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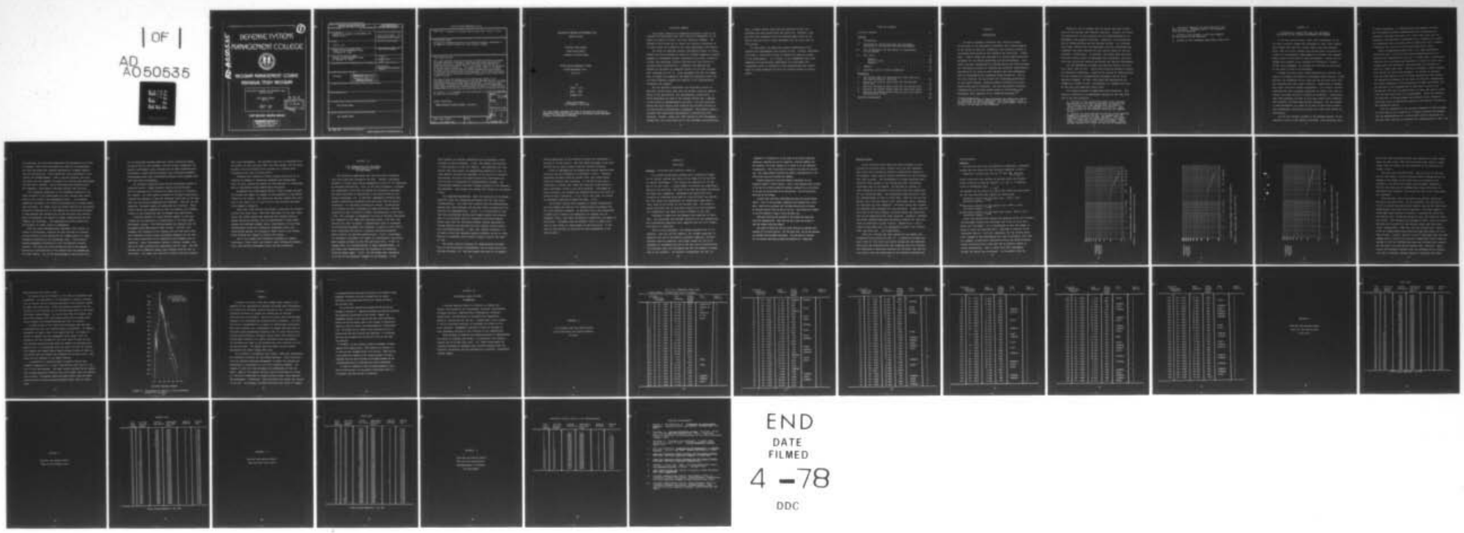

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

PROGRAM MANAGEMENT COURSE INDIVIDUAL STUDY PROGRAM

EVALUATION OF ORTHODOX JOB ENRICHMENT (OJE) RESULTS IN AFLC

STUDY PROJECT REPORT
PMC 77-2

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FORT BELVOIR, VIRGINIA 22060

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE: Evaluation of Orthodox Job Enrichment (OJE) Results in AFLC.

STUDY PROJECT GOALS:

To conduct an independent analysis of one the pilot projects implemented at the Ogden Air Logistics Center, Air Force Logistics Command.

STUDY REPORT ABSTRACT:

This report describes an Aircraft Division in a depot maintenance environment. Particular attention is devoted to identifying the extreme specialization, increased restrictions, and detailed job instructions that resulted in a highly structured environment. This in turn created a need for new approaches to increase worker productivity. The purpose of this report is to examine the manner in which one Air Logistics Center attempted to increase productivity through the implementation of OJE techniques. One of the pilot projects is examined in detail using data extracted from Resource Control Center (RCC) foreman's records.

The analysis shows that because of other simultaneous changes in the environment during the implementation of OJE, the observed increases in productivity may be attributed to other factors besides OJE. The greater increase in productivity in the control crew versus that of the pilot crew, based upon actual number of manhours per aircraft and quality defects, provides additional evidence that OJE may not have been the primary cause of the observed increase.

As a result, it is recommended that other approaches to productivity enhancement be objectivity investigated.

SUBJECT DESCRIPTORS:

HUMAN RESOURCES RESEARCH PROGRAM 10.05.06.01

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EVALUATION OF ORTHODOX JOB ENRICHMENT (OJE)

RESULTS IN AFLC

Individual Study Program

Study Project Report

Prepared as a Formal Report

Defense Systems Management College

Program Management Course

Class 77-2

by

Jackie L. Cox

Major USAF

November 1977

Study Project Advisor
Lt Col Donald S. Fujii, USAF

EXECUTIVE SUMMARY

This report involves an independent analysis of one of the Orthodox Job Enrichment (OJE) pilot projects implemented at the Ogden Air Logistics Center, Air Force Logistics Command. The purpose of this study was to conduct an objective evaluation of the data within the context of the depot maintenance environment.

The study is important because increasing pressure to reduce budgets and still maintain an effective defense capability requires managers to accomplish greater productivity with fewer resources. To meet this challenge, several theories have been offered to increase worker productivity. Herzberg's OJE approach was adopted by the Ogden Air Logistics Center and 11 pilot projects were conducted to test it. Early successes with OJE led management to expand the program at the Ogden Air Logistics Center and Air Force Logistics Command has adopted it for implementation throughout the Command.

The OJE approach concentrates job enrichment efforts on motivator factors since only they can produce long term improvements in job satisfaction, and subsequently, productivity. A brief description of some of the hygiene factors and a summary of the method of implementation are given. The data collected during the pilot project that involved the Aircraft Division in the Directorate of Maintenance are analyzed. The results clearly indicate that significant improvements in productivity were realized. However, there were other factors in the environment, besides OJE, that could have led to the increases in productivity.

Also, a control group, which was not subjected to OJE, out performed the pilot group which was given OJE. Moreover, bias may have been introduced into the original Ogden study by the method that was used to select personnel for the pilot and control groups.

In conclusion, the Ogden OJE projects demonstrated that productivity improvements were related to OJE. However, additional data must be collected in order to isolate the specific causes of the improvements. As a result, it is recommended that other approaches to productivity enhancement be investigated and independent tests be conducted to show conclusively that investments in these endeavors do yield the results claimed or anticipated.

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SECTION I

INTRODUCTION

The severe economic conditions that currently prevail, particularly in the Department of Defense, have caused managers at all levels to seek new, innovative, and effective methods of increasing productivity of the workforce and facilities. Significant sums of money have been spent to obtain highly productive equipment for the depots performing aircraft maintenance. Automation has been incorporated in varying degrees and work processes are continually reviewed to identify and eliminate inefficiencies. Reductions in the scope of work required have been implemented and new improvements are constantly being considered. But of all these efforts, the key element for increasing productivity is the worker himself. Theories abound concerning how worker productivity may be increased. One that has gained increasing consideration in the past several years is the Orthodox Job Enrichment (OJE) approach of Dr. Frederick Herzberg.(2)[1]

1 This notation will be used throughout the report for sources of quotations and major references. The first number is the source listed in the bibliography. The second number, when one is used, is the page in the reference.

Basically, OJE is founded upon the theory that man's needs exist on two distinct and different continua. Further, OJE places job satisfaction on one continuum and job dissatisfaction on an independent and separate continuum. Therefore, job satisfaction and job dissatisfaction are not directly related. Dr. Herzberg calls those factors that are associated with job dissatisfaction, "hygienes" and those factors that are related solely to job satisfaction, "motivators." In addition, his theory says that only motivator factors should be addressed when enriching a job since only they can produce enhanced motivation and improved performance.

OJE was implemented at Ogden Air Logistics Center, Hill Air Force Base, Utah in 1974. Eleven pilot projects employed orthodox job enrichment principles. Based on the success of these projects, OJE was accepted for implementation throughout the Air Force Logistics Command. To date, only Ogden has incorporated job changes as a result of OJE. Furthermore, all changes have been at the local Air Logistics Center level.

The results reported by Ogden have been impressive. This report is directed at an independent analysis of the data from one of the pilot projects.

A. Section II will provide the reader with a partial appreciation of the depot maintenance environment and will describe how it has changed over the years to produce a need for new emphasis on motivation. Most of the material in this section describes the hygiene factors.

B. Section III will describe how the Air Force Logistics Command was organized for OJE. The methods used for enriching jobs will be briefly described. The chronology of events will be listed and the scope of application, in very gross terms, will be reviewed. Dollar savings reported as a result of OJE will be summarized.

C. Section IV analyses the data from one of the pilot projects. Findings based on this analysis will also be reported.

D. Section V will present a very brief summary of the results of the analysis.

E. Section VI will recommend additional study areas.

SECTION II

A DISCUSSION OF TRENDS THAT MADE JOB ENRICHMENT APPLICABLE TO THE AIRCRAFT MAINTENANCE ENVIRONMENT

In the past several years, depot level maintenance in the Air Force Logistics Command has undergone at least three significant changes that have had a great impact upon each employee. First, jobs for direct workers have become highly structured as a result of technological improvements in hardware that demanded higher levels of precision in work performance. Second, policy changes were imposed in the interest of efficiency. Finally, rising prices throughout the economy have resulted in reductions in the scope of work to be performed.

Through the early years, depot maintenance of aircraft was based on an Inspect and Repair as Necessary (IRAN) concept. Formal man-hour job standards did not exist and the end-item costs that were reported were only crude estimates. Comparisons of planned and actual costs were seldom accomplished. As a result, aircraft entering IRAN were thoroughly inspected and repairs were made to restore the aging aircraft to nearly new condition. Undoubtedly, some "gold-plating" occurred in that some repairs were completed that resulted in better-than-required products. For the purpose of this discussion, the point to be made is that direct workers had considerable latitude and control over their work during the IRAN period.

In the late fifties, because of the growing concern, at the executive levels in the Federal Government, over spiraling costs of depot maintenance, a consulting firm was employed to study the environment and make recommendations for controlling and hopefully reversing this trend. (9) Their study which was comprehensive and exhaustive recommended that a standard cost system be implemented and a revolving fund be established with customers reimbursing the fund for services performed by the depot.

These recommendations gave rise to the Depot Maintenance Industrial Fund. The first step toward implementation was to develop labor standards for each job. A large staff of Industrial Engineers and technicians was organized to break each major work package down into operations, sub-operations, and elements required to repair each item. Literally thousands of these elements were defined for major work packages. An average or standard time was then applied to each of these elements and each element was sequentially numbered in the order it should be accomplished. With these standards it was now possible to apply an average cost per man-hour to all elements and to sum them to arrive at an average per unit cost of repair which, in turn, was used to establish end-item sales rates for reimbursement. While this achieved the objective of giving planned cost visibility and identified high cost areas, a significant portion of the workers' flexibility and control was removed.

With the existence of the detailed breakdown of work packages, the next step in the evolution of a highly structured environment was the implementation of a critical path network technique for aircraft which was used to schedule the accomplishment of jobs. (10)

Each morning, the production supervisor was presented with a deck of computer cards that represented the work to be accomplished for that day along with computer generated performance reports from the previous day. These cards were then distributed to the workers for accomplishment. When a job was finished, the card went back into the computer to update the critical path and prepare the next day's card deck. While efficiency and visibility may have improved, the mechanic lost more control over his work.

The increasing complexity of the equipment repaired in the depot resulted in the introduction of other factors that contributed to the further fractionalization of jobs. As technical complexity increased, the trend to specialization in worker skills also increased. No longer could one person achieve the proficiency required to maintain all of the systems on a particular aircraft. A team approach was required and as team size grew with advancement in technology, the degree of worker responsibility for the complete job decreased. Job responsibility moved upward from the mechanic to higher levels of management.

When the labor standards were developed, skill levels, or levels of proficiency, required for each job were not defined. Closely related to this action was the command policy of classifying all positions at the journeyman level. This provided maximum management flexibility in the utilization of direct workers. The policy was also directed at one of the hygiene factors as it provided all of the workers with the maximum pay for their skills. Two of the shortcomings of this policy were

(1) an individual mechanic could feel little distinction among his peers and (2) each mechanic received little recognition for superior performance since everyone had the same classification. Furthermore, highly skilled mechanics were frequently assigned unchallenging jobs while low skilled mechanics were assigned jobs that were quite challenging.

The increased complexity also forced increasing reliance on Technical Orders. Highly detailed step-by-step procedures told the mechanic how to perform the tasks and how to interpret the results. Air Force policy, enforced by frequent inspections, required the mechanic to have the Technical Order open to the page where the job being accomplished was displayed. When the job was completed, increased layers of inspection were required. These trends removed job responsibility from the mechanic and feedback related to the inspections went to managers and supervisors.

Continued pressure to reduce Defense budgets in the post-Vietnam war era resulted in a modification to the basic depot maintenance concept. The IRAN philosophy was replaced with the Programmed Depot Maintenance (PDM) concept. Aircraft work packages were designed by the customer and end-item sales rates were negotiated between depot maintenance managers and the user. Only repairs specified in the negotiated work package could be completed. Other requirements (safety of flight, economy, etc.) had to be fully justified and negotiated with the user. The PDM concept had an immediate impact upon feedback from the user to the worker. No longer were like-new or better aircraft returned from depot maintenance. The operators were not as satisfied with the product as they had been under the IRAN concept, and the depot mechanic was less satisfied with turning out a product that represented less than his best effort.

Pressures were exerted to reduce overhead which led to reductions in numbers of Industrial Engineers and technicians. This, in turn, reduced the amount of time available to restructure jobs or investigate method-improvement techniques.

Throughout this evolutionary period, little attempt was made to evaluate the impact of changes in job procedures on the direct workers in the depots. The result was that the workers were told what to do, when to do it, how to do it, and how much time they could expend in doing it.

There were other factors that further restricted the workers' control over their jobs. Start and stop times for the day, lunch hours, and coffee breaks were specified and rigidly enforced. Normal safety precautions, such as requirements to wear safety glasses and earplugs in danger areas, requirements to wear bulky, uncomfortable protective clothing in designated areas, and restrictions against the wearing of rings, watches, and jewelry while working were imposed to protect the worker.

All of the changes were considered necessary to improve efficiency, reduce costs, and create a safer working environment. This, then was the environment before OJE was introduced.

SECTION III

AFLC ORGANIZATION FOR AND METHOD OF IMPLEMENTATION OF ORTHODOX JOB-ENRICHMENT

The Industrial Engineering and time and motion techniques were fully exploited throughout the AFLC. However, continuing pressure to reduce costs forced management to look for new approaches to increase productivity. Thus, in the early seventies, a program was established within AFLC to upgrade the production equipment and depot facilities to capitalize on the state-of-the-art production techniques. (8) In addition, management concluded that further productivity increases could best come from the workers themselves. Dr. Frederick Herzberg had stated: "productivity is a function of both technology and human motivation, maximum productivity isn't achieved by simply increasing one or the other." (3,21) The challenge to management then was to increase motivation. The commander at the Ogden Air Logistics Center, Hill AFB, Utah directed his staff to conduct a comprehensive study to determine if motivational programs were available to assist in this effort. Their conclusion was that Dr. Herzberg's motivation-hygiene theory offered the greatest possibilities. (7,47) Accordingly, Dr. Herzberg's assistance was sought in establishing a job-enrichment program at Ogden in late 1972 and early 1973. (7,46) In January 1974, Dr. Herzberg agreed to begin implementation. An OJE office was established and the training of 16 carefully selected keymen began. (3,21) The OJE keymen were considered to be one of the essential elements of the program. (7,48)

They operated as internal consultants and coordinators of OJE training in their Divisions. (3,23) The keymen then selected 11 pilot projects to test the concept. Two committees for each project were then formed, an implementing committee of four to eight members included the supervisor of the area to be enriched, specialists, and other first-and second-level supervisors who could assist in developing the implementation strategy. The coordinating committee expedited changes proposed by the implementing committee. Both groups were advised and trained by the keymen. (7,49)

The implementing committee, under the direction of the keymen, generated ideas for installing motivators into the jobs under "greenlighting." The ideas that resulted from the greenlighting process were then evaluated and the most viable alternatives were selected for implementation. (7,49) It is interesting to note that only motivational factors were sought during this process. This is in accordance with Dr. Herzberg's Motivation-Hygiene Theory since only the motivators produce lasting improvements through improved job-satisfaction while hygiene factors affect only job-dissatisfaction. (2,78) Gen. Rafalko explained, "If we found an area had excessive hygiene problems, we had to clean them up to acceptable levels before trying to enrich the jobs." (7, 49)

The eleven projects selected for implementation included four in the Directorate of Maintenance, one of which was in the Aircraft Division. (5) The environment and some of the hygiene factors applicable to the Aircraft Division were discussed in Section II of this report. The case study presented in the next section was the pilot project from the Aircraft Division.

Costs of implementing the program and accrued benefits were collected and are documented in References 5 and 6. Benefits reportedly exceeded costs by October 1974, just seven months after the projects were initiated. At the end of one year's experience, in March 1975, Ogden ALC reported an 88% return on their investment (7,49) in the pilot projects. Encouraged by these successes, the program was expanded and by 31 Dec 1975, 48 projects were in progress. (7,53) By 31 July 1976, the return on investment reported by Ogden was 224%. (3,24)

The project results were presented to higher headquarters and the program was endorsed for implementation throughout the Air Force Logistics Command. An AFLC/OJE office was established at Ogden ALC to monitor and administer the program for the Commander, AFLC. Each AFLC installation established and manned an OJE office. Personnel from the AFLC/OJE office at Ogden were sent to each center to train keymen in OJE principles. At the time of this writing, no projects had been implemented at the other centers.

SECTION IV

CASE STUDY

<u>Scenario</u> (extracted from reference number 5)

An aircraft modification program was in progress at Ogden ALC to install leading edge slats on the wings of F-4E aircraft to improve performance. This project was important to the ALC and to the Air Force. A large number of aircraft and significant manhours were involved. The work to be done was highly specialized and tasks were fragmented. Management and supervisors were receptive to enriching these jobs so a pilot project was started. One work center was responsible for installing a three-piece steel strap on the bottom of the aircraft wing. The strap extended from wing fold to wing fold, required over 600 fasteners for installation, and added critical strength to the wing.

Training of supervisor and managers was completed in March 1974. The greenlight and redlight sessions with the implementing and coordinating committees were completed and the first changes were made on 1 April 1974.

Prior to Job Enrichment, the foreman assigned work to the mechanic. When the job was complete, the foreman inspected it, submitted the job to the quality assurance inspector, obtained feedback from the inspector, and either turned the job in as completed or reassigned the job if the work was not satisfactory. The procedure after job enrichment was for the foreman to assign work to the mechanic. The mechanic accomplished the job, he inspected it to determine if it was ready for the quality assurance inspection, submitted the job for inspection, received feedback from the inspector, and either reworked it or turned in the job completion as appropriate. Then he notified the foreman he was ready for the next job. This change greatly increased the workers' responsibility for the work he was doing and increased his feedback.

Another change was to make the mechanic responsible for the technical aspects of shift turnover. That is, the mechanic being relieved at the end of his shift briefed the mechanic replacing him on the status of the job and any problems he was encountering. This had previously been done by the foreman.

Integral work crews were established and they were paired between shifts. Prior to job enrichment, mechanics were assigned from a skill pool. There was no guarantee that the same workers would be working on the same aircraft from one day to the next. This change was intended to give the mechanic a sense of doing the whole job.

Workload visibility was provided to the foreman and supervisor after OJE implementation. More than one day's work was provided so that the foreman could plan ahead.

Two crews of twenty men each as nearly identical as possible were selected for the pilot project. For the pilot crew, the job was enriched via orthodox job enrichment techniques. The jobs were not enriched for the control crew which provided the baseline for a comparison.

Source of Data

Actual hands-on direct labor man-hours expended on each aircraft by the pilot crew, control crew, and the remaining skill pool were recorded to provide a quantitative measure of the program. Major quality defects discovered for each aircraft were also recorded. The accumulation of actual man-hours was a difficult task because of the costing and labor utilization techniques used in the depots. As explained in Section II, labor standards by operation within major jobs were established for all recurring tasks. The scheduling system produced a card for accomplishment of each of these jobs. When the job was completed, this card was turned in for "production count," meaning, the operation had been completed. The work center then "earned" the standard hours assigned for that operation. Actual hours did not exist in the data systems, therefore manual log books were kept by the supervisors for these projects. Appendix A contains the actual expended man-hours and quality defects for each aircraft as reflected by these records. Appendices B, C and D reflect these same data, but segregated as pilot crew, control crew, and skill pool, data respectively.

Costs for training and time expended by the keymen were accumulated and totaled $19,352. (5) A cumulative average man-hour curve for both pilot and control groups and the remaining skill pool was constructed and the learning curve was computed. The difference in man-hours required for the pilot crew and for the control crew was interpreted as the savings resulting from job enrichment.

Analysis

The data for each crew was smoothed by computing a cumulative average man-hour value for each aircraft completed (a unit).

$$\text{Cumulative Average Value for the } i^{th} \text{ unit} = \frac{\sum_1^i \text{man-hour}}{i}$$

These values were then plotted on Log-Log scales and useable trends resulted as shown in Figures 1, 2, and 3. A learning curve of exponential form;

$$Y = Ax^B$$

was assumed and the values of A and B were found by using values for the 21st and 60th unit numbers for each group;

Man-hours required for the pilot crew = 7508 x (unit production number) $^{-.4375}$

and, Man-hours required for the control crew = 8447 x (unit production number) $^{-.4748}$

and, Man-hours required for the skill pool crews = 3460 x (unit production number) $^{-.1764}$

Since this modification project was underway before the orthodox job-enrichment project was initiated, the first 20 units were before job enrichment. It is interesting to note the change in slope at about the twentieth unit. This may be evidence of the "Hawthorne effect," (1,51-54), especially for the control group. Other changes to the environment were also occurring at this time. For example, an AFLC-wide reduction-in-force was being discussed during this period and it may have had an indirect impact on worker productivity. Also, a major work load realignment between the depots was in process. It is possible that the

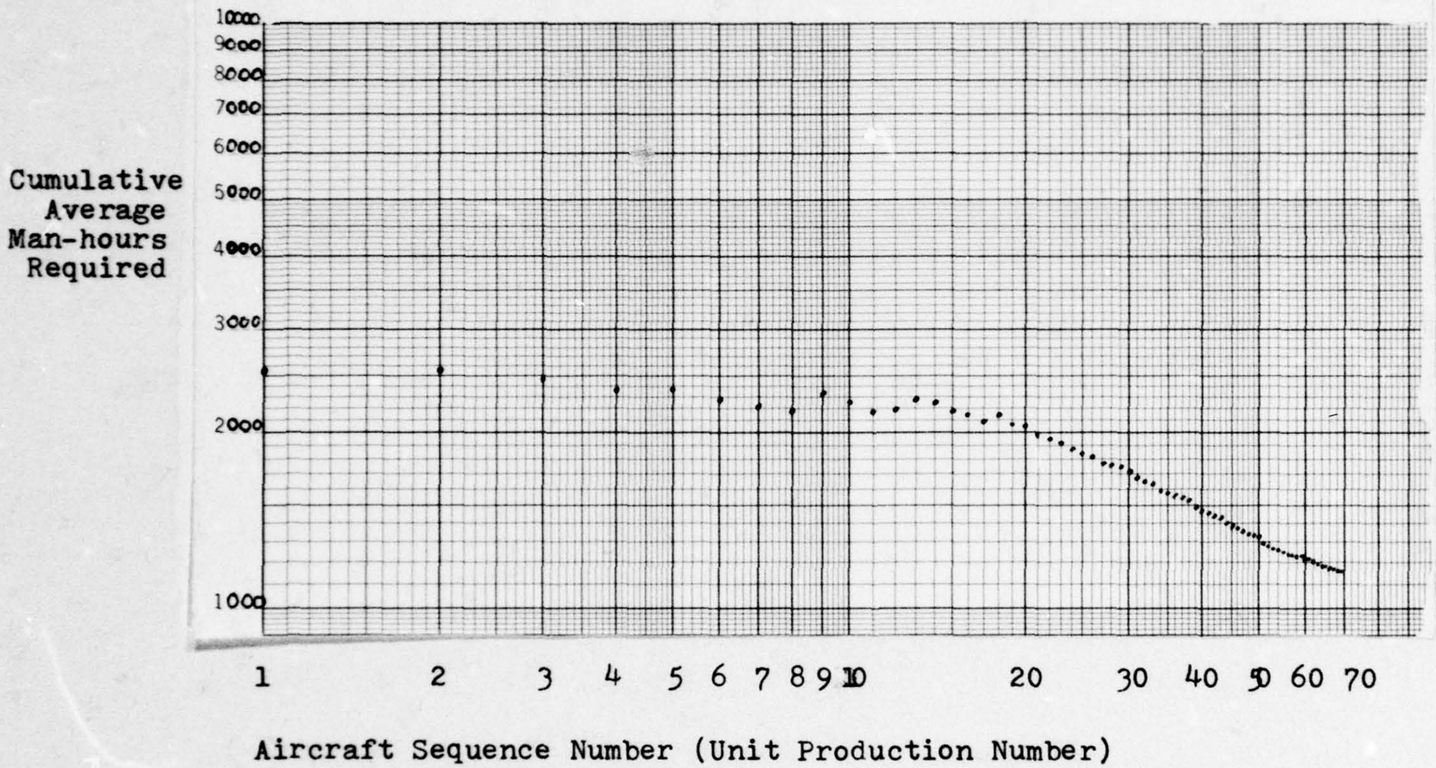

FIGURE 1. Learning Curve for the Control Crew

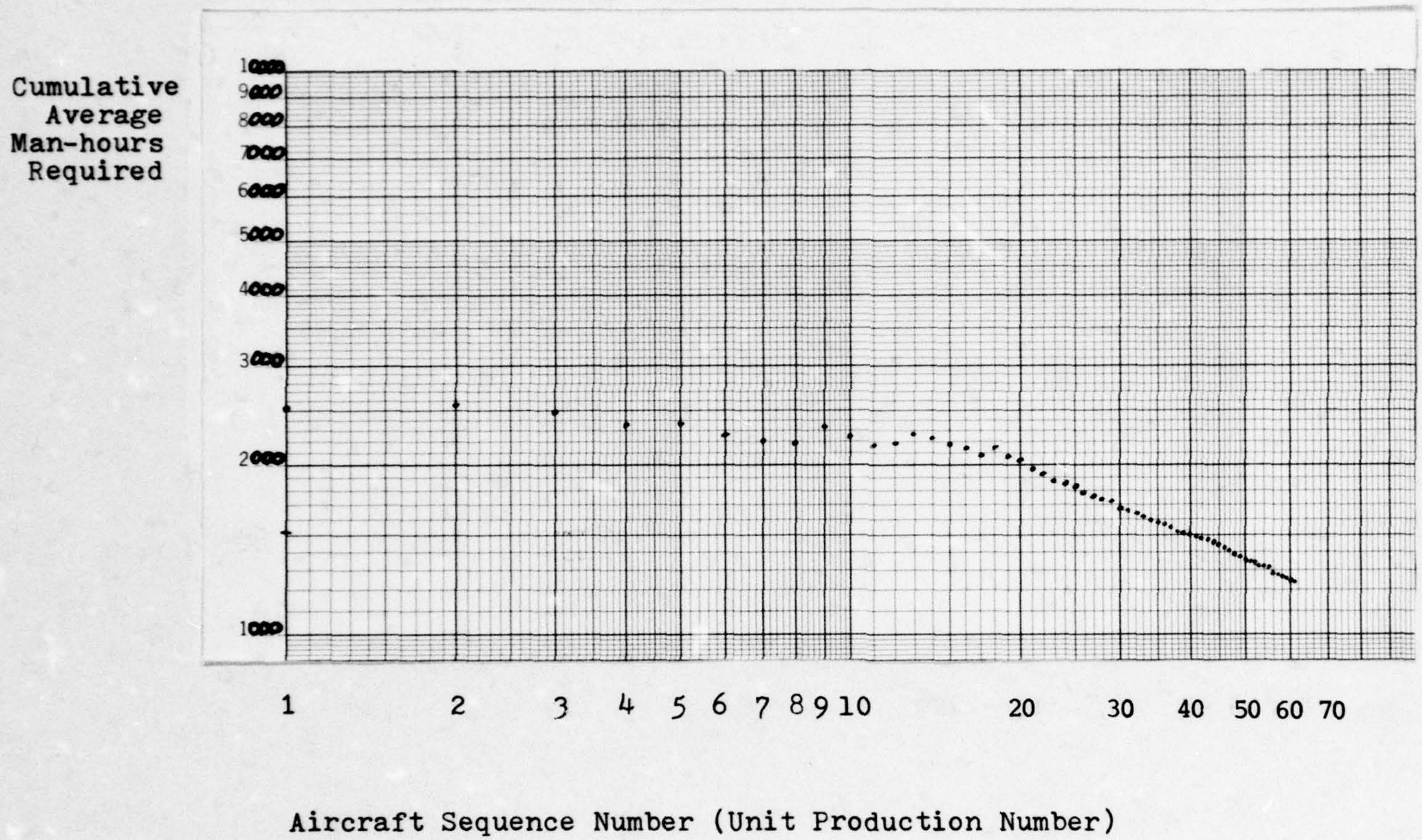

FIGURE 2. Learning Curve for the Pilot Crew

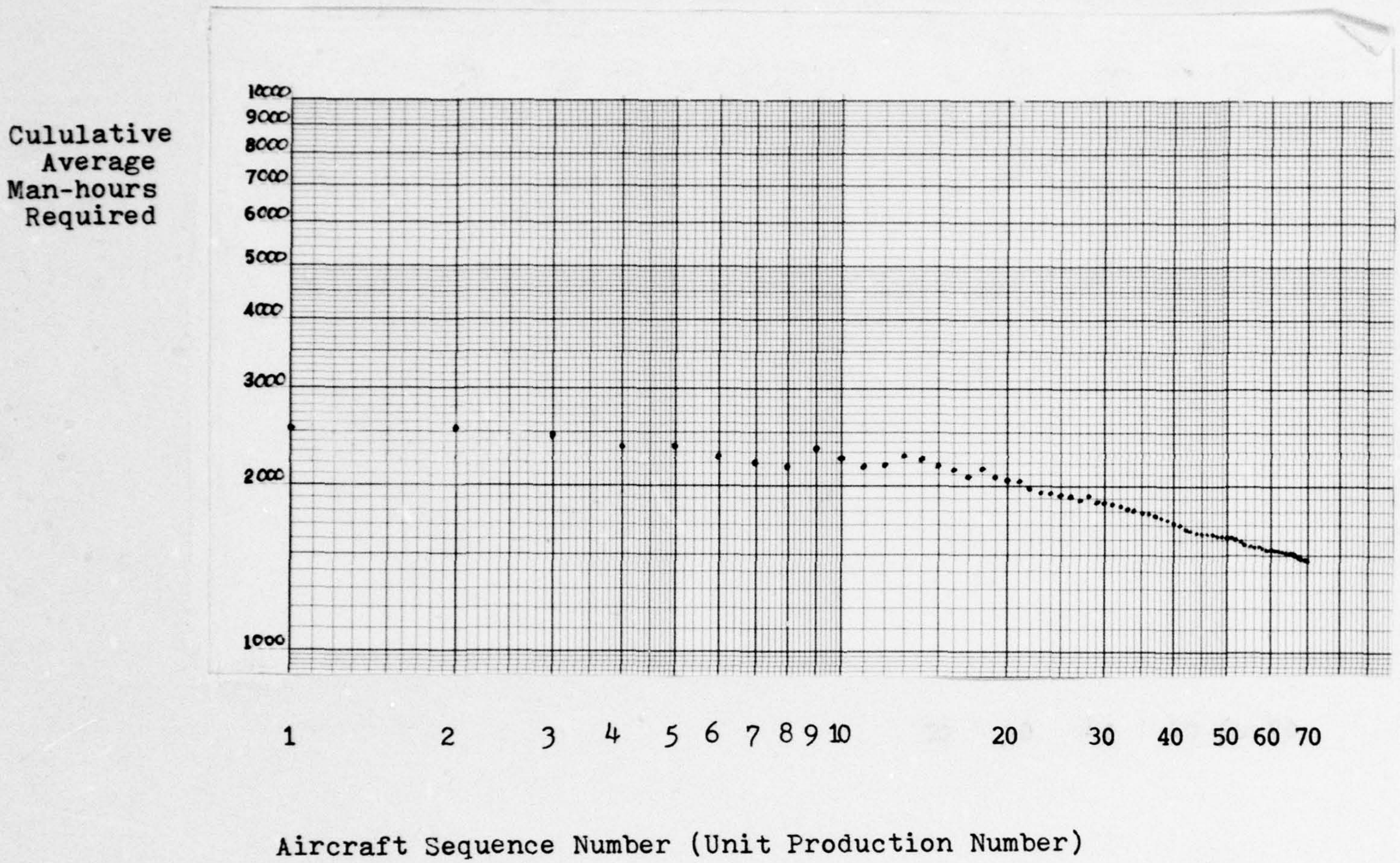

FIGURE 3. Learning Curve for Skill Pool Crews.

sum of all these influences could have produced the slope change since the pool crews, which did not receive OJE, showed a slope change that was similar to that exhibited by the pilot and the control crews.

Data for each crew were divided into two lots for the purpose of this study. One lot included units 1 through 20 and was assumed to be common to all crews since all mechanics were assigned to the skill pool before job-enrichment (Appendix E). This lot was used only to establish base values from which improvements were measured. The second lot was for all units after the twentieth.

From the data, only 41 aircraft were produced during the project by the pilot crew. To be consistent, the data from the first 41 aircraft produced by the control crew and the skill pool, respectively, were used for the analysis. The total number of actual man hours required to produce 41 aircraft was 32,983 for the control crew, 36,209 for the pilot crew, and 53,208 for skill pool crews. This equates to an average of 804.5, 883.1 and 1297.8 man hours per aircraft for the control, pilot, and skill pool crews, respectively. From this, one can conclude that discrete crews are significantly more efficient than skill pools for this type of work. However, there is no clear indication that the other changes made to enrich the jobs had a significant effect since an average of 78.6 or 9.8% more man-hours per aircraft were required for the pilot crew than for the control crew. Moreover, these trends will probably continue since the learning curves (Figures 1,2, and 3) indicate a greater amount of learning was being experienced by the control crew.

The project was not "mature" at the time the available data terminated. At some point it is reasonable to assume a plateau will be reached and the required man-hours will fluctuate randomly about some mean value. These flucuations represent the variability of the condition of the aircraft upon input to the depot and normal random delays. As can be seen from the figures, man-hours required were still fluctuating around the learning curve and no plateau was evident; learning was still in process.

A subtle point on crew selection procedures that may have introduced bias into the results should be addressed. It appears reasonable to expect that if the supervisor was no longer required to inspect the job, management would insure that the mechanics who were assigned to the crews would be able to work with minimum supervision and would be capable of producing high quality work. It is possible that the pilot crew and the control crew members had significantly higher average levels of skill at the outset than the members who remained in the skill pool. This point was not examined in the Ogden reports.

A cumulative or moving average of quality defects was computed (Appendices B, C, and D) and plotted (see Figure 4) for each of the three groups. The same trends exhibited by the cumulative average man-hours required were also evident with the quality defects data. The control group performed better than the pilot group and both of these groups performed better than the skill pool.

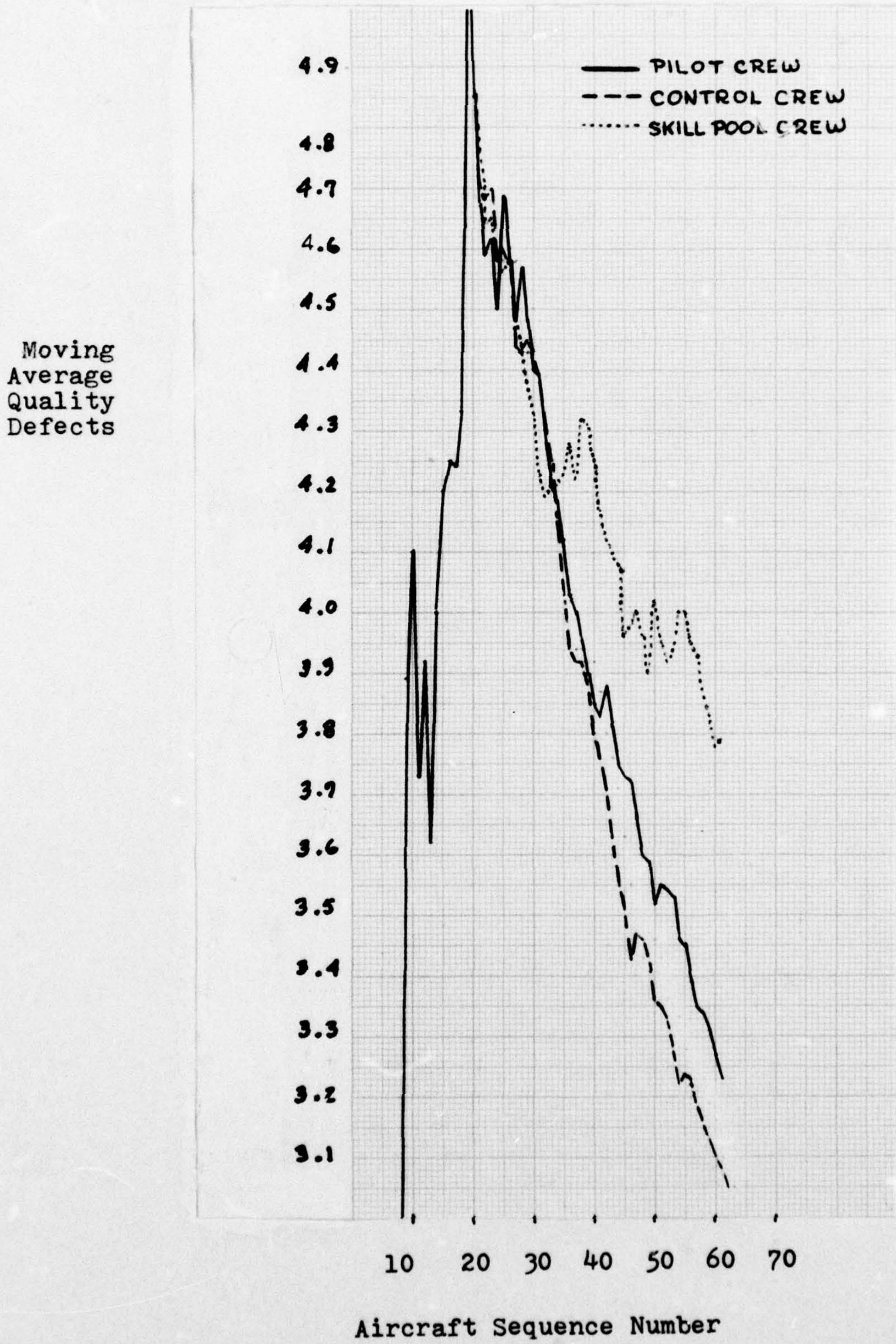

FIGURE 4. Improvement in Quality of Work Performed by Each of the Crews

SECTION V

SUMMARY

Pressures to reduce costs have brought many changes to all segments of the Department of Defense including depot maintenance. This trend will probably continue and may in-fact, accelerate as inflation continues to plague the economy and as national priorities are re-oriented. One way to reduce costs with minimal expense is by increasing the productivity of personnel. How this can best be accomplished is a subject of considerable discussion. This report opened with a discussion of changes that may have de-motivated depot maintenance mechanics over the past thirty years. Extreme specialization, increased restrictions, and detailed job instructions resulted in a highly structured work environment. The mechanic lost some of his feedback and his perspective of his job was narrowed. The impact upon the worker was not always considered when these changes were made.

In an effort to re-motivate the workers, Ogden ALC implemented Dr. Herzberg's Orthodox Job Enrichment approach. Early successes with the program encouraged management to expand the program and implemented it throughout the Air Force Logistics Command. All changes to jobs have been designed and accomplished at the ALC level. Many of the hygiene factors, such as described in Section II, can not be addressed or changed without higher level approval and assistance. Furthermore, some motivators are beyond the control of the ALC. For example, personnel policies that could be changed to increase motivation may require assistance at the highest levels. Management information and control systems that may contain restraints to any motivational efforts will require assistance from the AFLC level.

One of the pilot projects was analyzed and the results are discussed in Section IV. Improved performance was observed indicating that motivation and productivity are related. However, the independent analysis of the original data does raise the question whether OJE was the primary cause of the increase in productivity, especially since the control crew out-performed the "job-enriched" crew. The project was not "mature" since learning was still in progress when the data collection was terminated. It is possible that bias was introduced into the project by the way test crews were selected.

As evidenced by the literature, Ogden ALC management strongly supports OJE as applied there. Other benefits are reported (3), (7) that may give increased weight to the results. Based strictly on the quantitative results of the current analysis, the author concludes that the cause and effect relationship between OJE and increased productivity is definitely not clearly established.

If there is a message of value for program managers in this work it would be that it is far easier to de-motivate than it is to motivate, even with the best of intentions.

SECTION VI

ADDITIONAL AREAS OF STUDY RECOMMENDED

A systems approach should be utilized to examine the complex interaction of the environment, technical requirements, personnel policies, administrative requirements, personnel capabilities, and motivation to determine the appropriate amount of structuring for any job. Changes made in any element should be evaluated carefully to determine its effect on the other elements. Management indicators should be designed to keep management apprised of the "health" of the organization.

Other methods to satisfy the original purpose of implementing OJE should be examined and tested. To reiterate, the original purpose was to do more with less. (7) These tests should be carefully designed to minimize bias, provide adequate data for objective evaluation, and be performed by a qualified, independent outside agency.

APPENDIX A

F-4E Leading Edge Slat Modification

Actual Man-hours and Quality Defects

Raw Data

F4E L.E.S. UNDERWING STRAP DATA

*DATA SOURCE: Records kept by RCC Foreman.

Aircraft Completion Sequence		Date Complete	Total Actual Strap Hours	Crew I. D.	Type 1 Defects
1	69 - 7566	13 Aug	2517	Considered	0
2	69 - 0307	28 Aug	2564	Common to	1
3	69 - 7206	9 Sep	2406	the	3
4	69 - 7210	14 Sep	1944	Learning	3
5	69 - 7205	18 Sep	2453	of All	4
6	69 - 7215	26 Sep	1764	Crews	4
7	69 - 0304	28 Sep	1756		3
8	69 - 7201	4 Oct	2162		4
9	67 - 0262	5 Oct	3233		13
10	69 - 7208	18 Oct	1685		6
11	69 - 7231	19 Oct	1562		0
12	69 - 7582	23 Oct	2318		6
13	67 - 0203	5 Nov	3394		0
14	69 - 7258	6 Nov	1531		9
15	69 - 7263	16 Nov	1397		7
16	69 - 7233	16 Nov	1613		5
17	68 - 0488	21 Nov	1193		4
18	67 - 0308	30 Nov	2880		6
19	69 - 7253	30 Nov	1119		3
20	67 - 0222	3 Dec	1312		0
21	68 - 0462	4 Dec	813	PILOT	1
22	69 - 7265	5 Dec	1663		2
23	68 - 0395	10 Dec	842	PILOT	3
24	69 - 7257	11 Dec	1451		3
25	67 - 0227	11 Dec	1309		5
26	67 - 0305	12 Dec	1748		3
27	68 - 0431	13 Dec	989	CONTROL	2
28	68 - 0400	18 Dec	1163	CONTROL	4
29	67 - 0331	21 Dec	879	PILOT	5
30	68 - 0307	4 Jan	1379		4

Aircraft Completion Sequence		Date Complete	Total Actual Strap Hours	Crew I. D.	Type 1 Defects
31	68 - 0466	9 Jan	UNKNOWN	CONTROL	7
32	68 - 0423	11 Jan	1139		5
33	68 - 0438	11 Jan	1462		2
34	68 - 0317	15 Jan	1034	PILOT	2
35	68 - 0347	16 Jan	UNKNOWN		2
36	68 - 0330	18 Jan	2506		3
37	68 - 0473	18 Jan	1050	PILOT	9
38	69 - 0292	22 Jan	942	PILOT	2
39	68 - 0350	24 Jan	1163		3
40	66 - 0298	24 Jan	979	CONTROL	5
41	68 - 0308	24 Jan	1284		3
42	67 - 0338	30 Jan	1115	PILOT	2
43	66 - 0328	7 Feb	1417		1
44	69 - 7270	7 Feb	997	PILOT	7
45	66 - 0314	8 Feb	932	CONTROL	2
46	68 - 0325	12 Feb	1442		3
47	68 - 0318	13 Feb	1126		5
48	68 - 309	13 Feb	971	PILOT	2
49	67 - 0317	14 Feb	991	CONTROL	5
50	68 - 0474	15 Feb	1266	CONTROL	4
51	67 - 0398	15 Feb	UNKNOWN		5
52	69 - 7298	21 Feb	812	PILOT	2
53	67 - 0371	22 Feb	1051	PILOT	4
54	67 - 0336	28 Feb	1617		4
55	68 - 0358	28 Feb	1324		5
56	69 - 7251	4 Mar	UNKNOWN		2
57	67 - 0364	4 Mar	1200		6
58	69 - 7546	8 Mar	983	CONTROL	1
59	69 - 7301	15 Mar	1088	PILOT	1
60	69 - 7269	18 Mar	1028	CONTROL	4
61	68 - 0346	18 Mar	1337		2
62	66 - 0333	20 Mar	1459		8

Aircraft Completion Sequence		Date Complete	Total Actual Strap Hours	Crew I. D.	Type 1 Defects
63	66 - 0344	21 Mar	942		4
64	67 - 0354	21 Mar	1103	CONTROL	5
65	68 - 0364	22 Mar	533		2
66	69 - 7272	26 Mar	835	PILOT	2
67	68 - 0483	29 Mar	1029	PILOT	3
68	69 - 7286	29 Mar	828	CONTROL	4
69	67 - 0236	29 Mar	1383		1
70	69 - 7287	3 Apr	1235		2
71	68 - 0440	3 Apr	1041		2
72	67 - 0239	5 Apr	1296		2
73	69 - 7232	9 Apr	1113		1
74	69 - 7291	9 Apr	1530		5
75	67 - 0361	10 Apr	982	PILOT	2
76	67 - 0360	15 Apr	1333		5
77	67 - 0240	17 Apr	833	CONTROL	3
78	67 - 0356	17 Apr	779	CONTROL	0
79	69 - 0272	23 Apr	995	PILOT	1
80	67 - 0215	25 Apr	695	CONTROL	1
81	67 - 0255	29 Apr	1027	PILOT	3
82	69 - 0288	30 Apr	906		2
83	69 - 7235	30 Apr	1398		1
84	67 - 0332	30 Apr	1516		10
85	68 - 0493	3 May	739	CONTROL	3
86	68 - 0328	7 May	1124		1
87	68 - 0391	10 May	890	PILOT	2
88	68 - 0373	14 May	1254		2
89	69 -7289	15 May	1048		5
90	66 - 0348	16 May	1027		7
91	67 - 0370	16 May	667	CONTROL	1
92	68 - 0366	17 May	824	PILOT	2
93	67 - 0366	22 May	1090	PILOT	2
94	69 - 7262	22 May	807	CONTROL	1

Aircraft Completion Sequence		Date Complete	Total Actual Strap Hours	CREW I. D.	Type 1 Defects
95	68 - 0374	23 May	962		4
96	69 - 7292	27 May	1076		1
97	68 - 0326	30 May	1284		3
98	67 - 0356	4 Jun	1302		0
99	68 - 0426	5 Jun	886	CONTROL	3
100	68 - 0365	6 Jun	885	CONTROL	4
101	66 - 0353	6 Jun	1083		2
102	68 - 0367	7 Jun	1500		1
103	69 - 7293	11 Jun	1097	PILOT	3
104	68 - 0498	14 Jun	1296		4
105	69 - 0293	18 Jun	925		3
106	69 - 7583	21 Jun	776	CONTROL	2
107	? - 7295	24 Jun	997		2
108	69 - 0297	27 Jun	946	PILOT	6
109	? - 7300	28 Jun	806	CONTROL	1
110	? - 7580	28 Jun	1218		0
111	? - 7204	28 Jun	872	PILOT	1
112	69 - 7585	8 Jul	842		11
113	? - 0232	10 Jul	854	PILOT	1
114	67 - 0210	12 Jul	1006		6
115	68 - 0451	17 Jul	686	CONTROL	2
116	? - 0549	23 Jul	1045		0
117	66 - 0318	23 Jul	1021		3
118	68 - 0376	29 Jul	702	CONTROL	2
119	69 - 7202	29 Jul	677	PILOT	3
120	67 - 0265	31 Jul	833	PILOT	3
121	69 - 7579	1 Aug	1045		8
122	67 - 0246	1 Aug	981		0
123	68 - 0369	2 Aug	597	CONTROL	0
124	68 - 0343	5 Aug	624	CONTROL	0
125	67 - 0353	6 Aug	995		0

Aircraft Completion Sequence		Date Complete	Total Actual Strap Hours	CREW I. D.	Type 1 Defects
126	67 - 0264	7 Aug	599	PILOT	1
127	68 - 0342	8 Aug	1063		6
128	68 - 0355	9 Aug	592	CONTROL	2
129	68 - 0345	15 Aug	786	PILOT	1
130	68 - 0358	15 Aug	588	CONTROL	0
131	66 - 0304	16 Aug	1036		7
132	68 - 0361	20 Aug	869		0
133	68 - 0303	23 Aug	693	CONTROL	5
134	68 - 0357	26 Aug	764	PILOT	3
135	68 - 0340	26 Aug	845		4
136	68 - 0351	28 Aug	681	CONTROL	3
137	68 - 0387	30 Aug	739	CONTROL	2
138	67 - 0355	4 Sep	596	PILOT	0
139	66 - 0359	6 Sep	874		3
140	67 - 0238	13 Sep	912	PILOT	5
141	67 - 0350	13 Sep	797		1
142	68 - 0353	17 Sep	665	PILOT	3
143	68 - 0360	18 Sep	676	CONTROL	0
144	66 - 0306	20 Sep	614	CONTROL	3
145	67 - 0348	23 Sep	688	PILOT	3
146	67 - 0307	24 Sep	773		1
147	68 - 0450	26 Sep	664	CONTROL	2
148	68 - 0362	30 Sep	677		3
149	68 - 0363	4 Oct	677	CONTROL	1
150	68 - 0449	7 Oct	880		6
151	66 - 0364	8 Oct	807		3
152	68 - 0482	9 Oct	568	CONTROL	0
153	66 - 0303	9 Oct	809	PILOT	0
154	68 - 0334	9 Oct	784	CONTROL	4
155	68 - 0494	11 Oct	684	CONTROL	3
156	67 - 0226	16 Oct	777	PILOT	3

Aircraft Completion Sequence		Date Complete	Total Actual Strap Hours	CREW I. D.	Type 1 Defects
157	68 - 0354	22 Oct	960		4
158	67 - 0377	1 Nov	898	PILOT	0
159	66 - 0378	8 Nov	1237		1
160	67 - 0343	8 Nov	787	CONTROL	1
161	67 - 0258	8 Nov	910	PILOT	1
162	68 - 0463	18 Nov	910	CONTROL	1
163	68 - 0505	19 Nov	884	CONTROL	0
164	68 - 0511	21 Nov	940	CONTROL	2
165	67 - 0229	22 Nov	956		2
166	67 - 0372	22 Nov	771		2
167	67 - 0216	27 Nov	808	PILOT	3
168	66 - 0382	29 Nov	647	PILOT	1
169	67 - 0211	4 Dec	796		0
170	66 - 0366	4 Dec	758	CONTROL	1
171	68 - 0518	4 Dec	759	CONTROL	0
172	67 - 0373	13 Dec	859		8
173	66 - 0323	2 Jan	807	PILOT	1
174	66 - 0360	6 Jan	784	CONTROL	2
175	68 - 0330	6 Jan	589	CONTROL	0
176	66 - 0341	7 Jan	949		1
177	66 - 0337	13 Jan	784		1
178	68 - 0390	17 Jan	723	CONTROL	1
179	66 - 0349	17 Jan	837	CONTROL	2
180	66 - 0343	21 Jan	897		0
181	66 - 0370	23 Jan	819	CONTROL	5
182	66 - 7588	27 Jan	838		0
183	68 - 0504	29 Jan	789	CONTROL	2
184	69 - 7290	29 Jan	649	CONTROL	0
185	66 - 0354	30 Jan	998	PILOT	1
186	66 - 0362	30 Jan	856		1

APPENDIX B

Man-hour and Quality Defect Data for the Job-Enriched Pilot Crew

PILOT CREW

Crew Unit Number	A/C Production Number	Actual Man-hours	Cumulative Avg. Man-hours	Quality Defects	Moving Avg.
21	21	813	1982	1	4.67
22	23	842	1930	3	4.59
23	29	879	1884	5	4.61
24	34	1034	1849	2	4.50
25	37	1050	1817	9	4.68
26	38	942	1783	2	4.58
27	42	1115	1758	2	4.48
28	44	997	1731	7	4.57
29	48	971	1705	2	4.48
30	52	812	1675	2	4.40
31	53	1051	1655	4	4.39
32	59	1088	1637	1	4.28
33	66	835	1613	2	4.21
34	67	1029	1596	3	4.18
35	75	982	1578	2	4.11
36	79	995	1562	1	4.03
37	81	1027	1548	3	4.00
38	87	890	1530	2	3.95
39	92	824	1512	2	3.90
40	93	1090	1502	2	3.85
41	103	1097	1492	3	3.83
42	108	946	1479	6	3.88
43	111	872	1465	1	3.81
44	113	854	1451	1	3.75
45	119	677	1434	3	3.73
46	120	833	1421	3	3.72
47	126	599	1403	1	3.66
48	129	786	1390	1	3.60
49	134	764	1377	3	3.59
50	138	596	1362	0	3.52
51	140	912	1353	5	3.55
52	142	665	1340	3	3.54
53	145	688	1327	3	3.53
54	153	809	1318	0	3.46
55	156	777	1308	3	3.45
56	158	898	1285	0	3.39
57	161	910	1278	1	3.35
58	167	808	1270	3	3.34
59	168	647	1259	1	3.31
60	173	807	1252	1	3.27
61	185	998	1248	1	3.23

Total Actual Manhours = 36,209

APPENDIX C

Man-hour and Quality Defect

Data for the Control Crew

CONTROL CREW

Crew Unit Number	A/C Production Number	Actual Man-hours	Cumulative Avg. Man-hours	Quality Defects	Moving Avg.
21	27	989	1990	2	4.71
22	28	1163	1953	4	4.68
23	40	979	1910	5	4.70
24	45	932	1869	2	4.58
25	49	991	1834	5	4.60
26	50	1266	1812	4	4.58
27	58	983	1781	1	4.44
28	60	1028	1754	4	4.43
29	64	1103	1732	5	4.45
30	68	828	1702	4	4.43
31	77	833	1674	3	4.39
32	78	779	1646	0	4.25
33	80	695	1617	1	4.15
34	85	739	1591	3	4.12
35	91	667	1565	1	4.03
36	94	807	1544	1	3.94
37	99	886	1526	3	3.92
38	100	885	1509	4	3.92
39	106	776	1490	2	3.87
40	109	806	1473	1	3.80
41	115	686	1454	2	3.76
42	118	702	1436	2	3.71
43	123	597	1417	0	3.63
44	124	624	1399	0	3.55
45	128	592	1381	2	3.51
46	130	588	1363	0	3.43
47	133	693	1349	5	3.47
48	136	681	1335	3	3.46
49	137	739	1323	2	3.43
50	143	676	1310	0	3.36
51	144	614	1296	3	3.35
52	147	664	1284	2	3.33
53	149	677	1273	1	3.28
54	152	568	1260	0	3.22
55	154	784	1251	4	3.24
56	155	684	1241	3	3.23
57	160	787	1233	1	3.19
58	162	910	1227	1	3.16
59	163	884	1222	0	3.10
60	164	940	1217	2	3.08
61	170	758	1209	1	3.05

Total Actual Manhours = 32, 983

APPENDIX D

Man-hour and Quality Defect Data for Skill Pool Crews

SKILL POOL

Crew Unit Number	A/C Production Number	Actual Man-hours	Cumulative Avg. Man-hours	Quality Defects	Moving Avg.
21	22	1663	2022	2	4.71
22	24	1451	1996	3	4.64
23	25	1309	1966	5	4.65
24	26	1748	1957	3	4.58
25	30	1379	1934	4	4.56
26	32	1139	1904	5	4.58
27	33	1462	1887	2	4.48
28	36	2506	1909	3	4.43
29	39	1163	1884	3	4.38
30	41	1284	1864	3	4.33
31	43	1417	1849	1	4.23
32	46	1442	1836	3	4.19
33	47	1126	1815	5	4.21
34	54	1617	1809	4	4.21
35	55	1324	1795	5	4.23
36	57	1200	1779	6	4.28
37	61	1337	1767	2	4.22
38	62	1459	1759	8	4.32
39	63	942	1738	4	4.31
40	65	533	1708	2	4.25
41	69	1383	1700	1	4.17
42	70	1235	1689	2	4.12
43	71	1041	1674	2	4.07
44	72	1296	1665	2	4.02
45	73	1113	1653	1	3.96
46	74	1530	1650	5	3.98
47	76	1333	1643	5	4.00
48	82	906	1628	2	3.96
49	83	1398	1623	1	3.90
50	84	1516	1621	10	4.02
51	86	1124	1611	1	3.96
52	88	1254	1605	2	3.92
53	89	1048	1594	5	3.94
54	90	1027	1584	7	4.00
55	95	962	1572	4	4.00
56	96	1076	1563	1	3.95
57	97	1284	1558	3	3.93
58	98	1302	1554	0	3.86
59	101	1083	1546	2	3.83
60	102	1500	1545	1	3.78
61	104	1296	1541	4	3.79

Total Actual Manhours = 53, 208

APPENDIX E

Man-hour and Quality Defect
Data for all Crews Before
Implementation of Orthodox
Job Enrichment

Production History Prior to OJE Implementation

Crew Unit Number	A/C Production Number	Actual Man-hours	Cumulative Avg. Man-hours	Quality Defects	Moving Avg.
1	1	2517	2517	0	0
2	2	2564	2541	1	.5
3	3	2406	2496	3	1.33
4	4	1944	2358	3	1.75
5	5	2453	2377	4	2.20
6	6	1764	2275	4	2.50
7	7	1756	2201	3	2.57
8	8	2162	2196	4	2.75
9	9	3233	2311	13	3.89
10	10	1685	2248	6	4.10
11	11	1562	2186	0	3.73
12	12	2318	2197	6	3.92
13	13	3394	2289	0	3.62
14	14	1531	2235	9	4.00
15	15	1397	2179	7	4.20
16	16	1613	2144	5	4.25
17	17	1193	2088	4	4.24
18	18	2880	2132	6	4.33
19	19	1119	2078	3	5.11
20	20	1312	2040	0	4.85

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