the mechanic. Satisfaction is derived by knowing someone cares about your work, understanding of the processes, seeing immediate resolution to problems and being able to perform tasks within the RCC to help get the task accomplished.

MDMSC is proposing to study the seven RCCs characterized in T.O. No. 1 as to the applicability of group technology and cellular organization under the focus study titled "Investigation of Deltas Between Historical and UDOS 2.0 Simulated Flowtimes for Production Control Numbers and the Applicability of Group Technology and Cellular Organization Within MANP." Cellular organization within MANP offers some distinct advantages.

Cellular operations assign clear responsibility and authority for producing the product efficiently and with high quality. The supervisor of a cell has authority over the entire stream of processing for the part family in that cell, including the machines and operators needed for such processing. The workers are familiar with what they are working on and their immediate "customer" is the next worker in the same cell; thus, they have immediate feedback on the quality of their products. Communications between workers and the supervisor are direct, and immediate, so that quality becomes "everyone's business." Furthermore, costs

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of the product are focused upon in the cellular environment--e.g., reducing scrap and rework.*

Cellular organization with MANP will help eliminate or reduce many of the problems identified during the engineering assessment performed by MDMSC.

Group technology is the processing of like families of end items. MANP is utilizing a simple form of group technology in that it processes all of the Air Force landing gears, wheels, and brakes within MANP.

Creation of group technology and cellular organization within MANP will foster many of the features of Total Quality Management (TQM). TQM requires that human resources be effectively utilized, continuous improvements be a goal, customer satisfaction be the ultimate goal, and quality- and cost-consciousness pervade the entire organization. The process improvement of the cellular organization is consistent with many of these requirements *

To foster continuous improvements on the shop floor, TQM advocates the use of Statistical Process Control (SPC) to quantitatively determine whether a fixed process is stable or out of control and to help bring about improvements in a stabilized process. SPC is difficult, if not impossible, to accomplish in the current functional environment of DoD maintenance depots but may be possible in a cellular layout of those depots. SPC is virtually impossible because of inherent delays and lack of communication between the RCCs. For example, MANPGP identifies a machining problem, MANPRC makes a correction in the setup of the machine, and MANPRC machines the part. MANPGP does not have any WCDs to assemble parts for a period of time. During this period, MANPRC continues to machine parts without any feedback to know if the problem has been corrected.

*Simplify First: A Modernization Strategy for DoD Maintenance Depots Report AL7042, Logistics

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Group technology and cellular organization will compliment the TQM QP4 program that the Air Force has implemented at all ALCs. The QP4 is dependent on SPC.

Process characterization, modeled the repair process within each RCC. The repair processes were modeled for two reasons; first to establish a baseline from which improvements can be measured and second to identify improvements.

An 80/20 listing of PCNs (end items) was determined for each of the seven RCCs chosen for process characterization using production data from the G004L.MPC system for the months October 1, 1988 to January 31, 1989. An 80/20 list in theory says that 80% of the earned hours in an RCC comes from 20% of the end items.

MDMSC evaluated the 80/20 list for each RCC and determined that several of the 80/20 lists contain the same PCNs. It was decided to combine the 80/20 lists of each RCC and sort the PCNs by total hours and rank each PCN in each RCC as a percentage of the total RCC workload. Combining the 80/20 lists for each RCC and sorting by total hours, revealed that 216 PCNs made up 87.4% of the total workload through the seven RCCs.

The seven RCCs primarily support three product lines--aircraft landing gears, aircraft wheels, and aircraft brakes. It is proposed to use group technology to group aircraft landing gears, aircraft wheels, and aircraft brakes into families of end items. This concept to process characterize families of end item through the seven RCCs was proposed and agreed to by ALC-TI personnel on 17 April 1989. It was agreed to model the seven RCCs together as a continuous product flow for the end items. See section 7.1.2 Statistical System Performance Measures for greater detail and rationale on the methodology that was used for process characterized.

Historical data was developed for each PCN that was process characterized. This was accomplished by collecting completed WCDs and entering the

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induction and the sell dates into a database. A computer program computed average, minimum, and maximum flowtimes for each PCN unless the data was not available (WCDs not available).

The UDOS 2.0 model processed the model database. MDMSC and ALC personnel validated the model logic and database, compared historical and simulated throughputs, and compared historical and simulated flowtimes for each PCN. MDMSC and ALC personnel documented the discrepancies and the rationale for the discrepancies. Validation of the UDOS 2.0 simulated results confirmed the same problems that were identified during engineering assessment. The problems are:

- Parts shortage/parts robbing
- Engineering support
- Informal batching of parts
- Scheduling
- Undocumented rework

A brainstorming session was held at OO-ALC on 24 October 1989 to develop ideas for made experimentation. Several ideas were discussed and the following ideas were agreed to for experimentation:

- T-Jobs -To determine the effects T-Jobs to rob parts have on the repair cycle.
- T-56 Workload - Enter the T-56 gearbox workload for the C-130 aircraft into the present workload.
- HEEF 25 - HEEF 25 is a proprietary chrome plating bath. It increases the rate of chrome buildup on parts. An increase in the rate of chrome buildup decreases the process time the part is in the chrome tanks. It also increases the quality of the chrome deposit because it does not crack during the grinding process as opposed to the currently used chrome. It is estimated that the tank processing time can be reduced by 50 to 100%. A very conservative estimate of a 25% reduction in process times was used for experimentation. A conservative estimate is to be used until the actual process is installed and real data is provided for experimentation.

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- Rework - Reduce chrome rework from 20 to 5%. The rework of chrome based on the best available data varies from 20 to 30%. Rework includes chrome pitting, insufficient buildup of chrome, non-concentric buildup of chrome, burning of chrome, and grinding defects. It is estimated that the implementation of the proposed focus studies and quick fixes for MANPRC will reduce chrome rework from 20% to approximately 2%.
- Manpower/Scheduling - MANPRC is presently in the process of adding 30 additional people to the plating shop to work 3 shifts, 7 days a week. In the experimentation, 15 people were added to the 5 day week, 0 people to the 7 day week, 15 people to the 7 day week and 30 additional people to the 7 day week.
- Surge - To determine if the RCC could meet surge requirements.

The Taguchi methodology was used to design two L_4 arrays which, when evaluated along with a single factor experiment, allowed MDMSC to evaluate all of the factors which the ALC requested. MDMSC utilized each of the L_4 arrays to test two factors at two levels plus the interaction between them. The first array was designed to test the effects of manpower at two levels (existing number of workers, existing level plus 30) and rework at two levels (5% and 20%). The array also permitted evaluation of the interaction between manpower and rework. The second array was designed to test the effects of scheduling at two levels (5 days a week and 7 days a week) and manpower at two levels different from those that were already examined in the first array (existing level plus 5 and existing level plus 15). The interaction between scheduling and manpower was also modeled.

The single factor experiment examined the effects of using the HEEF 25 process. Because the HEEF process was not expected to interact with the control factors being tested in the two L_4 arrays. MDMSC felt comfortable with treating it as a separate experiment and believed that the validity of the experimental results would not be diminished by using three experiments rather than a single large one. In addition to a large model run time savings, the use of smaller experiments provided the capability of testing the degree of

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interaction between manpower and rework and between scheduling and manpower. When evaluated as a group, the experiments performed resulted in the testing of one factor (manpower) at four levels and three factors (scheduling, rework, and HEEF 25) at two levels.

Noise factors were considered in the experimental design, but were modeled as control factors because the UDOS 2.0 model is insensitive to random variation. Therefore, no sensitivity in the experimental results was lost by treating a factor like rework as a control rather than a noise factor.

The deterministic nature of the UDOS 2.0 model made it impractical to try to perform a signal-to-noise analysis. The running of multiple experimental runs would not yield any results of practical value. Performing ANOVA (analysis of variances) was not justified considering the resources that would be required to do it. The data which would be generated by ANOVA would not be very useful in terms of gaining a better understanding of the model outputs. MDMSC's opinion is that the degree of analysis which was performed on the experimental results was the most cost effective way of providing the ALC with valuable information concerning their operations.

The results of experimentation are:

T-Job - The T-Job inducted C-5 main wheels into the repair cycle to rob parts and return to supply. UDOS 2.0 results showed a 10.72% increase in the overall flowtime for the four wheel groupings as expected with no or little effect on the overall flowtime for landing gears or brakes.

T-56 Workload - Was included in the workload database for all of the experiments except for the T-Job. The T-Job experiment did not include the T-56 workload because the induction of the T-Jobs was compared to the original validation baseline that did not include T-56 workload.

Surge - The RCCs evaluated do not have the capability to meet the surge requirements as identified by HQ-ALC. The resources needed to meet surge requirements are shown in Table 7.1.2-12.

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HEEF 25. Rework. Manpower/Scheduling - After analyzing the different scenarios, MDMSC recommends working seven days a week, adding 15 people to the plating shop, reducing chrome rework to 5%, and implementing the HEEF 25 process. Analyzing the single effect of each of the identified control factors yielded different results. The combined effects of the control factors intuitively would yield more throughput with a decrease in flowtime. A confirmation experiment was performed using the identified control factors. The confirmation database compared to the validation baseline yielded the same total throughput with an increase of 9% in flowtime. The rationale for the increase in flowtime is that the validation baseline did not consider rework. A closer examination revealed that two landing gear PCNs throughput increased significantly. PCN 26338 throughput increased from 26% to 100%. PCN 69657A throughput increased from 5% to 21%. The overall throughput of all of the landing gear PCNs improved from 79 to 88%. The rationale for the drastic increase is that these PCNs require two separate chrome operations each. The reduction of 25% in the process time by using the HEEF 25 process allowed more parts to be processed through the plating shop MANPRC. An analysis of the database showed the additional throughput through MANPRC created a bottleneck in the grinding shop MANPRB and the machine shop MANPRA. MANPRC is working seven days a week, three shifts compared to 5 days a week, two shifts for MANPRA and MANPRB. PCNs are stacking up waiting on MANPRA and MANPRB for processing. The rationale is the difference of processing time available between the RCCs. The improvement in the landing gear throughput supported by experimentation justifies the recommendations from experimentation.

Areas of primary importance to ALC management associated with improvement opportunities are cost avoidance, investment cost, and annual savings. During the OO-ALC characterization process, four focus studies and 15 quick fixes were selected for further investigation. Cost avoidance, investment cost, and annual savings data associated with the four focus studies and 15 quick fixes are detailed in Tables 7.0-1 and 7.0-2 respectively.

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OO-ALC FOCUS STUDY RECOMMENDATION SUMMARY

TABLE 7.0-1

MDMSC RECOMMENDATION	IMPACT	ANNUAL BUDGET SAVINGS	COST AVOIDANCE			INVESTMENT COST
			FLOW TIME REDUCTION	WIP INVENTORY REDUCTION*	FLOOR SPACE REDUCTION	
STUDY AND DEVELOP THE BEST PLATING PROCEDURE FOR 300M STEEL (MANPRC)	DIRECT LABOR HOURS SAVED	\$518,243	0 DAYS	\$ 0	0 SQ. FT.	\$615,000
STUDY THE POTENTIAL IN DEVELOP- ING PLATING EQUIPMENT TO DE- CREASE MASKING AND INCREASE PLATING EFFICIENCY (MANPRC)	DIRECT LABOR HOURS SAVED	\$231,196	0 DAYS	\$0	0 SQ. FT.	\$171,500
IMPROVED BRAKING BY REMANUFAC- TURING STEEL BRAKE ROTORS (MANPGW)	DIRECT LABOR HOURS SAVED	\$1,688,389	0 DAYS	\$0	0 SQ. FT.	\$1,366,370
INVESTIGATION OF DELTAS BETWEEN HISTORICAL AND UDOS 2.0 SIMU- LATED FLOWTIMES FOR PCN'S AND THE APPLICABILITY OF GROUP TECHNOLOGY AND CELLULAR OR- GANIZATION WITHIN MANP (MANPGP)	REDUCTION IN WORK IN PROCESS INVEN- TORY	-0-	10 DAYS	\$13,299,494	0 SQ. FT.	**\$950,000
TOTALS		\$2,437,828.00	10 DAYS	\$13,299,494	0 SQ. FT.	\$3,102,870

NOTES: * WIP INVENTORY REDUCTION = $\frac{\# \text{ OF FLOW DAYS REDUCED}}{365 \text{ DAYS}} \times (\text{ASSET \$ VALUE}) \times (\text{YEARLY PRODUCTION RATE})$

** REPRESENTS FOCUS STUDY COST ONLY. IMPLEMENTATION COSTS TO BE IDENTIFIED BY FOCUS STUDY.

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OO-ALC QUICK FIX RECOMMENDATION SUMMARY
TABLE 7.0-2 (SHEET 1 OF 2)

MDMSC RECOMMENDATION	IMPACT	BUDGET SAVINGS	COST AVOIDANCE			INVESTMENT COST
			FLOW TIME REDUCTION	WIP INVENTORY REDUCTION	FLOOR SPACE REDUCTION	
MANPGP LANDING GEAR SUBUNIT QUALIFIED WORKLEADER INSTRUCTOR (MANPGP)	DIRECT LABOR HOURS SAVED	\$ 264,661	1 DAY	\$0	0 SQ. FT.	\$55,773
C-5 MAIN LANDING GEAR FLOOR CREEPER (MANPGP)	DIRECT LABOR HOURS SAVED	\$895	0 DAYS	\$0	0 SQ. FT.	\$100
PNEUMATIC TORQUE WRENCH (MANPGP)	STRUCTURAL INTEGRITY OF PART	\$0	0 DAYS	\$0	0 SQ. FT.	\$1,500
PARTS STORAGE CABINETS (MANPGP)	DIRECT LABOR HOURS SAVED	\$57,308	2 DAYS	\$0	0 SQ. FT.	\$2,303
C-5 BOGIE ASSEMBLY SPECIAL TOOL (MANPGP)	DIRECT LABOR HOURS SAVED	\$1,504	0 DAYS	\$0	0 SQ. FT.	\$286
C-5 YOKE ASSEMBLY SPECIAL TOOL (MANPGP)	DIRECT LABOR HOURS SAVED	\$2,239	0 DAYS	\$0	0 SQ. FT.	\$256
AIRCRAFT WHEELS BEAD BLASTING PROCESS (MANPGW)	DIRECT LABOR HOURS SAVED	\$123,155	0 DAYS	\$0	0 SQ. FT.	\$55,000
SEMI-AUTOMATED REMOVAL OF BRAKE LINERS (MANPGW)	DIRECT LABOR HOURS SAVED	\$33,931	0 DAYS	\$0	0 SQ. FT.	\$42,400
DECREASE GRINDING TIME (MANPRA, MANPRB)	DIRECT LABOR HOURS SAVED	\$285,638	1 DAY	\$0	0 SQ. FT.	\$100,000
INCREASE PARTS SALVAGING (MANPRC)	DIRECT LABOR HOURS SAVED	\$3,243	0 DAYS	\$0	0 SQ. FT.	\$0

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**OO-ALC QUICK FIX RECOMMENDATION SUMMARY
TABLE 7.0-2 (SHEET 2 OF 2)**

MDMSC RECOMMENDATION	IMPACT	BUDGET SAVINGS	COST AVOIDANCE			INVESTMENT COST
			FLOW TIME REDUCTION	WIP INVENTORY REDUCTION	FLOOR SPACE REDUCTION	
UNIFORM PLATING DEPOSITS WITH SHIELDS (MANPRC)	DIRECT LABOR HOURS SAVED	\$101,762	1 DAY	\$0	0 SQ. FT.	\$29,000
REWORK DUE TO INSUFFICIENT CHROME (MANPRC)	DIRECT LABOR HOURS SAVED	\$101,762	1 DAY	\$0	0 SQ. FT.	\$0
HEAT TREATMENT OF AIRCRAFT WHEELS (MANPWW)	DIRECT LABOR HOURS SAVED	\$1,478	1 DAY	\$0	0 SQ. FT.	\$180
METAL THERMAL COATING OPERATIONS (MANPWW)	DIRECT LABOR HOURS SAVED	\$1,791	0 DAYS	\$0	0 SQ. FT.	\$2,100
IMPROVE PERFORMANCE IN WELDING (MANPWW)	DIRECT LABOR HOURS SAVED	\$5,373	0 DAYS	\$0	0 SQ. FT.	\$0
TOTALS		\$984,740	7 DAYS	\$0	0 SQ. FT.	\$288,898

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The focus studies selected for further investigation and their associated RCCs are summarized as follows:

- | | |
|--------|---|
| MANPGP | Investigation of the deltas between historical and UDOS 2.0 simulated flowtimes for PCNs and the applicability of group technology and cellular organization within MANP. |
| MANPRC | Study and Develop the Best Plating Procedure for 300M Steel. Estimated Annual Cost Savings. |
| MANPRC | Study the Potential in Developing Plating Equipment to Eliminate Masking and Increase Plating Efficiency. |
| MANPGW | Improved braking by remanufacturing steel brake rotors. |

The detailed descriptions of quick fixes are provided in paragraphs 7.1 through 7.7 of the Quick Fix Plan. A brief summary of these quick fixes and their associated RCCs are summarized here as follows:

MANPGP

- Workleader Instructor - MDMSC proposes a workleader instructor for MANPGP landing gear subunit with the following duties.
 - Instruct mechanics on how to properly assemble the different landing gears.
 - Check all landing gear kits for the correct parts.
 - Be responsible for the Production Acceptance Certification program.
 - Continue improvement of the landing gear processes.Yearly savings of \$264,661 may be realized if this improvement opportunity is successfully implemented.

- C-5 Floor Creeper - Provide floor creepers for mechanics to use when working the lower section of the C-5 main landing gear. Yearly savings of \$895 may be realized if this opportunity is successfully implemented.

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- Pneumatic Torque Wrenches - Provides the C-5 main landing gear mechanic with the proper tools to avoid structural damage to the bogie assemble. No yearly savings are realized. Structural integrity of the bogie assembly is enhanced.
- Parts Storage Cabinets - Relocate the parts storage cabinets to the eight foot elevated assembly platform. Yearly savings of \$57,308 may be realized if this improvement opportunity is successfully implemented.
- C-5 Bogie Assy Special Tool - Design and fabricate a special tool to remove the 4G19067101A bolts from the C-5 bogie assembly. Yearly savings of \$1,504 may be realized if this improvement opportunity is successfully implemented.
- C-5 Yoke Assy Special Tool - Design and fabricate a special tool to properly set the chain tension between the yoke assembly and gear box. Yearly savings of \$2,239 may be realized if this improvement opportunity is successfully implemented.

MANPGW

- Wheels Bead Blasting Process - Automate the blasting booth that is not being used for landing gears to bead blast aircraft wheels. Yearly savings of \$123,155 may be realized if this improvement opportunity is successfully implemented.
- Semi-Automated Removal of Brake Liners - Use a combination drill and punch press with automatic indexing to remove rivets from the brake liners. Yearly savings of \$33,931 may be realized if this improvement opportunity is successfully implemented.

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MANPRB

- Decrease Grinding Time - Decrease grinding time of chrome landing gear part by switching from grinding wheel to a sanding belt. Yearly savings of \$285,638 may be realized if this improvement opportunity is successfully implemented.

MANPRC

- Increase Parts Salvaging - Rework parts by using an outside vendor when it is not economically feasible to be reworked by the ALC. Yearly savings of \$3,243 per 100 parts may be realized if this improvement opportunity is successfully implemented.
- Uniform Plating Deposits with Shields - Use plating shields to obtain uniform distribution of chrome on the steel by positioning the parts in the cylinders correctly. Yearly savings of \$101,762 may be realized if this improvement opportunity is successfully implemented.
- Rework Due to Insufficient Chrome - Recommends to properly care for all anodes. Insufficient chrome build-up on parts can be the result of defective anodes. Yearly savings of \$101,762 may be realized if this improvement opportunity is successfully implemented.

MANPWW

- Heat Treatment of Aircraft Brakes - Recommends that MANPWW perform inspection of the brakes for flatness. Yearly savings of \$1,478 may be realized if this improvement opportunity is successfully implemented.
- Metal Thermal Coating Operations - Convert a suction-type blast gun on a blasting booth to a pressure-type blast gun for a back-up. Yearly savings of \$1,791 may be realized if this improvement opportunity is successfully implemented.

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- Improve Performance in Welding - Provide the welder with sufficient information to weld the part with the paperwork at the beginning. Yearly savings of \$5,373 may be realized if this improvement opportunity is successfully implemented.

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7.1 MANPGP ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MANPGP is a Resource Control Center (RCC) under the MANP branch of the Industrial Products Division (MAN) at OO-ALC. MANPGP assembles aircraft wheels, brakes, and landing gears under the disassembly/assembly repair section (MANPG).

During the initial characterization of MANPGP, a total of ten improvement opportunities were identified; reference MANPGW Database Documentation Book (DDB), potential improvement opportunities section.

One of the improvement opportunities is classified as a focus study and investigates the delta between historical flowtime for production control flowtime and the Universal Depot Overhaul Simulator (UDOS) 2.0 model simulated flowtime. The focus study titled, "Delta Between Historical and Simulated Flowtimes for Production Control Numbers," is presented in detail in paragraphs 7.1.4 through 7.1.4.4.

Six of the improvement opportunities are classified as quick fixes. The quick fixes address safety, training, and process changes. Quick fixes are described in detail under separate cover (reference Technology Insertion-Engineering Services (TI-ES) Task Order No. 1, Volume IV Quick Fix Plan, OO-ALC, MANPGP Quick Fix Opportunities Section). The other potential improvement opportunities are classified as other observations and discussed in paragraph 7.1.5.

7.1.1 Description of Current Operation

MANPGP's function is to paint component parts of end items and assemble the component parts into the end item. MANPGP is broken into five subunits; paint, wheel assembly, brake assembly, C-5 landing gear assembly and all other landing gear assembly. MANPGP is located in Building 507.

The paint subunit is responsible for the painting of component parts. The paint subunit has two different conveyor lines setup for painting. One line is responsible for painting wheels and brake housings. The other line is setup to

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paint landing gear components. A third paint area is setup to handle oversize parts that cannot be processed on one of the two conveyor lines. One foreman and 25 mechanics support the paint subunit of MANPGP.

The wheel assembly subunit is responsible for the assembly of wheels. Wheels enter MANPGP as two painted wheel halves. The wheel halves are manually balanced on a wheel static balancing machine. MANPGP wheel assembly subunit has an electronic dynamic wheel balancing machine that is not being used. The rationale for not using the electronic wheel balancing machine is that every time the forklift passes by, the machine has to be recalibrated. The problem with the electronic dynamic wheel balancing machine was confirmed by a mechanic that does the balancing of the wheel halves. The machine is hard mounted to the floor. This problem can be resolved by mounting the machine on rubber absorption pads. The rubber pads will absorb the shock vibrations from the floor created by the passing of the forklift. After the wheel halves are balanced, the material inventory control personnel match the necessary hardware with the wheel halves so the mechanics can assemble the two wheel halves and the hardware into an end item. The end item known as a wheel is inspected for completeness and for defects in the paint. Paint defects are corrected and the wheel stamped off complete by MANPGP. Depot supply personnel complete the necessary paperwork and package the wheel for shipment. The wheel subunit is supported by one foreman and 21 mechanics.

The brake assembly subunit is responsible for the assembly of brakes. Brakes enter MANPGP as various component parts. The brake housing is painted by the MANPGP paint subunit. The material inventory control personnel match the various brake components and hardware needed for a brake assembly. The mechanics assemble the brake components and hardware into an end item. The end item is known as a brake assembly. The brake assembly is inspected for completeness and for defects in the paint. Paint defects are corrected and the assembly stamped off completed by MANPGP. Depot supply personnel complete the necessary paperwork and package the brake assembly for shipment.

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The C-5A landing gear assembly subunit is responsible for the disassembly and assembly of the main landing gear and nose landing gear. This subunit is unique in that it performs both the disassembly and assembly of the C-5A main landing gear and nose landing gear whereas the disassembly of all other aircraft landing gears is performed by MANPGW. This subunit is specially equipped with disassembly/assembly fixtures for the C-5A main landing gear. The landing gear components that are disassembled are sent to MANPGW to be processed like all other landing gear components starting at the clean line. For landing gear components that are to be assembled, material inventory control matches up the components and hardware necessary for assembly. The mechanics assemble the components into an end item known as a landing gear assembly. The landing gear assembly is then tested per technical data requirement using a hydraulic test setup. After the landing gear assembly passes test, the landing gear assembly is checked for compliance to the technical data and stamped completed by MANPGP. Depot supply personnel complete the necessary paperwork and crate the landing gear assembly for shipment. The C-5 landing gear subunit is supported by one foreman and 16 mechanics.

The landing gear assembly subunit for aircraft other than the C-5A is responsible for only the assembly of landing gears. The material inventory control personnel match the landing gear components and hardware. The mechanics assemble the components and hardware into an end item known as a landing gear assembly. The landing gear assembly is then tested per technical data requirements using a hydraulic test stand setup. After the landing gear is assembled and passes testing, the landing gear assembly is sent to the MANPGP subunit for paint. Painting is accomplished on the conveyor line that is setup for painting landing gear. The landing gear subunit is supported by one foreman and 20 mechanics.

MANPGP was designed and laid out to support each of its subunits. Each subunit is laid out to support an orderly flow sequence of assembling the end item. The two paint areas are automated using an overhead carriage system to move the parts through the paint cycle.

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MANSV is the scheduling section that supports MANPGP. Scheduling negotiates the quantity of end items to be inducted each quarter with the different item managers. Scheduling ensures the component parts are made available to material inventory control for match up when needed in order for MANPGP to complete the number of end items required by the item manager. Scheduling accomplishes this task by issuing weekly "hot sheets" of what component parts are needed by a specific date by MANPGP.

MANE is the planning section that supports MANPGP. The planners ensure that the work control documents are current with the latest technical data. The planners plan the sequence of operations necessary to assemble an end item. The planners determine any special tooling that may be needed for the assembly of an end item.

The planners are the liaison between support engineering and production. The planners are in the process of updating the work control documents for the DMMIS project. The work control documents are up to date and accurately reflect the part flow through the repair cycle.

7.1.2 Statistical System Performance Measures

Statistical system performance measurement of a RCC is the output statistics generated from a database that is processed by UDOS 2.0 to establish a simulated baseline that emulates the As-Is environment of the RCC.

The simulated baseline is the output statistics of UDOS 2.0. This reflects the throughput and flow times of end items (PCNs) and accurately depicts the manpower and equipment utilization within the RCC. The simulated baseline is to be used to measure effects of "what if" experiments that are designed to improve the operations of a RCC.

The process of developing a statistical performance measurement of a RCC is very labor intensive and time consuming. A logical sequence of events, followed to develop a statistical system performance measurement for a RCC is:

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- 80/20 List Development
- Data Collection
- Data Verification
- Model Verification
- Run Simulation
- Model Validation
- Brainstorming
- Experimentation
- Analysis of Results

An 80/20 listing of PCNs (end items) was determined for each of the seven RCCs chosen for process characterization using production data from the G004L.MPC system for the months October 1, 1988 to January 31, 1989. An 80/20 list in theory says that 80% of the earned hours in an RCC comes from 20% of the end items (reference the DDB for the 80/20 listing for each RCC). The Simulation Model Definition Document (SMDD) Revision D, dated 8 December 1989, section 3.1.3.1 describes in detail how to determine an 80/20 list of PCNs for an RCC. MDMSC evaluated the 80/20 list for each RCC and determined that several of the 80/20 lists contain the same PCNs. MDMSC decided to combine the 80/20 lists of each RCC and sort the PCNs by total hours and rank each PCN in each RCC as a percentage of the total RCC workload. Combining the 80/20 lists for each RCC and sorting by total hours, revealed that 216 PCNs made up 87.4% of the total workload through the seven RCCs. This is possible because it takes more PCNs to comprise the 80% workload for the two supporting RCCs, MANPNA and MANPWW. These PCNs did not make the 80/20 lists of the other RCCs, but these PCNs are common to the RCCs and are added to the other RCCs to meet the minimum 80% workload for MANPNA and MANPWW. See Table 7.1.2-1 for the 80/20 list for the seven RCCs. This approach to the combined 80/20 list for the seven RCCs was discussed in detail by the OO-ALC and MDMSC teams and agreed to on 31 March 1989 at OO-ALC.

Data collection is the systematic gathering of information about an RCC to be processed by the UDOS 2.0 model to emulate the As-Is environment of an

OGDEN 80/20 SORTED BY TOTAL HOURS
TABLE 7.1.2-1

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PART CONTROL NUMBER	MANPGP SEQUENCE	MANPGW SEQUENCE	MANPNA SEQUENCE	MANPRA SEQUENCE	MANPRB SEQUENCE	MANPRC SEQUENCE	MANPWW SEQUENCE	EARNED HOURS	PERCENT OF EARNED HOURS
15648A		1	4	4		6		6348.32	0.031
90101A		4	37	1		7		5902.71	0.060
17576A		29	41	17	15	20		5315.04	0.086
16837A		15	6	8	1	2	29	5200.55	0.112
17143A		8	21	5	5	1	54	5134.89	0.137
16836A		13	9	10	2	4	24	4870.74	0.161
17565A		10	24	6	3	8	27	4318.94	0.182
17142A		9	23	9	6	3	55	4241.38	0.203
15828A		9	25	7				3978.63	0.223
74527A		14	47	2	26	10	51	3785.10	0.242
62927A		3	13	11		23		3748.80	0.260
00124B			2	227		11	1	3744.75	0.279
17575A		48	26	14	8	17	87	3744.30	0.297
00126B			1			16	2	3575.29	0.315
15592A		99	16	3				2774.30	0.328
16915A		20	15	45	7	9	12	2315.59	0.340
69354A		12	33	21	34	13	19	2313.41	0.351
74524A		22	17	12		14		2234.99	0.362
19588A		42	31	16	12	59		2187.93	0.373
15162A		23	48	15	176	65	30	2178.78	0.384
69595A		7	73	23		15		2127.89	0.394
17578A		65	63	47	18	42	103	2027.08	0.404
T7576A								1906.90	0.414
74521A		21	34	13		34	46	1894.49	0.423
15359A		16	36	18		64		1690.43	0.432
26183A		11	35	24		48		1680.61	0.440
17402A		30	90	25	11	39	44	1662.46	0.448
15641A		35	45	22		193	7	1654.54	0.456
16019A		46	39	40	10	18	191	1633.71	0.464

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TABLE 7.1.2-1

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PROCESS CHARACTERIZATION

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PART CONTROL NUMBER	MANPGP SEQUENCE	MANPGW SEQUENCE	MANPNA SEQUENCE	MANPRA SEQUENCE	MANPRB SEQUENCE	MANPRC SEQUENCE	MANPWW SEQUENCE	EARNED HOURS	PERCENT OF EARNED HOURS
17557A	4	17	55	29	19	26		1575.78	0.472
17478A	55		3					1559.86	0.480
T4885I			64	38	13	240	20	1559.04	0.487
15068A	24	45	49	44	38	24	69	1508.12	0.495
74692A	18	56	192	91		220	97	1474.91	0.502
25874A	7	27	79	34		91		1472.57	0.509
68521A	32	5	80	71	9	21		1463.73	0.517
25737A	33	126	42	26	16	38	72	1342.79	0.523
17577A		47	102	64		152		1330.45	0.530
62905A	20	6	51	37	22	22		1298.94	0.536
19844A	87	49	71	46	79	318	26	1275.75	0.542
15295A	14	40			88	5	14	1241.53	0.549
74805A			71		23	27		1230.31	0.555
17239A	106	53	50	41	27	30		1131.17	0.560
17327A	122	51	61	33	27	30		1100.24	0.566
19937A	58	74	101	36	21	44		1069.49	0.571
17357A	71	26	27		44	19		1066.71	0.576
15054A	27	25	98	30	84	146		1061.11	0.581
74516A	141	95	104	19	82	62	85	1049.96	0.587
M9662K					4	51		990.91	0.592
15139A	47	32	147	53		31		969.84	0.596
15523A	137	43	172	20		131	250	968.16	0.601
15161A	36	67	94	27	110	164	90	876.01	0.605
62923A	66	37	87	28		100		847.68	0.610
17451A	139	66	68	62	37	28		828.28	0.614
15752A	29	52	143	31	130	263		812.15	0.618
17354A	94	58	100	101	24	32		806.90	0.622
15485A	63	33	59	100		33		803.50	0.626
00129B	190		10			72	11	754.50	0.629

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TASK ORDER NO. 1
PROCESS CHARACTERIZATION

OGDEN 80/20 SORTED BY TOTAL HOURS
TABLE 7.1.2-1

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PART CONTROL NUMBER	MANPGP SEQUENCE	MANPGW SEQUENCE	MANPNA SEQUENCE	MANPRA SEQUENCE	MANPRB SEQUENCE	MANPRC SEQUENCE	MANPWW SEQUENCE	EARNED HOURS	PERCENT OF EARNED HOURS
26338A	59	36	83		48	35		746.53	0.633
25425A	46	31	106	60		110		745.61	0.637
72898A	85	28	152	39		95		740.77	0.460
15757A	56	18	188	66		128	107	732.30	0.644
15327A	50	24	228	129		303	21	726.82	0.648
T5736I	48	55	75				13	707.24	0.651
15603A	52	50	114	50			73	672.35	0.654
26337A	370	59	117	42	54	52		666.92	0.658
14539A			20				8	665.96	0.661
M4631D							3	659.87	0.664
17313A	162	94	95	49	39	58	246	648.01	0.667
69324A		147	76	172		12		645.19	0.671
69657A	41	34	56	230		101		638.09	0.674
T5797J	13							630.31	0.677
16266A	42	39	165	73		145		626.30	0.680
17245A	81	97	69	56		53		625.32	0.683
T6295I	143	150	200	35	105	104	34	618.24	0.686
69855A	237	177	89	52		25		606.15	0.689
17348A	78	57	118		59	36		596.69	0.692
13822A						88	6	566.85	0.695
16123A	28	93	58	133		87		566.53	0.698
74568A	54	71	242	51		304	116	551.37	0.700
16264A	83	76	136	58		61		538.55	0.703
13829A			44				9	538.22	0.706
15526A	84	38	182	75		89		537.98	0.708
17474A	95	68	149	69	49	78		523.19	0.711
00199B	169		7				38	509.36	0.713
15387A	77	41	173	88		322	57	502.40	0.716
T7333Q							5	499.66	0.718

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OGDEN 80/20 SORTED BY TOTAL HOURS
TABLE 7.1.2-1

PART CONTROL NUMBER	MANPGP SEQUENCE	MANPGW SEQUENCE	MANPNA SEQUENCE	MANPRA SEQUENCE	MANPRB SEQUENCE	MANPRC SEQUENCE	MANPWW SEQUENCE	EARNED HOURS	PERCENT OF EARNED HOURS
T7266Q	91	133	88	134	31	85	4	499.66	0.721
72877A	73	44	213	106		79	125	496.12	0.723
15686A	79	137	111	43	136			490.77	0.726
26642A			103		14	90		487.13	0.728
15988A	68	64	236	65		127		480.77	0.730
16267A	115	87	123	114	89	41		479.10	0.733
17347A	86	114	77	72		75		471.29	0.735
T1302A	103	131	153	130	41	55	211	447.02	0.737
42626A	49	61	93				71	445.07	0.740
72896A			5					443.17	0.742
00458A	181	153	284	112	28	57		437.55	0.744
26111A	254		18			109	25	433.88	0.746
00119B	129	91	198	97	74	63	75	428.73	0.748
16297A	99	79	160	54		223		426.37	0.750
62922A	30	54						425.51	0.752
26413A	75	69	62			76		422.02	0.754
69549A	105	70	217	146	32	483	74	421.75	0.756
15583A		221	109		43	238	15	416.86	0.759
14781A	182		14			108	39	409.79	0.761
00109B	147	109	134	165	30	84		409.67	0.763
17407A			53		52	37		407.06	0.765
17631A	109	121	128	128	33	142		392.79	0.767
17527A		19	72					391.40	0.768
15592J	98	62	178	67				382.38	0.770
15746A			8					371.33	0.772
T4989Q	174		120	98	56	47	152	369.58	0.774
19938A	90	77		68		150		367.01	0.776
69136A	142	212	191	119	36	74		362.89	0.778
15866A								353.31	0.779

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PROCESS CHARACTERIZATION

OGDEN 80/20 SORTED BY TOTAL HOURS
TABLE 7.1.2-1

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PART CONTROL NUMBER	MANPGP SEQUENCE	MANPGW SEQUENCE	MANPNA SEQUENCE	MANPRA SEQUENCE	MANPRB SEQUENCE	MANPRC SEQUENCE	MANPWW SEQUENCE	EARNED HOURS	PERCENT OF EARNED HOURS
74652A	107	154	148	116	57	82	143	346.33	0.781
83317A	110	78	126	111		112	76	343.87	0.783
T6912A	271	201	455	78	40	77		341.83	0.784
74524A					17			340.98	0.786
74553A	124	84	132	76		122	10	340.34	0.788
15728A								336.28	0.789
69543A				32				328.29	0.791
72573A			115		35	50		327.61	0.793
63822A			158			40	47	322.91	0.794
17568A	113	92	209	229		56		318.87	0.796
74528A	193	180	223	48		216		311.59	0.797
M3009K						45	35	305.19	0.799
00473A		73	11					303.73	0.800
26411A	53		12					301.29	0.802
T4582Q								299.48	0.803
26176A						29		282.65	0.805
T5773J	31							275.26	0.806
69794A	72	115	119	122		316		274.35	0.807
74521A					20			272.04	0.809
M6276K			43			49		271.38	0.810
17476A	127	82	203	139	94	123		270.14	0.811
T5822J	35							263.29	0.813
13288A			46				32	255.84	0.814
26559A	60	89						254.99	0.815
T5802J	38							251.32	0.817
T5821J	40							247.33	0.818
94332A			91	74	137	97		245.80	0.819
M7871K				94		111	16	244.28	0.820
69554A	189	81						243.14	0.821

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OGDEN 80/20 SORTED BY TOTAL HOURS
TABLE 7.1.2-1

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TASK ORDER NO. 1
PROCESS CHARACTERIZATION

PART CONTROL NUMBER	MANPGP SEQUENCE	MANPGW SEQUENCE	MANPNA SEQUENCE	MANPRA SEQUENCE	MANPRB SEQUENCE	MANPRC SEQUENCE	MANPWW SEQUENCE	EARNED HOURS	PERCENT OF EARNED HOURS
M4586K								239.52	0.823
M4587K							17	239.52	0.824
T5817J	45						18	239.35	0.825
T5493I	43							239.35	0.826
T5530I	118	116	156				41	237.32	0.827
T6254A	283	182	222	105	65	80		234.55	0.828
T7601I	117	75	30	121	123	178		232.38	0.830
00141B		376	206	189	125	147	119	230.42	0.831
15519A	153	60	550	113	51	73	139	215.45	0.832
17567A	232	415		185	25	402	358	215.10	0.833
15698A	67	173			107		111	213.25	0.834
16283A			84	120		83		208.69	0.835
17396A			19					205.95	0.836
00131B	76	106					138	198.55	0.837
26560A			97		86			194.95	0.838
69828A						67		193.94	0.839
22642A			218		152	43		193.55	0.840
63819A					29	60	66	193.37	0.841
17595A								188.19	0.842
T5811J	57							187.49	0.843
00121B	236		57			194	59	183.49	0.844
36192A	152	72	186	204			113	182.61	0.844
T4452Q			22					180.54	0.845
63393A						66	56	180.30	0.846
13816A			164				28	179.32	0.847
T7600I	62		215	221	138	68		178.99	0.848
98929A					68			176.23	0.849
M4823K							22	176.07	0.850

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TABLE 7.1.2-1

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TASK ORDER NO. 1
PROCESS CHARACTERIZATION

PART CONTROL NUMBER	MANPGP SEQUENCE	MANPGW SEQUENCE	MANPNA SEQUENCE	MANPRA SEQUENCE	MANPRB SEQUENCE	MANPRC SEQUENCE	MANPWW SEQUENCE	EARNED HOURS	PERCENT OF EARNED HOURS
M7202K	61					46		172.05	0.851
T7582I	64							171.54	0.851
T9355I	65							167.55	0.852
T5846J								163.56	0.853
16214A				277	182	54		161.39	0.854
26727A								159.30	0.855
18133A							33	158.70	0.855
15746J		63						157.10	0.856
69603A								155.05	0.857
T1532I								150.80	0.858
T4971Q	235					139	31	150.69	0.858
00118B					47		42	143.91	0.859
69752A								133.22	0.860
14729A							36	126.90	0.860
T1385Q	223	85						125.15	0.861
T1386Q	227	86						125.15	0.862
T1434A		83			148	157		122.64	0.862
T1531I								118.94	0.863
62963A		265				70	247	117.97	0.863
M6966K							37	115.79	0.864
62964A		272				71	248	115.10	0.865
M6055K						69		115.08	0.865
13822A								114.69	0.866
63079A		218				81		107.00	0.866
15519J	80							99.00	0.867
001188								98.00	0.867
25584A								96.00	0.868
25638A							40	95.00	0.868
M6118K						388	43	93.00	0.869

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OGDEN 80/20 SORTED BY TOTAL HOURS
TABLE 7.1.2-1

PART CONTROL NUMBER	MANPGP SEQUENCE	MANPGW SEQUENCE	MANPNA SEQUENCE	MANPRA SEQUENCE	M/.NPRB SEQUENCE	MANPRC SEQUENCE	MANPWW SEQUENCE	EARNED HOURS	PERCENT OF EARNED HOURS
T2733I			60					89.00	0.869
68769A			266				48	87.00	0.869
M1641K							45	87.00	0.870
T2532A			65					83.00	0.870
T5733N			66					81.00	0.871
M8586K						86		80.00	0.871
68661A			67					79.00	0.871
18365A			74		162	426	178	72.00	0.872
M1069K			70					70.00	0.872
18863A			81			427	186	62.00	0.872
14729A			78					59.00	0.873
A4141N			82					55.00	0.873
T1384I			86					53.00	0.873
T2709I							23	17.00	0.873
								<u>177130</u>	

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TASK ORDER NO. 1
PROCESS CHARACTERIZATION

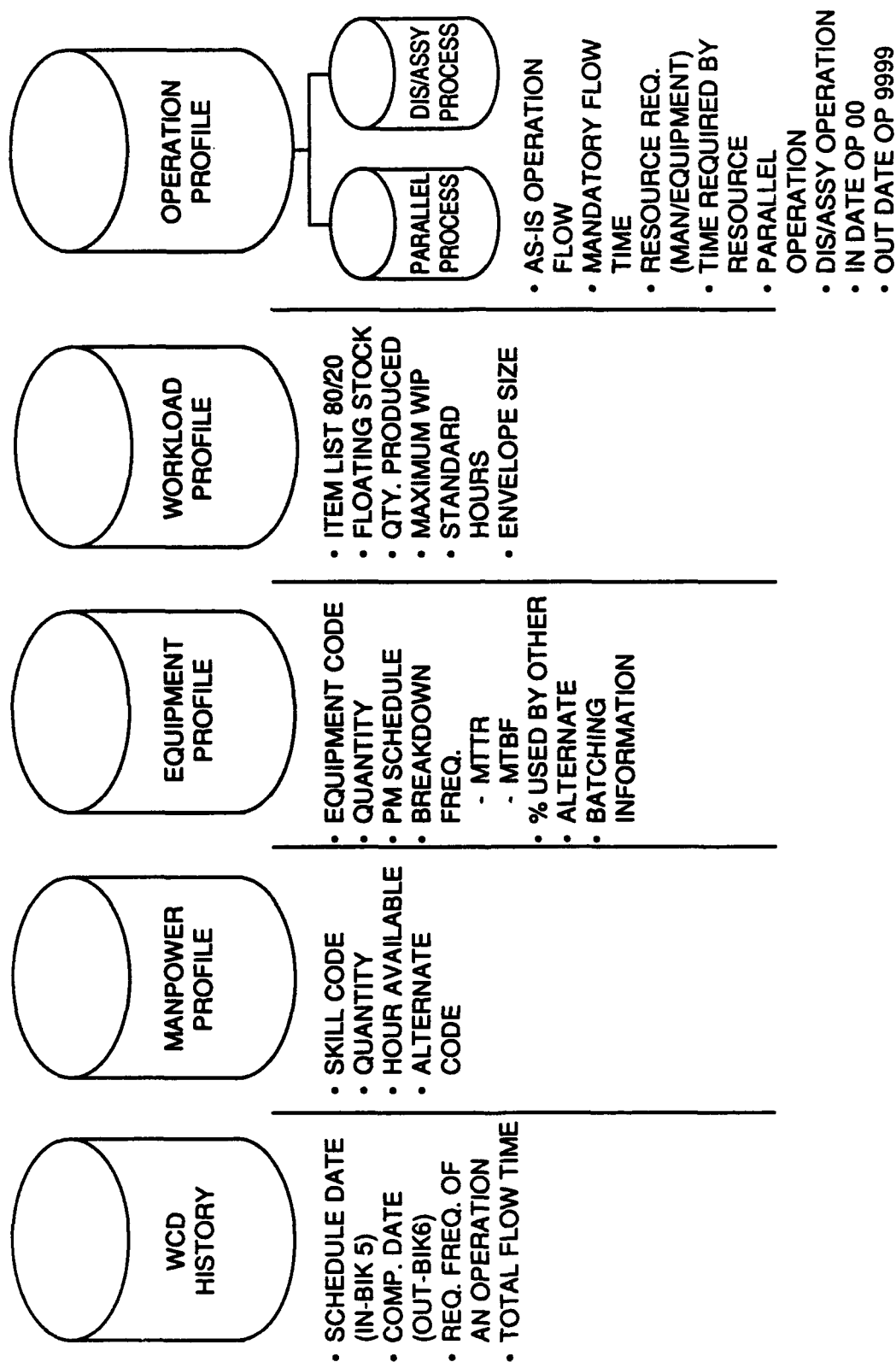
RCC. Data profile sheets were developed by the simulation modeling group to ensure that the necessary data and the data collected was consistent at all AFLC sites. A typical data bank for UDOS 2.0 showing each profiled item and the data needed to properly fill out each profile sheet is shown in Figure 7.1.2-1. The first step in data collection is to obtain the Work Control Documents (WCDs) for each PCN. It was quickly noticed that each PCN was averaging ten WCDs. Two hundred sixteen PCNs would produce 2,160 WCDs. MDMSC realized that it would be impossible to accurately process characterize 216 PCNs that involved over 2,160 WCDs.

A strategy session was held by the OO-ALC/MDMSC team to discuss the problem. It was determined that the seven RCCs chosen for process characterization support three product lines - aircraft wheels, brakes, and landing gear assemblies. The seven RCCs are designed and laid out in Buildings 505 and 507 to support three product lines. MDMSC proposed analyzing the 216 PCNs on the 80/20 list and determine how many of the PCNs were other work besides wheels, brakes, and landing gear assemblies. MDMSC proposed to process characterize the wheels, brakes, and landing gear components as families based on similar processes, similar flow cycle, standard hours to repair, and likeness of materials.

MDMSC analyzed the 80/20 listing of the 216 PCNs and determined the composition of workload for each RCC. See Table 7.1.2-2. MDMSC held a meeting with Air Force personnel, TI Program Manager, TI engineers, planners, schedulers, and production workers to determine proposed families (groupings) of wheels, brakes, and landing gears. MDMSC verified that these families of wheels, brakes, and landing gears met the criteria that was agreed upon by the OO-ALC/MDMSC team. See Tables 7.1.2-3 through 7.1.2-5 for the families of wheels, brakes, and landing gears.

A joint meeting by the OO-ALC/MDMSC team was held on 17 April 1989 to discuss process characterization of the seven RCCs at OO-ALC. MDMSC presented the families of wheels, brakes, and landing gears to be process characterized. MDMSC presented the breakdown of the workload for each

**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**



**TI DATA BANK/SIMULATION MODEL
FIGURE 7.1.2-1**

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PERCENT OF OTHER WORKLOAD FOR EACH RCC
(80/20 LISTING)

TABLE 7.1.2-2

JOB TYPES	MANPGP	MANPGW	MANPNA	MANPRA	MANPRB	MANPRC	MANPWW
MSTR (WHEELS, BRAKES, LANDING GEARS)	85.28	97.37	52.92	97.41	91.67	83.46	47.64
TEMPORARY	13.72	2.35	15.11	1.40	1.05	1.35	1.05
MANUFACTURE	0.00	0.00	0.92	0.00	4.51	2.74	12.50
PDM	1.00	0.00	22.79	0.04	0.07	4.39	22.44
ARMAMENT	0.00	0.23	1.26	0.04	0.03	4.18	2.38
HYDRAULICS	0.00	0.05	7.00	1.11	2.67	3.88	13.99

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WHEEL GROUPINGS TO BE PROCESS CHARACTERIZED
TABLE 7.1.2-3

FAMILY NO.	FAMILY CHARACTERISTICS	AIRCRAFT	STD. HRS. (MANPGP)
1	MAGNESIUM	KC-135N"	2.67
2	ALUMINUM - LARGE	B-52M	2.47
3	ALUMINUM - MEDIUM (MAIN WHEELS)	"KC-135M" A-10M, C-5M C-130M, C-141M E-34M, F-4M 4-5M, F-15M F-16M, F-100M F-106M, F-111M FB-111M	2.75
4	ALUMINUM - SMALL	"T-38N" A-10N, C-5N A-7N, C-130N E-3AN, F-4N	2.09

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BRAKE GROUPINGS TO BE PROCESS CHARACTERIZED
TABLE 7.1.2-4

FAMILY NO.	FAMILY CHARACTERISTICS	AIRCRAFT	STD. HRS. (MANPGP)
1	MAGNESIUM HOUSING - STEEL BRAKE	"B-52" A-37, F-106 T-33, F-100	6.59 6.20
2	ALUMINUM HOUSING - STEEL BRAKE	"KC-135" A-7D, T-38 T-39, F-111 F-5, A-10 C-130, C-141 E-3A	6.69 4.78 6.55, 6.41 5.68, 4.38 6.63
3	ALUMINUM HOUSING - BERYLLIUM BRAKE	"C-5A"	13.41
4	ALUMINUM HOUSING - CARBON BRAKE	"C-5B" F-15	13.41
5	ALUMINUM HOUSING - CARBON BRAKE - SPECIAL ASSEMBLY CHARACTERISTICS	"F-16"	7.16
6	ALUMINUM HOUSING - STEEL BRAKE, SINGLE ROTOR	"C-130"	6.63

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**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**

**LANDING GEAR GROUPINGS TO BE PROCESS CHARACTERIZED
TABLE 7.1.2-5**

FAMILY NO.	FAMILY CHARACTERISTICS	AIRCRAFT	STD. HRS. (MANPGP)
1	STEEL/STEEL	"F-15 MLG"	11.60
2	STEEL/STEEL	"C-141 NLG"	8.03
3	STEEL/STEEL	"KC-135 MLG" F-4 NLG C-130 NLG C-130 MLG F-111 MLG A-7 MLG F-4 MLG	6.09 5.44 4.81 3.29 5.29 3.35 4.75
4	ALUMINUM/STEEL	"F-15 NLG" F-16 NLG A-7 NLG T-38 MLG T-38 NLG	4.35 3.84 4.92 3.40 4.67
5	ALUMINUM/STEEL	"KC-135 NLG" C-141 NLG A-10 MLG F-111 NLG A-10 NLG	6.66 6.66 7.75 5.75 7.75
6	ALUMINUM/STEEL	B-52 MLG B-52 TIP	11.20
7	C-5 MLG STRUT ASSY	C-5	
8	C-5 MLG BOGIE ASSY	C-5	
9	C-5 NLG	C-5	

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PROCESS CHARACTERIZATION

RCC. See Table 7.1.2-2. The OO-ALC/MDMSC team agreed that characterizing the families of parts would accurately represent each RCC. It was agreed to process the wheels, brakes, and landing gears as product lines through the seven RCCs to represent the As-Is using the UDOS 2.0 model. The OO-ALC/MDMSC team agreed to only process characterize wheels, brakes, and landing gears through MANPNA and MANPWW. It was agreed that MDMSC would review the other functions of MANPNA and MANPWW for possible process improvement opportunities.

The operation profile sheets, disassembly/assembly profile sheets, and the parallel process profile sheets were developed for each PCN of the families of parts by interviewing the mechanics most familiar with the repair processes of that PCN. The WCDs were used as a guideline in the development of the operation profile sheets. The operation profile developed for each PCN represents the actual sequential repair process of a PCN. These developed operation profiles, in some instances, vary greatly from the WCD used for a PCN. The WCDs do not necessarily represent a sequential step by step repair process for a PCN. In some instances, the mechanics were not willing to give process times or occurrence factors for operations. The information that was needed was obtained from MRP reports of DMMIS.

The workload profile was developed for third and fourth quarter FY 88 and first and second quarter FY 89 using data from the G019C system that lists the number of completions per PCN for each quarter. To develop the workload quantities per family of parts, it was necessary to add the completions of all other aircraft parts within the family to the PCN that was process characterized.

The equipment profile for an RCC was the most difficult profile sheet to develop. Several techniques had to be used to gather equipment data like surveying each RCC to obtain the equipment code, interviewing mechanics for information, and reviewing data supplied by facilities engineering. The facilities engineering section provided MDMSC with two reports for analysis which were the preventative maintenance inventory report and the analysis report of trouble calls.

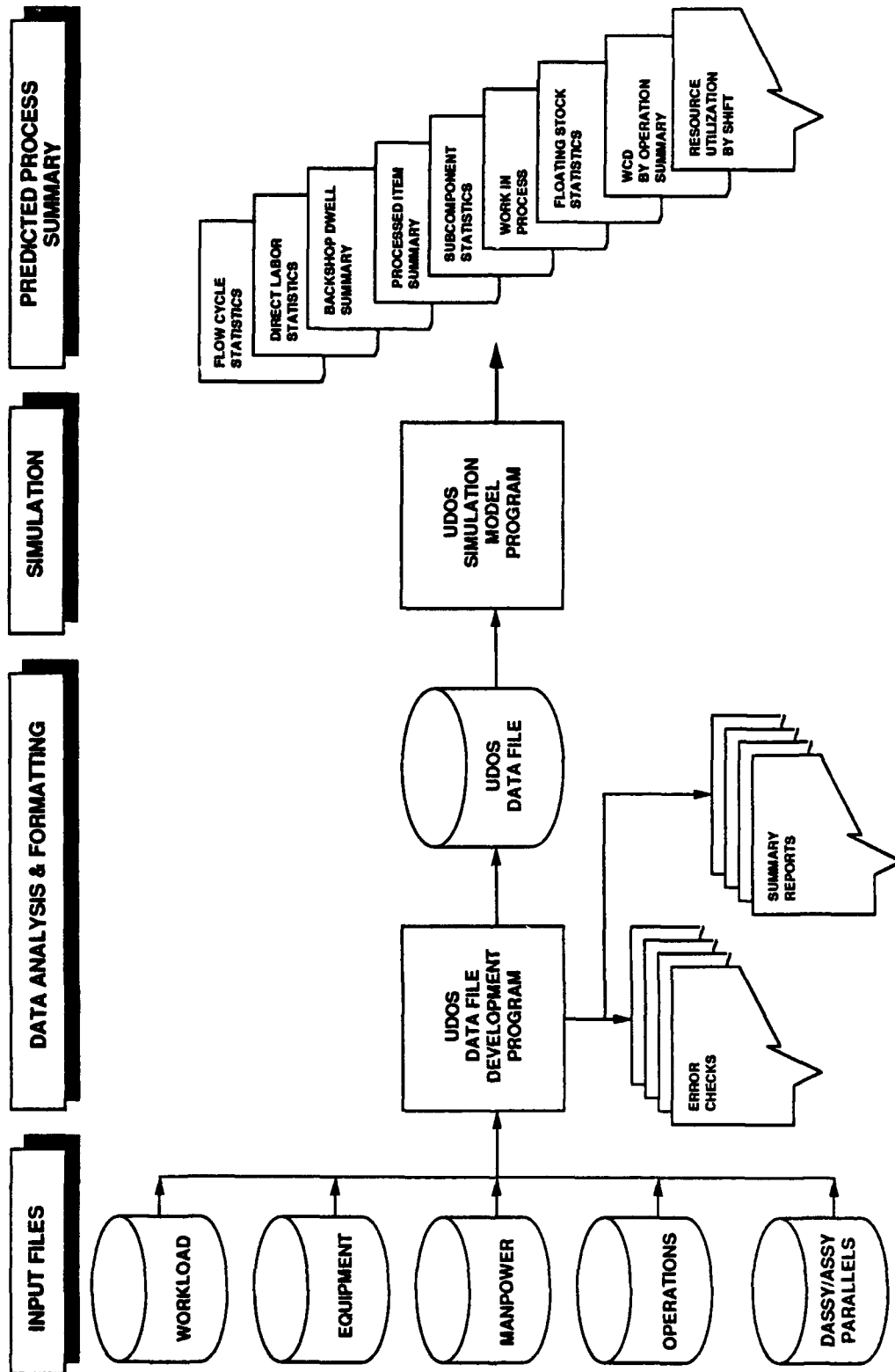
TASK ORDER NO. 1
PROCESS CHARACTERIZATION

A WCD historical profile was developed for each PCN of the families of parts for wheels, brakes, and landing gears. This was accomplished by gathering all of the completed WCDs for a PCN from the scheduling office. The scheduling office keeps completed WCDs for a minimum of one year. However, MDMSC did discover that scheduling throws away the WCDs for brake components. The only documents kept for brakes were for the brake housing and final assembly. The data that was necessary to develop a historical profile was entered into a MDMSC history program (software program). The history program developed average, minimum, and maximum flow times for a PCN and occurrence factors for each operation of a WCD.

Data processing involved the input of data from six different types of profile sheets into the UDOS data file development program and the generation of the UDOS 2.0 model flat files for the three product lines. See Figure 7.1.2-2 for data analysis and formatting. The data from the profile sheets was entered by data entry personnel at OO-ALC. Error checking reports were generated at MDMSC in St. Louis. The error reports were used to markup the printouts from the computer for correctness to the original data sheets. The SMDD Revision D, dated 8 December 1989, section 4.1.2, describes the data processing error checking reports in detail. This iteration was repeated until all of the errors had been corrected. The printout of the data entered into the computer was compared one last time for correctness to the original data sheets. This process is known as data verification. Dee Mackliet, USAF helped MDMSC with data verification from 24 July 1989 to 2 August 1989 in St. Louis. The final step in data verification is to convert the data into model flat files for use by UDOS 2.0.

The UDOS 2.0 was used to generate pre-validation simulation runs. These runs were checked for obvious errors in the output statistics. The database was corrected as required. A typical example is the wrong number (shortage) of manpower by skill code and level in the database, causing excessive queues and long flow times for a PCN. This process was repeated until all of the obvious errors were corrected and the output statistics were preliminarily

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UNIVERSAL DEPOT OVERHAUL SIMULATOR (UDOS 2.0) FUNCTIONAL FLOW DIAGRAM
FIGURE 7.1.2-2

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determined realistic. This final run of UDOS 2.0 database was used to start the validation process.

Validation of the simulation results of UDOS 2.0 for aircraft wheels, brakes, and landing gears was determined using the following procedure:

- Definition of Validation
- Determination of Validation Criteria
- List of Assumptions
- Analysis of Output Data by PCN
- Conclusion

Validation by definition is the determination by the OO-ALC/MDMSC team that the simulation results (output statistics) of UDOS 2.0 emulates the As-Is for wheels, brakes, and landing gears based on the validation criteria and the assumptions that were made during data collection.

The following criteria were agreed upon by the OO-ALC/MDMSC team for validating the repair/refurbishment process for aircraft wheels, brakes, and landing gears:

- Verify Model Logic and Validate Database - Ensuring the interaction of the model logic and collected data mimics the real system. Running the simulation, comparing the model's output with real world behavior, and altering database as appropriate.
- Throughputs - Comparison of historical outputs per Production Control Number (PCN) of RCC MANPGP from fourth quarter FY 88 through third quarter FY 89 to simulated results of the UDOS 2.0 model.
- Flow times - Comparison of historical (WCD) flow time (hrs) to simulated flow time for each PCN.

Assumptions made during data collection had to be reviewed with the validation criteria to determine if the UDOS 2.0 simulated results emulates the repair/refurbishment process for aircraft wheels, brakes, and landing gears. The following is the list of assumptions that were made during data collection:

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- All repair parts are available to production personnel. Supply shortages are not considered by the model.
- Undocumented rework is not considered in the model.
- Condemnation, at any level, is not considered in the model.
- Management decisions to prioritize specific end items within the end item classification were not considered; i.e., all MISTR items have equal priority.
- Delays due to engineering support are not considered in the model.
- Model assumes that personnel are available for the adjusted manpower availability factor and not reassigned during the hours available.
- The inductions to the model are random, it does not mirror the induction schedule of the RCCs.
- The model will form a batch of any parts waiting when a minimum threshold is reached. This may not accurately reflect the batching of like parts in the machine shop. The model will utilize equipment when available.
- Informal batching is not recognized by the model.
- The queuing discipline is First-In First-Out (FIFO).
- The model does not consider interruptions to production such as T jobs to induct end items to rob parts needed by production to meet quota.

The workload/manpower was configured for each RCC based on the percentage of the workload for the RCC that was aircraft wheels, brakes, and landing gears. The following is the manpower criteria for each RCC:

- MANPGW - 100% of the people available for work were used as input data for each quarter as the aircraft wheels, brakes, and landing gears represent 97% of the workload.
- MANPGP - 100% of the people available for work were used as input data for each quarter as the aircraft wheels, brakes, and landing gears represent 99% of the workload.
- MANPRA - 100% of the people available for work were used as input data for each quarter as the aircraft wheels, brakes, and landing gears represent 97% of the workload.

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- MANPRB - 100% of the people available for work were used as input data for each quarter as the aircraft wheels, brakes, and landing gears represent 92% of the workload.
- MANPRC - 100% of the people available for work were used as input data for each quarter as the aircraft wheels, brakes, and landing gears represent 83% of the workload.
- MANPNA - The number of people available to work aircraft wheels, brakes, and landing gears was used as input data for each quarter.
- MANPWW - The number of people available to work aircraft wheels, brakes, and landing gears was used as input data for each quarter.

The analysis of the simulated results of UDOS 2.0 for throughput and flow times statistics are shown in Tables 7.1.2-6 through 7.1.2-11. The tables show the results for the final assembly of aircraft wheels, brakes, and landing gears. See the validation section of the DDB for the analysis of throughput and flow times for the components that make up the assemblies of aircraft wheels, brakes, and landing gears.

The OO-ALC/MDMSC team agreed that the UDOS 2.0 model accurately represents the repair/refurbishment processes of aircraft wheels, brakes, and landing gears under idealistic conditions. However, idealistic conditions do not exist as demonstrated by the differences between historical and simulated flow times. The OO-ALC/MDMSC team investigated the causes for the differences between historical and simulated flow times for each PCN. The OO-ALC/MDMSC team determined several causes why the differences in flow times were present. Following are some of the causes identified:

- Parts shortage/parts robbing
- Engineering support
- Informal batching of parts
- Management decisions - scheduling
- Undocumented rework

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PCN THROUGHPUT ANALYSIS - WHEELS
TABLE 7.1.2-6

PART CONTROL NUMBER (PCN)	ACTUAL THROUGHPUT	SIMULATED THROUGHPUT	DIFFERENCE	PERCENT DIFFERENCE	RATIONALE/COMMENT
16367A F-4 NOSE WHEEL	1004	1015	11	1.08	DIFFERENCE IS DUE TO SIMULATION WARMUP PERIOD, WHEN STATS WERE CLEARED AT 65 DAYS - PARTS WERE IN SYSTEM TO BE COMPLETED.
90101A C-5 MAIN WHEEL	7624	7670	46	.60	DIFFERENCE IS DUE TO SIMULATION WARMUP PERIOD, WHEN STATS WERE CLEARED AT 65 DAYS - PARTS WERE IN SYSTEM TO BE COMPLETED.
69595A B-52 MAIN WHEEL	888	902	14	1.55	DIFFERENCE IS DUE TO SIMULATION WARMUP PERIOD, WHEN STATS WERE CLEARED AT 65 DAYS - PARTS WERE IN SYSTEM TO BE COMPLETED.
15592A KC-135 NOSE WHEEL	332	318	14	4.40	PARTS ARE RANDOMLY INDUCTED THROUGHOUT THE QTR. USING UDOS 2.0. INSTEAD OF ALL PARTS BEING INDUCTED AT THE BEGINNING OF THE QUARTER AS ON THE SHOP FLOOR - NOT SIGNIFICANT.

DIFFERENCE = ACTUAL THROUGHPUT - SIMULATED THROUGHPUT

PERCENT DIFFERENCE = $\frac{\text{ACTUAL THROUGHPUT} - \text{SIMULATED THROUGHPUT}}{\text{SIMULATED THROUGHPUT}} \times 100$

ONLY THE FINAL ASSEMBLY STATISTICS ARE SHOWN IN THE ABOVE TABLE FOR EACH PCN. SEE THE DDB VALIDATION SECTION FOR THE STATISTICS FOR THE INDIVIDUAL COMPONENTS.

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PCN FLOWTIME ANALYSIS - WHEELS
TABLE 7.1.2-7

PART CONTROL NUMBER (PCN)	ACTUAL FLOWTIMES (HRS)	SIMULATED FLOWTIMES (HRS)	DIFFERENCE (HRS)	PERCENT DIFFERENCE	RATIONALE/COMMENT
16267A F-4 NOSE WHEEL	1676.5	263.26	1413.0	536.82	MAJOR BOLT AND NUT PROBLEM DURING PROCESS CHARACTERIZATION STUDY.
90101A C-5 MAIN WHEEL	627.5	116.64	511.0	437.98	WAITING AT MATCHUP FOR BUSHING. NO VENDOR TO MAKE BUSHING. PROBLEM FOR 1 YR. INBD HALF BUSHING; 488 WHEELS QTR FOR MINIMUM OF 1 YR. RUNNING 750 WHEELS TO PROCESS 488 WHEELS 47% REJECT RATE; WORKAROUND 3RD QTR. 88 IS FIRST TIME MEET NEGOTIATED IN 4 QTRS. WAITING ENGINEERING SUPPORT.
68595A B-52 MAIN WHEEL	652.0	125.30	527.0	421.06	BEARING CUP PROBLEM DURING STUDY. RESOLVED. BUSHING PROBLEM ON B-52. WAITING MATCHUP FOR PARTS.
15592A KC-135 NOSE WHEEL	2500.7	536.68	1964.0	365.96	BEARING BORE BUSHING WAITING AT MATCHUP.

DIFFERENCE = ACTUAL FLOWTIME - SIMULATED FLOWTIME

PERCENT DIFFERENCE = $\frac{\text{ACTUAL FLOWTIME} - \text{SIMULATED FLOWTIME}}{\text{SIMULATED FLOWTIME}} \times 100$

ONLY THE FINAL ASSEMBLY STATISTICS ARE SHOWN IN THE ABOVE TABLE FOR EACH PCN. SEE THE DDB VALIDATION SECTION FOR THE STATISTICS FOR THE INDIVIDUAL COMPONENTS.

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PCN THROUGHPUT ANALYSIS - BRAKES
TABLE 7.1.2-8

PART CONTROL NUMBER (PCN)	ACTUAL THROUGHPUT	SIMULATED THROUGHPUT	DIFFERENCE	PERCENT DIFFERENCE	RATIONALE/COMMENT
68735A F-15	67	67	0.0	0.00	DIFFERENCE IS DUE TO SIMULATION WARMUP PERIOD, WHEN STATS WERE CLEARED AT 65 DAYS - PARTS WERE IN SYSTEM TO BE COMPLETED.
25674A F-16	441	445	4.0	0.90	DIFFERENCE IS DUE TO SIMULATION WARMUP PERIOD, WHEN STATS WERE CLEARED AT 65 DAYS - PARTS WERE IN SYSTEM TO BE COMPLETED.
15068 B-52	445	454	9.0	1.98	DIFFERENCE IS DUE TO SIMULATION WARMUP PERIOD, WHEN STATS WERE CLEARED AT 65 DAYS - PARTS WERE IN SYSTEM TO BE COMPLETED.
15053A C-130	236	239	3.0	1.26	DIFFERENCE IS DUE TO SIMULATION WARMUP PERIOD, WHEN STATS WERE CLEARED AT 65 DAYS - PARTS WERE IN SYSTEM TO BE COMPLETED.
15698A C-5A	46	52	6.0	11.54	DIFFERENCE IS DUE TO SIMULATION WARMUP PERIOD, WHEN STATS WERE CLEARED AT 65 DAYS - PARTS WERE IN SYSTEM TO BE COMPLETED.
15162A KC-135	1380	1384	4.0	0.29	DIFFERENCE IS DUE TO SIMULATION WARMUP PERIOD, WHEN STATS WERE CLEARED AT 65 DAYS - PARTS WERE IN SYSTEM TO BE COMPLETED.

DIFFERENCE = ACTUAL THROUGHPUT - SIMULATED THROUGHPUT

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PERCENT DIFFERENCE = $\frac{\text{ACTUAL THROUGHPUT} - \text{SIMULATED THROUGHPUT}}{\text{SIMULATED THROUGHPUT}} \times 100$

ONLY THE FINAL ASSEMBLY STATISTICS ARE SHOWN IN THE ABOVE TABLE FOR EACH PCN. SEE THE DDB VALIDATION SECTION FOR THE STATISTICS FOR THE INDIVIDUAL COMPONENTS.

PCN FLOWTIME ANALYSIS - BRAKES
TABLE 7.1.2-9

PART CONTROL NUMBER (PCN)	ACTUAL FLOWTIMES (HRS)	SIMULATED FLOWTIMES (HRS)	DIFFERENCE (HRS)	PERCENT DIFFERENCE	RATIONALE/COMMENT
68735A F-15	5882.00	692.04	5190.0	749.95	LACK OF ENGINEERING UNDERSTANDING HEAT DAMAGE TO HOUSING. REWORK OF CARBON STACK.
25874A F-16	2638.20	337.22	2301.0	682.34	REWORK OF CARBON STACK. PARTS PROBLEM. NEW WEAPON SYSTEM - NO SPARES.
15068A B-52	961.00	365.20	596.0	163.14	MAGNESIUM CASTING EXTREME WORK DUE TO CORROSION, TANK PROBLEM FOR DOW 7, DOWNTIME WITH IMPREGATION TANK, PARTS PROBLEM WITH PISTONS, HIGH REPLACEMENT OF PARTS.
15053A C-130	3491.28	359.28	3132.0	871.96	SINGLE ROTOR BRAKE. PARTS PROBLEM KITS. INDIVIDUAL PARTS. PARTS ROBBING. PRESSURE PLATE. BACKING PLATE HIGH CONDEMNATION RATE.
15068A C-5	1366.30	673.07	693.0	103.00	BERYLLIUM BRAKE TOXIC. SPECIAL WORK CONDITIONS SHUTDOWN OF FACILITIES DUE TO TOXIC SUBSTANCE. PEOPLE PROBLEM ENVIRONMENTAL, PARTS, MACHINE SHOP, PRIORITIZING OF WORKLOAD.
15162A KC-135	3137.80	203.85	2934.0	1439.27	PARTS PROBLEM; HIGH REPLACEMENT OF PARTS. RECLAIM SMALL PARTS NOT TRUE INDUCTIONS OF REPLACEMENT PARTS.

DIFFERENCE = ACTUAL FLOWTIME - SIMULATED FLOWTIME

$$\text{PERCENT DIFFERENCE} = \left| \frac{\text{ACTUAL FLOWTIME} - \text{SIMULATED FLOWTIME}}{\text{SIMULATED FLOWTIME}} \right| \times 100$$

ONLY THE FINAL ASSEMBLY STATISTICS ARE SHOWN IN THE ABOVE TABLE FOR EACH PCN. SEE THE DDB VALIDATION SECTION FOR THE STATISTICS FOR THE INDIVIDUAL COMPONENTS.

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**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**

**PCN THROUGHPUT ANALYSIS - MAIN LANDING GEAR
TABLE 7.1.2-10 (SHEET 1 OF 2)**

PART CONTROL NUMBER (PCN)	ACTUAL THROUGHPUT	SIMULATED THROUGHPUT	DIFFERENCE	PERCENT DIFFERENCE	RATIONALE/COMMENT
60657A KC-135 MLG	519	101	418.0	413.66	PLATING SHOP BACK-UP AND BAKE OVEN BOTTLENECK. PLATING PROBLEMS WITH KC-135 MAIN AXLE. FLOATING STOCK IS USED TO MAKE PRODUCTION.
74652A C-5 MLG	81	74	7.0	8.47	PLATING SHOP BOTTLENECK AND BAKE OVEN. FLOATING STOCK USED TO MEET PRODUCTION.
74692A C-5 BOGIE ASSY	20	16	4.0	25.00	PLATING SHOP BOTTLENECK AND BAKE OVEN. FLOATING STOCK USED TO MEET PRODUCTION.
17143A B-52 MLG	143	136	7.0	5.15	PLATING SHOP BOTTLENECK AND BAKE OVEN. FLOATING STOCK USED TO MEET PRODUCTION.
17402A F-15 NLG	193	166	27.0	16.27	PLATING SHOP BOTTLENECK AND BAKE OVEN. FLOATING STOCK USED TO MEET PRODUCTION.
72877A C-5 NLG	7	9	2.0	22.22	PLATING SHOP BOTTLENECK AND BAKE OVEN. FLOATING STOCK USED TO MEET PRODUCTION.
60354A KC-135 NLG	193	186	7.0	3.76	PLATING SHOP BOTTLENECK AND BAKE OVEN. FLOATING STOCK USED TO MEET PRODUCTION.
74521A C-141 NLG	62	56	6.0	10.71	PLATING SHOP BOTTLENECK AND BAKE OVEN. FLOATING STOCK USED TO MEET PRODUCTION.

DIFFERENCE = ACTUAL THROUGHPUT - SIMULATED THROUGHPUT

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PERCENT DIFFERENCE = $\frac{\text{ACTUAL THROUGHPUT} - \text{SIMULATED THROUGHPUT}}{\text{SIMULATED THROUGHPUT}} \times 100$

ONLY THE FINAL ASSEMBLY STATISTICS ARE SHOWN IN THE ABOVE TABLE FOR EACH PCN. SEE THE DDB VALIDATION SECTION FOR THE STATISTICS FOR THE INDIVIDUAL COMPONENTS.

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**PCN THROUGHPUT ANALYSIS - MAIN LANDING GEAR
TABLE 7.1.2-10 (SHEET 2 OF 2)**

PART CONTROL NUMBER (PCN)	ACTUAL THROUGHPUT	SIMULATED THROUGHPUT	DIFFERENCE	PERCENT DIFFERENCE	RATIONALE/COMMENT
26338A F-15 MLG	42	33	9.0	27.27	PLATING SHOP BOTTLENECK AND BAKE OVEN. FLOATING STOCK USED TO MEET PRODUCTION.
17576A C-8 MLG	41	40	1.0	2.50	PLATING SHOP BOTTLENECK AND BAKE OVEN. FLOATING STOCK USED TO MEET PRODUCTION.

DIFFERENCE = ACTUAL THROUGHPUT - SIMULATED THROUGHPUT

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PERCENT DIFFERENCE = $\frac{\text{ACTUAL THROUGHPUT} - \text{SIMULATED THROUGHPUT}}{\text{SIMULATED THROUGHPUT}} \times 100$

ONLY THE FINAL ASSEMBLY STATISTICS ARE SHOWN IN THE ABOVE TABLE FOR EACH PCN. SEE THE DDB VALIDATION SECTION FOR THE STATISTICS FOR THE INDIVIDUAL COMPONENTS.

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**PCN FLOWTIME ANALYSIS - MAIN LANDING GEAR
TABLE 7.1.2-11 (SHEET 1 OF 2)**

PART CONTROL NUMBER (PCN)	ACTUAL FLOWTIMES (HRS)	SIMULATED FLOWTIMES (HRS)	DIFFERENCE (HRS)	PERCENT DIFFERENCE	RATIONALE/COMMENT
69657A KC-135 MLG	2730.15	211.0	2519.15	92.27	KC-135 SHORTAGE OF LINK. HOLD UP ON PISTON, BACK SHOP PROBLEM
74652A C-5 MLG	772.78	0	—	—	HISTORICAL DATA NOT AVAILABLE FOR PARENT WCD. PARTS SHORTAGE, BATCHING OF PARTS BY MACHINE SHOP.
74692A C-5 BOGIE ASSY	1574.79	0	—	—	HISTORICAL DATA NOT AVAILABLE FOR PARENT WCD. SIX MONTH PLATING SHOP TURNAROUND BATCHING OF PARTS IN MACHINE SHOP. MINIMUM OF EIGHT PARTS BEFORE STARTING WORK. PARTS SUPPORTABILITY (LITTLE PARTS) NO FOLLOW-UP. USE OF FLOATING STOCK TO MAKE END ITEM OUT THE DOOR.
17143A B-52 MLG	699.86	685.6	16.00	2.04	FLOATING STOCK FROM CAGE IS UTILIZED. BATCHING OF PARTS IN MACHINE SHOP. BASHING REQUIRE MAJOR REWORK. STEERING PLATES REQUIRE A LOT OF NEW BUSHINGS. 139 DAYS TO PROCESS PARTS SHORTAGE.
69354A KC-135 NLG	442.02	259.6	182.42	41.27	TRUNION PIN PROBLEM. PARTS SHORTAGE NEW AND USED. REWORK OF STEERING PIN HAD TO MATCHUP WITH COLLAR.
74521A C-141 NLG	973.06	630.5	342.56	35.20	REWORK OF BUSHINGS, OLDER AIRCRAFT MORE REWORK. BATCHING OF PARTS IN MACHINE SHOP. 100% REPLACEMENT OF BUSHINGS REWORK OF STEERING PLATES LONG TIME TO REWORK - MACHINE SETUP.
26338A F-15 MLG	2101.19	648.7	1452.00	69.13	F-15 MLG IS MORE COMPLICATED. BATCHING PARTS IN MACHINE SHOP PARTS SHORTAGE, PLATING SHOP - WAITING FOR CHROME.

DIFFERENCE = ACTUAL FLOWTIME - SIMULATED FLOWTIME

PERCENT DIFFERENCE = $\frac{\text{ACTUAL FLOWTIME} - \text{SIMULATED FLOWTIME}}{\text{SIMULATED FLOWTIME}} \times 100$

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ONLY THE FINAL ASSEMBLY STATISTICS ARE SHOWN IN THE ABOVE TABLE FOR EACH PCN. SEE THE DDB VALIDATION SECTION FOR THE STATISTICS FOR THE INDIVIDUAL COMPONENTS.

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**PCN FLOWTIME ANALYSIS - MAIN LANDING GEAR
TABLE 7.1.2-11 (SHEET 2 OF 2)**

PART CONTROL NUMBER (PCN)	ACTUAL FLOWTIMES (HRS)	SIMULATED FLOWTIMES (HRS)	DIFFERENCE (HRS)	PERCENT DIFFERENCE	RATIONALE/COMMENT
17576A C-5 MLG	1006.67	---	---	---	SIX MONTHS PLATING TURNAROUND MACHINE SHOP BATCHING OF PARTS MINIMUM OF EIGHT PARTS BEFORE MACHINE SHOP WILL WORK ON PARTS. PARTS SUPPORTABILITY - NO FOLLOW-UP USE OF FLOATING STOCK TO MAKE END ITEMS OUT THE DOOR.
17402A F-15 NLG	1173.96	575.4	599.00	50.99	MISMATCH OF PARTS. BACK SHOP, SET ASIDE UNTIL GET ENOUGH WORK (MACHINE SHOP) PARTS SHORTAGE.
72877A C-5 NLG	1305.82	348.0	957.82	73.35	SIX MONTHS PLATING SHOP TURNAROUND MACHINE SHOP BATCHING OF PARTS MINIMUM OF EIGHT PARTS BEFORE MACHINE SHOP WILL WORK ON PARTS. PARTS SUPPORTABILITY - NO FOLLOW-UP. USE OF FLOATING STOCK TO MAKE END ITEM OUT THE DOOR.

DIFFERENCE = ACTUAL FLOWTIME - SIMULATED FLOWTIME

PERCENT DIFFERENCE = $\frac{\text{ACTUAL FLOWTIME} - \text{SIMULATED FLOWTIME}}{\text{SIMULATED FLOWTIME}} \times 100$

**ONLY THE FINAL ASSEMBLY STATISTICS ARE SHOWN IN THE ABOVE TABLE FOR EACH PCN. SEE THE DDB VALIDATION
SECTION FOR THE STATISTICS FOR THE INDIVIDUAL COMPONENTS.**

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Each of the above causes extends the actual flow time to repair end items. This is not a consideration of the UDOS 2.0 model. For example, the C-5 wheels have a major parts shortage that is presently a year old. The Directorate of Material Management initiated a work around by inducting C-5 wheels from supply for the purpose of robbing the needed part and returning the C-5 wheels to supply in "X" condition. Another example is the lack of engineering support to disposition defects that are beyond the limits of Technical Order data. End items sit idle in the repair cycle until an engineer dispositions a fix for the defect. The delay time between when a request (Form 103) is initiated to engineering and when the request is answered is non-productive time that is included in the overall flow time.

An analysis of the operation by operation report revealed that the chrome plating process was a bottleneck in the repair/refurbishment of aircraft landing gears. The chrome plating process for aircraft landing gears had been suspected as a bottleneck from the industrial engineering assessment. Further analysis revealed that the three ovens used to bake parts to relieve hydrogen from steel parts is a secondary bottleneck in the repair/refurbishment of aircraft landing gears.

A brainstorming session was held on 24 October 1989 to develop the experimentation plan for OO-ALC. The following people were in attendance:

Andy Currie	USAF	Working Group Member
Stephanie Austin	USAF	Alternate Working Group Member
Dee Mackliet	USAF	TI Engineer
Mike Ploharz	USAF	TI Engineer
Trixie Brown	USAF	AFLC-HQ Deputy Program Manager
Gene Evans	MDMSC	MDMSC Site Leader
Steve Irvine	MDMSC	MDMSC Simulation Expert

Several ideas were discussed for experimentation using the UDOS 2.0 model. The following paragraphs will discuss what ideas were presented for experimentation, the rationale of why or why not the idea should be considered

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for experimentation, and under what conditions (limiting factors) should the idea be considered for experimentation.

T-Jobs - During validation, it was discovered that (three) temporary jobs had been created to induct C-5 wheels into disassembly (MANPGW) to rob component parts from the wheels so that these component parts could be used by assembly (MANPGP) to meet production quota.

The group wanted to assess the impact to production of entering T-Jobs into the system by observing the changes to the flow time and throughput of the other parts in the system. The group also wanted to develop the real cost associated by entering T-Jobs into production to rob parts. Two T-Job scenarios were discussed for experimentation:

- Induct parts into disassembly; continue to E/I; reassemble wheel halves and return to supply in "x" condition.
 - Make bushings for wheels in the machine shop.
 - The group visited production in Building 507 and talked to Paul Murray (MANPGP foreman) about making bushings for the C-5 wheels. He told the group that bushings were made in Building 510 machine shop. Also, the data was not readily available to the group to develop WCDs to manufacture the bushings.
-
- Action: The group decided not to experiment with the T-Job to make bushings because Building 510 machine shop was not one of the RCCs process characterized.

The only T-Job experiment would be to develop a WCD to induct C-5 wheels, remove component parts, reassemble wheel halves, and return to supply in "x" condition.

A cost analysis will be performed comparing the cost of the OO-ALC machine shop (Building 510) to make the bushing compared to the T-Job to rob the bushing. An additional cost

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analysis will be performed comparing the cost of buying the bushing to the T-Job to rob the bushing.

Haru Workload - OO-ALC is supposed to receive a workload from the Canadians to repair/refurbish wheels, brakes, and landing gears. Mike Ploharz had a list of aircraft that OO-ALC would repair/refurbish. A majority of these aircraft are already in the USAF museums across the country. It was determined that these parts could be added to the existing families that had been developed for wheels, brakes, and landing gears. The only information needed was workload data part quantities by quarter. Mike Ploharz tried diligently to obtain workload data for the Haru workload, but could not obtain it in sufficient detail.

- **Action:** Due to insufficient data being available for the workload, the group decided to eliminate the Haru Workload from experimentation.

T-56 Workload - The T-56 gearbox workload for the C-130 aircraft is presently being transferred in from SA-ALC.

The group wanted to determine the impact to flowtime and throughput by adding the T-56 workload to the present workload. The main effect will be in the plating shop (MANPRC) utilizing the chrome plating processes. The workload is 1.5 gear boxes per production day.

The baseline to compare all other experimentation against is the present workload and T-56 with the present manpower configuration (5-day week in MANPRC) as determined by the group.

MDMSC/OO-ALC developed generic WCDs for the different parts of the T-56 gear boxes by like processes. MDMSC/OO-ALC developed WCDs for the processes that affect the plating shop (MANPRC).

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- Action: MDMSC developed one experiment to measure the effects of other proposed experiments. The experiment used present workload and T-56 workload with the present manpower configuration (5-day week) for the plating shop (MANPRC).

T-56 will be part of the workload for all other experimentation.

HEEF 25 - Is a process change in chrome plating which will reduce processing times as much as 25%. OO-ALC is presently in the process of testing the validity of the HEEF 25 process by converting two tanks to this process.

The group wanted to determine the effects (flow time and throughput) of using the HEEF 25 on the workload.

- Action: An experimentation will be set up to determine the effects (flow time and throughput) of utilizing or not utilizing the HEEF 25 process. This will be accomplished using Taguchi experimentation design in which HEEF 25 is a control factor using two levels. The two levels are to use HEEF 25 or not to use HEEF 25.

Rework - Mike Ploharz related that the total rework for chrome plating was approximately 20%. Emphasis is being made to reduce the chrome rework to less than 6%. Mike Ploharz has been assigned to the plating shop (MANPRC) full time as a process engineer to help accomplish this task.

The group wants to determine the effects (flow time and throughput) of reducing rework from 20% to 5% in 5% increments on the workload.

- Action: An experiment will be set up to determine the effects (flow time and throughput) of reducing rework from 20% to 5% in 5% increments. This will be accomplished using Taguchi experimentation design in which rework is a control factor using

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four levels. The four levels are reducing rework from 20% to 5% in 5% increments.

Manpower - The plating shop is presently in the process of interviewing applicants for 30 additional personnel. The plating shop will be operating three shifts/day seven days a week with the addition of the new personnel.

The group wanted to determine the effects (flow time and throughput) of adding 30 people to the plating shop using four different scenarios. The four scenarios are; zero additional people five days a week; rearranging present number of people to seven days a week, adding 15 people seven days a week (actual manpower configuration to be determined by the plating shop), and adding 30 people seven days a week (actual manpower configuration to be determined by the plating shop).

- **Action:** An experiment will be set up to determine the effects (flow time and throughput) of adding additional people to the plating shop using four different scenarios. This will be accomplished using Taguchi experimentation design in manpower as a control factor using four levels. The four levels are the four different scenarios of utilizing people.

Taguchi methodology was used to design experiments for the different control factors at different levels chosen by the group to minimize the number of experiments which will yield meaningful results through analysis. The following are the Taguchi control factors and levels to be considered for experimentation:

<u>Control</u> <u>Factors</u>	<u>Levels</u>			
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
Manpower	0 ₅	0 ₇	15 ₇	30 ₇
Rework	20%	15%	10%	5%
HEEF 25	Yes	No		

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

0₅ zero additional people 5 days/week
0₇ zero additional people 7 days/week
15₇ 15 additional people 7 days/week
30₇ 30 additional people 7 days/week

Quality characteristics are flow time and throughput. MDMSC determined that the best Taguchi experimentation design to fit the data would utilize two L₄ arrays with an independent run for the HEEF 25 process. It was determined that the HEEF 25 process is independent of the other control factors and could be tested independently.

The reason for using two separate L₄ arrays was to test the interactions between schedule and manpower; and manpower and rework. Our experience in modeling other RCCs leads us to expect interactions between these factors. If these factors were combined in a single array it would have made analysis of the data unreliable because of the confounding of the interactions with the control factors. The two separate L₄ arrays are proposed for experimentation.

ARRAY NO. 1

<u>Manpower</u>	<u>Rework</u>	<u>Interaction</u>
0 ₇	5%	Manpower x Rework
0 ₇	20%	Manpower x Rework
30 ₇	5%	Manpower x Rework
30 ₇	20%	Manpower x Rework

0₇ = No additional people seven days a week/three shifts.
30₇ = Thirty additional people seven days a week/three shifts.

From this array an analysis can determine the effects of manpower and rework independently along with determining the interaction between manpower and rework.

**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**

ARRAY NO. 2

<u>Schedule</u>	<u>Manpower</u>	<u>Interaction</u>
0 ₅	5 ₅	(Schedule) x (Manpower)
0 ₅	15 ₅	(Schedule) x (Manpower)
0 ₇	5 ₇	(Schedule) x (Manpower)
0 ₇	15 ₇	(Schedule) x (Manpower)

- 5₅ = Five additional people five days a week/three shifts.
15₅ = Fifteen additional people five days a week/three shifts.
5₇ = Five additional people seven days a week/three shifts.
15₇ = Fifteen additional people seven days a week/three shifts.

From this array an analysis can determine the effects of manpower and schedule independently along with determining the interaction between manpower and schedule.

Conclusion: From the analysis of the two L₄ arrays plus the single factor experiment for the HEEF 25 process change, a recommendation can be made to best set each level for the control factor as determined by experimentation. A confirmation experiment will be developed to verify the recommendation.

The other experiments for OO-ALC:

- T-Job
- Surge
- T-56 + present workload using present manpower configuration (baseline)

Surge experimentation was attempted using the adjusted validation workload plus the additional T-56 workload OO-ALC is expecting to receive from SA-ALC in January 1990. It is assumed that manpower would be divided into two shifts working 12 hours a day, seven days a week. It is also assumed that equipment is available 24 hours a day, seven days a week. The validation workload plus

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

the T-56 workload quantities by quarter for each PCN were changed to reflect the surge factor for each aircraft model/type as provided by HQ-ALC. MDMSC executed the UDOS 2.0 model for surge experimentation. MDMSC aborted the UDOS 2.0 model for surge after 15 hours of CPU on a VAX 6210 (3 MIP) had only resulted in 104 hours of the required 10296 hours simulated time.

Surge experimentation on the VAX 6210 would have required at least 1485 CPU hours to execute the UDOS 2.0 model. The UDOS 2.0 model was building enormous queues for parts that were waiting on manpower and equipment resources that were not available for the increased workload that was required for surge. OO-ALC does not have the capacity to meet the surge requirement as provided by HQ-AFLC. MDMSC generated a usage report that identifies the hours that are required for each manpower and equipment resource that is required for the simulated workload. MDMSC generated a table showing each manpower and equipment resource and the required increase in capacity in percent to meet the surge requirements. See Table 7.1.2-12.

T-Job experimentation was performed by MDMSC using the UDOS 2.0 model. A real scenario was set-up using the C-5 wheel T-Job data that was collected during validation. A WCD was created to induct the wheels into disassembly (MANPGW), separate wheel halves, rob parts, reassemble wheel halves; and return to supply. Three hundred seventy-seven C-5 wheels were inducted each quarter to represent the T-Jobs. The results from this experimentation showed an increase in the overall flow time for the four wheel groupings as expected with no or little effect on the overall flow time for landing gears or brakes. The landing gear and brakes share few common resources with wheels. The wheel flow times for validation and the T-Job experiment are shown below.

RESOURCE REQUIREMENTS FOR SURGE
TABLE 7.1.2-12 (SHEET 1 OF 2)

RESOURCE, MANPOWER, OR EQUIPMENT CODE	NAME	REQUIRED INCREASE IN CAPACITY (PERCENT) X 100
PM6999	OVEN	7.89
HB05	FLUID SYS	1.14
JA	MACHINIST	1.21
WF08H	HEATRT	1.02
YK09	PNEUMECH	1.68
YK10	PNEUMECH	1.19
CHRPLT	CHROME PLATE	2.52
C00002	ROLLER CON	7.04
CE25	CRANE	1.17
PM0426	OVEN	7.69
FLO002	FORKLIFT	7.71
HP0001	HVD PRESS	1.13
PM0053	WAXTANK	1.16
PM0080	ENG LATHE	1.62
PM0303	DEGREASER	2.37
PM0416	BLASTBOOT	2.95
PM0435	BEARGOVEN	4.97
PM0616	A1/MAGCLE	2.38
PM0753	OVEN	9.58
PM0931	OVENLCONV	1.44
PM0936	OVENUCONV	2.00
PM0959	WHEELCONV	2.78
PM1309	CIN GRNDR	1.12
PM2576	RAD DRILL	2.04
PM4131	ENG LATHE	1.88

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TASK ORDER NO. 1
PROCESS CHARACTERIZATION

RESOURCE REQUIREMENTS FOR SURGE
TABLE 7.1.2-12 (SHEET 2 OF 2)

RESOURCE, MANPOWER, OR EQUIPMENT CODE	NAME	REQUIRED INCREASE IN CAPACITY (PERCENT) X 100
PM4563	BORE MILL	1.38
PM4720	OVENVAR	1.56
PM5288	ENG LATHE	1.52
PM5307	JIG GRNDR	1.57
PM5372	SHOTPEEN	2.28
PM5453	OVEN 4HR.	15.07
PM5454	OVEN 24HR.	31.35
PM5558D	TESTSTAND	1.65
PM5737	OVEN	21.73
PM5819P	505 PENTL	2.54
PM5849	NISPLATE	2.71
PM6600	SUR GRNDR	1.10
PM6654	BLANCHARD	1.35
PM6670	MAG-BOOTH	1.23
PM7215	HORZ MILL	1.73
PM7218	HORZ MILL	1.46
T.S.01	PREASYFIX	3.72
WA0002	WORKAREA2	6.13
WA0003	WORKAREA3	1.53
WA0004	WORKAREA4	1.43
WB0001	WORK BENC	1.12

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**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**

FLOW TIMES (SIMULATED HOURS)

Wheel <u>Grouping</u>	Validation <u>Results</u>	T-Job Experimentation <u>Results</u>	Percent <u>Difference</u>
16267A F-4N	212.48	252.02	18.60
90101A C-5M	103.69	114.36	10.29
69595A B-52M	110.88	123.04	10.96
15592A KC-135N	647.59	667.47	3.06

$$\text{Percent Difference} = \frac{\text{T-Job} - \text{Validation}}{\text{Validation}} \times 100$$

Experimentation confirms that inducting end items into the repair cycle at disassembly (MANPGW) to rob parts so that assembly (MANPGP) has parts to assemble end items has an effect on the overall flow time of end items that are repaired.

The true cost of not having parts available to assemble end items is the cost of performing the T-Job plus the additional cost of having the wheels in the repair cycle longer than required than if parts were available. The length of the repair cycle for each end item is a direct factor in determining the number of end items an item manager must keep in useable inventory. The shorter the repair cycle the fewer number of end items an item manager must keep.

Manpower loading in the plating, reduction in chrome rework, and the HEEF 25 process experimentation will be discussed in the following paragraphs.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

An analysis of the first L_4 array "Rework & Manpower" revealed that the combined throughput and flow times for all PCNs, wheels, brakes, and landing gears were only slightly affected by the addition of manpower in the plating shop. The reduction of rework for chrome from 20% to 5% had little effect on combined throughput for all the PCNs, wheels, brakes, and landing gears. A closer examination revealed that the influence of adding manpower and reducing chrome rework only affected the flow times of the landing gear PCNs.

The Taguchi statistical analysis of the L_4 array "Manpower & Rework" are shown in Tables 7.1.2-13 through 7.1.2-16. The interactions for "Manpower & Rework" are graphically displayed in Figure 7.1.2-3.

An analysis of the second L_4 array "Schedule and Manpower" revealed that the combined throughput and combined flow times for all PCNs were only slightly affected by the increase in manpower of 15 people. Changing from a five day work week to a seven day work week had little effect on the combined throughput for all the PCNs wheels, brakes, and landing gears but the combined flow times increased seven percent. The reason for the increase in flow time is that more landing gear components are being processed by the plating shop (MANPRC). Landing gear components are competing for like resources in the machine (MANPRA) and grinding (MANPRB) shops with wheels and brakes. The Taguchi statistical analysis of the L_4 array "Schedule & Manpower" are shown in Tables 7.1.2-17 through 7.1.2-20. The interactions for "Schedule & Manpower" are graphically displayed in Figure 7.1.2-4.

An analysis of the HEEF 25 process to the validation--T56 baseline revealed that the combined throughput for all PCNs did not change. The combined flow times for all PCNs increased approximately 13% because of the increase of landing gear components competing for like resources in the machine (MANPRA) and grinding (MANPRB) shops with wheels and brakes. A close analysis of the landing gear PCNs revealed a drastic improvement for the throughput of two PCNs 69657A (KC-135M) and 26338A (F-15M) from 5% to 17% and 26% to 100% respectively.

**L₄ TAGUCHI ORTHOGONAL ARRAY EXPERIMENTAL RESULTS
FOR ALL COMBINED PCNs
(WHEELS, BRAKES, AND LANDING GEARS)**

TABLE 7.1.2-13

EXP #	MANPOWER	REWORK	INTERACTION	% THROUGHPUT	FLOWTIME AVG
1	0 ₇	5%	MANPOWER X REWORK	93	675.2
2	0 ₇	20%	MANPOWER X REWORK	93	809.4
3	30 ₇	5%	MANPOWER X REWORK	94	728.1
4	30 ₇	20%	MANPOWER X REWORK	92	790.5

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LEVEL AVERAGES:

FOR 0₇ : (93 + 93) + 2 = 93 (675.2 + 809.4) + 2 = 742.3
 FOR 30₇ : (94 + 92) + 2 = 93 (728.1 + 790.5) + 2 = 759.3
 FOR 5% : (93 + 94) + 2 = 93.5 (675.2 + 728.1) + 2 = 701.7
 FOR 20% : (93 + 92) + 2 = 92.5 (809.4 + 790.5) + 2 = 800.0

BEST LEVEL : 0₇ 5%

**L₄ TAGUCHI ORTHOGONAL ARRAY EXPERIMENTAL
RESULTS - BRAKES**

TABLE 7.1.2-14

EXP #	MANPOWER	REWORK	INTERACTION	% THROUGHPUT	FLOWTIME AVG
1	0 ₇	5%	MANPOWER X REWORK	105	367.9
2	0 ₇	20%	MANPOWER X REWORK	106	322.3
3	30 ₇	5%	MANPOWER X REWORK	106	307.1
4	30 ₇	20%	MANPOWER X REWORK	105	324.8

LEVEL AVERAGES:

FOR 0₇ : (105 + 106) + 2 = 105.5
 FOR 30₇ : (106 + 105) + 2 = 105.5
 FOR 5% : (105 + 106) + 2 = 105.5
 FOR 20% : (106 + 105) + 2 = 105.5

(367.9 + 322.3) + 2 = 345.1
 (307.1 + 324.8) + 2 = 316.0
 (367.9 + 307.1) + 2 = 337.5
 (322.3 + 324.8) + 2 = 323.6

BEST LEVEL : 30₇ 20%

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**L₄ TAGUCHI ORTHOGONAL ARRAY EXPERIMENTAL
RESULTS - WHEELS**

TABLE 7.1.2-15

EXP #	MANPOWER	REWORK	INTERACTION	% THROUGHPUT	FLOWTIME AVG
1	0 ₇	5%	MANPOWER X REWORK	98	224.7
2	0 ₇	20%	MANPOWER X REWORK	100	196.2
3	30 ₇	5%	MANPOWER X REWORK	100	216.7
4	30 ₇	20%	MANPOWER X REWORK	99	198.0

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LEVEL AVERAGES:

FOR 0₇ : (98 + 100) + 2 = 99 (224.7 + 196.2) + 2 = 210.5
 FOR 30₇ : (100 + 99) + 2 = 99.5 (216.7 + 198.0) + 2 = 207.4
 FOR 5 % : (98 + 100) + 2 = 99 (224.7 + 216.7) + 2 = 220.7
 FOR 20% : (100 + 99) + 2 = 99.5 (196.2 + 198.0) + 2 = 197.1

BEST LEVEL : 30₇ 20%

**L₄ TAGUCHI ORTHOGONAL ARRAY EXPERIMENTAL
RESULTS - LANDING GEARS**

TABLE 7.1.2-16

EXP #	MANPOWER	REWORK	INTERACTION	% THROUGHPUT	FLOWTIME AVG
1	0 ₇	5%	MANPOWER X REWORK	84	1039.9
2	0 ₇	20%	MANPOWER X REWORK	83	1347.1
3	30 ₇	5%	MANPOWER X REWORK	84	1185.3
4	30 ₇	20%	MANPOWER X REWORK	82	1307.0

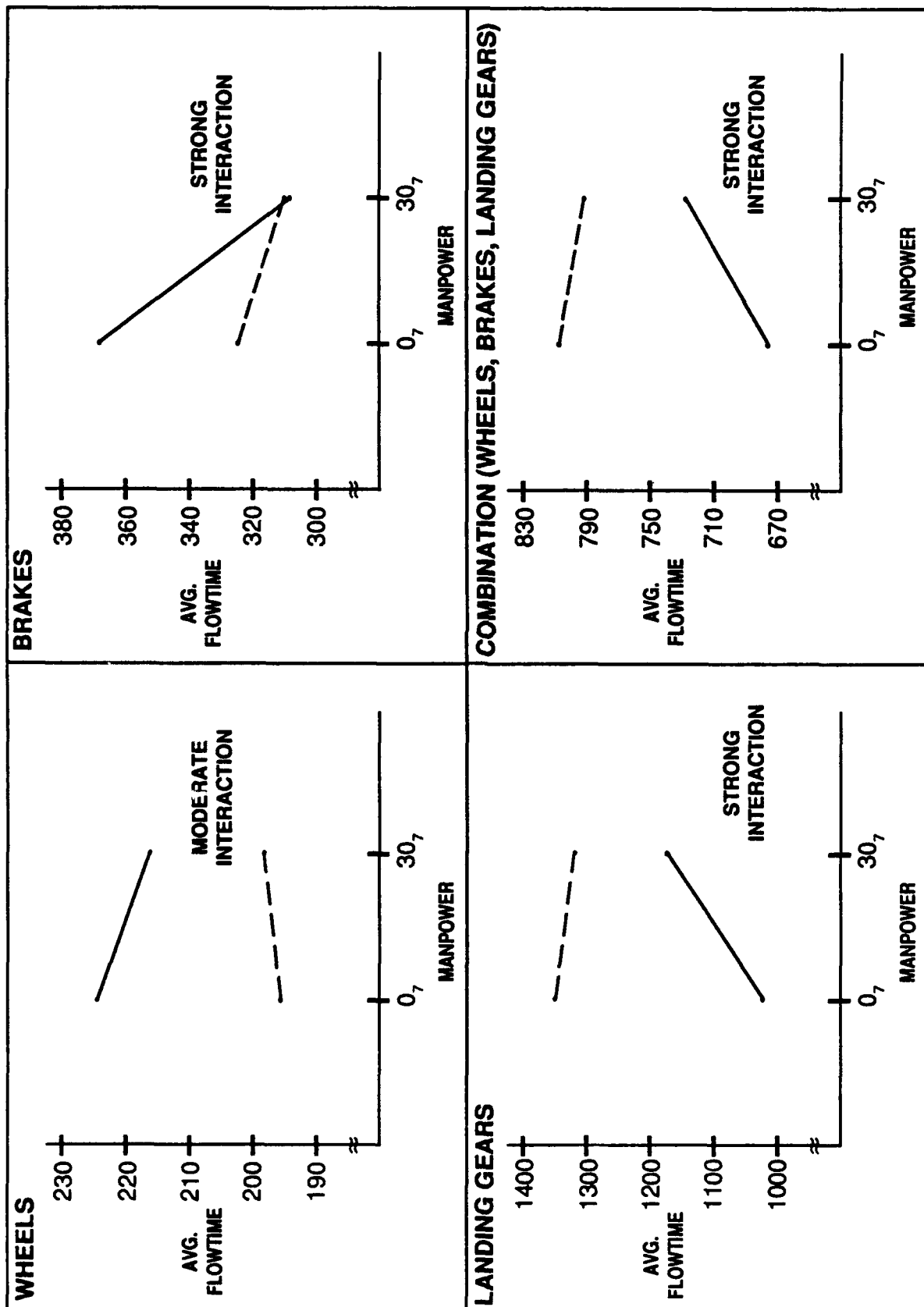
LSC-20688

LEVEL AVERAGES:

FOR 0₇ : (84 + 83) + 2 = 83.5 (1039.9 + 1347.1) + 2 = 1193.5
 FOR 30₇ : (84 + 82) + 2 = 83 (1185.3 + 1307.0) + 2 = 1246.2
 FOR 5 % : (84 + 84) + 2 = 84 (1039.9 + 1185.3) + 2 = 1112.6
 FOR 20% : (83 + 82) + 2 = 82.5 (1347.1 + 1307.0) + 2 = 1327.1

BEST LEVEL : 0₇ 5%

**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**



INTERACTION DIAGRAMS FOR MANPOWER VS. REWORK

FIGURE 7.1.2-3

LSC-20692

**L₄ TAGUCHI ORTHOGONAL ARRAY EXPERIMENTAL RESULTS
FOR ALL COMBINED PCNs
(WHEELS, BRAKES, AND LANDING GEARS)**

TABLE 7.1.2-17

EXP #	SCHEDULE	MANPOWER	INTERACTION	% THROUGHPUT	FLOWTIME AVG
1	0 ₅	5 ₅	SCHEDULE X MANPOWER	93	583.6
2	0 ₅	15 ₅	SCHEDULE X MANPOWER	93	608.6
3	0 ₇	5 ₅	SCHEDULE X MANPOWER	92	647.4
4	0 ₇	15 ₅	SCHEDULE X MANPOWER	95	628.0
AUG			SCHEDULE X MANPOWER	93.3	616.9

LEVEL AVERAGES:

FOR 0₅ : (93 + 93) + 2 = 93 (536.6 + 608.6) + 2 = 593.6
 FOR 0₇ : (92 + 95) + 2 = 93.5 (647.4 + 628.0) + 2 = 637.7
 FOR 5₅ : (93 + 92) + 2 = 92.5 (583.6 + 647.4) + 2 = 615.5
 FOR 15₅ : (93 + 95) + 2 = 94 (608.6 + 628.0) + 2 = 618.3

BEST LEVEL : 0₅ 15₅

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**L₄ TAGUCHI ORTHOGONAL ARRAY EXPERIMENTAL
RESULTS - WHEELS**

TABLE 7.1.2-18

EXP #	SCHEDULE	MANPOWER	INTERACTION	% THROUGHPUT	FLOWTIME AVG
1	0 ₅	5 ₅	SCHEDULE X MANPOWER	100	181.6
2	0 ₅	15 ₅	SCHEDULE X MANPOWER	99	171.2
3	0 ₇	5 ₅	SCHEDULE X MANPOWER	96	260.8
4	0 ₇	15 ₅	SCHEDULE X MANPOWER	99	266.9

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LEVEL AVERAGES:

FOR 0₅ : (100 + 99) + 2 = 99.5 (181.6 + 171.2) + 2 = 176.4
 FOR 0₇ : (96 + 99) + 2 = 97.5 (260.8 + 266.9) + 2 = 263.9
 FOR 5₅ : (100 + 96) + 2 = 98 (181.6 + 260.8) + 2 = 221.2
 FOR 15₅ : (99 + 99) + 2 = 99 (171.2 + 266.9) + 2 = 219.1

BEST LEVEL : 0₅ 15₅

**L₄ TAGUCHI ORTHOGONAL ARRAY EXPERIMENTAL
RESULTS - BRAKES**

TABLE 7.1.2-19

EXP #	SCHEDULE	MANPOWER	INTERACTION	% THROUGHPUT	FLOWTIME AVG
1	0 ₅	5 ₅	SCHEDULE X MANPOWER	106	296.3
2	0 ₅	15 ₅	SCHEDULE X MANPOWER	106	328.8
3	0 ₇	5 ₅	SCHEDULE X MANPOWER	105	358.3
4	0 ₇	15 ₅	SCHEDULE X MANPOWER	107	354.6

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LEVEL AVERAGES:

FOR 0₅ : (106 + 106) + 2 = 106
 (296.3 + 328.8) + 2 = 312.6
 FOR 0₇ : (105 + 107) + 2 = 106
 (358.3 + 354.6) + 2 = 356.5
 FOR 5₅ : (106 + 105) + 2 = 105.5
 (296.3 + 358.3) + 2 = 327.3
 FOR 15₅ : (106 + 107) + 2 = 106.5
 (328.8 + 354.6) + 2 = 341.7

BEST LEVEL : 0₅ 5₅

**L₄ TAGUCHI ORTHOGONAL ARRAY EXPERIMENTAL
RESULTS - LANDING GEARS**

TABLE 7.1.2-20

EXP #	SCHEDULE	MANPOWER	INTERACTION	% THROUGHPUT	FLOWTIME AVG
1	0 ₅	5 ₅	SCHEDULE X MANPOWER	73	1249.9
2	0 ₅	15 ₅	SCHEDULE X MANPOWER	73	1294.2
3	0 ₇	5 ₅	SCHEDULE X MANPOWER	73	1303.7
4	0 ₇	15 ₅	SCHEDULE X MANPOWER	77	1244.8

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LEVEL AVERAGES:

FOR 0₅ : (73 + 73) + 2 = 73

FOR 0₇ : (73 + 77) + 2 = 75

FOR 5₅ : (73 + 73) + 2 = 73

FOR 15₅ : (73 + 77) + 2 = 75

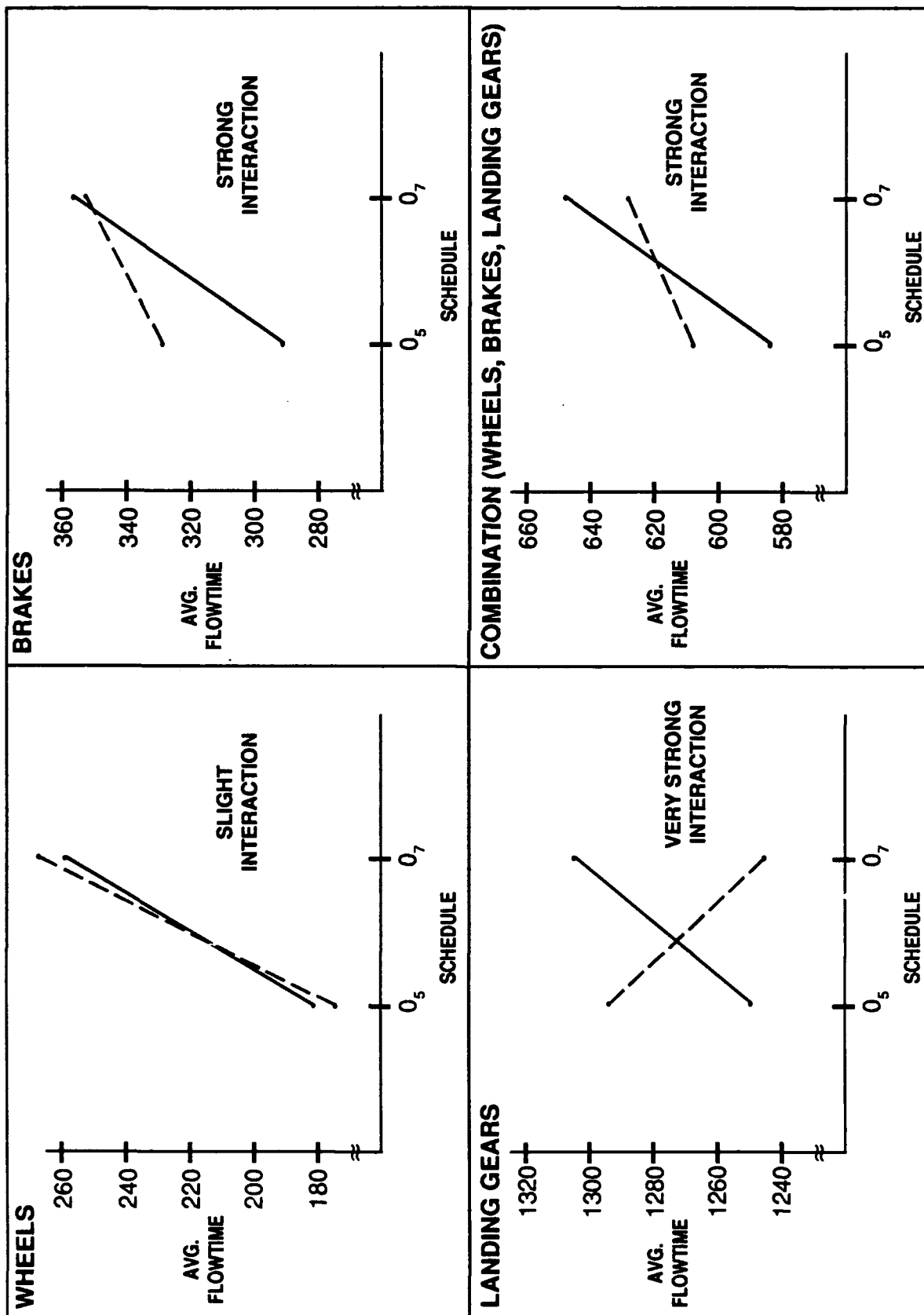
(1249.9 + 1294.2) + 2 = 1272.1

(1303.7 + 1244.8) + 2 = 1274.3

(1249.9 + 1303.7) + 2 = 1276.8

(1294.2 + 1244.8) + 2 = 1269.5

BEST LEVEL : 0₇ 15₅



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INTERACTION DIAGRAMS FOR SCHEDULE VS. MANPOWER

FIGURE 7.1.2-4

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

After analyzing the results of the two L₄ arrays and the results of the HEEF 25 process, MDMSC recommends a seven day a week plating operation, adding 15 people to the plating shop, reducing chrome rework to 5%, and implementing the change to the HEEF 25 process. MDMSC designed an experiment to test the recommendations. The results were compared to the baseline of the present workload and T56 workload validation results.

The analysis of the MDMSC recommendation to work seven days a week in the plating shop, add 15 people to the plating shop, reduce chrome rework to 5% and implement the HEEF 25 process compared to the validation yield the same total throughput with an increase of 9% in flow time. A closer examination reveals that two landing gear PCNs throughput increased significantly. PCN 26338A throughput increased from 26% to 100%. PCN 69657A throughput increased from 5% to 21%. The overall throughput of all of the landing gear PCNs improved from 79% to 88%. The improvements in the landing gear throughput using UDOS 2.0 justifies the recommendations from experimentation. A close examination needs to be performed on how to improve the throughput through the grinding (MANPRB) and machine (MANPRA) shops as more parts are being processed through MANPRC. The UDOS 2.0 is showing queues waiting on grinding and machining operations to be performed.

In summary, MDMSC recommends a seven day a week schedule for the plating shop (MANPRC), add 15 people to the plating shop, reduce chrome rework to 5%, and implement the change to the HEEF 25 process based on the results of UDOS 2.0 experimentation. Evaluate MANPRA and MANPRB to improve throughput of end items as the UDOS 2.0 model reveals that parts are waiting on resources to perform operations. Parts will stack up waiting on MANPRA and MANPRB because MANPRC will be working seven days a week, three shift operations compared to two shifts five days a week for MANPRA and MANPRB. During experimentation MDMSC found an error in the operation database where an operation had the wrong equipment. The error was corrected. A computer run with the correction was executed. This computer run with the correction was compared to the like run with the error to determine the effects of

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

the error. The error yielded less than one half of 1% change in throughput and flow times.

MDMSC did not perform a signal to noise ratio because noise factors were not considered in the UDOS 2.0 model.

MDMSC did not perform an analysis of variance because only single runs were performed for each experiment.

7.1.3 Description of Process Problems

MDMSC personnel, along with ALC personnel, identified several problems that affect the performance of the RCCs during the engineering assessment. These problems were confirmed during the validation of the UDOS 2.0 simulation results. Deltas exist between historical and UDOS 2.0 simulated flowtimes for PCNs. The problems that were identified in the engineering assessment were confirmed to be the rationale for the deltas between historical and UDOS 2.0 flowtimes. The problems are:

- Parts shortages
- Parts robbing
- Scheduling
- Lack of raw materials
- Undocumented rework
- Informal batching of parts
- Material Management engineering support

The layout of the RCCs within MANP is of a functional design. The functional design enhances some of the problems identified like scheduling, undocumented rework, and informal batching of parts.

**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**

7.1.4 Recommended Focus Study: Investigation of Deltas Between Historical and UDOS 2.0 Simulated Results for Production Control Numbers and the Applicability of Group Technology and Cellular Organization Within MANP

The purpose of this focus study is to improve flowtimes, improve throughputs, reduce work in process inventory, improve surge capabilities, and improve quality of aircraft landing gears, aircraft wheels, and aircraft brakes through the repair cycle.

MDMSC is proposing two methods to fulfill the purpose of this focus study. The first method is to investigate, quantify, and recommend solutions to the problems that were identified during the engineering assessment of the RCCs characterized and confirmed during validation of UDOS 2.0 simulation results. The second method is to use the data gathered in the first method to redesign the flow processes of landing gears, wheels, and brakes using group technology and cellular organization principles. The redesign of the flow processes will be validated using UDOS 2.0.

MDMSC will follow a logical sequence in accomplishing method one of this focus study. The logical sequence is:

- Identify problems from Task Order No. 1 that were identified to be part of the delta between historical and simulated flowtimes
- Develop criteria to measure each problem associated with the flow process of PCNs
- Determine PCNs to be studied
- Determine sample size needed based on yearly production
- Track PCNs progress on daily basis
- Analyze data
- Reach a conclusion; verify conclusion if possible
- Recommend solutions
- Set-up statistical process control to measure solution.

MDMSC will follow a logical sequence in accomplishing method two of this focus study. The logical sequence is:

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

- Study the flow processes of landing gears, wheels, and brakes
- Flow chart the processes of landing gears, wheels, and brakes
- Redesign each flow process - landing gears, wheels, and brakes; incorporating data from Method 1 using group technology and cellular organization principles
- Chart new flow process for landing gears, wheels, and brakes
- Create simulation database for each flow process - landing gears, wheels, and brakes
- Execute UDOS 2.0
- Analyze results
- Make Improvements
- Execute UDOS 2.0
- Analyze results
- Summarize focus study.

Table 7.1.4-1 details the areas that will be affected by this focus study.

7.1.4.1 Rationale Leading to Change

Several problems that affect the flowtimes of PCNs were identified. These problems comprised the deltas between the historical and UDOS 2.0 simulated flowtimes. It was impossible to resolve the impact of each problem on the flow process of PCNs because the problem has not been quantified as to its effects on the process flow. The functional flow of the PCNs through the seven RCCs makes the task of quantifying the effects of the problems on the PCNs difficult because no RCC is responsible for the flow process of the PCN. Each problem must be understood and quantified as to its effects on each PCN before a solution can be implemented to correct the factor. Statistical process control can be used to monitor the solution.

The RCCs within MANP are laid out using a functional design. The nature of the design of the RCCs compounds the problems associated with scheduling, rework, and informal batching of parts.

The design of the RCCs have to be changed to minimize the problems caused by the functional design on the flow process of PCNs. MDMSC is

FOCUS STUDY CRITERIA CHECKLIST
TABLE 7.1.4-1 (SHEET 1 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)	LEVEL OF EFFORT		
		MIN	AVG	MAX
Process/Material Flow	Redesign process flow for landing gears, wheels, and brakes using group technology and cellular organization principles.			X
Equipment/Work Place Layout	The new jigs/tools/layout will improve throughput productivity due to the dedicated work place and workstation(s). New work place layouts will be made to maximize full utilization of all equipment and work places. Redesign of equipment/work place layout to support cellular organization of landing gears, wheels, and brakes.			X
Facility Requirements	The existing facility/space requirements in Building 169 should not change. The existing facilities requirement in Building 507 and Building 505 should not change.		X	
Labor Standards	Labor standards will change due to simplification.		X	
Manpower	The manpower requirements should be reduced and/or existing manpower used to better advantage.		X	
Task Assignments	All tasks assignments will change due to the flow process changes. This will be fully explored in the study to define maximum benefits.		X	
Material Requirements	The material requirements will not change.	X		
Scrap Rates	Scrap rates should decrease because of better control of the flow process.		X	

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**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**

FOCUS STUDY CRITERIA CHECKLIST
TABLE 7.1.4-1 (SHEET 2 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)	LEVEL OF EFFORT		
		MIN	AVG	MAX
Material Handling & Storage Methods	Material handling should decrease with the redesign of the flow process.		X	
Inspection Techniques	No change anticipated.	X		
Equipment/Tools/Fixtures	New equipment may be needed; some of the existing equipment may not be needed.			X
Process Delays	Process delays will be minimized with the redesign of the flow process--landing gears, wheels, and brakes.		X	
Part Identification	No change anticipated.	X		
Quality	Total quality will improve because one organization will be responsible for the total repair process.			X
Personnel Safety	No change anticipated.	X		
Environmental Assessments	No change anticipated.	X		

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recommending the use of group technology and cellular organization principles to redesign the layout of the RCCs. Group technology is the processing of families of parts that have similar processes. Cellular organization is the principle that all repair work to a PCN is performed by one cell. MANP is presently using group technology in MANPGP in that all C-5 landing gears, all other aircraft landing gears, all aircraft wheels, and all aircraft brakes are assembled by independent subunits of MANPGP.

Cellular operations assign clear responsibility and authority for producing the product efficiently and with high quality. The supervisor of a cell has authority over the entire stream of processing for the part family in that cell, including the machines and operators needed for such processing. The workers are familiar with what they are working on and their immediate "customer" is the next worker in the same cell; thus, they have immediate feedback on the quality of their products. Communications between workers and the supervisor are direct, and immediate, so that quality becomes "everyone's business." Furthermore, costs of the product are focused upon in the cellular environment--e.g., reducing scrap and rework.*

7.1.4.2 Potential Cost Benefits

The majority of the savings will be realized as cost avoidance opportunities. The elimination of T-jobs will reduce WIP inventory and produce budget savings. The reduction of ten flow days for the aircraft wheels, brakes, and landing gears will result in \$3,756,780 in WIP inventory reductions.

The focus study cost of the recommendation is estimated at \$950,000. This cost is an engineering estimate for use in engineering trade studies only and does not represent firm pricing.

*Simplify First: A Modernization Strategy for DoD Maintenance Depots Report
AL7042, Logistics

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An example of the savings from the elimination of T-jobs can be shown by looking at the aircraft wheels. The elimination of the three T-jobs resulted in a reduction of \$9,542,714 in WIP inventory.

This analysis will use data that was collected on PCN 90101A C-5 main wheel. Directorate of Material Management (MM) initiated a work around for part shortages in 1989. Three T-jobs were initiated that allowed MANPGW to induct approximately 377 C-5 wheels per quarter to disassemble wheels, rob parts, reassemble wheels, and return to supply in "x" condition. The robbed parts were needed by MANPGP assembly to meet production quota.

MDMSC performed an experiment using UDOS 2.0 to quantify the effect of inducting T-jobs to rob parts on the process flow of the four wheel groupings. The flowtimes of the four wheel groupings with the T-job was compared to the validation baseline.

PCN	Validation		Difference	Yearly	Asset
	Baseline	T-Job			
<u>Wheel Grouping</u>	<u>Flowtime (hrs)</u>	<u>Flowtime (hrs)</u>	<u>(hrs)</u>	<u>Production</u>	<u>\$ Value*</u>
16267A F-4N	212.48	252.02	39.54	985	736.24
90101A C-5M	103.69	114.36	10.67	7,640	6,328.06
69595A B-52M	110.88	123.04	12.46	886	3,572.00
15592A KC-135N	647.59	667.47	19.88	328	1,122.70

Cost of work in process for the additional flow day increase caused by the T-jobs.

WIP inventory addition = (# of flow days added/365) x (asset \$ value) x (yearly production rate)

*All cost data was obtained from the "Haystack Replacement Cost System

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The difference in hours was converted to days:

Example:

$$\text{PCN 16267A} = (1.65 \text{ day}/365 \text{ days}) \times (\$736.24/\text{wheel}) \times (985 \text{ wheels}/\text{yr})$$

$$\text{PCN 16267A} = \$3,278/\text{yr}$$

$$\text{PCN 90101A} = \$58,280/\text{yr}$$

$$\text{PCN 69595A} = \$4,422/\text{yr}$$

$$\text{PCN 15592A} = \$827/\text{yr}$$

Total cost in additional flow days due to T-job = \$66,807/yr

The increase in WIP inventory due to the unusable PCN 90101A C-5 main wheels/yr = $377 \text{ wheels}/\text{qtr} \times 4 \text{ qtr}/\text{yr} \times 6,328.06/\text{wheel} = \$9,542,714/\text{yr}$.

Cost of the three T-jobs = \$45,579 (per validation report)

Vendor cost of missing bushing \$18.35/each
(FSN 5310011990263LE)
(Cost accounting, MAX FIFE)

MDMSC estimated material and \$115.63/each
labor cost for OO-ALC to manufacture
the bushing (FSN 5310011990263LE)
(see DDB MANPGP section for analysis)

MDMSC conservatively estimates that a savings of ten days of flowtime can be realized by successfully completing the proposed focus study.

WIP inventory reduction = $(\# \text{ of flow days reduced}/365) \times (\text{asset } \$ \text{ value}) \times$
(yearly production rate)

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Aircraft Brakes

<u>PCN</u>	<u>(Asset \$ Value)</u>	<u>Yearly Production Rate</u>
68735A	17,343.47	71
25874A	9,921.63	439
15068A	6,644.00	466
15053A	5,684.31	240
15598A	35,525.73	54
15162A	5,350.00	1,372

Example:

$$\text{PCN 68735A} = (10 \text{ days}/365 \text{ days}) \times (\$17,343.17/\text{brake}) \times (71 \text{ brake/yr})$$

$$\text{PCN 68735A} = \$33,736/\text{yr}$$

$$\text{PCN 25874A} = \$119,331/\text{yr}$$

$$\text{PCN 15068A} = \$84,824/\text{yr}$$

$$\text{PCN 15053A} = \$37,376/\text{yr}$$

$$\text{PCN 15698A} = \$52,558/\text{yr}$$

$$\text{PCN 15162A} = \$201,101/\text{yr}$$

$$\text{Total WIP brake reduction} = \$528,925/\text{yr}$$

Landing Gears

<u>PCN</u>	<u>(Asset \$ Value)</u>	<u>Yearly Production Rate</u>
69657A	\$65,124.00	527
74652A	\$4,997.56	80
74692A	\$284,280.00	18
17143A	\$28,609.00	150

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69354A	\$15,751.00	170
74521A	\$105,223.77	62
26338A	\$68,828.72	48
17576A	\$15,751.00	40
72877A	\$351,745.00	6
17402A	\$29,701.88	197

Example:

PCN 69657A = (10 days/365 days) x (\$65,124/landing gear) x (527 landing gear/yr)

PCN 69657A = \$940,281/yr

PCN 74652A = \$10,953/yr

PCN 74692A = \$140,193/yr

PCN 17143A = \$117,571/yr

PCN 69354A = \$73,361/yr

PCN 74521A = \$178,735/yr

PCN 26338A = \$90,514/yr

PCN 17576A = \$17,261/yr

PCN 72877A = \$57,820/yr

PCN 17402A = \$160,308/yr

Total WIP landing gear reduction = \$1,786,637/yr.

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Wheels

<u>PCN</u>	<u>(Asset \$ Value)</u>	<u>Yearly Production Rate</u>
16267A	\$736.84	985
90101A	\$6,328.06	7,640
69595A	\$3,572.00	886
15592A	\$1,122.70	328

Example:

$$\text{PCN 16267AA} = (10 \text{ days}/365 \text{ days}) \times (\$736.24/\text{wheel}) \times (985 \text{ wheels}/\text{yr})$$

$$\text{PCN 16267A} = \$19,868/\text{yr}$$

$$\text{PCN 90101A} = \$1,324,555/\text{yr}$$

$$\text{PCN 69595A} = \$86,706/\text{yr}$$

$$\text{PCN 15592A} = \$10,089/\text{yr}$$

Total WIP wheel reduction = \$1,441,218/yr.

7.1.4.3 Risk Assessment

The following is a list of the possible risks in achieving the study goals

- The cost of the focus study
- Lack of recognition of the problems by other Directorate

7.1.4.4 Duration and Level of Effort

MDMSC recommends a nine month focus study period of performance to:

- Establish criteria to measure problems
- Track PCNs daily
- Analyze data
- Make recommendations
- Develop statistical process control to monitor solution
- Redesign flow processes - landing gears, wheels, and brakes

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- Validate with UDOS 2.0
- Refine flow processes
- Validate with UDOS 2.0
- Summarize results of focus study

Table 7.1.4-2 illustrates the proposed schedule. It is estimated that \$950,000 is required to successfully complete this focus study. The number is an engineering Rough Order of Magnitude (ROM) estimate for engineering track studies; it does not represent firm price.

7.1.5 Other Observations

- Increase the Utilization of the Brake Automated Riveting Machine
 - Current Condition: Presently the C-130 brake is the only brake that utilizes the automated riveting machine.
 - MDMSC Recommendation: Investigate using the automated riveting machine for other high volume aircraft brakes.
- Increase the Efficiency of the Landing Gear Hydraulic Test Stands
 - Current Condition: The test stands are old and worn. It requires excessive time for the test stand to buildup pressure to test the landing gears.
 - MDMSC Recommendation: Upgrade the test stand to perform more efficiently or investigate the possibly of designing and manufacturing automated test equipment to test the landing gears.
- Improve Part Quality
 - Current Condition: MANPGP receives parts from MANPRA (machine shop) that do not meet requirements. MANPGP has to send the parts back on emergency rework informally because they are usually waiting on these parts to assemble landing gear.
 - MDMSC Recommendation: Establish a formal system to return parts for emergency rework to another RCC. Assign a QP-4 process action team to resolve repetitive problems.
- Improve Directorate of Material Management Engineering Support
 - Current Condition: MDMSC has observed that Directorate of Material Management engineering support is inconsistent. MDMSC has

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PROPOSED FOCUS STUDY SCHEDULE
TABLE 7.1.4-2

ACTIVITY/TASK	MO #1	MO #2	MO #3	MO #4	MO #5	MO #6	MO #7	MO #8	MO #9
DEVELOP CRITERIA, PCN'S TO BE STUDIED, SAMPLE SIZE									
TRACK PCN'S DAILY									
ANALYZE DATA									
CONCLUSIONS & RECOMMENDATIONS									
STATISTICAL PROCESS CONTROL									
STUDY FLOW PROCESSES									
FLOW CHART PROCESSES									
REDESIGN FLOW PROCESSES									
CREATE SIMULATION DATABASES									
EXECUTE UDOS 2.0 & ANALYZE									
MAKE IMPROVEMENTS - EXECUTE UDOS 2.0									
ANALYZE RESULTS									
CONTRACT SUMMARY REPORT									

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documented during process characterization that validation engineering response varies from one day to 60 days to disposition a fix (repair) for a nonconformance on an end item.

- MDMSC Recommendation: MDMSC recommends that the Directorate of Material Management assign direct engineering support to MANP section to support the different RCCs.

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7.2 MANPGW ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MANPGW RCC performs four separate operations under the disassembly/assembly repair section (MANPG). These operations are disassembly, cleaning, nick and deburr, and Evaluation and Inspection (E&I). The four operations are discussed in detail in paragraph 7.2.1.

During the initial characterization of MANPGW a total of five improvement opportunities were identified; reference MANPGW Data Documentation Book (DDB), Potential Improvement Opportunities section.

One of the improvement opportunities is classified as a focus study and addresses the need to improve the mechanical wearing of brake rotors. The focus study titled, "Improved Braking by Remanufacturing Steel Rotors," is presented in detail in paragraphs 7.2.4 through 7.2.4.4.

One of the improvement opportunities is classified as a quick fix and addresses converting an automated blasting machine to process wheels. Quick fixes are described in detail under separate cover (reference TI-ES Task Order (TO) No. 1, Volume VII Quick Fix Plan, OO-ALC, MANPGW Quick Fix Opportunities section). The other potential improvement opportunities are discussed in section 7.2.5, Other Observations.

7.2.1 Description of Current Operation

MANPGW is a Resource Control Center (RCC) under the MANP branch of the Industrial Products Division (MAN) at OO-ALC. MANPGW is located on the east wall of Building 507 extending the length of the building. MANPGW manpower consists of an average of 30 direct labor mechanics and four supervisors with one general foreman.

MANPGW mainly processes three different end items; aircraft landing gears, wheels, and brakes. These three end items are classified as Management of Items Subject to Repair (MISTR) items which comprises 97% of the workload. The other 3% consist of temporary workload which is usually the induction of

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one of the three end items by planning (MANE) for a specific task to be accomplished to the end item. See Table 7.1.2-2.

MANPGW is responsible to perform four functions on every aircraft landing gear, wheel, and brake assembly:

- Teardown/disassemble
- Clean
- Corrosion removal/nick and deburr
- Evaluate and inspect

MANPGW disassembles landing gear, wheel, and brake assemblies into individual components for further processing. Three different areas have been designed and equipped for this operation. MDMSC observed that no work control document exist for the teardown/disassemble process. The mechanics use the Technical Orders to determine how to teardown/disassembly landing gears, wheels, and brakes. MDMSC observed a process engineer from MANEP working with the mechanics to disassemble landing gears. His task is to prototype the disassembly of the 26 different landing gears that OO-ALC processes. During prototyping, his responsibilities are to write-up the procedure for disassembly and design tooling to make disassembly easier and minimize damage to the components. MDMSC views the action of a process engineer working with production as a very positive step in improving the disassembly operation of landing gear.

Wheel and brake assemblies are disassembled in their respective areas which are equipped accordingly for the disassembly process. After the landing gears, wheels, and brakes are disassembled into component parts, the parts are cleaned either chemically or mechanically and made ready for inspection. Many of the brake components do not pass E&I because they are worn too badly. These parts are currently condemned and new parts are installed on the brake assembly. The parts that are affected the most are the rotors and brake disc pads. MDMSC recommends that the appropriate parts be re-manufactured, reference paragraph 7.2.4 through 7.2.4.4, which will provide a substantial cost

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savings by increasing service life, providing an improved functioning part, and reducing inventory.

The cleaning of most component parts is accomplished by processing the parts through one of the four automated chemical processing lines. The exceptions are the backing rotor, and stator plates of brakes which are required to be mechanically cleaned by an automated grit blaster. There are four chemical lines: two to process aluminum parts and two to process steel parts. The parts and their associated WCDs are hung on an overhead carriage in a plastic packet. A computer program is initiated to start the chemical cleaning process. The aluminum parts are additionally inspected using liquid penetrant by MANPNA. The steel parts are baked for four hours to relieve hydrogen, induced by the chemical cleaning, from the parts. After cool down, the steel parts are magnetically particle inspected by MANPNA. It is often necessary to mechanically clean the parts by manually blasting to remove foreign materials from the parts that the chemical process did not remove. MANPGW has a blasting booth that was purchased for blasting landing gear components. Due to the number of components and various configurations, it was deemed impractical for use. After the aluminum and steel parts are inspected by MANPNA and no defects are found, the parts are processed through nick and deburr. If minor defects are found, MANPNA circles 10 on the Work Control Document (WCD) identifying the defect. The part continues its normal process flow to E&I. E&I determines if the part can be repaired and routes the part to the proper RCC for repair. If the part cannot be repaired, then E&I scraps the part. If major defects are found, MANPNA scraps the part.

Nick and deburr is responsible for the mechanical removal of nicks, scratches, gouges, surface defects, and surface corrosion from parts identified by inspection. Nick and deburr is equipped with seven work stations, although MDMSC has observed no more than three stations manned at any one time. Nick and deburr is a strenuous and dirty task that has to be performed on the parts.

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Nick and deburr is the bottleneck in the process for MANPGW. MDMSC observed that parts stack up at nick and deburr. After the parts are processed through nick and deburr, the parts are moved to E&I for evaluation and inspection of the dimensional criteria of each part to the technical data.

E&I evaluates parts for dimensional conformances to the Technical Order data for each part. At this point, E&I determines the flow of the part through the repair cycle to repair the nonconformances to the technical data. E&I stamps on the left side of the work control document the operations that are necessary to repair the nonconformances found by E&I. The landing gear component parts are evaluated and inspected in an environmentally controlled room. The rationale is the parts are in a temperature controlled environment so critical part dimensions can be measured to the nearest ten thousandth inch without the influence of thermal expansion of the metal due to temperature changes.

The wheel and brake components dimensions are not as critical as the landing gear components, so the evaluation and inspection of these components are performed in an open environment. The parts are moved from E&I and stacked along the infamous wall in Building 507 waiting processing by the RCC that is responsible for performing the next required operation or the operation to be performed as designated by the stamp of E&I on the left side of the WCD. Parts can flow in many different directions at this point. The condition of the part and the required repair work to be performed determines the process flow of the part.

MANPGW was designed and laid out to meet its requirement of processing parts in an orderly and timely manner. MANPGW is laid out to handle three different products at disassembly. The cleaning area is designed to process aluminum and steel parts through different chemical lines automatically by using an overhead carriage system that moves parts from tank to tank using a computer program. The nick and deburr area is laid out as seven different workstations independent of each other so individual parts can be worked. E&I also has an environmentally controlled room to process landing gear components that have critical dimensions that must be maintained. See DDB

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floor layout section for the layout of MANPGW. MANPGW is similar to other RCCs in that the design of the layout supports a continuous process flow of parts. See DDB flow diagram section for parts flow diagram.

MANSV is the scheduling section that supports MANPGW. Scheduling negotiates the quantity of end items to be inducted each quarter with the different Item Managers (IM). Scheduling orders the end items from supply to be delivered at the disassembly areas of MANPGW. Scheduling does not determine when or how long each item should flow through MANPGW.

MANE is the planning section that supports MANPGW. The planners ensure that the work control documents are current with the latest technical data. The planners also help plan each task ensuring that technical data and special tooling are available to perform the task. The planners also function as liaison between support engineers and production. The planners are in the process of updating the work control documents for the DMMIS project. The work control documents are to update and accurately reflect the part flow through the repair cycle.

7.2.2 Statistical System Performance Measures

Refer to paragraph 7.1.2.

7.2.3 Description of Process Problems

The brakes on several aircraft using steel rotors have a metal composite brake pad that is squeezed against it during braking to stop the aircraft. This grabbing action on the rotors by the brake pads eventually wear out both the rotor and the break pads. Both parts wear out because of several factors. One is that corrosion (rusting) on the steel rotors roughen the breaking surface with pits, decreasing the surface contact area. Another is that torn metal and burrs are produced on the rotors by the non-uniform machining action of the pads which put grooves in the rotor. Finally the pads are rough and made of an abrasive material that deteriorates easily when gouged by roughened metal on the rotors. Whenever one of the two components begins deteriorating the wear factor is

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compounded because not only is the other part damaged but that damage then causes the first part to be further damaged itself.

7.2.4 Recommended Focus Study: Improved Braking by
Remanufacturing Steel Brake Rotors

During the characterization of the MANP RCCs, MDMSC observed the procedures for brake repair and found a potential repair method that would reduce inventory, provide better braking, and increase service life of brake assemblies. The objective of the focus study is to determine the benefits of modifying aircraft braking systems by chromium plating the rotors. Table 7.2.4-1 details the areas that will be affected by the focus study.

7.2.4.1 Rationale Leading to Change

Currently several aircraft still use brake assemblies with steel rotors that are replaced approximately every 500 landings. The eleven type of aircraft that would benefit from the recommended improvement are: the B-52, the KC-135, the C-130, the A-10, the F-5, F-111, the A-7D, the T-38, the C-141, the A-37, and the E-3A. Approximately 1896 brakes were processed in 1988 that would be affected by this focus study recommendation. All are on older model aircraft and modifying them to a braking system not using steel rotors is cost prohibitive.

The steel rotors will function better and last longer if they are chrome plated to offset the wear and corrosion that is now deteriorating them. This was proven by tests that were run under experimental and actual conditions by Engineering Plating and Processing, Inc., a Kansas City, Kansas company, in the 1970s. A test bed utilizing a large engine lathe with a Mooney landing gear assembly anchored to it was used to record the different hydraulic pressures. A twin engine Piper Chieftan with a chrome plated single rotor braking system, designated by the Federal Aviation Administration (FAA), was used to test for stopping distances. The results showed that under all conditions especially emergency landings, 1) less pressure was required to stop the aircraft, 2) more control was provided, and 3) the plane stopped in less distance. The FAA

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FOCUS STUDY CRITERIA CHECKLIST
TABLE 7.2.4-1 (SHEET 1 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)	LEVEL OF EFFORT		
		MIN	AVG	MAX
Process/Material Flow	The process time will increase per part, but because the quantity will decrease, so will material flow.			X
Equipment/Work Place Layout	Placement of new equipment will require work place/layout modifications.			X
Facility Requirements	The existing facility/space requirements in Building 507 should not change.	X		
Labor Standards	Will increase labor standards per PCN for plating process.	X		
Manpower	Manpower will be the same until remanufacturing is complete then it will be reduced significantly.		X	
Task Assignments	Some task assignments will change due to additional equipment. This will be explored in the study to define maximum benefits.	X		
Material Requirements	Minor material requirements will change. Supplies for the belt grinders will be required.		X	
Scrap Rates	The scrap rates of rotor and discs will be greatly reduced.			X

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FOCUS STUDY CRITERIA CHECKLIST
TABLE 7.2.4-1 (SHEET 2 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)	LEVEL OF EFFORT		
		MIN	AVG	MAX
Material Handling & Storage Methods	No change anticipated.	x		
Inspection Techniques	No change anticipated.	x		
Equipment/Tools/Fixtures	Three new disc, belt grinders will be required to remanufacture rotors.			x
Process Delays	None expected.	x		
Part Identification	No change anticipated.	x		
Quality	The remanufactured rotors will improve their function.			x
Personnel Safety	The brake assemblies will operate with better control and reliability.			x
Environmental Assessments	No change anticipated.	x		

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approved the modifications because of the marked improvement in product quality and safety. A synopsis of logs kept on the tests as well as other supporting information is in the MANPGW Data Documentation Book (DDB) in the supporting data section.

Historical documents of Engineering Plating and Processing show that on the average the rotors lasted eight times longer and the brake pads lasted twice as long. Problems such as ground looping (violent swerving on landing) caused by rusted rotors was also eliminated.

Although the model shows that there is a bottleneck in MANPRC, that bottleneck can be reduced and allow MANPRC to accommodate the workload created by this focus study. By implementing the quick fixes and proposed focus studies recommended in this CSR more than enough capacity should be available.

7.2.4.2 Potential Cost Benefits

An annual recurring cost savings of \$1,688,389 occurs from the implementation of the recommended improvements as shown in Table 7.2.4-2.

The investment cost of the recommendations is estimated at \$1,366,370. This cost includes the focus study effort and the implementation cost.

The Cost Benefit Analysis (CBA) shows an Internal Rate of Return (IRR) of 110% and a savings of \$4,714,167 in terms of Net Present Value (NPV) using constant FY89 dollars, see Figure 7.2.4-1. The CBA is in compliance with regulation AFR173-15, cost analysis procedures, dated 4 Mar 88.

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.

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**SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS
(CONSTANT FY 89 DOLLARS)
TABLE 7.2.4-2 (SHEET 1 OF 2)**

	CURRENT ANNUAL COSTS	<u>PROPOSED CHANGE</u>	
		<u>INVESTMENT COSTS</u>	<u>ANNUAL COSTS</u>
NONRECURRING COSTS (1)			
FOCUS STUDY	\$0	\$210,000 (2)	\$0
FACILITIES			
LAND	\$0	\$0	\$0
BUILDINGS	\$0	\$0	\$0
SUPPORT EQUIPMENT			
DEVELOPMENT	\$0	\$150,000 (3)	\$0
ACQUISITION	\$0	\$200,000 (4)	\$0
INSTALL & CHECKOUT	\$0	\$806,370 (5)	\$0
LOGISTICS SUPPORT			
INITIAL SPARES	\$0	\$0	\$0
INITIAL TRAINING	\$0	\$0	\$0
(DEV & PRESENTATION)			
TECHNICAL DATA	\$0	\$0	\$0
TOTAL NONRECURRING COST	\$0	\$1,366,370	\$0
RECURRING COSTS (1)			
TOUCH LABOR	\$1,088,775 (6)	\$0	\$435,510 (7)
SUPPORT EQUIP MAINT	\$0	\$0	\$0
SPARES AND SPARES MGMT	\$1,686,377 (8)	\$0	\$651,254 (9)
TECHNICAL DATA	\$0	\$0	\$0
MOD KITS	\$0	\$0	\$0
CONFIGURATION DATA MGMT	\$0	\$0	\$0
UTILITIES	\$0	\$0	\$0
TOTAL RECURRING COSTS	\$2,775,152	\$0	\$1,086,764
TOTAL COSTS	\$2,775,152	\$1,366,370	\$1,086,764
ANNUAL COST SAVINGS	\$1,688,389		

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

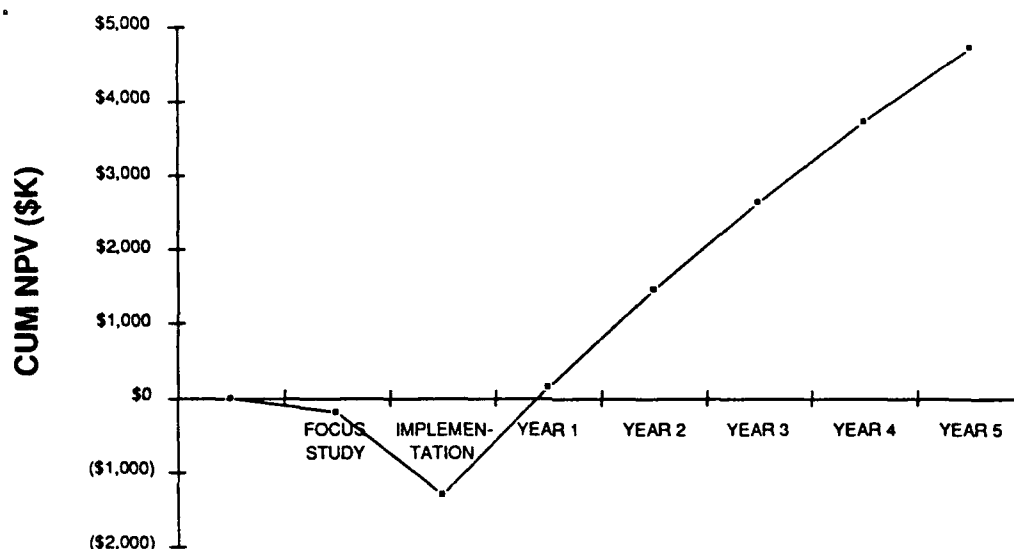
**SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS
(CONSTANT FY 89 DOLLARS)
TABLE 7.2.4-2 (SHEET 2 OF 2)**

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) ENGINEERING ESTIMATE FOR AN IMPLEMENTATION PLAN
- (4) COST FOR PLATING FIXTURES ARE APPROXIMATELY \$2,500 EACH X 20 = \$50,000 AND 3 BELT SURFACE GRIND/.POLISHER APPROXIMATELY \$50,000 EACH = \$150,000
- (5) COST TO PLATE THE ROTORS FIRST TIME. THIS IS ESTIMATED TO BE APPROXIMATELY THE COST OF NEW ONES $293,578 + 431,504 + 81,288$
- (6) BASED ON HOURS TO REPAIR B-52 BRAKE ASSEMBLIES PROVIDED BY OO-ALC THE FOLLOWING CURRENT LABOR COSTS HAVE BEEN APPROXIMATED AS BEST POSSIBLE WITH INFORMATION GIVEN. REFERENCE SUPPORTING DATA SECTION OF MANPRC DDB.

 $\$440,147$ FOR B-52 + $594,019$ FOR LARGER AIRCRAFT + $54,609$ FOR SMALLER AIRCRAFT = $\$1,088,775$
- (7) BASED ON BETWEEN 50% AND 70% REDUCTION IN LABOR COSTS, AN AVERAGE OF $(50\% + 30\%)/2 = 40\%$ OF THE ORIGINAL COSTS $1,088,775 \times .4 = \$435,510$
- (8) TOTAL CURRENT MATERIAL COSTS CONSIDERED
ROTORS = $293,578 + 431,504 + 81,288 = 806,370$
DISCS = $273,734 + 402,338 + 50,630 = 726,702$
MISC. = $56,731 + 83,384 + 13,190 = 153,305$
 $1,686,377$ TOTAL
- (9) TOTAL MATERIAL COSTS AFTER RECOMMENDED CHANGES
30% OF CURRENT ROTOR AND MISC MATERIAL COSTS =
 $806,370 + 153,305 = 959,675 \times .3 = \$287,903$
50% OF DISC COSTS =
 $726,702 \times .5 = \$363,351$
TOTAL $287,903 + 363,351 = \$651,254$

**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**

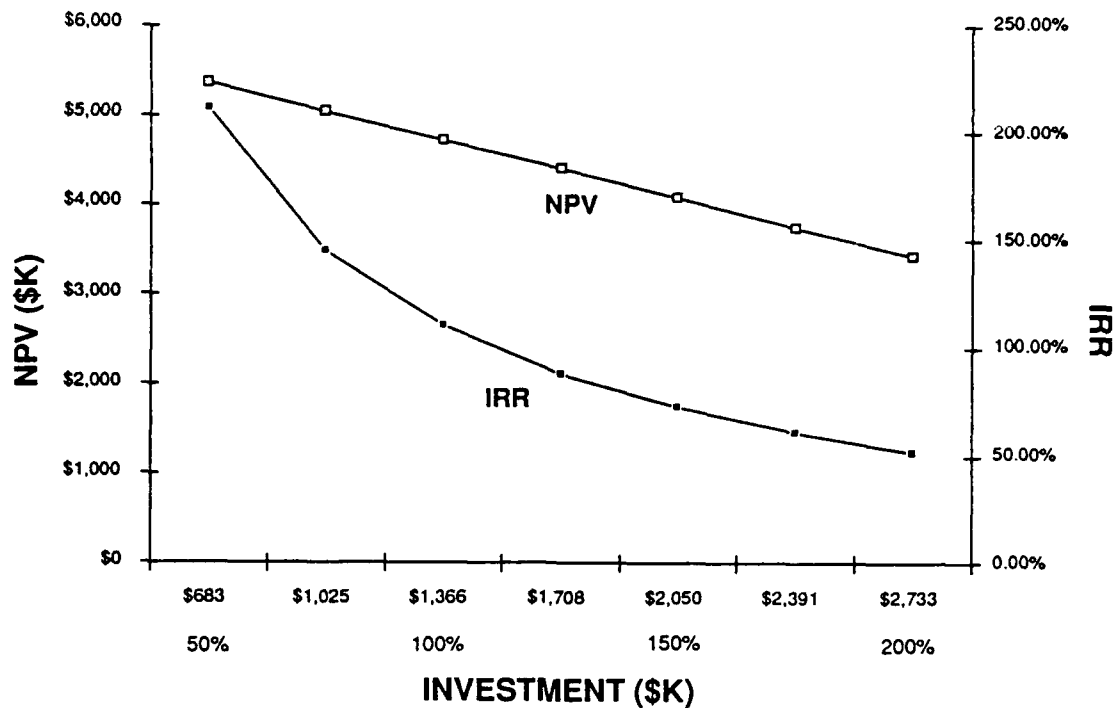


**CUM NPV IN CONSTANT FY89 DOLLARS
FIGURE 7.2.4-1**

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 FY90 is worth \$.91 in FY89 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 7.2.4-2.

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**CBA SENSITIVITY ANALYSIS
FIGURE 7.2.4-2**

7.2.4.3 Risk Assessment

- The actual cost savings can only be quantified after the detailed focus study is completed and detailed recommendations made.
- Implementation costs may involve some facility assessment and rearrangement of equipment that will be estimated.
- Process control procedures and Technical Orders will require changing and updating which will not be included in the focus study.
- Any detailed information required for an implementation will not be included in this study.

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7.2.4.4 Duration and Level of Effort

MDMSC recommends a five month focus study period of performance to:

- Make an assessment and categorize those items that are definitely amendable to this method of remanufacture.
- After selected parts are assessed, two will have preliminary plating fixture working sketches and a detailed cost evaluation for those parts. One part will be of the larger type aircraft rotor (B-52, etc.) and one will be of the smaller aircraft (F-111, etc.) rotor.
- The fixtures developed for the selected parts will be evaluated and designed for adaptability to the other similar parts to keep the number of different fixtures to a minimum.
- Different belt grinding/polishing equipment will be researched as to the best equipment available for this application.
- Proper processing procedures will be developed for OO-ALC's incorporation into it's processing specifications.
- Any required testing procedures will be outlined and examined. If tests are easily performed test rotors will be plated and belt ground. (Any testing may require the use of OO-ALC personnel and equipment)

Table 7.2.4-3 illustrates the proposed schedule to accomplish the focus study recommendation. It is estimated that a total of \$210,000 is required to implement this recommendation. This number is an engineering Rough Order of Magnitude (ROM) estimate for engineering trade studies only; it does not represent firm pricing.

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PROPOSED FOCUS STUDY SCHEDULE
TABLE 7.2.4-3

ACTIVITY/TASK	MO #1	MO #2	MO #3	MO #4	MO #5
DEFINE ITEMS FOR REMANUFACTURE					
FIXTURE DEFINITION/EVALUATION					
GRINDING/POLISHING EQUIP. RESEARCH					
PROCEDURE DEVELOPMENT					
TESTING (AS APPLICABLE)					
STATUS REPORTS					
EXECUTIVE SUMMARY BRIEFING					
CONTRACT SUMMARY REPORT					

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7.2.5 Other Observations

- Simplify Tooling Request
 - Current Condition: The present method available to mechanics to acquire new tools or have special tools fabricated is cumbersome. The present system required five signatures from the RCC foreman to the Director of tool control.
 - MDMSC Recommendation: Let the RCC foreman be responsible for tool control and the acquisition of new tools or special tools that have a value of less than \$1,000.
- Improve Documentation
 - Current Condition: MDMSC observed mechanics' disassembly landing gears, brakes, and wheels with little or no documentation.
 - MDMSC Recommendation: MDMSC endorses MANEP's process engineering effort to document the disassembly of landing gears and provide special tooling needed for the process. MDMSC observed a process engineer documenting the repair process of landing gears during process characterization validation.

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7.3 MANPNA ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MANPNA is a Resource Control Center (RCC) under the MANP branch of the Industrial Products Division (MAN) at OO-ALC. MANPNA performs Non Destructive Inspection (NDI) on a wide range of assets for all repair RCCs at OO-ALC. The specific inspection responsibilities and methods of inspection are presented in paragraph 7.3.1.

During the initial characterization of MANPNA RCC, a total of three improvement opportunities were identified (reference MANPNA Data Documentation Book (DDB), Potential Improvement Opportunities section. The three potential improvement opportunities were classified as other observations and are discussed in section 7.3.4. MDMSC is not recommending any focus studies or quick fixes for this RCC.

7.3.1 Description of Current Operation

During process characterization it was agreed by the OO-ALC/MDMSC site team to study only the functions of MANPNA that support the wheels, brakes, and landing gear processes. MDMSC did perform a review of all other MANPNA supporting functions at various locations for possible process improvement opportunities. The following functions were studied in Buildings 505 and 507:

- (1) Fluorescent Magnetic Particle Inspection
- (2) Fluorescent Penetrant Inspection
- (3) Eddy Current Inspection
- (4) Temper Etch Inspection

MANPNA supports the wheels, brakes, and landing gears processes at the end of the cleaning line of MANPGW.

After being cleaned, all parts are inspected for defects. Fluorescent magnetic particle inspection is used to inspect steel parts. Wet fluorescent penetrant inspection is used to inspect aluminum, magnesium, and steel parts. Eddy current is used to inspect parts for defects that could have been missed by fluorescent penetrant inspection.

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Two wet fluorescent penetrant processing lines are set up at the end of the cleaning lines in Building 507. The two penetrant processing lines process the parts automatically through the necessary operations until the parts get to the inspector in the dark booth. The inspector uses an ultra-violet spotlight to examine the part for any fluorescent indications that could be a possible defect. Fluorescent penetrant inspection is used to inspect aluminum wheels, magnesium wheels, aluminum brake housings, magnesium brake housing, and small steel component parts.

Five fluorescent magnetic particle inspection stations are at the end of the cleaning line in Building 507. Three magnetic particle inspection stations are in Building 505. The parts are sprayed with a fluorescent magnetic particle fluid. The part is magnetized longitudinally by applying the proper amperage on the machine. Each part requires its unique amperage setting based on the mass and geometric configuration of the part. Machine amperage settings are presently determined by the judgement and experience of the inspectors. The inspector uses an ultra-violet spotlight to examine the part for fluorescent indications that could be possible defects. The part is then magnetized in the circumferential direction and re-examined. When finished, the inspector demagnetizes the part so it does not affect the aircraft navigational system. The five magnetic inspection station areas in Building 507 are usually clustered with pallets of parts awaiting inspection. The inspectors have to work around the pallets to perform their jobs.

MANPNA has the capability to eddy current inspect parts for defects. Eddy current uses a metal probe and metering device. The probe is moved slowly across the part enabling the meter to detect any defect in the surface of the part. MANPNA uses the eddy current inspection technique mainly to inspect wheels to find defects that could be missed by fluorescent inspection because the defect may have been filled with a foreign material such as rubber.

MANPNA uses temper etch inspection to determine if the temper of the part has been changed. The part is processed through a sequence of initial etching

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operations. The inspector examines the part for variations in the shade of color of the part that may indicate a change in the temper of the metal. Usually temper etch inspection is performed after machine or grinding of a part to ensure the temper of the metal has not changed due to the build-up of heat from machining or grinding.

If MANPNA finds a defect, a determination is made to scrap the part or mark the defect and send it to E&I for evaluation. E&I determines if the defect can be repaired within the limits of the technical data. If it can, the part continues normal flow. If it cannot, E&I submits a form 103 to the Directorate of Material Management describing the defect and requesting a disposition (a fix) of the part.

MANPNA is integrated into the flow processes of wheels, brakes, and landing gear. MANPNA was designed and laid out next to MANPGW in Building 507 to support the plating and grinding of metal finishes that have been applied to the parts and thereby provide uninterrupted product flow.

MANPNA is supported by one master planner from the MANEL section to help other planners determine the appropriate inspection techniques for a part. MANPNA is a support shop to other RCCs; therefore, it has no planned workload of its own.

MANSV scheduling section supports MANPNA. The scheduler role is limited because the arrival of work is determined by the RCCs supplying parts to MANPNA for inspection. The scheduler can and often does prioritize certain types of workload to help expedite the workload through the processing cycle.

MANPNA is well equipped to perform the different inspection techniques required by other RCCs and is constantly looking for better and new equipment to accomplish inspection tasks.

MANPNA staffs the different inspection stations within Buildings 505 and 507 according to the flow of parts to be inspected. Sometimes bottlenecks occur at

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these inspection stations because inspectors are assigned to other locations when parts were not immediately available to be inspected. For example, if assembly does not start processing parts through the clean line until 8:30 a.m. it would be 10:30 a.m. before parts would reach MANPNA for inspection. Consequently the inspector is reassigned to another location for a eight hour shift and the parts queue awaiting inspection.

7.3.2 Statistical System Performance Measures

Refer to paragraph 7.1.2.

7.3.3 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 MANPNA at this time, improvement opportunities discussed in 7.3.1 are classified as other observations in this report.

7.3.4 Other Observations

The following recommendations were not considered as focus studies or quick fixes because the elements of time, quality, and cost that are necessary for those type of studies were not developed during the scope of T.O. No. 1 assessment.

These recommendations are considered significant to the operation at OO-ALC and helpful to improve operations.

Operational Improvement Opportunities

- **Staff the NDI Stations to Avoid Bottlenecks**
 - Current Condition: MANPNA RCC is not staffing NDI stations to avoid bottlenecks in the process flow of wheels, brakes, and landing gear components. MANPNA will not staff the NDI stations at the beginning of a shift when no work is available even though the cleaning lines will start stacking parts up for inspection within two hours. Parts stack up until the start of the next shift when manpower is available to staff the NDI stations.

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- MDMSC Recommendation: Staff the NDI stations to avoid bottlenecks in the process flow of wheel, brake, and landing gear components. Measure the efficiency of the flow process of wheel, brake, and landing gear components. Do not measure the efficiency of the personnel.
- Standardize the Amperage Settings on the Fluorescent Magnetic Particle Inspection Machine for Individual Parts
 - Current Condition: The inspectors presently set the amperage settings for each part based on experience. Every mechanic sets the amperage setting a little different each time.
 - MDMSC Recommendation: MDMSC recommends standardizing the amperage setting procedure for the fluorescent magnetic particle inspection machine. MDMSC also recommends developing a 3 x 5 file card index for all of the parts MANPNA inspects. Each card should list the WCD number, federal stock number, part name, amperage setting, and noted defects that may be inherent to the part.
- Work In Progress Storage Racks
 - Current Condition: Parts are stacked on pallets in the work area of MANPNA. The pallets are usually disorganized in arrangement. The pallets are pushed into the MANPNA until all of the work area is filled. The inspector usually has to get a pallet mover and rearrange the pallets in order to have room to work.
 - MDMSC Recommendation: MDMSC recommends to install work in progress racks in MANPNA. Arrange the rack to have incoming and outgoing racks. Racks will allow for an orderly arrangement of the work area.

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7.4 MANPRA ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MANPRA is a Resource Control Center (RCC) under the production branch (MANP) of the Industrial Product Division (MAN) at OO-ALC. The MANPRA RCC is responsible for machining the landing gear, brake, and wheel components that are overhauled in coordination with the other RCCs that have been characterized at OO-ALC.

During the initial characterization of MANPRA, three improvement opportunities were identified (reference MANPRA Database Documentation Book (DDB), Potential Improvement Opportunities section) to be investigated in the TIES Program activities relating to MANPRA. After review of the three improvement opportunities by the MDMSC/ALC team, all three were classified as other observations and are detailed in paragraph 7.4.4. These observations address improvements on quality control of parts, part movement from work station to work station as well as from shop to shop, and concerns about the loss of trained personnel.

MDMSC did not recommend any focus studies or quick fixes for this RCC.

7.4.1 Description of Current Operations

MANPRA RCC is located in Building 507 (reference MANPRA DDB for floor layout). MANPRA manpower consists of an average of 64 machinists, three day shift foremen and one swing shift foreman which is shared with MANPRB.

Approximately 97% of the workload in MANPRA is Management of Items Subject to Repair (MISTR) with the remaining three percent divided between the other workload job categories.

Components are machined to remove defects caused by mechanical wear and corrosion. These components are repaired to standards established in technical data such as Technical Orders, repair drawings, process specifications and form 103 dispositions by Materials Management (MM) engineering. The majority of parts that require other additional repairs such as welding, metalizing or plating will also require machining afterwards. The machining operations are done by

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grinding or machining depending on the tolerances required and the hardness of the coating. The parts controlled by very close tolerances and parts coated with hard metalizing or plating are usually ground while the rest are machined. The machining operation varies in time depending on the size of the part, the thickness of the part, the thickness of the coating, and the shape of the part. The thickness of metal removed per pass, the coolants, and other critical parameters are determined by military standards listed on the WCDs and or process specifications established by MANPRA.

The equipment used in the RCC (refer to the MANPRA DDB, Equipment section) for the most part is adequate for the jobs performed. Some of the equipment is in need of repairs or replacing but does not interfere with achieving workload requirements.

MANPRA has a good training program for the machinists. They are assigned a machine and trained only on that machine in their designated work area. After learning how to use the first machine properly, they are trained on each of the other machines in their work area one at a time until they become proficient with all of the equipment in that area. Finally they are trained on each of the machines out of their assigned area until they are able to operate all of the equipment in the RCC.

Workload in the machine shop is fairly consistent throughout the year except for the third quarter. The negotiated workload is usually higher for the third quarter. The result is that overtime is required to accomplish the work.

Scheduling procedures observed by MDMSC personnel are inefficient. The paperwork system appears adequate but the actual flow of parts is not. Parts not on hot sheets are not under the direction of any one individual and are moved according to an operator's discretion and initiative. The hot sheets are lists of parts that are urgently needed. Parts on these lists are closely followed by a supervisor and or scheduler who makes sure the part gets on the first available machine. Many parts are worked only when they are listed on the hot sheets. Many parts stay in the system unworked or unfinished because of this.

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The system generates confusion and inefficiency and parts flow only on self perpetuating emergencies. MDMSC personnel along with ALC personnel on two separate occasions randomly pulled work control documents within RCCs and along the infamous wall. This action resulted in discovering parts over a year old in the repair cycle being worked with parts that were in the repair cycle two weeks. The analysis of historical data reveals drastic flow time differences exist per production control number.

Quality control and inspection under the Production Acceptance Certification (PAC) program functions by having the operators inspect and approve their own work. This system functions well for checking each separate dimension of an operation that the operator has performed. The problem is that no one is responsible for checking accumulated positional tolerances on parts with more than one area of repair, performed by more than one operator. Frequently parts having multiple repairs will not fit together during assembly. It is estimated by the foreman for the assembly of landing gears that five hours of mechanic labor is lost per week because of rework. These parts are usually needed to meet production quota. The parts are usually returned informally to the supporting RCC without the proper paperwork to document the defect, or the parts are reworked by mechanics within MANPGP until the parts fit.

7.4.2 Statistical System Performance Measures

Refer to paragraph 7.1.2.

7.4.3 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 MANPRA at this time, improvement opportunities discussed in paragraph 7.4.1 are defined as other observations in this report.

The problems of greatest concern at MANPRA are those concerning quality control of individual parts with multiple repair areas. By not checking the tolerance of each repair against the accumulated allowable tolerances for the total repair, many parts do not fit together during assembly and require rework

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by returning the parts to the machine shop or the MANPGP mechanics having to hand machine and fit the parts. Both methods of correction are expensive and delay the repair procedures.

Parts are not scheduled well throughout the system and many parts get lost until they are singled out , searched for and finally put on hot sheets. Parts are found regularly that have been in the RCC for over a year and yet not finished or even worked on.

The turnover rate in the RCC is high. When the machinists leave, the extensive and expensive training required to develop them to be the type of personnel that is required is lost. The people need to have their personality screened for the type of work performed before they are accepted for training.

Another problem that is addressed in paragraph 7.1.2-1 in the MANPGP section that affects the efficiency of MANPRA is that MANPGP continually runs out of bushings needed for final sizing before installation. Bushings are manufactured by MANPME RCC or supplied by a vendor. When MANPRA runs out of bushings for a particular production control number it is forced to stop production of that particular production control number.

This problem also affects MANPGP and the recommended solution is discussed in paragraph 7.1.4 through 7.1.4.4.

7.4.4 Other Observations

- Quality Control on a Part with Multiple Repairs
 - Current Condition: Many parts repaired in MANPRB are not in overall dimension limits by the time a part is ready for assembly. Quality inspections made by the operators may be accurate but many parts have multiple repairs done by different mechanics. The aggregate tolerances are not being checked. The parts have to be sent back for rework or hand filed, ground, or sanded by the assembly mechanic.

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- MDMSC Recommendation: A quality control inspector needs to be assigned to inspect parts with multiple repair areas. He should monitor these parts after each critical operation that could cause delays during assembly. The inspector should be assigned to a MANPRB foreman. He should check the part after each separate repair procedure for total tolerance conformity.
- Part Movement and Scheduling
 - Current Condition: Other than urgent hot items, parts are not controlled by any one person. This leads to lost parts and more recently received parts being worked before those brought in previously.
 - MDMSC Recommendation: Develop a color code system that will identify the length of time a part has been in the RCC for repair and train personnel to record, track, and monitor parts in their area.

A coded system could be developed that would allow attaching color coded tags to the WCDs attached to the parts. A color could be assigned for each month of the year; e.g., white for January, blue for February, etc. The schedulers and mechanics would work the jobs that have the colored tags attached to the WCDs. The color coded tags on the WCDs could only be changed by a general foreman.

This visual system is simple and easy to institute and has been used in the office environment successfully to keep paperwork moving. Once the part is finished, the tag can be removed and scheduled for transfer to the next operation.

It is also recommended that a MANS expeditor or a "light duty" injured mechanic be assigned the task of moving the oldest, non-hot end item.

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- Personality Characteristics Testing

- **Current Condition:** The monotony involved watching parts requiring extended grinding hours, some up to 23 hours because of the part size, configuration, and the allowable amount of material that can be removed per pass, causes many people to transfer out of MANPRB. The months of training that person had are then lost.
- **MDMSC Recommendation:** A test needs to be given to determine a person's ability to work under the required conditions. The ability to stay alert and attentive under such tedious conditions should be more important than their machinist skills.

The training program offered is able to produce good grinding personnel but cannot change a person's resistance to conditions contrary to his psychological profile.

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7.5 MANPRB ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MANPRB is a Resource Control Center (RCC) under the direction of MANPA, the Industrial Products Division at OO-ALC. MANPRB is responsible for grinding landing gear, brake, and wheel components.

During characterization of MANPRB RCC, four improvement opportunities were identified, reference the Potential Improvement Opportunities section of the Database Documentation Book (DDB).

One of the improvement opportunities is classified as a quick fix and addresses decreasing grinding time by using different equipment. This quick fix is described in detail in paragraphs 7.5 through 7.5.1.6 of the Quick Fix Plan.

The other three improvement opportunities are classified as other observations and address; quality control of parts which have multiple repairs that can affect overall tolerances, part measurement and operation scheduling, and personnel testing. These observations are described in detail in paragraph 7.5.4 of this CSR. There are no focus studies recommended for this RCC.

7.5.1 Description of Current Operation

The MANPRB RCC is located in two separate buildings; the southeast part of Building 505 and the northwest corner of Building 507. MANPRB manpower consists of an average of nine direct labor personnel in Building 505 and an average of 24 direct labor personnel in Building 507. They work two shifts, are supervised by three foremen on days, and share a foreman with MANPRA on the swing shift.

Approximately 91% of the workload in MANPRB is Management of Items Subject to Repair (MISTR) with the remaining 9% divided among the other workload job type categories; Temporary (T), Manufacture (M), and Programmed Depot Maintenance (PDM).

Surfaces to be repaired are ground to remove all defects before reassembly or metal coating. This operation varies in time depending on the size, the

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thickness of the base metal, and the shape of the part. The more solid parts grind faster than the thinner material such as hydraulic cylinders. The thickness of metal removed per pass, coolant used, and other critical parameters, are determined by military standards listed on the WCDs and process specifications provided by MANPRB. More pressure is applied during the first passes to reduce grinding time, but to get the proper surface finish for plating the final passes use less pressure, cut less, polish more, and thus take more time.

The MANPRB equipment in Building 505 consists of six gap grinders. Five of them are new computer numerical controlled (CNC) machines. One is an older machine that should be replaced because it is limited to grinding smaller parts. Ninety-five percent of the large O.D. parts, such as C5 components, are ground in this area. The only other work done in this area is honing large cylinders on a vertical hone. The equipment is manned by nine people working two shifts.

MANPRB equipment in Building 507 is much more varied. Not only is O.D. grinding done with equipment similar to that in Building 505, but centerless grinding is done for simpler shaped small parts. Ninety-five percent of small O.D. parts are ground in Building 507. Small O.D.s, threads, I.D.s, and flat surfaces of brake, wheel, and landing gear components are ground in Building 507.

There are between 33-40 personnel in MANPRB. Of this number, nine or ten are grinding machinists and operators located in Building 505. Their training program is very good. The people are first trained on all of the machines in one area. Next they are trained on equipment in the other areas until the people are proficient on all of the equipment.

In an attempt to be more cost effective, manpower has been reduced which requires the grinding personnel to do more work with fewer people. Morale is negatively affected because the operators believe they should be paid more if they do more work. In conjunction with this problem the overall monotony of operating machinery that takes hours before a job is finished gives many of the people a reason to leave this RCC and get other jobs.

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The training program keeps the operators interested in their work but once the training is over, they eventually get bored by monotonous work. The CNC equipment helps eliminate operator error for those monotonous jobs because the equipment monitors itself and automatically makes any necessary adjustments. All but one of the grinders in Building 505 have been replaced with this type of equipment while most of the equipment in Building 507 has not.

Workloads are consistent most of the year except during the summer months when workloads increase markedly. This is a result of more flights logged during this time of year.

Scheduling procedures observed by MDMSC personnel are very inefficient. The paperwork system seems adequate but the actual parts flow is very ineffective. Parts flow not controlled by "hot sheets" (priority) is left up to the operators' discretion and initiative. The parts on hot sheets are followed closely by a supervisor who makes sure a scheduler gets the part to the first available machine. Many parts are finally completed when they are designated as hot. Thus many parts stay in the system for some time before being worked. The system appears to be one that generates emergencies and confusion.

Quality control and inspection under the Production Acceptance Certification (PAC) program now has the operators checking their own work. This system functions well for checking critical dimensions that each operator works on. The problem is that there is apparently no one checking accumulated positional tolerances on parts that have multiple areas of repair. Frequently, parts with multiple repairs will not fit during assembly and either have to be reworked or hand worked before they will fit.

7.5.2 Statistical System Performance Measures

Refer to paragraph 7.1.2.

7.5.3 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

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problems requiring focus studies for MANPRB at this time, improvement opportunities are presented as other observations in paragraph 7.5.4 and as quick fixes in the Quick Fix Plan.

7.5.4 Other Observations

- **Quality Control on a Part with Multiple Repairs**
 - **Current Condition:** Many parts repaired in MANPRB are not in overall dimension limits by the time a part is ready for assembly. Quality inspections made by the operators may be accurate but many parts have multiple repairs done by different mechanics. The aggregate tolerances are not being checked. The parts have to be sent back for rework or hand filed, ground, or sanded by the assembly mechanic. The PAC program does not address problems such as this.
 - **MDMSC Recommendation:** A quality control inspector needs to be assigned to inspect parts with multiple repair areas. He should monitor these parts after each critical operation that could cause delays during assembly. The inspector should be assigned to a MANPRB foreman. He should check the part after each separate repair procedure for total tolerance conformity.
- **Part Movement and Scheduling**
 - **Current Condition:** Other than urgent hot items, parts are not controlled by any one person. This leads to lost parts and more recently received parts being worked before those brought in previously.
 - **MDMSC Recommendation:** Develop a color code system that will identify the length of time a part has been in the RCC for repair and train personnel to record, track, and monitor parts in their area.

A coded system could be developed that would allow attaching color coded tags to the WCDs attached to the parts. A color could be assigned for each month of the year; e.g., white for January, blue for

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February, etc. The schedulers and mechanics would work the jobs that have the colored tags attached to the WCDs. The color coded tags on the WCDs could only be changed by a general foreman.

This visual system is simple and easy to institute and has been used in the office environment successfully to keep paperwork moving. Once the part is finished, the tag can be removed and scheduled for transfer to the next operation.

- Personality Characteristics Testing

- Current Condition: The monotony involved watching parts requiring extended grinding hours, some up to 23 hours, causes many people to transfer out of MANPRB. The months of training that person had are then lost.
- MDMSC Recommendation: A test needs to be given to determine a person's ability to work under the required conditions. The ability to stay alert and attentive under such tedious conditions should be more important than their machinist skills.

The training program offered is able to produce good grinding personnel but cannot change a person's resistance to conditions contrary to his psychological profile.

7.6 MANPRC ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MANPRC is a Resource Control Center (RCC) under the MANP branch of the Industrial Products Division (MAN) at OO-ALC. MANPRC performs various manufacturing and repair operations, under the Repair Support Section (MANPR), relative to metal coating/metal protective (inorganic) surface finishes.

During characterization of the MANPRC RCC, 12 improvement opportunities were identified; reference the Potential Improvement Opportunities section of the Database Documentation Book (DDB).

Two of the improvement opportunities are classified as focus studies and address the need to improve activation procedures to properly plate parts. The first focus study titled, "Study and Develop the Best Plating Procedure for 300M Steel" is presented in detail in paragraphs 7.6.4 through 7.6.4.4. The second focus study titled, "Study the Potential in Developing Plating Efficiency" is presented in detail in paragraphs 7.6.5 through 7.6.5.4.

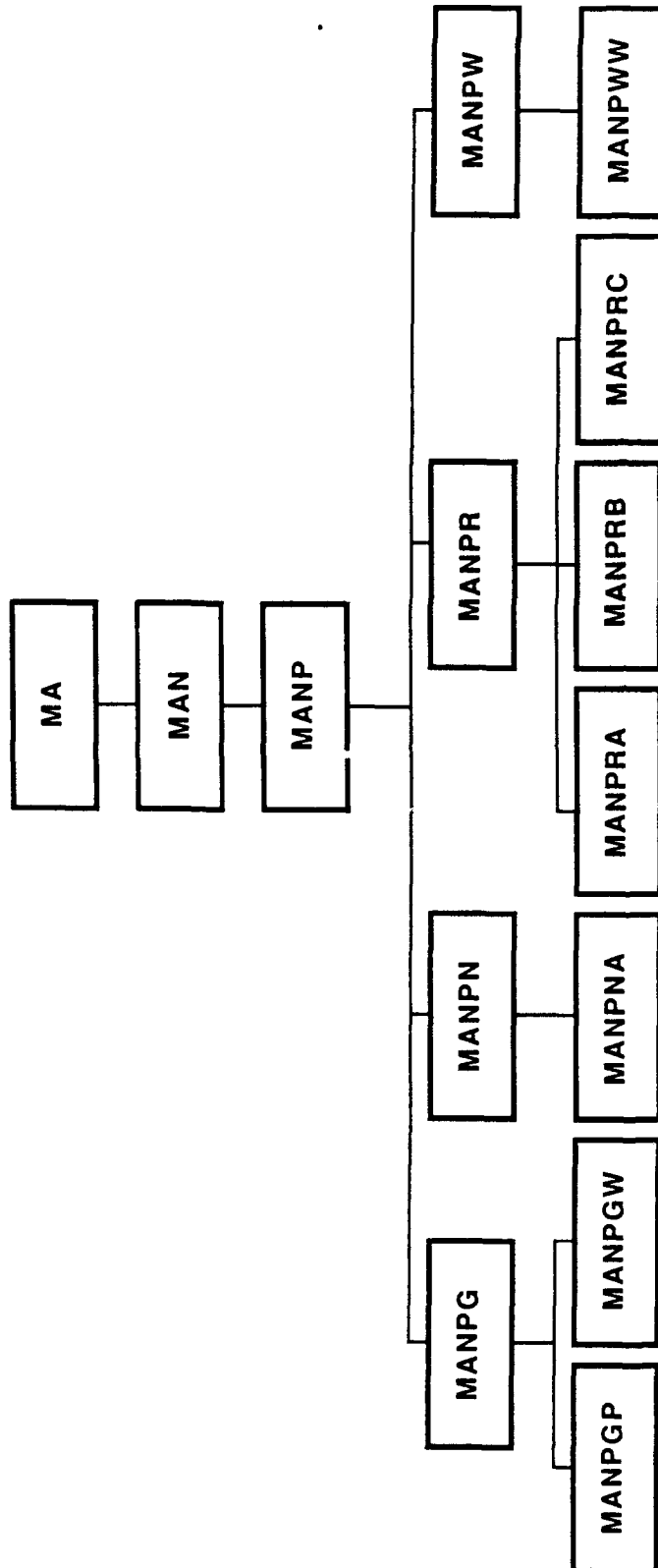
Three of the improvement opportunities are classified as quick fixes and address: increasing the number of salvageable parts, improving plating uniformity by using shields, and eliminating rework caused by improper anode care. These quick fixes are described in detail in paragraphs 7.6.1 through 7.6.3.6 of the OO-ALC Quick Fix Plan.

The remaining eight improvement opportunities are classified as other observations and are described in detail in paragraph 7.6.6 of this Contract Summary Report (CSR).

7.6.1 Description of Current Operation

The MANPRC RCC primary function is to perform various manufacturing and repair operations on aircraft landing gears including brakes, struts, and wheels. MANPRC manpower consists of an average of 64 direct-labor mechanics and three shift supervisors with one general foreman, see Figures 7.6.1-1 and 7.6.1-2.

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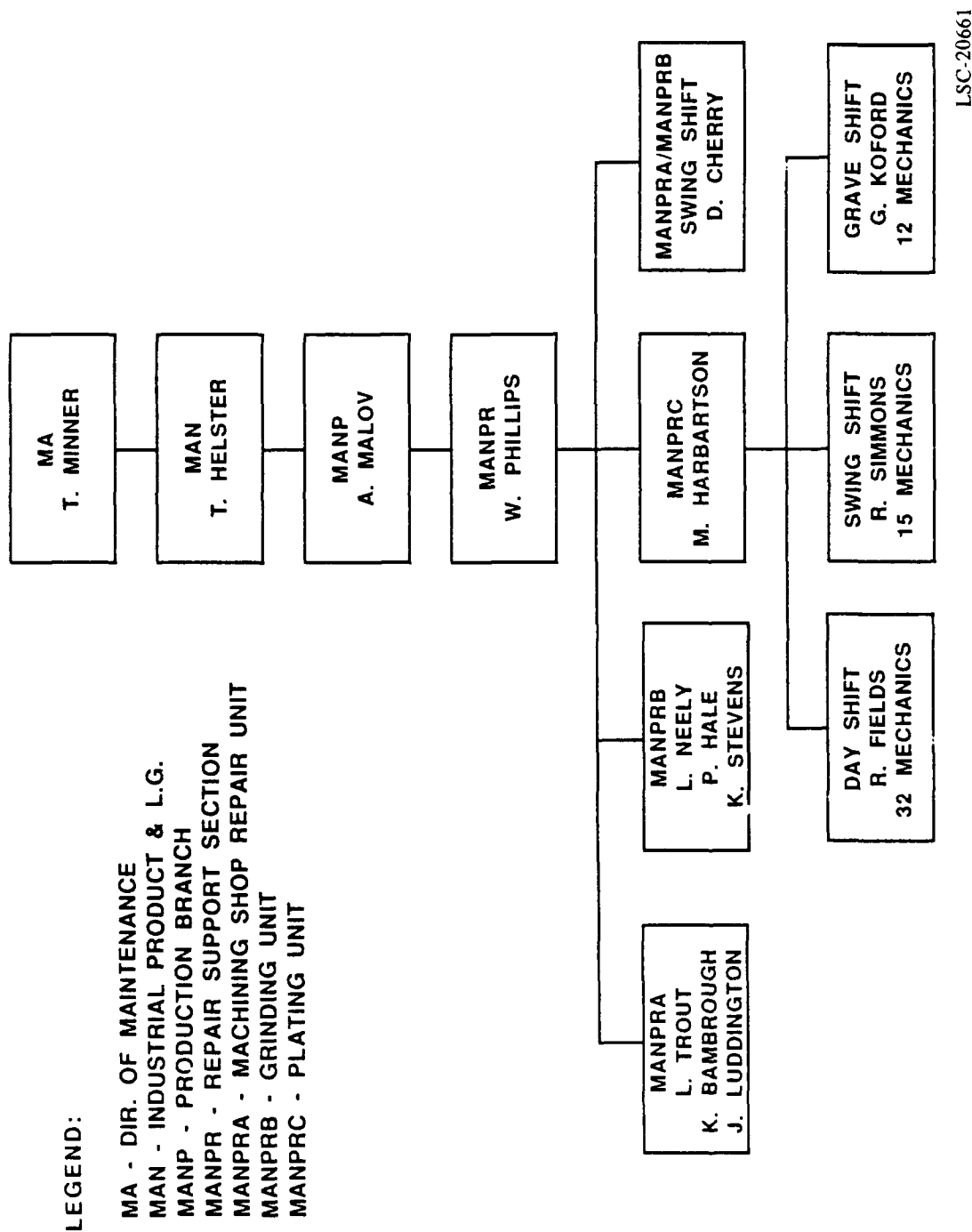
MA = DIR. OF MAINT.
MAN = INDUSTRIAL PRODUCTS & L. G. DIVISION
MANP = PRODUCTION BRANCH
MANPG = LANDING GEAR SECTION
MANPGP = ASSEMBLY UNIT
MANPGW = DISASSEMBLY UNIT
MANPN = NONDESTRUCTIVE TEST SUPPORT SECTION
MANPNA = NONDESTRUCTIVE TEST UNIT

MANPR = REPAIR SUPPORT SECTION
MANPRA = MACHINING SHOP REPAIR UNIT
MANPRB = GRINDING UNIT
MANPRC = PLATING UNIT
MANPW = MISC. MANUFACTURING/REPAIR SECTION
MANPWW = FLAME SPRAY UNIT

OO-ALC RCC PROCESS CHARACTERIZATION COVERAGE
FIGURE 7.6.1-1

LSC-20376

TASK ORDER NO. 1
PROCESS CHARACTERIZATION



OO-ALC MANPR ORGANIZATION

FIGURE 7.6.1-2

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

Approximately 90% of the workload in MANPRC is Management of Items Subject to Repair (MISTR) with the remaining 10% divided equally between Planned Depot Maintenance (PDM) and Temporary (Manufacture).

MANPRC utilizes chemical tanks and associated plumbing and exhaust ventilation, plus the waste treatment facilities relative to hazardous chemicals currently in use. These facilities are located in Building 505, see Figure 7.6.1-3.

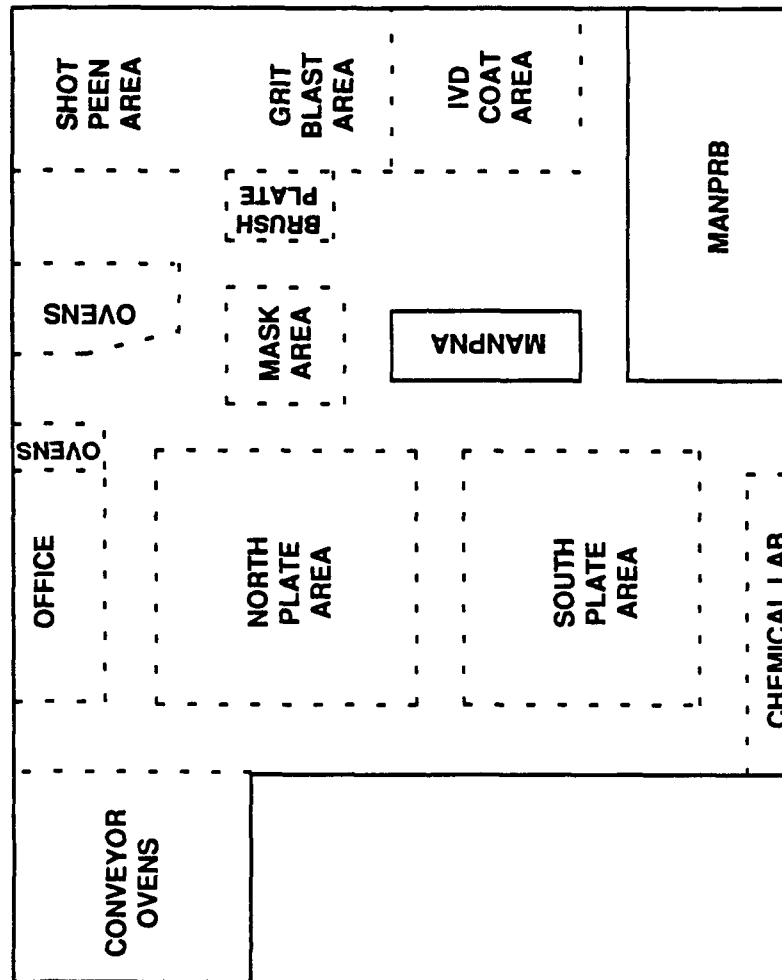
MANPRC performs many interrelated repair functions which include the following:

- Abrasive dry-blasting for preparation of metal surfaces prior to the various finishing operations.
- Shot-peening of metals to mechanically stress-relieve parts prior and subsequent to metal finishing.
- Chemical stripping (removal) of coatings from metal parts to be repaired.
- Alkaline cleaning and vapor (solvent) degreasing to remove oil type soils to obtain good bonding of the applied surface finishes.
- Deposition of metallic coatings, both with and without electricity to repair parts and to provide corrosion and wear (abrasion) resistance during in-service life.
- Brush plating of metallic coatings for repair of parts both on the bench and on the operational aircraft.
- Baking of parts, both prior to and subsequent to metal finishing to: 1) relieve service induced and process induced stresses, and 2) relieve stresses induced by absorption of hydrogen gas during the various chemical operations.
- Application of dry-film lubricants to provide anti-seize surfaces on the repaired parts.

The main function of MANPRC is to apply metallic and non-metallic coatings on metal parts of aircraft landing gear. These coating processes include the following:

- Chromate conversion treatment of aluminum as a paint base and as a provision for some corrosion protection.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION



BUILDING 505
FIGURE 7.5.1-3

LSC-20664

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

- Anodizing (chromic acid, sulfuric acid, and hard coat types) of aluminum to; provide additional corrosion protection, add better paint base, and add a hard coat which will provide excellent wear resistance of bearing surfaces.
- Cadmium deposition for corrosion protection of ferrous metals.
- Dry-film coatings to improve the lubricity and anti-seize properties of aluminum and ferrous alloy parts.
- Nickel deposition for buildup of wear surfaces and for corrosion resistance.
- Ion-vapor deposition of aluminum as a viable substitute for the toxic cadmium metal and for increased corrosion protection.
- Passivation of stainless steels to increase the corrosion protection.
- Phosphate conversion coating of ferrous alloys to increase corrosion protection and to provide a paint base.
- Silver deposition to decrease electrical resistance of contacts and to provide anti-galling surfaces in sliding contact applications.
- Tin deposition of ferrous alloys to provide increased lubricity on sliding contact surfaces.

The second most important function of MANPRC is the considerable amount of grit blasting it performs in which various grit materials such as aluminum oxide, garnet and glass beads are used to condition the metal surfaces and to remove corrosion. Two, large, walk-in sandblast enclosures and two small sandblast cabinets are available. At least two mechanics are assigned to perform the sandblasting operations; however, the plating personnel often perform the blasting on parts as required during their chemical processing operations. A large amount of space in the grit blast area is used to store the various grit materials, making the movement of personnel difficult at times. Floor space is not available for storing work in process. Parts are obtained from the staging area just in time. Requirements for fixturing are minimal but some masking with rubber or plastic blankets is used particularly with the larger parts. Appropriate safety equipment, including ear muffs/plugs, is used by the mechanics in the blast enclosures. The blast enclosures are provided with exhaust ventilation and air cleaning equipment.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

Shot-peening is used to relieve stresses induced in the landing gear parts. This operation is auxiliary to the stress relief baking operations performed prior to shot-peening before plating. Three large walk-in enclosures, for large parts requiring hoist-assist, are available plus one shot-peen cabinet for small parts. Various sizes of steel shot are used depending on the specifications that have to be satisfied. The shot is blasted at the surface of the part with compressed air. The peening action of the shot moves the surface metal around, filling in scratches and removing burrs. A beneficial side effect of the shot-peening is to remove heavy heat treat scale and corrosion products which would require extensive grit blasting. A minimum of two mechanics is required to handle the normal workload, particularly when rigging and handling the very large landing gear parts. More space is available for traffic in this area than the grit blast area due to the greatly reduced storage of supplies. The shot lasts longer than the grit, therefore less storage area for the shot material is required. As with the grit blast operations, fixturing is minimal. Compliance with safety and environmental standards was evident.

Defective metallic and non-metallic coatings are chemically-removed (stripped) prior to machining or the reapplication of the specified coating. The aluminum anodize coatings and metal coatings, such as cadmium, chromium, and nickel are among those more commonly stripped by MANPRC using either immersion or electrochemical methods in both the north and south plate areas. Masking of the plated, anodized, or phosphatized, parts is not normally required. Masking is done only when stripping selected areas next to areas not requiring stripping. The platers perform the stripping operations on parts being repaired. No special fixturing is required except for those coatings removed by electrolytic means. The stripping operation is the first chemical repair operation on parts released from the staging area. There is normally no problem storing parts to be stripped except for those parts with nickel deposits. Nickel is removed very slowly when stripped chemically. Because of this, at times, there are more parts to be stripped than there is available strip tank capacity. Adherence to safety and environmental regulations is generally pursued by all assigned personnel.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

Cleaning of parts prior to the application of the desired coating consists of vapor degreasing utilizing trichloroethane solvent with or without a subsequent alkaline cleaner. Some parts are only vapor degreased following one of the sandblasting operations. All soils, whether products of oil or corrosion, that are not removed by the cleaning operations impair coating quality. Extra care is exercised on those parts which are susceptible to hydrogen embrittlement. These are cleaned by sandblasting plus vapor degreasing. The vapor degreasers are marginal in size for some of the larger parts. The largest degreaser (CA-33) in the north plate area has been down for quite some time. The degreaser does not have enough heating coils, for the volume of fluid, to degrease parts quickly and the condensing coil is not sized sufficiently to keep the fumes from spilling out when the cover is opened or when the parts are removed. This degreaser should be repaired to eliminate overburdening the other degreaser in the area during workload surges. Having this degreaser operational would also reduce chrome contamination in the other degreaser. If the recommendation to change the masking material to wax, recommended in Task Order No. 7's Masking Evaluation, is implemented, the degreaser would be essential to the operation. None of the vapor degreasers have a solvent recovery still. All solvent/sludge mixtures are transported to a central solvent recovery still for the ALC. Only two of the three degreasers (CA-12 and CR-72) are operational in the north plate area while all degreasers (CA-25, AH-3 and AN-25) are operational in the south plate area. Alkaline cleaning is performed using three different solutions, two of which are listed in Technical Order 42C2-1-7. One is a modification that MANPRC has developed. This modified solution is a mixture of Formula P (a non-etching formulation for aluminum) and of a proprietary alkaline rust remover. This product is designated as Formula P-R. The cleaner does work quite well as an etching type cleaner plus its chemical composition is more easily determined by analytical means.

The main methods of repair performed by MANPRC involve the deposition of metals and non-metallic coatings to landing gear parts (axles, hydraulic cylinders, struts and trunnions) plus a variety of a smaller number of aircraft parts requiring corrosion and/or abrasion protection. The majority of coatings are applied electrolytically in appropriate chemical solutions. However,

TASK ORDER NO. 1
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MANPRC does process a number of parts by ion-vapor deposition, an aluminum deposited replacement for cadmium plating, as well as cadmium plating by immersion or brush plating. Brush plating performs the same task as does immersion plating except small areas may be repaired without extensive fixturing or masking and, in addition, repairs may be made on operational aircraft using the portable equipment and supplies. The primary methods of masking for metal finishing operations involves the use of metal foil and vinyl tapes and the use of a hot melt plastic applied by immersion of the part in a large tank and quenching in water. Task Order No. 7 addressed the masking features at each ALC in more detail. Extensive fixturing is commonly used for the metal deposition processes, particularly when hard chromium plating landing gear parts and using conforming anodes and auxiliary molded plastic masking fixtures. A total of 34 mechanics are employed as journeymen platers for the three shift operation. The storage areas for MANPRC are inadequate and much floor space needed for manufacturing operations and safe movement of the material is being utilized for the storage of parts on wooden skids. Since no bridge crane exists in either the north or south plate areas, parts must be dismantled from one monorail/hoist and transferred to another when the chemical operations involve more than one tank line. There are 19 tank lines in the shop with one monorail hoist for each pair of tank lines, except for tank line no. 19. The monorail system over line 19 does not connect with the rest of the interconnected serpentine monorail system. Solution maintenance of the chemical tanks, in both the north and south plate areas, is extremely poor. Virtually every rinse tank and treatment tank has visible dirt and miscellaneous debris in them. A few of the plate solutions, particularly chromium plate solutions, are infrequently transferred to a holding tank to remove sludge and debris. This is partially due to not having a storage tank specifically designated for this purpose. Improved quality of all the wet chemical operations would result with cleaner solutions. Additions of dry chemical replenishment or treatment compounds result in rough, nodular deposits until the chemical replenishment is dissolved or until the treatment compounds are filtered.

Parts are baked to relieve stresses induced by in-service work hardening and by absorption of hydrogen gas during certain chemical operations. These

TASK ORDER NO. 1
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operations cause an embrittlement of 300M alloy, high strength, steel metal landing gear parts. Three batch type ovens are available for baking, plus one large conveyORIZED oven in the RCC. All ovens are maintained at $375^{\circ}\text{F} \pm 25^{\circ}\text{F}$. The conveyORIZED oven has two separate conveyors, each operated at a different speed. The bake cycle for normal stress relief is four hours and a minimum of 23 hours for hydrogen embrittlement relief. Floor layout drawings of MANPRC and the individual process areas within Building 505 are in the MANPRC DDB.

Parts requiring the application of dry-film coatings are cleaned by suitable means and masked. After masking, parts are sprayed with the dry-film lubricant and then baked per the applicable process order.

7.6.2 Statistical System Performance Measures

Refer to paragraph 7.1.2.

7.6.3 Description of Process Problems

Excessive quantities of parts are requiring rework because of pitting in plated deposits and poor bond of the deposit to the part being repaired. Parts have non-uniform and eccentric plating deposits that do not finish grind to the required tolerances. Parts are burned and have rough deposits because of improper bath controls and bath contamination.

Some parts are not being repaired because of high internal repairs costs but could be repaired economically by outside vendors.

Time is wasted looking for parts because the facilities have inefficient part storage and transfer methods. The parts on the wooden pallets stored on the floor take up working and transfer aiseways space. It is difficult to walk around the work area to move or locate parts to be repaired. It is a complicated process getting a lift truck to the parts to be moved. Parts that are in the way must be moved first, then reorganized after the pallet with the part is removed. The hoisting system used to lift the parts into the processing tanks requires the parts to be transported under it. Any clutter in the work area must be moved

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

before processing can begin. In conjunction with this, parts are not easily identified. It may take quite some time to locate a specific part when the floorspace is filled with pallets. The parts are not effectively tracked which requires people to be assigned to locate needed parts listed on hot sheets.

Records are not kept as well as they should be on problems with process equipment or solutions. Problems that cause rework cannot be easily identified for corrective action. Too many rejects are repeated because of this.

The platers are not being trained to their capacity. They have the ability to do more and better work. Helping them understand their equipment and process better would facilitate this. They need to be taught different techniques specific to engineering chemical process applications, which will help them accomplish their work.

Plating technology that could increase production and produce better parts is not being put to use.

Some of these problems are often interrelated. The problems associated with pitted metal and poor bond at MANPRC directly affect costs and rework at MANPRB.

7.6.4 Recommended Focus Study: Study and Develop the Best Plating Procedure for 300M Steel

Twenty percent (1080) of the 5,400 parts chrome plated were designated as rework for experimentation, and of that number, 41.6% (449) are rejected because chrome deposits are pitted, 9 1/2% (102) are reworked because of poor bond etc. It is estimated that 1,200 landing gear parts are nickel plated annually. Of the 1,200 parts nickel plated, 8 1/2% (102) are recorded as rework because of poor bond and defective deposits. This information was supplied by MANPRC.

This study will provide a detailed investigation and analysis of the best metal activation procedure for nickel and chrome plating, and chromium plating

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

solution parameters to reduce rework because of pitting and poor bond on 300M and 300M types of steel.

7.6.4.1 Rationale Leading to Change

Landing gears are exposed to high mechanical and structural stress requiring transverse ductility; therefore, many landing gear parts are manufactured from 300M steel which satisfies this requirement. These parts include C141 axles, inner and outer cylinders, all C5 parts, and KC135 aft axles.

The crystalline structure and chemical composition of the different alloying constituents allow this type of steel to corrode and pit easily. Reoccurring problems have been identified where parts repaired by chromium and nickel electro plating have unacceptable plating defects. The defective chromium plating must be stripped and the part reprocessed. If possible, the defective nickel plating is machined because of the time and difficulty to chemically strip it. Repeated efforts to get an acceptable deposit fail frequently before a good deposit is obtained. Besides the extra expense of stripping, grit blasting and remasking, several hundred parts require the added expense of grinding.

The factors that influence the causes for 300M steel to produce defective plating are: the activation procedure for plating, the composition of the plating solution to achieve optimum covering ability, and contaminants in the plating solution.

Proper activation of the 300M steel is extremely important to keep the chrome and nickel from pitting. The process for chrome used at OO-ALC is simply to grit blast the plating area before masking then cleaning the plating area with aluminum oxide sanding belts. In the past parts were etched in sulfuric acid but draining the part was difficult, so the etch is no longer used. The parts for nickel plate are prepared using an acid dip before being put into the nickel plating solution to remove any oxides which would cause a defective coating. The acid dip used may not be the best method to achieve the best possible bond for these engineering specifications. There are also nickel strike solution formulations that may be used to further assure bond.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

The chromium plating baths are currently made with 33 ounces of chromic acid and .33 ounces of sulfuric acid per gallon of water per Technical Order 42C2-1-7. This chrome concentration and catalyst ratio may not be the best to cover the part with chromium as quickly as possible. Different concentrations and catalyst ratios need to be developed that will cover the surface with chrome most efficiently yet not sacrifice plating rate. By not covering the plating area quickly, some of the components such as manganese or silicon will passivate, generating pits from the surface of the base metal. Even if the passive surfaces slowly activate and finally cover, the resulting pits may be too deep to grind out without adding extra deposits of chrome. Either case requires extra expense to correct the defective plating.

Contaminants such as copper, iron, and organic materials that build up at the plating surface reduce the covering ability of the plating solution or do not allow the gas bubbles, generated at the surface of the part, to release. The gas bubbles prevent plating by acting as a maskant.

Identifying the detrimental contaminants, monitoring them, and even removing them will help decrease this reason for the pitting and poor adhesion.

Without proper activation the silicon and manganese may be passive and not cover with chrome or nickel thus allowing the possibility of pitting which is one of the two major reasons for rejects at MANPRC. By changing the activation procedures and the plating bath compositions, the pitting and bond problem should be eliminated in chrome plating and significantly reduced in the nickel plating. The current Technical Orders do not properly address this problem partly because they are developed by manufacturers that do not do rework.

7.6.4.2 Potential Cost Benefits

An annual recurring cost savings of \$231,196 occurs from the implementation of the recommended improvements as shown in Table 7.6.4-1.

SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS
(CONSTANT FY 89 DOLLARS)
TABLE 7.6.4-1 (SHEET 1 OF 3)

	CURRENT ANNUAL COSTS	<u>PROPOSED CHANGE</u>	
		INVESTMENT COSTS	ANNUAL COSTS
NONRECURRING COSTS (1)			
FOCUS STUDY	\$0	\$170,000 (2)	\$0
FACILITIES			
LAND	\$0	\$0	\$0
BUILDINGS	\$0	\$0	\$0
SUPPORT EQUIPMENT			
DEVELOPMENT	\$0	\$0	\$0
ACQUISITION	\$0	\$500 (3)	\$0
INSTALL & CHECKOUT	\$0	\$1,000 (4)	\$0
LOGISTICS SUPPORT			
INITIAL SPARES	\$0	\$0	\$0
INITIAL TRAINING	\$0	\$0	\$0
(DEV & PRESENTATION)			
TECHNICAL DATA	\$0	\$0	\$0
TOTAL NONRECURRING COST	\$0	\$171,500	\$0
RECURRING COSTS (1)			
TOUCH LABOR	\$233,951 (5)	\$0	\$2,755 (6)
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	\$233,951	\$0	\$2,755
TOTAL COSTS	\$233,951	\$171,500	\$2,755
ANNUAL COST SAVINGS	\$231,196		

NUMBER OF MONTHS FOR FOCUS STUDY 4

NUMBER OF MONTHS TO IMPLEMENT CHANGES 1

**SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS
(CONSTANT FY 89 DOLLARS)
TABLE 7.6.4-1 (SHEET 2 OF 3)**

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) ESTIMATED COSTS FOR ACID AND CLEANING TEST MATERIAL
- (4) ESTIMATED LABOR COST TO INSTALL ACIDS
- (5) 15 PEOPLE ARE ASSIGNED TO THE CHROME AREA
5400 ESTIMATED PARTS ARE CHROME PLATED PER YEAR (INCLUDING REWORK)
5130 PARTS (95%) ARE ESTIMATED CHROME GROUND PER YEAR
- * GRINDING TIME IS ESTIMATED TO BE 40% TO GRIND THE PART BEFORE PLATE AND 60% TO GRIND THE PART AFTER PLATE.

THE AVERAGE ESTIMATED GRINDING TIME IS 13.5 HOURS FOR ALL SIZED PARTS. (FLOWTIME HOURS PROVIDED BY MANPRB)

THE AVERAGE BEFORE PLATE GRINDING TIME IS $13.5 \text{ HOURS} \times 40\% = 5.4 \text{ HOURS}$

THE AVERAGE AFTER PLATE GRINDING TIME IS $13.5 \text{ HOURS} \times 60\% = 8.1 \text{ HOURS}$

ANNUAL COST OF A PLATER IS 1744 HOURS/YEAR (PER AFLCP.173-10, 6/17/87)
 $\times \$31.98/\text{HOUR} = \$55,773.$

OVERTIME HOURS PER PLATER ARE ESTIMATED TO BE 7.5% OF HOURS WORKED OR 130.8 HOURS. (THIS OVERTIME PERCENTAGE WAS PROVIDED FOR TASK ORDER NO. 1 MODELING).

THE DIRECT LABOR PORTION OF THE \$31.98 IS ESTIMATED TO BE \$10/HOUR.
 $\$10/\text{HOUR} \times 1.5 = \text{OVERTIME RATE} = \$15/\text{HOUR}.$ $\$15/\text{HOUR} \times 130.8 \text{ HOURS} = \$1,962 \text{ OF OVERTIME PER YEAR}.$

THE TOTAL ESTIMATED ANNUAL COST PER PLATER = $\$55,773 + 1,962 = \$57,735/\text{YEAR PER MAN}.$

THE TOTAL ESTIMATED ANNUAL WAGES IN THE CHROME AREA IS
 $\$57,735/\text{YEAR} \times 15 \text{ PEOPLE} = \$866,025/\text{YEAR}.$

THE TOTAL CHROME PLATING COSTS FOR 5400 PARTS = $\$866,025/\text{YEAR}.$ THE COST PER CHROME PLATED PART = $\$866,025/5400 = \$160.38.$

**SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS
(CONSTANT FY 89 DOLLARS)
TABLE 7.6.4-1 (SHEET 3 OF 3)**

BEFORE PLATE GRINDING COSTS FOR CHROME PLATED PARTS = 5.4 HOUR X
\$31.98 X 1.035 = \$178.74/PART.

AFTER PLATE GRINDING COST FOR CHROME PLATED PARTS = 8.1 X \$31.98 X
1.035 = \$268.10.

THE TOTAL COST FOR A PART CHROME PLATED THE FIRST TIME IS:

\$178.74	BEFORE PLATE GRINDING
160.38	CHROME PLATE WORK
<u>268.10</u>	AFTER PLATE GRINDING
\$507.22	

THE TOTAL COST FOR A REWORKED CHROME PART IS:

\$160.38	CHROME PLATE WORK
<u>268.10</u>	AFTER PLATE GRINDING
\$428.48	

THE 449 CHROME REJECTS (PER PARAGRAPH 7.6.4) CAN BE ELIMINATED WITH
THIS FOCUS STUDY RECOMMENDATION PER YEAR:

449 X \$428.48 = \$192,388

IF NICKEL REJECTS ARE 8.1% OF 1,200 PARTS NICKEL PLATED = 97
REJECTS/YEAR.

THE TIME NEEDED TO GRIND OR MACHINE, PREPARE, AND LEAVE IN THE
PLATING TANK IS BASICALLY THE SAME FOR ELECTROLYTIC NICKEL PLATING
AND HARD CHROME PLATING. REWORK TIME WILL THEREFORE BE BASICALLY
THE SAME ALSO.

97 REJECTS X \$428.48 = \$41,563

TOUCH LABOR = \$192,388 CHROME REWORK/YR + 41,563 NICKEL REWORK/YR =
\$233,951/YR TOTAL

- (6) THE REJECTS WILL BE REDUCED FOR CHROME AND NICKEL. ESTIMATED
REJECTS ARE 1% FOR CHROME AND 2% FOR NICKEL.
CHROME REJECT COST APPROX. 1% REWORK RATE = \$192,388 X .01 = \$1,924
NICKEL REJECT COST APPROX. 2% REWORK RATE = \$41,563 X .02 = \$831

TOTAL REJECT RATE ALLOWED = \$1,924 + \$831 = \$2,755

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

The investment cost of the recommendations is estimated at \$171,500. This cost includes the focus study effort and the implementation cost.

The Cost Benefit Analysis (CBA) shows an Internal Rate of Return (IRR) of 187% and a savings of \$734,105 in terms of Net Present Value (NPV) using constant FY89 dollars, see Figure 7.6.4-1. The CBA is in compliance with regulation AFR173-15, cost analysis procedures, dated 4 Mar 88.

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 FY90 is worth \$.91 in FY89 terms ($\$1.00/1.1$), due to the ability to borrow or lend at a positive interest rate.

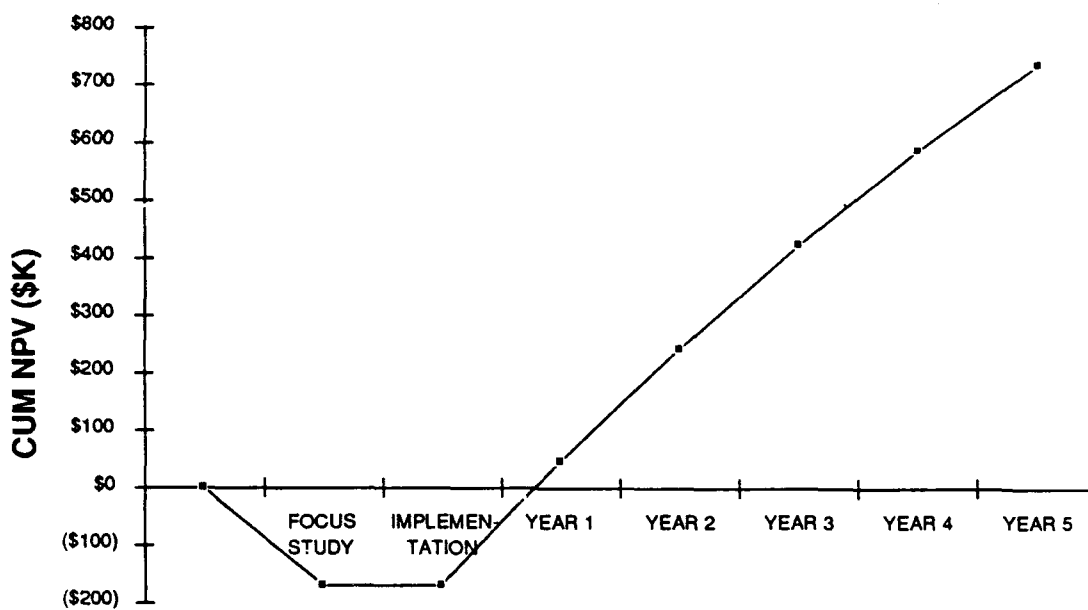
A sensitivity analysis was performed in which the investment cost varied between 50% and 200% of the estimated costs, see Figure 7.6.4-2.

7.6.4.3 Risk Assessment

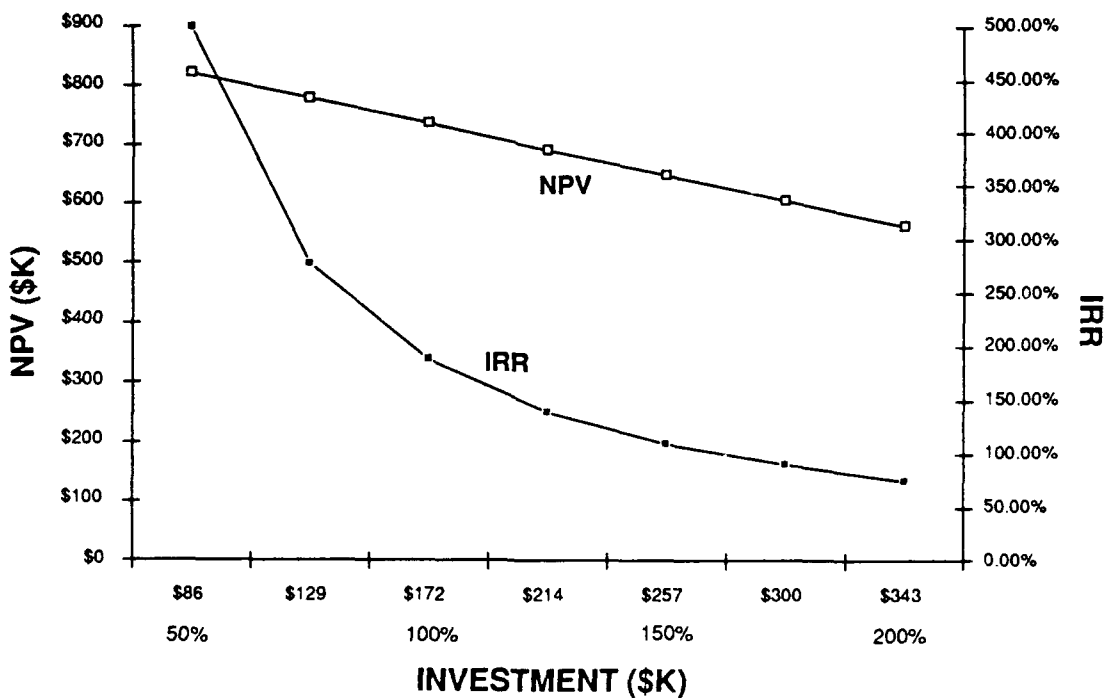
The following is a list of the possible risks in achieving the study goals. MDMSC believes these risks are minimal.

- The actual cost savings can be quantified only after the detailed focus study is completed and the optimum recommendations selected for recommendation.
- Some risks are associated with historical data on rework rates and more detail may be required although OO-ALC is now in the process of evaluating this problem.
- Implementation cost will involve some facility assessment and rearrangement which will not be considered in this focus study.

**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**



**CUM NPV IN CONSTANT FY89 DOLLARS
FIGURE 7.6.4-1**



**CBA SENSITIVITY ANALYSIS
FIGURE 7.6.4-2**

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

- Process control procedures and possibly modifications to Technical Orders will be required.
- Implementation costs are estimates and will be adjusted after the focus study.

7.6.4.4 Duration and Level of Effort

MDMSC recommends a four month long focus study period of performance to:

- Research and establish plating studies previously done in the aircraft industry and aircraft steels.
- Assess all technical aspects, facilities, and equipment, along with related process operations that will effect the RCC if any changes are experienced.
- Include alternatives, if any, and rank their effectiveness against the costs.

Table 7.6.4-2 illustrates the proposed schedule to accomplish this focus study. Table 7.6.4-3 outlines the major criteria defining the effort anticipated for focus study performance.

7.6.5 Recommended Focus Study: Study the Potential in Developing Plating Equipment to Decrease Masking and Increase Plating Efficiency

Most of the parts in the chromium and nickel plating areas require masking before plating to protect areas not being plated.

Plating equipment can be designed to eliminate masking and increase plating speed by 100%.

7.6.5.1 Rationale Leading to Change

Because parts are now immersed into a tank of plating solution, the areas not requiring repairs must be masked to protect them from plating. It is equally important to protect the areas not requiring plating from the etching effects of the acids and electrolysis.

PROPOSED FOCUS STUDY SCHEDULE
TABLE 7.6.4-2

ACTIVITY/TASK	MO #1	MO #2	MO #3	MO #4
METAL ACTIVATION RESEARCH				
ASSESS EFFECTS OF CHANGE ON RCC				
LIST AND RANK				
STATUS REPORTS				
EXECUTIVE SUMMARY BRIEFING				
CONTRACT SUMMARY REPORT				

LSC-20699

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

STUDY AND DEVELOP THE BEST PLATING PROCEDURE
FOR 300M STEEL FOCUS STUDY CRITERIA CHECKLIST

TABLE 7.6.4-3 (SHEET 1 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)	LEVEL OF EFFORT		
		MIN	AVG	MAX
Process/Material Flow	Implementation of the focus study increase material flow during process.			X
Equipment/Work Place Layout	Modified work place layouts and minor equipment (tanks) adjustments made.		X	
Facility Requirements	The existing facility/space requirements in Building 507 will not change.	X		
Labor Standards	No change anticipated.	X		
Manpower	No change anticipated.	X		
Task Assignments	No change anticipated.	X		
Material Requirements	Activation chemicals will be required.		X	
Scrap Rates	Scrap rates will be eliminated or significantly reduced.			X

LSC-21696

**STUDY AND DEVELOP THE BEST PLATING PROCEDURE
FOR 300M STEEL FOCUS STUDY CRITERIA CHECKLIST**

TABLE 7.6.4-3 (SHEET 2 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)	LEVEL OF EFFORT		
		MIN	AVG	MAX
Material Handling & Storage Methods	No change anticipated.	X		
Inspection Techniques	No change anticipated.	X		
Equipment/Tools/Fixtures	Reclassification or proposed rearrangements of processing tanks may be required.			X
Process Delays	Implementation should not delay processing.	X		
Part Identification	No change anticipated.	X		
Quality	New activation procedures will increase the part quality significantly.		X	
Personnel Safety	No change anticipated.	X		
Environmental Assessments	No change anticipated.	X		

LSC-20696

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

At OO-ALC the parts are currently being masked with a hot melt plastic. All masking materials are expensive, and this material is especially so. The labor and time required to apply and remove the maskant further increase the costs.

It may be possible to plate the majority of the varied parts plated with chrome and nickel by designing equipment and procedures to plate only the areas needing plating. This would require equipment similar to that now being used to plate C5A outer cylinder parts, except the solution would be forced by pump through removable tubes attached to the outside of the part. These tubes would house the anodes and fit uniformly around the part. Solution would be pumped from a reservoir tank through the tube back into the reservoir tank. The unplated area would not be exposed to the chemicals thus no masking would be required.

Pumping the solution in the tube exposes the plating surface to the more efficient hexavalent chromium, thus increasing plating efficiency by as much as 300%. It should also decrease rejects on 300M steels because the increased efficiency will cause the alloyed steel to cover faster and reduce or remove the other causes of rejects such as contaminants and/or gas bubbles.

A preliminary study must be made to categorize the shapes and sizes of parts plated and evaluate how many can be processed this way. This would categorize them from greatest potential to those with least potential. After the evaluation, an estimate can be made of costs for those with potential and estimate cost saving over the present plating methods.

This technology will reduce the hazardous waste by decreasing the amount of plating solution that is introduced into the rinse water systems. It will also improve the quality of the deposit by making it smoother, keeping more nearly to size, and improving the covering power on difficult to plate metal alloys.

7.6.5.2 Potential Cost Benefits

An annual recurring cost savings of \$518,243 occurs from the implementation of the recommended improvements as shown in Table 7.6.5-1.

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**SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS
(CONSTANT FY 89 DOLLARS)
TABLE 7.6.5-1 (SHEET 1 OF 3)**

	CURRENT ANNUAL COSTS	<u>PROPOSED CHANGE</u>	
		INVESTMENT COSTS	ANNUAL COSTS
NONRECURRING COSTS (1)			
FOCUS STUDY	\$0	\$390,000 (2)	\$0
FACILITIES			
LAND	\$0	\$0	\$0
BUILDINGS	\$0	\$0	\$0
SUPPORT EQUIPMENT			
DEVELOPMENT	\$0	\$125,000 (3)	\$0
ACQUISITION	\$0	\$100,000 (4)	\$0
INSTALL & CHECKOUT	\$0	\$0	\$0
LOGISTICS SUPPORT			
INITIAL SPARES	\$0	\$0	\$0
INITIAL TRAINING	\$0	\$0	\$0
(DEV & PRESENTATION)			
TECHNICAL DATA	\$0	\$0	\$0
TOTAL NONRECURRING COST	\$0	\$615,000	\$0
RECURRING COSTS (1)			
TOUCH LABOR	\$3,080,800 (5)	\$0	\$2,768,758 (6)
SUPPORT EQUIP MAINT	\$0	\$0	\$0
SPARES AND SPARES MGMT	\$237,383 (7)	\$0	\$59,346 (8)
TECHNICAL DATA	\$0	\$0	\$0
MOD KITS	\$0	\$0	\$0
CONFIGURATION DATA MGMT	\$0	\$0	\$0
UTILITIES	\$37,552 (9)	\$0	\$9,388 (10)
TOTAL RECURRING COSTS	\$3,355,735	\$0	\$2,837,492
TOTAL COSTS	\$3,355,735	\$615,000	\$2,837,492
ANNUAL COST SAVINGS	\$518,243		

NUMBER OF MONTHS FOR FOCUS STUDY 6

NUMBER OF MONTHS TO IMPLEMENT CHANGES 12

**SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS
(CONSTANT FY 89 DOLLARS)
TABLE 7.6.5-1 (SHEET 2 OF 3)**

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) ESTIMATED DESIGN AND DEVELOPMENT COSTS BASED ON A 1.5 MAN EFFORT FOR FOUR MONTHS.
- (4) ESTIMATED COST OF NEW EQUIPMENT BASED ON EXPERIENCE WITH SIMILAR EQUIPMENT AND EQUIPMENT BEING PURCHASED DURING IMPLEMENTATION.
- (5) THE COST FOR LABOR IN THE CHROME PLATING AREA, ASSUMING AT LEAST 3 1/2% OF THE TOTAL WORKLOAD IS OVERTIME = \$866,025, (SEE TABLE 7.6.4-1 FOOTNOTE (5) FOR CALCULATIONS). OF THE ABOVE COST, \$83,840 IS TOUCH LABOR COST. THIS COST WAS ESTABLISHED IN TASK ORDER NO. 7'S CSR REVISION B, TABLE 6.3-1, FOOTNOTE (8). ALL OTHER LABOR THEN IS \$866,025 - \$83,840 = \$782,185.

GRINDING COST ESTIMATES OF PARTS CURRENTLY BEING GROUND IS 5,130 PARTS X 13.5 HOURS X \$31.98 = \$2,214,775.

ESTIMATES FOR GRINDING COST OF THOSE PARTS BEING GROUND ON IS 5130 PARTS X 13.5 HOURS (INCLUDES FLOWTIME) EACH PART X \$31.98/HR. = \$2,214,775.

TOTAL CURRENT LABOR COST = 83,840 + 782,185 + 2,214,775 = 3,080,800

**TASK ORDER NO. 1
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**SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS
(CONSTANT FY 89 DOLLARS)
TABLE 7.6.5-1 (SHEET 3 OF 3)**

- (6) TOUCH LABOR COSTS ESTIMATED AFTER THE FOCUS STUDY IMPLEMENTATION.

IF MASKING IS REDUCED TO 25% OF CURRENT COSTS = $\$83,840 \times .25 = \$20,960$. OTHER CHROME LABOR COSTS WILL REMAIN THE SAME AT \$782,185.

SIGNIFICANTLY IMPROVED PLATING DEPOSITS THAT ARE UNIFORM, CONCENTRIC, SMOOTH, AND HAVE A MINIMUM AMOUNT OF GRINDING STOCK, WILL REDUCE GRINDING TIME. A 15% REDUCTION IN GRINDING COSTS HAS BEEN USED AS A CONSERVATIVE ESTIMATE FOR THE 75% OF PARTS THAT WILL BE EFFECTED.

$$2,214,775 \times .85 \times .75 = \$1,411,919$$

25% OF GRINDING LABOR WILL STAY THE SAME

$$2,214,775 \times .25 = 553,694$$

TOTAL PROPOSED COSTS = $\$20,960 + \$782,185 + \$1,411,919 + \$553,694 = \$2,768,758$

- (7) COSTS FOR ANNUAL PLASTIC MASKANT COSTS
- (8) THE CURRENT MASKANT USAGE COULD BE REDUCED BY 75% IF ALL OF THE LARGER PARTS CAN BE PLATED WITH THIS METHOD. SMALLER PARTS WILL NOT REQUIRE THE SAME VOLUME OF MASKANT AS IS CURRENTLY USED. THE VOLUME CAN BE REDUCED BY PUTTING MORE ENCAPSULATED HOLLOW TANKS IN THE EXISTING MASKING TANK.
- (9) ESTIMATED COST FOR CURRENT MASKING HEATING BASED ON TASK ORDER NO. 7 DATA PROVIDED = \$37,552
- (10) BY REDUCING THE VOLUME OF MASKANT BY 75%, LESS HEAT WOULD BE REQUIRED.

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The investment cost of the recommendations is estimated at \$615,000. This cost includes the focus study effort to determine the parts applicable to this technology and implementation costs.

The Cost Benefit Analysis (CBA) shows an Internal Rate of Return (IRR) of 60% and a savings of \$1,232,427 in terms of Net Present Value (NPV) using constant FY89 dollars, see Figure 7.6.5-1. The CBA is in compliance with regulation AFR173-15, cost analysis procedures, dated 4 Mar 88.

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.

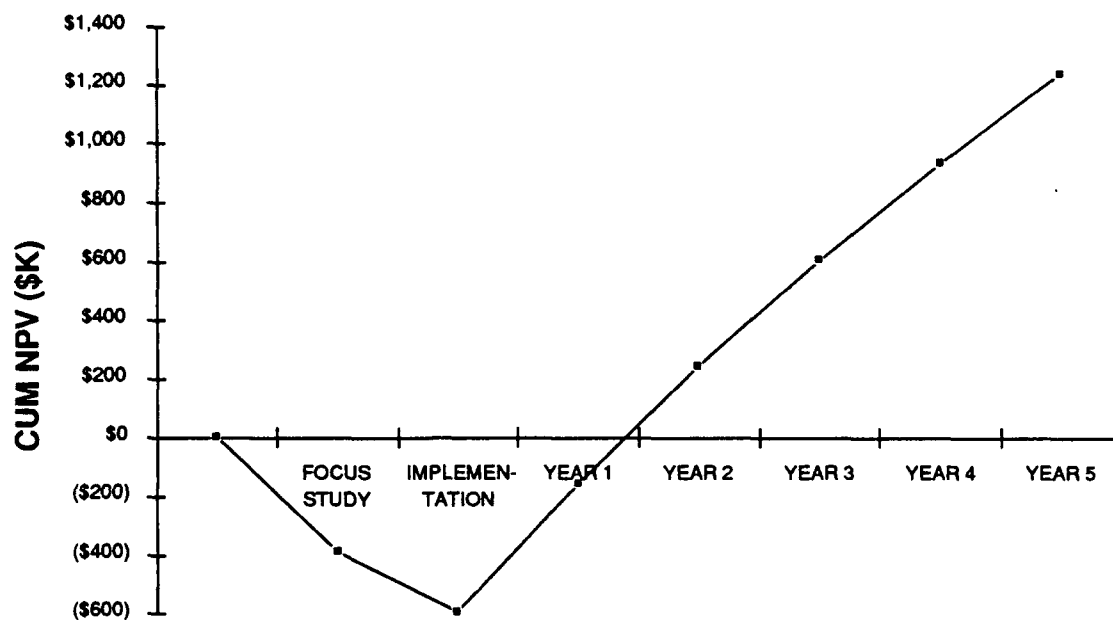
The NPV takes into account the time value of money and is calculated by discounting a cash flow. The focus study cost, implementation cost, and the recurring savings were spread by fiscal year quarters and discounted back to the first quarter by using a mid-quarter discounting factor equivalent to an annual discount factor of 10%. Basically, this means a dollar that is earned in FY90 is worth \$.91 in FY89 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 7.6.5-2.

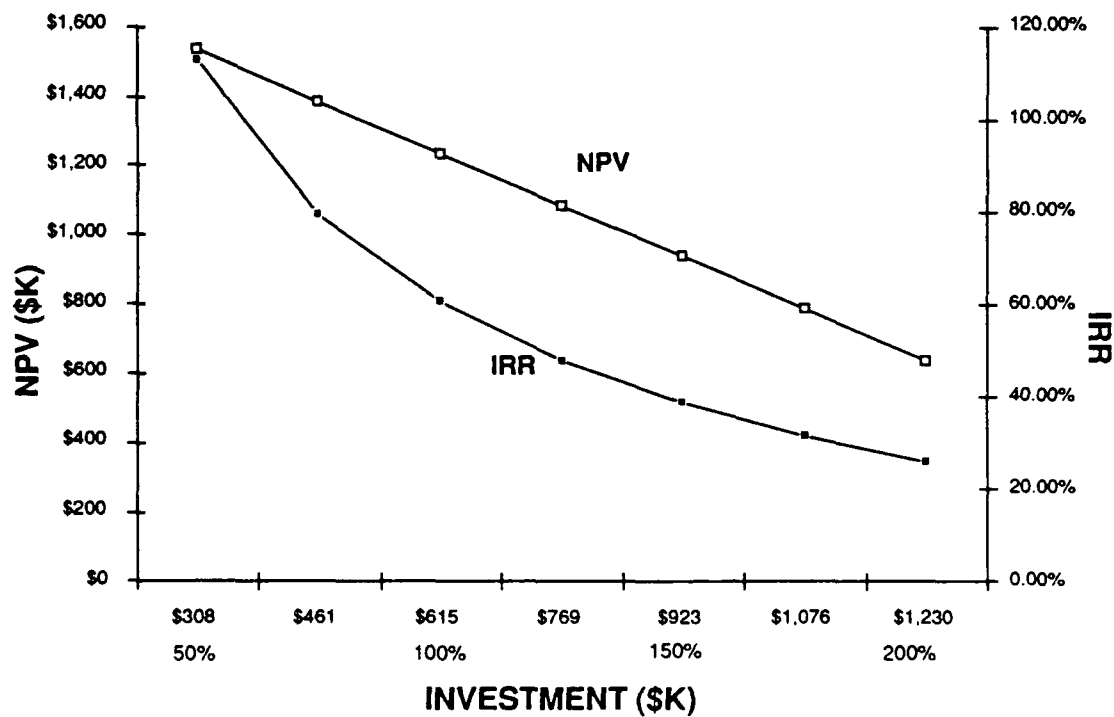
7.6.5.3 Risk Assessment

- The actual cost savings can only be quantified after the detailed focus study is completed and detailed recommendations made.
- Implementation costs will involve some facility assessment and rearrangement of equipment.
- Process control procedures and Technical Orders will require changing and updating which will not be included in the focus study.
- Any detailed information required for an implementation will not be included in this study.
- Any prototype costs are estimates for purchase from vendors.

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**CUM NPV IN CONSTANT FY89 DOLLARS
FIGURE 7.6.5-1**



**CBA SENSITIVITY ANALYSIS
FIGURE 7.6.5-2**

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7.6.5.4 Duration and Level of Effort

MDMSC recommends a six month focus study period of performance to:

- Make an initial assessment and categorize those items that will work with this method of plating and develop a system to rate the potential.
- Visit facilities within the United States that use or are planning to use this method of plating technology, to assure all concerned that the best equipment and latest technology is incorporated.
- One part will be selected to demonstrate the viability of the proposed process.
- After the part has been selected, a prototype will be manufactured for analysis and detailed cost evaluation.

Table 7.6.5-2 illustrates the proposed schedule to accomplish this focus study. Table 7.6.5-3 outlines the major criteria defining the effort anticipated for focus study performance.

7.6.6 Other Observations

The following recommendations were not considered as focus studies or quick fixes. These recommendations are considered significant to the operation at OO-ALC and if incorporated will improve operations.

Environmental Improvement Opportunities

- Chromium Recovery System and Zero Discharge
 - Current Condition: The extensive use of chromium plating within MANPRC generates large volumes of waste water contaminated with chromium. Chromium has been designated as a carcinogen and all possible avenues should be explored to keep this material from the environment including hazardous waste landfills. The scope of such a study is too large to be a part of any other studies to be effective. It is difficult, if not impossible, to justify such an observation under the quality, time and cost guidelines for focus study proposals. The recommendation will not make the parts better or produce them more economically, it will simply make the environment safer. Similar commercial enterprises are forced to install such systems because of

PROPOSED FOCUS STUDY SCHEDULE
TABLE 7.6.5-2

ACTIVITY/TASK	MO #1	MO #2	MO #3	MO #4	MO #5	MO #6
CATEGORIZE PARTS AFFECTED						
TRADE STUDIES						
DEVELOP/DETAIL ONE PART						
MANUFACTURE/DEMONSTRATE PROTOTYPE						
STATUS REPORTS						
EXECUTIVE SUMMARY BRIEFING						
CONTRACT SUMMARY REPORT						

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STUDY THE POTENTIAL IN DEVELOPING PLATING EQUIPMENT TO DECREASE MASKING AND INCREASE PLATING EFFICIENCY FOCUS STUDY CRITERIA CHECKLIST

TABLE 7.6.5-3 (SHEET 1 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)	LEVEL OF EFFORT		
		MIN	AVG	MAX
Process/Material Flow	Implementation of the focus study will increase selected material flow during plating process.			X
Equipment/Work Place Layout	Minimum changes anticipated.		X	
Facility Requirements	The existing facility/space requirements in Building 505 should not change.	X		
Labor Standards	No change anticipated.	X		
Manpower	No change anticipated.	X		
Task Assignments	Some task assignments may be adjusted.		X	
Material Requirements	No change anticipated.	X		
Scrap Rates	Scrap rates will be significantly reduced.			X

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STUDY THE POTENTIAL IN DEVELOPING PLATING EQUIPMENT TO DECREASE
MASKING AND INCREASE PLATING EFFICIENCY FOCUS STUDY CRITERIA CHECKLIST

TABLE 7.6.5-3 (SHEET 2 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)	LEVEL OF EFFORT		
		MIN	AVG	MAX
Material Handling & Storage Methods	No change anticipated.	X		
Inspection Techniques	No change anticipated.	X		
Equipment/Tools/Fixtures	New equipment will have to be added.			X
Process Delays	None expected.	X		
Part Identification	No change anticipated.	X		
Quality	Parts will have fewer rejects and improve follow-up processing.			X
Personnel Safety	No change anticipated.	X		
Environmental Assessments	Waste water discharges will be reduced.		X	

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artificial saving created by EPA requirements and penalties not easily enforced at the ALCs. Even the Pacer Reduce program goals to reduce the amount of waste water instituted by AGMC, are too easily ignored or bypassed.

Presently parts with chromium salts are rinsed in water tanks that do not conserve water nor return that contaminated water to the plating tanks. There is little or no attempt to keep the salts in the plating tanks.

- MDMSC Recommendation: The facility should install proper spray nozzles on each plating tank to rinse the majority of the solution back into the plating tank. By doing this alone, it is estimated that 80% of the chromium can be removed from the parts and returned to the tanks.

The present rinse tanks need to be replaced with properly designed backflow rinse tanks. Water from these tanks should be used to replace water evaporated from the plating tanks.

The excess water can be evaporated and the chromium separated. The reconcentrated chromium can be returned to the plating tanks. The evaporated water is very pure and with most other harmful impurities removed, it can be reused in the rinses. The evaporation process produces warm water which is excellent for better rinsing.

Finally with the use of porous pots that are being purchased by MANPRC, most harmful contaminants returned to the plating solution in the concentrated chromium effluent, can be maintained at acceptable levels.

- Hazard Communication Signs
 - Current Conditions: The chemical processing tanks in MANPRC are being refurbished by sand blasting and repainting. Signs normally on

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the tank, notifying personnel of the contents and hazards the chemicals impose, have been removed

- MDMSC Recommendation: Each tank should be labeled with the chemicals and their associated hazards as soon as chemicals are put into them per Occupational Safety and Health Administration (OSHA) hazardous communication standard, 29 Code of Federal Regulations (CFR) 1910.1200. These signs are necessary to identify any hazards associated with their contents.

Operational Improvement Opportunities

- On Sight Training by Outside Resources
 - Current Condition: Most of the training of plating personnel is done within the RCC itself. Part of the personnel in one process line is rotated to another line and the operators that have not been rotated train the new person. The supervisors normally do not have the time to assist in the training and rely on the personnel to train one another.

On occasion, personnel are sent to a training course outside of the ALC. Many times this training is not directly applicable to the type of procedures performed at OO-ALC. Shop personnel that have attended these training seminars state that many of the questions they have are not answered.

- MDMSC Recommendation: Because of the complexity of plating procedures at OO-ALC, periodic seminars for the personnel need to be given, but at the RCC itself. Bringing training consultants to the RCC that have the ability to teach supervisors, engineers, as well as the plating personnel, using the actual equipment and material, will optimize the training. The training becomes very practical under such conditions and less hypothetical.

This recommendation is especially pertinent if the plating personnel have a high turnover rate. Consistent standard information would

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always be taught even if the information is lost with the reassigned or transient operators.

- **Rework Accountability**

- **Current Condition:** Ways for determining responsibility for defective repairs at either MANPRC or MANPRB have not been established. Specifically, parts under repair have a high incidence of pitting or bond failure in the plated deposit. If it is determined that the plating deposit might clean up in the grinding process, the part is sent to MANPRB. If the parts have defects left when the part is at finish size, the deposit is ground to remove the defect.

The defect is charged to MANPRC by MANPRB without any substantiation. The plating personnel in turn blame MANPRB for misgrinding the part.

- **MDMSC Recommendation:** Because of the confusion over who's responsible for rejects on chromium plating deposits, a procedure needs to be established so historical data can be kept accurately determining reasons.

Any parts with bad bond need to be rejected back to MANPRC for chemical stripping. Parts being ground that show bond failure during grinding, should stop being ground leaving the defects showing and then also sent back to PRC for chemical stripping.

Pitted parts sent to PRB that obviously won't clean up need to be returned to PRC for chemical stripping. Parts that are pitted and are not acceptable after grinding, should have the worst representative area plunge ground until the part is 2-3 mils over finish size. If the part cleans up in that area the rest of the area will probably clean up. If the part is ground and while at finish size pits appear, the pits should be circled with a marker, no further grinding done, and returned to MANPRC for chemical stripping. If the part doesn't clean

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up, the grinding operation should be terminated and the part sent to PRC for chemical stripping.

If parts are ground and known defects removed, but other defects introduced, the responsibility of rejects should be placed on the grinding department. If the rejects are left for the plating department to see, they could not deny their accountability.

Grinding to remove chrome is very expensive when compared to chemical stripping and should not be performed unless absolutely necessary.

- Record Keeping

- Current Condition: Although some historical data is kept on computer in the plating shop it is currently not accurate enough to pinpoint problems that occur. This is currently being evaluated and MDMSC encourages this effort.

Currently substantial discrepancies are noted between records kept in other areas such as the grinding shop and the computer data kept by the plating shop.

- MDMSC Recommendation: The following types of data should be kept for each process if possible, but especially for nickel and chromium plating which require extra expensive grinding or machining processes.
 - Quantity of parts as well as areas plated (by day).
 - Reject rate by process and tank (by day).
 - Reason for reject recorded such as inadequate thickness, streaking, burning, out of roundness, inadequate coverage, etc.
 - Chemical tank dumps (date, amount, and reason).
 - Daily chemical consumption.

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Process Capability Opportunities

- Racks and Fixtures

- Current Condition: Many parts are currently being plated at OO-ALC with improper fixturing. Parts are hung in the plating tank with undersized bus bars inserted through existing holes in the parts.
- MDMSC Recommendation: A minimum of one square inch of contact area be utilized for every 1000 amperes of current. If this is not done heat will be generated at the contact point. This heat can get high enough to create fires, melt and/or burn the masking materials, and possibly damage the structure of the high strength steels.

The contact areas must be thoroughly cleaned with scratch pads or sandpaper and not grit blasted, unless the insulating grit is meticulously wiped off with a cloth.

The contacts must also be securely attached to prevent oxide films from forming during the plating cycle. These oxide films will gradually increase the resistance and also cause the parts to seriously overheat. Secured contacts also eliminate the chance of electrical arcing at the point of contact. This arcing may pit the part enough to require extra labor after plating. The pits may have to be locally polished per process procedures before bushings are installed or other rework performed.

Currently some parts are getting so hot that organisol maskants are applied around the contact area before the hot melt plastic maskant is applied.

Without the organisol maskant the heat generated at the poor contacts is melting the plastic maskant during the plating exposing the parts to the plating solutions. At times the rubber based organisol maskant is even burned.

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A study needs to be made of the current required for all parts plated and fixtures designed with the proper contact area.

- Extend Life of Cyanide Solutions

- Current Condition: The cyanide solutions in the existing tanks are air agitated. Air agitation in cyanide solutions increase the contact of oxygen and cyanide, which causes a buildup of carbonates. The carbonates should be maintained within specific limits. Excessive buildup of carbonates results in more frequent treatment or disposal.
- MDMSC Recommendation: The use of mechanical mixers or in tank pumps in place of air agitation would reduce the rate of carbonate buildup, thus increasing the life of the cyanide solutions. This would reduce waste treatment and solution makeup costs while increasing plating quality and efficiency. Excessive buildup of carbonates increases the length of plating time and causes uneven plating. An excessive concentration can also cause rough plating. Use of the recommended agitation equipment is a quick method to reduce carbonate buildup which increases hazardous waste. This equipment can be added to the current tanks immediately, taking less than one day to install on a tank.

- Hull Cells

- Current Condition: Control of the plating baths are currently only being done by the chemical processing lab, and that method is not being done often enough. As a result, the chrome plating solutions are giving different results from tank to tank and day to day. Some tanks cause pitting more than others, some burn more than others, some cover parts worse than others, and some plate at different rates than others. As a result, a high degree of inconsistency in chrome deposits occur with unacceptably high reject rates.
- MDMSC Recommendation: Hanging hull cells need to be used in conjunction with the analysis information from the chemical lab.

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Information on this equipment is included in the Database Documentation Book for MANPRC. This equipment is very economical (approximately \$250 per unit plus the test panels). It will give immediate visual results on bath conditions such as burning, efficiency, throwing and covering power, and contamination.

This practical test will not only show the existing capabilities of the plating bath, but show the results of any corrective action that may have been made.

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7.7 MANPWW ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MANPWW is a Resource Control Center (RCC) under the production (MANP) branch of the Industrial Product Division (MAN) at OO-ALC. MANPWW performs four separate repair/manufacture operations under the Miscellaneous Manufacturing/Repair section (MANPW).

During the initial characterization of MANPWW RCC, a total of four improvement opportunities were identified, reference MANPWW Data Documentation Book (DDB), Potential Improvement Opportunities section. Three of the opportunities were classified as quick fixes and are described in detail under separate cover (reference TI-ES Task Order (TO) No. 1, Volume IV Quick Fix Plan, OO-ALC, MANPWW Quick Fix Opportunities section). The other potential improvement opportunities are classified as other observations and are discussed in section 7.7.4. MDMSC is not recommending any focus study for this RCC.

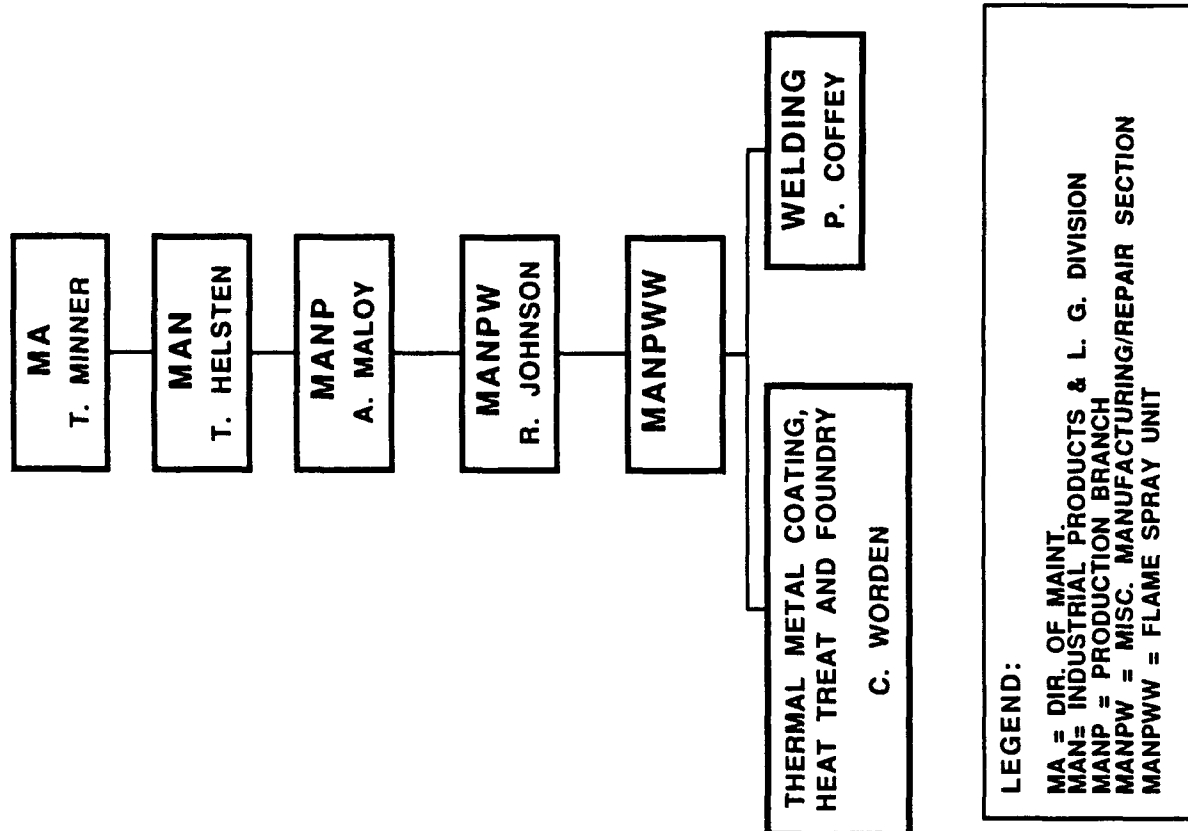
7.7.1 Description of Current Operations

The four repair/manufacture operations MANPWW performs consist of flame spray operations, herein noted as metal thermal coating, casting, heat treating, and welding operations. MANPWW utilizes facilities in both Building 507 and Building 511. The metal thermal coating operation is performed in Building 511 while the casting, heat treating, and welding operations are performed in Building 507. MANPWW manpower consists of an average of 30 mechanics and two foremen. See Figure 7.7.1-1.

At least 75% of the workload in MANPWW is Management of Items Subject to Repair (MISTR) for all operations except welding which is approximately 25%. The remainder of the workload of the RCC is Planned Depot Maintenance (PDM).

The metal thermal coating operation applies metallic coatings by use of two different procedures. The two procedures pertain to metals and alloys capable

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OO-ALC MANPW ORGANIZATION
FIGURE 7.7.1-1

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of being coated per the Type I combustion procedure and metals and alloys capable of being coated per the Type III plasma procedure. The two procedures are controlled by MIL-STD-869 (USAF).

The metal casting operations in Building 507 use a number of metals and alloys but chiefly zinc-based casting alloys plus aluminum and bronze. One of the larger production requirements of the foundry is aircraft landing arresting hooks.

The heat treatment operations in Building 507 utilize a variety of furnaces having atmospheres ranging from ambient to vacuum-type to inert gas types, plus an induction heat treat operation where heat is applied to only specific areas of a part.

The welding area utilizes the conventional torch welding processes in addition to both Metal Inert Gas (MIG) and Tungsten Inert Gas (TIG) techniques.

7.7.2 Statistical System Performance Measures

Refer to paragraph 7.1.2.

7.7.3 Description of Process Problems

The intent of this paragraph is to expound on major processes for which there are focus study recommendations. Since there are no major process problems identified for MANPWW at this time, improvement opportunities discussed in 7.3.1 are classified either as other observations in this report or as quick fixes in the Quick Fix Plan.

7.7.4 Other Observations

The following observations were originally identified as potential quick fix opportunities. Due to the difficulty assessing and then assigning cost benefits/savings, it was agreed that they should be presented as observations.

- Consumable Material Requisitioning
 - Current Condition: The RCC receives the minimum unit of purchase; i.e., 48" x 96" aluminum sheet or 100 lb drum of steel bolts, per each

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identified item regardless of actual needs such as a 12"x 24" section of aluminum sheet or a quantity of six steel bolts. Unused material is stored by the RCC until eventually used or declared as salvageable material which then leaves the ALC at a fraction of original cost. This practice was verified by mechanics in the RCC.

- MDMSC Recommendation: The ALC should establish a storeroom capable of supplying only those quantities of material requisitioned and meeting the existing needs of the RCC. A significant reduction in material declared as salvage in addition to reduced storage space would be realized. MDMSC also recommends a QP4 process action team investigate and study the problem.
- Storage of Safety-Related Equipment
 - Current Condition: Safety related equipment used by designated shop mechanics (ear muffs/plugs, face shields, and respirators) are stored on any available shelf or work table and subjected not only to soiling but also physical damage. Some of this gear is personal in nature and should be maintained in sanitary condition for the next usage. Current ALC regulations require that these types of personal, safety items be stored in suitable cabinets under the control of the assigned mechanics.
 - MDMSC Recommendation: A suitable locker should be assigned to each mechanic to store the safety-related items. The mechanic would then be responsible for their maintenance and degree of sanitary cleanliness. Suitable lockers are available on base at a cost of \$60.90 each.

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

**VOLUME IV
OO-ALC**

**QUICK FIX PLAN
15 DECEMBER 1989**

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

MCDONNELL DOUGLAS

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LIST OF ACRONYMS AND ABBREVIATIONS

DLH	DIRECT LABOR HOURS
E&I	EVALUATION AND INSPECTION
FY	FISCAL YEAR
MDMSC	MCDONNELL DOUGLAS MISSILE SYSTEMS COMPANY
O.D.	OUTSIDE DIAMETER
OO-ALC	OGDEN AIR LOGISTICS CENTER
PAC	PRODUCTION ACCEPTANCE CERTIFICATION
RCC	RESOURCE CONTROL CENTER
ROM	ROUGH ORDER OF MAGNITUDE
TI-ES	TECHNOLOGY INSERTION-ENGINEERING SERVICES

OO-ALC QUICK FIX PLAN

7.0 OGDEN AIR LOGISTICS CENTER (OO-ALC)

During the fourth quarter FY 89, McDonnell Douglas Missile Systems Company (MDMSC) completed process characterization of seven Resource Control Centers (RCCs) at OO-ALC in Ogden, Utah. The process characterization was performed as a part of the Technology Insertion-Engineering Services (TI-ES) Program.

This OO-ALC Quick Fix Plan is presented by RCC in alphabetical order. Table 7.0-1 presents an applicability matrix depicting the scope of each quick fix recommendation. Table 7.0-2 summarizes the impact of each quick fix recommendation.

The quick fix recommendation provided for MANPRB is also applicable to MANPRA for many parts now being machined; therefore, to eliminate any confusion from overlapping cost savings no quick fix is identified for MANPRA. No quick fixes are identified for RCC MANPNA since MANPNA performs only non-destructive inspection tests. Since the techniques utilized are proven processes, they provide no quick fix opportunities.

QUICK FIX APPLICABILITY MATRIX
TABLE 7.0-1

QUICK FIX TITLE	SCOPE (RCC AFFECTED)						
	MANPGP	MANPGW	MANPNA	MANPRA	MANPRB	MANPRC	MANPWW
WORKLEADER INSTRUCTOR	7.1.1						
C-5 FLOOR CREEPER	7.1.2						
PNEUMATIC TORQUE WRENCH	7.1.3						
PARTS STORAGE CABINETS	7.1.4						
C-5 BOGIE ASSY SPECIAL TOOL	7.1.5						
C-5 YOKE ASSY SPECIAL TOOL	7.1.6						
WHEELS BEAD BLASTING PROCESS		7.2.1					
SEMI-AUTOMATED REMOVAL OF BRAKE LINERS		7.2.2					
DECREASE GRINDING TIME				7.5.1	7.5.1		
INCREASE PARTS SALVAGING						7.6.1	
UNIFORM PLATING DEPOSITS WITH SHIELDS						7.6.2	
REWORK DUE TO INSUFFICIENT CHROME						7.6.3	
HEAT TREATMENT OF WHEELS							7.7.1
METAL THERMAL COATING OPERATIONS							7.7.2
IMPROVE PERFORMANCE IN WELDING							7.7.3

LSC-20693

OO-ALC QUICK FIX RECOMMENDATION SUMMARY
TABLE 7.0-2 (SHEET 1 OF 2)

MDMSC RECOMMENDATION	IMPACT	BUDGET SAVINGS	COST AVOIDANCE			INVESTMENT COST
			FLOW TIME REDUCTION	WIP INVENTORY REDUCTION	FLOOR SPACE REDUCTION	
MANPGP LANDING GEAR SUBUNIT QUALIFIED WORKLEADER INSTRUCTOR (MANPGP)	DIRECT LABOR HOURS SAVED	\$ 264,661	1 DAY	\$0	0 SQ. FT.	\$55,773
C-5 MAIN LANDING GEAR FLOOR CREEPER (MANPGP)	DIRECT LABOR HOURS SAVED	\$895	0 DAYS	\$0	0 SQ. FT.	\$100
PNEUMATIC TORQUE WRENCH (MANPGP)	STRUCTURAL INTEGRITY OF PART	\$0	0 DAYS	\$0	0 SQ. FT.	\$1,500
PARTS STORAGE CABINETS (MANPGP)	DIRECT LABOR HOURS SAVED	\$57,308	2 DAYS	\$0	0 SQ. FT.	\$2,303
C-5 BOGIE ASSEMBLY SPECIAL TOOL (MANPGP)	DIRECT LABOR HOURS SAVED	\$1,504	0 DAYS	\$0	0 SQ. FT.	\$286
C-5 YOKE ASSEMBLY SPECIAL TOOL (MANPGP)	DIRECT LABOR HOURS SAVED	\$2,239	0 DAYS	\$0	0 SQ. FT.	\$256
AIRCRAFT WHEELS BEAD BLASTING PROCESS (MANPGW)	DIRECT LABOR HOURS SAVED	\$123,155	0 DAYS	\$0	0 SQ. FT.	\$55,000
SEMI-AUTOMATED REMOVAL OF BRAKE LINERS (MANPGW)	DIRECT LABOR HOURS SAVED	\$33,931	0 DAYS	\$0	0 SQ. FT.	\$42,400
DECREASE GRINDING TIME (MANPRA, MANPRB)	DIRECT LABOR HOURS SAVED	\$285,638	1 DAY	\$0	0 SQ. FT.	\$100,000
INCREASE PARTS SALVAGING (MANPRC)	DIRECT LABOR HOURS SAVED	\$3,243	0 DAYS	\$0	0 SQ. FT.	\$0

LSC-20067

OO-ALC QUICK FIX RECOMMENDATION SUMMARY
TABLE 7.0-2 (SHEET 2 OF 2)

MDMSC RECOMMENDATION	IMPACT	BUDGET SAVINGS	COST AVOIDANCE			INVESTMENT COST
			FLOW TIME REDUCTION	WIP INVENTORY REDUCTION	FLOOR SPACE REDUCTION	
UNIFORM PLATING DEPOSITS WITH SHIELDS (MANPRC)	DIRECT LABOR HOURS SAVED	\$101,762	1 DAY	\$0	0 SQ. FT.	\$29,000
REWORK DUE TO INSUFFICIENT CHROME (MANPRC)	DIRECT LABOR HOURS SAVED	\$ 101,762	1 DAY	\$0	0 SQ. FT.	\$0
HEAT TREATMENT OF AIRCRAFT WHEELS (MANPWW)	DIRECT LABOR HOURS SAVED	\$1,478	1 DAY	\$0	0 SQ. FT.	\$180
METAL THERMAL COATING OPERATIONS (MANPWW)	DIRECT LABOR HOURS SAVED	\$1,791	0 DAYS	\$0	0 SQ. FT.	\$2,100
IMPROVE PERFORMANCE IN WELDING (MANPWW)	DIRECT LABOR HOURS SAVED	\$5,373	0 DAYS	\$0	0 SQ. FT.	\$0
TOTALS		\$984,740	7 DAYS	\$0	0 SQ. FT.	\$288,898

LSC-20667

7.1 MANPGP QUICK FIX OPPORTUNITIES

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

This section develops and presents six quick fix opportunities to assist MANPGP in meeting its objectives. The first opportunity, Workleader Instructor, recommends a workleader instructor for MANPGP landing gear subunit; the second opportunity, Creeper, recommends the use of a creeper for the mechanics to use while working on the lower assembly of the C-5 main landing gear; the third opportunity, Pneumatic Torque Wrench, recommends the use of pneumatic torque wrenches to tighten structural bolts on the C-5 bogie assembly; the fourth opportunity, Relocate Parts Storage Cabinets, recommends relocating the parts storage cabinets to the eight foot elevated platform of the C-5 main landing gear assembly; the fifth opportunity, Removal of the 4G19067101A bolt, recommends designing and fabricating a special tool to remove the 4G19067101A bolt, and the sixth opportunity, Chain Tension, recommends designing and fabricating a special tool to set the chain tension between the C-5 yoke and gearbox.

7.1.1 Quick Fix Opportunity to Provide the MANPGP Landing Gear Subunit With a Qualified Workleader Instructor

7.1.1.1 Description of Current Operations

MANPGP landing gear subunit is functioning without a workleader instructor. The new mechanics receive training from other mechanics on how to assemble a particular landing gear.

7.1.1.2 Description of Current Process Problems

MANPGP landing gear subunit does not have a qualified workleader instructor to properly instruct mechanics on how to assemble different landing gears.

7.1.1.3 Description of New Process

Establish a workleader instructor position within MANPGP landing gear subunit. The workleader instructor will be assigned the following duties:

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

- Instruct mechanics on how to properly assemble the different landing gears
- Check all landing gear kits for the correct parts
- Be responsible for the production acceptance certification program
- Continue improvement of the landing gear processes

7.1.1.4 Rationale Leading to Change

A workleader instructor will help reduce rework, improve productivity through training, and will continue to improve the landing gear processes.

7.1.1.5 Estimated Cost Savings

The following information was developed with Dave Bennion, foreman of the MANPGP landing gear subunit. The cost savings will be based on rework cost, mechanic cost to train another mechanic, and improved productivity with the aid of a workleader instructor.

- **Rework Cost**

An average of five hours a day mechanic labor is lost due to the wrong parts in a kit, unusable parts, and improper assembly of parts

Rework Cost Savings = (5 hrs/day) (251 days/yr) (\$31.98/hr)

Rework Cost Savings = \$40,135/yr

- **Training Cost**

An average of 60 hours a week mechanic labor is lost due to experienced mechanics training inexperienced mechanics

Training Cost Savings = (60 hrs/wk) (52 wk/yr) (\$31.98)

Training Cost Savings = \$99,778/yr

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

- **Productivity Improvement**

According to Dave Bennion if he had a workleader instructor, production of landing gears could increase from 30 landing gears per month to 60 landing gears per month. MDMSC feels that doubling production is optimistic. MDMSC feels a productivity gain of 25% is realistic.

Facts: 16 people are assigned to the MANPGP landing gear subunit.

5.6 hours is the effective hours per day for a mechanic

21 working days per month, 12 months per year

Direct Labor Cost of assembling 30 landing gears a month/yr = (16 people) (5.6 hrs/day) (21 days/month) (12 months/yr) (31.98/hr) = \$722,082/yr

Direct labor cost saved based on a 25% productivity gain per year = $(.25)(\$722,082) = \$180,521/\text{yr}$

Cost of workleader instructor = (1,744 hrs/WLI) (\$31.98/hr)

Cost of workleader instructor = \$55,773

Cost savings = [rework cost savings + training cost savings + productivity improvement cost savings] - cost of mechanic

Cost savings = [\$40,135 + \$99,778 + \$180,521] - 55,773

Cost savings = \$264,661

7.1.1.6 Implementation Cost/Schedule

Cost of workleader instructor = \$55,773

It should take less than three months to implement.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

7.1.2 Quick Fix Opportunity to Allow the Mechanics to Use a Creeper While Working on the Lower Assembly of the C-5 Main Landing Gear

7.1.2.1 Description of Current Operations

Mechanics are presently using a 4" foam rubber pad to lay on the floor so they can work on the lower assembly of the C-5 main landing gear. The mechanics repeatedly have to get up and reposition the rubber pad so they can work on a different area of the lower assembly of the landing gear.

7.1.2.2 Description of Current Process Problems

Mechanics have to get up and reposition the foam pad each time they change work areas when working on the lower assembly of the C-5 main landing gear. Repositioning the foam pad interrupts the work process.

7.1.2.3 Description of New Process

Purchase a creeper for the mechanic to use while working on the lower assembly of the C-5 main landing gear. The mechanic will be able to reposition himself to work on the lower assembly without having to physically get up and move a foam pad.

7.1.2.4 Rationale Leading to Change

The use of a creeper will save time in the work process of the lower assembly of the C-5 main landing gear. The creeper will give the mechanic freedom of movement to work on the lower assembly of the C-5 main landing gear.

7.1.2.5 Estimated Cost Savings

It is estimated by the mechanic that the creeper will save a half hour per C-5 main landing gear.

Cost savings = (.5 hrs/assy) (56 assys/yr) (31.98/hr)

Cost savings = \$895

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

7.1.2.6 Implementation Cost/Schedule

Cost of creeper = \$100

Implementation should take less than one month.

7.1.3 Quick Fix Opportunity to Use a Pneumatic Torque Wrench to Tighten Structural Bolts

7.1.3.1 Description of Current Operations

The mechanics are presently using a 3/8 impact wrench to tighten structural bolts on the C-5 bogie assembly that have specified torque values. The mechanic checks each bolt with a torque wrench to determine if the bolt meets the minimum torque requirement.

7.1.3.2 Description of Current Process Problems

The tightening of bolts by a 3/8 impact wrench results in the bolts exceeding torque limits. If bolts exceed their torque values, it becomes an unknown as structural analysis is performed with known values. This condition could result in premature failure of the assembly.

7.1.3.3 Description of New Process

Use pneumatic torque wrenches to tighten the structural bolts on the C-5 bogie assembly. The torque value can be set on the torque wrench which will ensure that no bolts are tightened beyond the specified torque limit.

7.1.3.4 Rationale Leading to Change

The use of the pneumatic torque wrench will ensure that the structural bolts on the C-5 bogie assembly are not tightened beyond the specified torque limits. Properly torqued bolts will help ensure that the structural integrity of the C-5 bogie assembly is maintained.

7.1.3.5 Estimated Cost Savings

The use of pneumatic torque wrench will help maintain the structural integrity of the C-5 bogie assembly. MDMSC feels that maintaining the structural integrity

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

of the C-5 bogie assembly justifies this quick fix improvement. MDMSC realizes that the process times for both processes will be approximately the same.

7.1.3.6 Implementation Cost/Schedule

Cost of pneumatic torque wrench \$1,500

Implementation should take less than one month.

7.1.4 Quick Fix Opportunity to Relocate the Parts Storage Cabinets to the Elevated Platform of the C-5 Main Landing Gear Assembly

7.1.4.1 Description of Current Operations

Parts storage cabinets are located on the floor in the C-5 assembly area. Mechanics have to make numerous trips up and down an eight foot elevated assembly platform to get parts, exchange parts, and pick-up dropped parts.

7.1.4.2 Description of Current Process Problems

Time unnecessarily used to obtain and handle parts can be eliminated if the storage cabinets are relocated.

7.1.4.3 Description of New Process

Relocate the parts storage cabinets on the elevated platform with the mechanics. Relocating the storage cabinets on the elevated platform will eliminate the delay times in the process.

7.1.4.4 Rationale Leading to Change

Relocating the parts storage cabinets on the elevated platform will minimize delay times in obtaining parts. Reducing delay times will reduce the overall flow time needed to complete an assembly of a C-5 main landing gear.

7.1.4.5 Estimated Cost Savings

It is requiring two mechanics 64 flow hours to complete a C-5 main landing gear assembly. Relocating the parts storage cabinets to the elevated platform would only require 48 flow hours to complete a C-5 main landing gear assembly. A

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

savings of 16 flow hours for two mechanics is realized. The storage cabinets were located on the platform before implementing the MRP II system.

Cost savings = (2 mechanics) (16 hours/assy) (56 assys/yr) (31.98/hr)

Cost savings = \$57,308/yr

7.1.4.6 Implementation Cost/Schedule

A Rough Order of Magnitude (ROM) estimate for implementing this recommendation is as follows:

Relocate cabinets to elevated platform	\$2,303
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Implementation should take less than one month.

7.1.5 Quick Fix Opportunity to Design and Fabricate a Special Tool to Remove the 4G19067101A Bolt From the C-5 Bogie Assembly

7.1.5.1 Description of Current Operations

Two mechanics are required to remove the 4G19067101A bolts from the C-5 bogie assembly. One mechanic holds a brass rod against the end of the bolt while the other mechanic taps the brass rod to remove the bolt.

7.1.5.2 Description of Current Process Problems

The mechanics often will pick-up the nearest piece of metal and use the metal to remove the bolt. This action results in damage to the bolt. The bolt is usually scrapped and a new bolt required for reassembly. A mechanic can be injured seriously by the hammer bouncing off the metal uncontrolled or by flying metal chips produced when the hammer strikes the metal.

7.1.5.3 Description of New Process

Design a punch tool that is inserted through the hole in the bolt and secure by a nut. (See Database Documentation Book (DDB) MANPGP potential improvement opportunities section for sketch). The use of this tool would require only one mechanic.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

7.1.5.4 Rationale Leading to Change

Safety is the primary reason for change. The new process will eliminate the possibility of a mechanic being hit due to the hammer bouncing off the metal uncontrolled or by flying metal. The new process will eliminate the scrapping of bolts because of damage incurred during the removal process.

7.1.5.5 Estimated Cost Savings

Removing the bolt using the new process will require only one mechanic .08 hours whereas the present method requires two mechanics .25 hours.

Cost Savings = (present method) - (new method)

Present Method = (2 mechanics) (2 bolts/assy) (56 assys/yr) (.25 hrs/bolt)
(31.98/mechanic hrs.)

Present method = \$1,790/yr

New method = (1 mechanic) (2 bolts/assy) (56 assys/yr) (.08 hrs)
(31.98/mechanic hr)

New method = \$286/yr

Cost savings \$1,504/yr

7.1.5.6 Implementation Cost/Schedule

A ROM estimate for implementing this recommendation is as follows:

Design and manufacture tool	\$128
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Implementation should take less than one month.

7.1.6 Quick Fix Opportunity to Design and Fabricate a Special Tool to Set the Chain Tension Between the C-5 Yoke Assembly and Gearbox

7.1.6.1 Description of Current Operations

Mechanics are presently using a pry bar to pry the gearbox from the C-5 yoke to obtain the correct chain tension. The mechanics obtain the correct chain tension and shims are inserted between the gearbox and yoke to maintain the chain tension.

7.1.6.2 Description of Current Process Problems

The operation is unsafe because the mechanic is using his body to hold the pry bar while trying to insert the proper shims between the gearbox and the yoke.

7.1.6.3 Description of New Process

Design a simple tool (see DDB MANPGP potential improvement opportunities section for sketch) to apply pressure to move the gearbox away from the yoke by tightening a bolt. A constant chain tension can be obtained by the uniform application of pressure.

7.1.6.4 Rationale Leading to Change

Safety of the mechanics is the principal reason to change the process. Uniform chain tension can be obtained and the correct shims can be inserted the first time.

7.1.6.5 Estimated Cost Savings

The idea of a special tool to apply the correct chain tension and inserting the proper shims between the gearbox and yoke was discussed with the mechanics. The mechanics estimate that 1.25 hours could be saved per landing gear using this special tool.

Cost savings = (1.25 hrs/gear) (56 gears/yr) x (31.98/hr)

Cost savings = \$2,239

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

7.1.6.6 Implementation Cost/Schedule

A ROM estimate for implementing this recommendation is as follows:

Design and manufacture tool	\$256
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Implementation should take less than one month.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

7.2 MANPGW QUICK FIX OPPORTUNITIES

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

This section develops and presents two quick fix opportunities to assist MANPGW in meeting its objectives. The first opportunity is titled, Automate the Bead Blasting Process for Aircraft Wheels From a Manual Process and the second opportunity is titled, Semi-Automate the Removal of Brake Liners From a Manual Process.

7.2.1 Quick Fix Opportunity to Automate the Bead Blasting Process for Aircraft Wheels

7.2.1.1 Description of Current Operations

Aircraft wheels are manually bead blasted to remove any paint residue and surface corrosion after being chemically cleaned. Each wheel half is blasted separately.

7.2.1.2 Description of Current Process Problems

Bead blasting each wheel half is very labor intensive. It is a very dirty and strenuous task to be performed by a mechanic. It is difficult to find mechanics who want to perform this task. Often times wheels will stack up waiting to be bead blasted because mechanics are not available to perform the task.

7.2.1.3 Description of New Process

MDMSC recommends moving the automated blasting booth that is not being used from the end of the landing gear chemical cleaning line to the end of the chemical cleaning line for wheels. Configure the nozzles within the blasting booth to blast the wheels similar to the rotoblaster for brakes.

7.2.1.4 Rationale Leading to Change

Automated blasting will reduce the number of mechanics needed to perform the dirty and strenuous task of bead blasting wheels. Bead blasting will become

**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**

machine dependent instead of labor dependent. Process times will drop drastically. Stack of wheels waiting on mechanics to bead blast will disappear with automation.

7.2.1.5 Estimated Cost Savings

Based on the data collected for the UDOS 2.0 model, blasting requires approximately 20 minutes per wheel half. It is estimated that automation will save approximately 15 minutes per wheel half.

$(\text{DLH-saved/wheel half}) \times (\text{number of wheel halves/yr}) = \text{direct labor hours saved/yr.}$

$$(.25) \times (15,404) = 3,851 \text{ hrs/yr}$$

$$(3,851 \text{ hrs/yr}) \times (\$31.98/\text{hr}) = \$123,155/\text{yr}$$

$$\text{Cost savings} = \$123,155 \text{ per year}$$

$$\text{Cost Savings} = (\text{DLH saved}) \times (\text{RCC labor hour rate})$$

7.2.1.6 Implementation Cost/Schedule

A Rough Order of Magnitude (ROM) estimate for implementing this recommendation is as follows:

Move blasting booth and make operational	\$5,000
Redesign and configure blasting nozzles	\$50,000

Moving the automated blasting booth and redesigning the nozzles for aircraft wheels should take less than six months.

7.2.2 Quick Fix Opportunity to Semi-Automate the Removal of Brake Liners From the Rotors

7.2.2.1 Description of Current Operations

Brake liners are removed from the rotors using a drill press to drill the rivet head off followed by the mechanic punching the stem of the rivet out.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

7.2.2.2 Description of Current Process Problems

The operation is time consuming in that it requires the mechanic to locate each rivet under the drill. Drill the rivet head off and punch the stem of the rivet out.

7.2.2.3 Description of New Process

Use a combination drill and punch press with automatic indexing to remove the rivet from the liner.

7.2.2.4 Rationale Leading to Change

Implementing this change will reduce the processing time per rotor assembly approximately six minutes. It will improve the quality of the task from a strictly manual to a semi-automated task.

7.2.2.5 Estimated Cost Savings

The B-52 and KC-135 brakes comprise approximately 70% of the annual brake volume. B-52 = 460 units/yr, KC-135 = 1,385 units/yr.

Direct Labor Hours =

$$(\text{number of units}) \times \frac{(\text{no. of rotor assemblies})}{\text{unit}} \times \frac{(\text{time saved})}{\text{rotor assemblies}}$$

Saved per year

$$230 = (460) \times (5) \times (.1) \\ (\text{B-52})$$

$$831 = (1,385) \times (6) \times (.1) \\ (\text{KC-135})$$

Total Direct Labor Hours = B-52 + KC-135

$$1,061 = 230 + 831$$

Cost Savings = (DLH saved) x (RCC hourly rate)

$$33,391 = (1,061) \times (31.98)$$

Cost Savings per year = \$33,931

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

7.2.2.6 Implementation Cost/Schedule

A ROM estimate for implementing this recommendation is as follows:

Purchase of equipment	\$37,400
Installation of equipment	\$5,000

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

7.3 MANPNA QUICK FIX OPPORTUNITIES

MDMSC has not identified quick fix opportunities for this RCC.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

7.4 MANPRA QUICK FIX OPPORTUNITIES

MDMSC has not identified quick fix opportunities for this RCC.

7.5 MANPRB QUICK FIX OPPORTUNITIES

During the characterization of the MANPRB RCC, MDMSC identified a potential opportunity to improve repair operations within the RCC. This quick fix addresses grinding methods for O.D. hydraulic components (main and nose landing gear cylinders) and similarly shaped parts and will improve processing operations and help MANPRB and MANPRC more effectively meet its requirements.

7.5.1 Quick Fix Opportunity to Decrease Grinding Time

7.5.1.1 Description of Current Operations

All parts requiring close O.D. dimensional tolerances are currently being ground with hard wheel external grinders. The time to grind a part with these machines is indirectly regulated by military specifications and procedures. These procedures are based on maximum allowable heat generated during the grinding operation. The heat generated is determined by the thickness of the part being ground, the depth of the cut, the hardness of the wheel, and the volume and type of coolant.

7.5.1.2 Description of Current Process Problems

During the grinding operation, frictional heat is generated at the point of contact with the grinding wheel. Even with the optimum selection of grinding wheels, coolants, and coolant flow, such extreme temperatures are still being generated that the depth per pass and metal removed is limited. This is further aggravated by metals such as chromium which, because of its hardness, generates even more friction and therefore heat.

Metals such as stainless steel and nickel, although not hard, are tough and tend to smear easily. These metals take even more time to grind than others because if they are ground too quickly, they tend to imbed into the grinding wheel. This requires excessive wheel dressing to remove the imbedded metal or the wheel chatters and bounces on the part. The end result is that the grinding time is prolonged.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

7.5.1.3 Description of New Process

MANPRB should convert an older grinder that currently uses a grinding wheel to one that uses a sanding belt assembly. This will decrease grinding time on most metals by 50% as demonstrated by facilities using such equipment. The grinding time for nickel and copper will be even faster. Grinding time on thin walled tubing may be three to four times faster than current hard wheel grinding time.

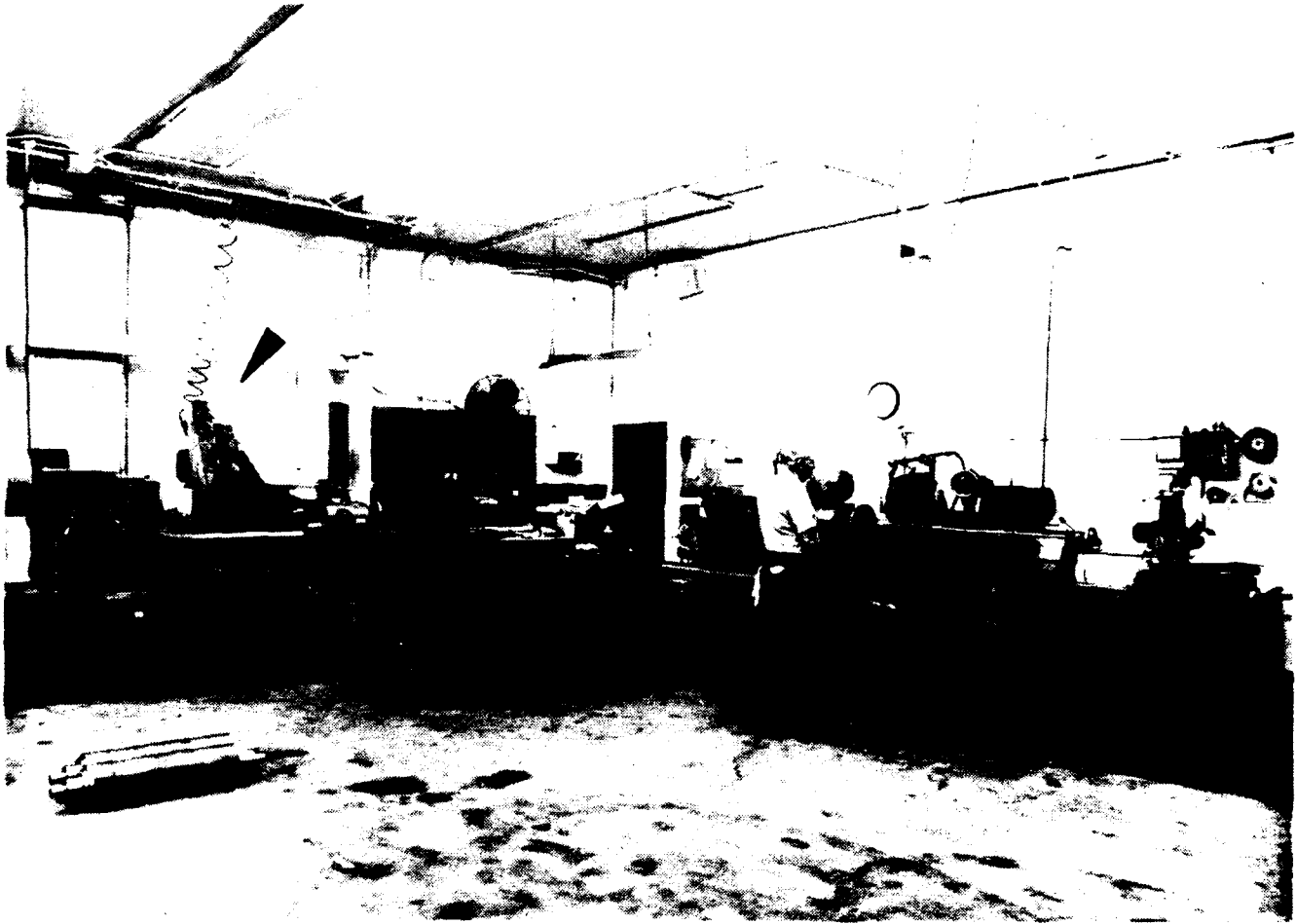
7.5.1.4 Rationale Leading to Change

Grinding equipment using sanding belts and contact wheels does not generate as much heat for the amount of metal removed as hard wheels. It also contacts more surface per pass than a hard wheel; consequently, more metal is removed faster. The equipment is basically the same as a standard grinding machine. The part is supported and powered in the same manner, the contact area is flooded with water soluble coolants, and the contact wheel is moved in and out the same. Figure 7.5.1-1 shows a grinder with the type of modifications described.

The changes that do make this equipment uniquely different though, are significant. The hard grinding wheel attachments are replaced with a contact wheel that can be removed like a hard wheel. The grinding wheel assembly is modified with an idler arm mounted behind the contact wheel to keep the grinding belt rigid. The contact wheel is the size of a new hard wheel and always stays that size; therefore, the wheel speed always remains constant, and always operates at its maximum efficiency.

The belt does not require dressing like the hard wheel, but when its grinding efficiency is too low, the belt must be replaced. It is essential that the belts are replaced as often as required to cut properly; therefore, the operators must stay more involved in the operation to achieve pre-established efficiency standards. If the belt is not replaced, cutting eventually stops and the part is merely polished but little metal is removed.

**TASK ORDER NO. 1
PROCESS CHARACTERIZATION**



**CYLINDER GRINDER MODIFIED WITH A BELT
SANDING HEAD
FIGURE 7.5.1-1**

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

On thinner walled cylinder material the belt grinder will not "suck" the part into the belt as a hard wheel can if grinding continues in one place too long. If a hard wheel stays in one place while grinding, more heat is generated than the coolant can keep cool. This expands the metal part causing the wheel to grind more metal which causes more heat until finally the part is gouged, or the part is thrown out of the grinder, or the grinding wheel breaks and explodes. This hazard is reduced with a belt grinder because there is no hard wheel.

There is a risk in switching to this simpler technology. Grinding machine operators will have to rely more on their skills and less on the equipment because it is not an automated process.

7.5.1.5 Estimated Cost Savings

Based on the available grinding time (350 days per year) for one machine that is currently operated on two shifts, an average of 376 parts can now be ground on one hard wheel grinding machine per year at a cost of \$179,000.

$350 \text{ days} \times 16 \text{ hours/day} = 5,600 \text{ hours of grinding time available for one machine}$
 $5,600 \text{ hours} \times \$31.98/\text{hour} = \$179,000.$

The average grinding time for larger hydraulic cylinder parts, derived from information provided by MANPRB, is approximately 18.75 hours. The average grinding time for smaller hydraulic cylinder parts, derived from information provided by MANPRB, is approximately 11 hours. The average number of grinding hours is $(18.75 \text{ hours} + 11 \text{ hours})/2 = 14.875 \text{ average hours}.$

The average number of parts that could be produced per year = $5,600 \text{ available machine hours} / 14.875 = 376 \text{ average parts ground per machine per year}.$

With a belt grinder, 752 parts could be ground in the same time doubling production for the same cost of \$179,000.

TASK ORDER NO. 1
PROCESS CHARACTERIZATION

Information provided by MANPRB indicates that there is an average of 1,200 parts/year that could be ground. With the belt grinder equipment, two grinders would require modification to perform the grinding. The total possible savings per year would then be approximately \$285,638.

7.5.1.6 Implementation Cost/Schedule

Costs to convert an existing machine will depend on that machine and its features. CNC equipment is not required nor desired for this type of modification, older non automated equipment would be ideal. A grinder that is suited for modification can be converted for a cost estimated to be between \$20,000 and \$80,000 depending on the size and type of grinder. No more than an estimated \$100,000 should be required to modify two grinders to gain maximum benefits.

It would take about three months for a company such as G & P Machinery Corporation in Indianapolis, Indiana to modify the head and return it. Disassembly and reassembly could be done with maintenance personnel and should not take longer than two weeks.

7.6 MANPRC QUICK FIX OPPORTUNITIES

During the characterization of the MANPRC RCC, MDMSC noted potential opportunities to improve the MANPRC repair operations.

Three quick fix opportunities have been recommended to improve processing operations and help MANPRC more effectively meet its requirements. These quick fixes address increasing the number of salvageable parts, improving plating uniformity by using shields, and eliminating rework caused by improper anode care.

7.6.1 Quick Fix Opportunity to Increase Parts Salvaging

7.6.1.1 Description of Current Operations

Parts such as trunnion pins that require chrome plating and grinding are not currently repaired. They are scrapped out but not destroyed. They are categorized and saved. If there is an emergency situation, the ones that take the least effort will be repaired and used first.

7.6.1.2 Description of Current Process Problems

Parts such as trunnion pins are not repaired because the cost to replace them with new parts is less than the cost to repair them at OO-ALC. When overhead expenses of a large facility such as OO-ALC are injected in the repair costs, many smaller parts that are repairable cannot be economically justified. The parts not being repaired are unnecessarily inflating the storage costs and increasing the need for new parts and new part inventory.

7.6.1.3 Description of New Process

The now unrepaired trunnion pins should be accumulated and sent to qualified outside vendors that can repair them by performing that part of the repair operation that is not economically feasible to do within the RCCs.

7.6.1.4 Rationale Leading to Change

Smaller qualified facilities that have lower overhead expenses could repair many of the smaller jobs now left unrepaired. These outside vendors can

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economically repair them if the quantities are large enough to do the expensive set-ups for grinding and plating once for the batch. That charge is then adequately absorbed by the volume of parts.

The batch sizes can be determined by quotations presented for different quantities.

7.6.1.5 Estimated Cost Savings

The cost for a new trunnion pin (SN 1620000 271196) is \$189.43.

An outside vendor, A & M Machine Works in Kansas City estimated the charges to remanufacture trunnion pins in the following lots at:

0 - 10 lots	- \$178.50 each
11 - 25 lots	- \$162.00 each
26 - 50 lots	- \$157.00 each
51 - 100 lots	- \$153.00 each

If two lots of 50 is the quantity repaired per year, the cost per parts = $\$157 \times 100 = \$15,700$.

The cost to purchase 100 new ones = $100 \times 189.43 = 18,943$.

Cost savings = $18,943 - 15,700 = \$3,243$ for each 100 parts.

Another undefined savings occurs with chrome plating because chrome plated pins last much longer. If they last at least 50% longer than new parts the inventory would be reduced by that percentage.

7.6.1.6 Implementation Cost/Schedule

There is no cost to institute this plan other than freight costs if the parts are shipped out of the local area for repairs.

7.6.2 Quick Fix Opportunity to Decrease Costs - Uniform Plating Deposits with Shields

7.6.2.1 Description of Current Operations

Approximately 5400 landing gear parts are chrome plated yearly by MANPRC. These parts go through several costly operations before and after chrome plating. These operations are cleaning, grit blasting, baking, machining, grinding, nickel plating, and cadmium plating. There are multiple combinations of each of these processes.

Lead wire mat anodes (called bird cage anodes) are used to carry the positive current. These anodes are grid shaped 67% antimony alloy sheet lead which is curled to form different fixed sized cylinders. These cylinders are soldered to lead bars that have copper electrical hooks at the end. These hooks are hung on copper bus bars above the lip of the plating tank. The lead bars extend into the plating solution with the anode cage completely immersed in the solution.

The part to be plated is placed in the anode cage and hung by the negative bus bar or cathode bar. The part is overplated ten to fifteen mils for grinding stock to assure the surface will completely clean up.

7.6.2.2 Description of Current Process Problems

The parts are not currently checked for positioning in the anode cage. After the parts are put in the cage under the chrome solution they can not be seen as the solution is too dark to see through. Any part placement at this point is an approximation and often is not centered. Because of this the plated deposit is not concentric with the part. Excessive material is deposited where the anode is closest to the part and too little material is deposited where the anode is too far away from the part.

When the part is ground, the side with the excessive chrome grinds satisfactorily, but the area deficient in chrome is not touched by the grinding wheel. The part is then identified as having insufficient chrome and sent back to

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the plating shop. The part then has to go through all of the costly operations again.

Many parts are overplated ten to 15 mils to make sure the part will clean up. The grinding is a prolonged process to remove this excess. Chrome must be ground slowly to prevent over heating and damage to the deposit.

7.6.2.3 Description of New Process

Each cylindrical part needs to have a CPVC shield attached next to the plating area. One just above the top area to be plated and one just below the plating area. These shields would be attached to plastic coated parts by taping the shield to the outside of the maskant. If the part is waxed, fastening ears can be attached to the part before waxing then the shields attached to the ears.

The shields are circular and have an inner hole diameter the size of the part with maskant.

7.6.2.4 Rationale Leading to Change

The shielded part will stay located in the center of the anode keeping the deposit concentric with the part. The shields also keep stray currents from building up chromium on the plating area bordering the maskant. With the more uniform deposits that the shields create, excessive extra chrome for grinding stock is not necessary. The parts need only five mils of extra chrome. This decreases tank time five to ten hours per load and reduces grinding time. (These savings are not quantifiable and are not included in our estimated savings.)

Rework due to insufficient chrome should be virtually eliminated because of part location in the anodes.

7.6.2.5 Estimated Cost Savings

20% (1080) of the 5400 parts plated were designated as rework for experimentation, and of that number, 40.8% (441) are rejected because chrome deposits are not concentric. The two most obvious reasons for these rejects at

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MANPRC is the one written to here, misalignment of parts during plating, and the one discussed in the Quick Fix Plan, paragraph 7.6.3. No definitive measure can be made to determine percentages of one reason versus the other, so one half of the cost savings will be applied in each section.

15 people are assigned to the chrome area
5400 estimated parts are chrome plated per year

5130 parts (95%) are estimated chrome ground per year

Grinding time is estimated to be 40% before plate grinding and 60% after plate grinding.

The average estimated grinding time is 13.5 hours.

The average before plate grinding time is $13.5 \text{ hours} \times 40\% = 5.4 \text{ hours}$

The average after plate grinding time is $13.5 \text{ hours} \times 60\% = 8.1 \text{ hours}$

Labor rates per man for the 5400 parts chrome plated are $1744 \text{ hours/year} \times \$31.98/\text{hour} = \$55,773$.

Overtime hours are estimated at 7.5% of hours worked or 130.8 hours.

The direct labor portion of the \$31.98 is estimated to be \$10/hour.

$\$10/\text{hour} \times 1.5 = \text{overtime rate} = \$15/\text{hour}$. $\$15/\text{hour} \times 130.8 \text{ hours} = \$1,962$ of overtime per year.

The total estimated annual wages per man = $\$55,773 + 1,962 = \$57,735/\text{year}$.

The total estimated annual wages in the chrome area is $\$57,735/\text{year} \times 15 \text{ people} = \$866,025/\text{year}$.

The total chrome plating costs for 5400 parts = $\$866,025/\text{year}$. The cost per chrome plated part = $\$866,025/5400 = \$160.38$.

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7.5% overtime rates are an added 3.5% of regular wages.

Before plate grinding costs for chrome plated parts = 5.4 hour x \$31.98 x 1.035
= \$178.74.

After plate grinding cost for chrome plated parts = 8.1 hours x \$31.98 x 1.035 =
\$268.10.

One hour is estimated for transport time per part by MANSVC = \$31.98.

The total cost for a part plated the first time is:

\$178.74	before plate grinding
160.38	chrome plate work
268.10	after plate grinding
<u>31.98</u>	transport/miscellaneous
\$539.20	

The total cost for a reworked parts is:

\$160.38	chrome plate area work
268.10	after plate grinding
<u>31.98</u>	transport/miscellaneous
\$460.46	

221 rejects can be eliminated with this quick fix recommendation per year:

$$221 \times \$460.46 = \$101,762$$

7.6.2.6 Implementation Cost/Schedule

Estimated number of various part applicable. There are some 600 reported different types of parts chrome plated. Of that amount some are flashed only and/or short run parts that shielding may not benefit. Four hundred maximum parts may be able to have shield work effectively based on these estimates.

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Two average sets of shields per part = $400 \times 2 = 800$ sets of shields.

Estimated cost of shields = $\$30/\text{set} \times 800 \text{ sets} = \$24,000$

Storage racks for shields = $\$5,000$

Total Cost = $\$24,000 + \$5,000 = \$29,000$

7.6.3 Quick Fix Opportunity to Eliminate Rework Due to Insufficient Chrome Because of Anode Care

7.6.3.1 Description of Current Operations

Parts chrome plated use antimonial lead anodes to carry the current in the plating solution. The anodes are not cared for in any consistent manner. Many are left in the plating baths when not used. Others are hung on bars that are over empty tanks, some are hung in water tanks.

7.6.3.2 Description of Current Process Problems

The lead alloy anodes form passive coatings on the electrode surface if they are not properly stored.

The anodes left in the plating tank form a yellow lead chromate coating which will not carry the electricity to the part. Areas with thicker lead chromate coatings will not allow plating until it is cleaned or activated.

Anodes left in water form a tenacious coating combination of lead oxide, lead sulfate, and lead chromate. This coating can be so thick and adherent that it must be chemically stripped or blasted off. The chemical strippers are very ineffective and the coating is so hard that blasting may not work. In this event, it is cheaper to throw the electrode away.

The anodes hung in the air are the easiest to reactivate in the plating baths, but because of the difficulty in removing many of the anodes, it is not feasible to

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remove them. Storage space would also be required for them and if no storage fixtures are available, this cannot be done.

Passive anodes cause nonuniform current distribution on the parts. This can create high and low areas and nonuniform chromium deposits. If not caught, the parts may not clean up to the desired dimensions after grinding and require replating.

7.6.3.3 Description of New Process

MDMSC recommends that no anodes ever be stored in water. If they are, they should be grit blasted to remove the coating before plating. Anodes stored in the plating bath should be activated with a dummy (scrap part that will act as a cathode) before plating the part under repair.

Store all anodes possible in the air, not in any solution. The anodes stored in this manner will always reactivate faster and give more reliable plating.

Activate all anodes with a dummy (a scrap part or piece of steel that will act as a cathode). The dummy needs to be as long as the part to be plated. This procedure is extremely important for the anodes that have been stored in the chrome plating solution. If the anode is easily lifted for observation, one can tell that it is activated with a dark brown lead peroxide coating on the surface.

Any anodes that do not form a dark uniform coating when activated or during operation are dead and should be removed for repairs or disposal.

7.6.3.4 Rationale Leading to Change

Many parts that are chrome plated do not clean up to a required uniform dimension because of defective or inactive anodes.

The rework rates are very high because of the insufficient chrome. Part of the insufficient chrome problems are caused by this reason and the other due to improper cathode alignment, refer to Quick Fix Plan, paragraph 7.6.2. Because

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no quantifiable data has been collected as to how much insufficient deposits each problem causes, half has been attributed to this quick fix recommendation.

7.6.3.5 Estimated Cost Savings

20% (1080) of the 5400 parts plated were designated as rework for experimentation, and of that number, 40.8% (442) are rejected because chrome deposits are not concentric. The two most obvious reasons for these rejects at MANPRC is the one written to here on improper anode care, and the one discussed in the Quick Fix Plan, paragraph 7.6.2. No definitive measure can be made to determine percentages of one reason versus the other, so one half of the cost savings will be applied in each section.

221 rejects can be eliminated per year with this quick fix recommendation.

$221 \times \$460.46 = \$101,762$ (See paragraph 7.6.2.5 for calculations)

7.6.3.6 Implementation Cost/Schedule

There is no cost to implement this quick fix recommendation and it can be accomplished immediately.

7.7 MANPWW QUICK FIX OPPORTUNITIES

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

This section develops and presents three quick fix opportunities to assist MANPWW in meeting its objectives. The first opportunity, Heat Treatment of Aircraft Brakes, recommends that MANPWW check the flatness of brakes, the second opportunity, Improve Performance of Metal Thermal Coating Operations, recommends converting a grit blasting machine with a suction-type gun to a pressure-type using a readily-available kit for a backup system, and the third opportunity, Improved Welding Process, recommends that engineers from MANEE update the drawings of part that require welding to include all of the necessary data to perform the task.

7.7.1 Quick Fix Opportunity to Improve Performance of the Heat Treatment of Aircraft Wheel Brakes

7.7.1.1 Description of Current Operations

MANPWW Heat Treat Shop in Building 507 at OO-ALC currently treats wheel brakes to relieve service induced stresses and to return the brakes to the original degree of flatness. These are accomplished by utilizing a heat treatment in a furnace using inert gas (argon) atmosphere. Beryllium wheel brakes are treated for 12 hours at 1350°F followed by a furnace cool-down of four hours and then followed by 14 hours of room temperature cool-down in air. Steel wheel brakes are treated for six hours at 1200°F followed by ten hours of room temperature cool-down in air. The wheel brakes prior to treatment are placed into a specially-designed fixture in which a 1000 lb. load is continuously exerting pressure on the loaded stack.

7.7.1.2 Description of Current Process Problems

The heat-treated wheel brakes must be transported to the nearest Evaluation and Inspection (E&I) location so each brake can be checked separately for flatness using a flat-surface granite block and a dial indicator. The nearest E&I

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location for the Heat Treat Shop is the other side of Building 507 in the Machine Shop. Those brakes not meeting the requirements for flatness are returned to the Heat Treat Shop for further reprocessing. This sequence is repeated until the wheel brakes meet specification.

7.7.1.3 Description of New Process

Acquire and locate a suitable flat-surface granite block and dial indicator in the heat treat shop where a mechanic, trained and certified within the Production Acceptance Certification (PAC) program, can inspect the wheel brakes.

7.7.1.4 Rationale Leading to Change

A significant improvement in flow time for the heat treatment of wheel brakes can be realized since a mechanic in the heat treat shop would have knowledge of the degree of non-flatness for any single batch of wheel brakes to be treated. Longer time under load for those extremely non-flat brakes would be warranted. Also, with an E&I station within the heat treat area, transfer time between the heat treatment and the E&I determination would be reduced to zero.

7.7.1.5 Estimated Cost Savings

Assuming five shipments of treated brakes per week are brought to the E&I station and returned for reprocessing, reduction of approximately 30% of the flowtime may be realized. A savings in indirect labor for transport of the brakes will also occur. Transport savings are calculated as follows:

$$\begin{aligned}\text{Transport Cost Savings} &= \frac{\text{no. hrs.}}{\text{trip}} \times \frac{\text{no. trips}}{\text{year}} \times \text{Indirect base per hr.} \\ &= \frac{0.1778 \text{ hr.}}{\text{trip}} \times \frac{260 \text{ trips}}{\text{year}} \times \$31.98 \\ &= \$1,478 \text{ savings per year in transport}\end{aligned}$$

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7.7.1.6 Implementation Cost/Schedule

Implementation of this recommendation should take less than six months. Estimated cost of a 2' x 2' x 4" granite surface table is \$180.

7.7.2 Quick Fix Opportunity to Improve Performance of Metal Thermal Coating (Flame Spray) Operations

7.7.2.1 Description of Current Operations

MANPWW metal thermal coating operations in Building 511 currently prepare all parts for the three different processes; arc-spray, flame combustion, and plasma-jet by vapor degreasing cleaning all parts in trichloroethane solvent followed by a grit blasting operation (using 38 mesh aluminum oxide) to remove all oxidation (rust plus corrosion products) and to provide for mechanical adhesion of the subsequent metal coating.

7.7.2.2 Description of Current Process Problems

The single grit blasting machine in Building 511 is inherently self destructive due to the abrasiveness of the aluminum oxide grit being propelled at high velocity from a gun powered with compressed air. When the machine is inoperative due to repair, the entire metal coating operation is nonproductive.

7.7.2.3 Description of New Process

By converting the existing suction-type blast gun to a pressure-type using a readily-available kit, a backup machine would be available during those downtime periods for the repair of either machine.

7.7.2.4 Rationale Leading to Change

Since the facility depends upon grit blasting to remove surface corrosion and to prepare the surface texture of the parts to accept mechanical bonding of the metal coating material, a working grit blasting unit must be available at all times to perform repairs on various aircraft parts. The purchase of a new grit blaster similar to the existing machine would cost an estimated \$30,000. A conversion kit to change an existing suction-type blaster to a pressure-type blaster is estimated to cost \$2,100.

7.7.2.5 Estimated Cost Savings

Assuming a maximum of seven mechanics per eight hour shift and a direct labor rate of \$31.98/hour would result in a cost savings of \$1,790.88 for prevention of production downtime of only one shift.

7.7.2.6 Implementation Cost/Schedule

Requisition of the conversion kit and implementation of this recommendation should take less than six months with measurable results as follow-on activities for the first year. Estimated cost of the conversion kit is \$2,100.

7.7.3 Quick Fix Opportunity to Improve Performance in Welding Operations

7.7.3.1 Description of Current Operations

MANPWW weld shop in Building 507 currently performs approximately 70% of the total workload as Planned Depot Maintenance (PDM) and the remainder as Management of Item Subject to Repair (MISTR). The existing drawings for these PDM parts, maintained by MANEE, are not sufficiently dimensioned for the mechanics to properly calculate the allowable metal buildup during welding.

7.7.3.2 Description of Current Process Problems

The mechanic must lay the part out with their own dimensioning to properly determine the final dimensions actually desired to meet the drawings and to have the part meet the basic criteria for form, fit and function. This additional burden on the mechanic detracts from his ability to perform the welding efficiently. No documentation of the dimensioning of the part is performed by the mechanic as this is an engineering function.

7.7.3.3 Description of New Process

Engineering people from MANEE should be assigned to work in the operating RCC areas to determine those drawings which need revision of the dimensions. This would permit proper dimensioning to be done correctly and then be documented so the problem will not be repeated.

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7.7.3.4 Rationale Leading to Change

Providing welding data on drawings will allow the welder to perform the welding without interruptions. Welding data on the drawings will standardize the process for each end item and will improve the quality of the end item.

7.7.3.5 Estimated Cost Savings

Interviews with individual mechanics revealed that an average of two hours of direct labor are consumed per job to analyze the dimensioning and the amount of allowable buildup of metal welds. Since an average of seven jobs per month require this additional effort, the cost savings can be calculated as:

$$\begin{array}{ccccccc} \underline{2 \text{ hrs.}} & \times & \underline{7 \text{ jobs}} & \times & \underline{12 \text{ months}} & \times & \underline{\$31.98} & = & \$5,373 \\ \text{job} & & \text{month} & & \text{year} & & \text{manhour} & & \end{array}$$

7.7.3.6 Implementation Cost/Schedule

The implementation of this recommendation should take less than six months for Directorate of Material Management Engineers to study the drawings of those parts requiring attention with measurement of results as follow-on activities for the first year. Engineering support should be provided from existing staff at no additional cost.