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ANALYSIS OF GARMENT PRODUCTION METHODS, PART I: Comparison of Cost and Production Between a Traditional Bundle System and a Unit Production System Installation

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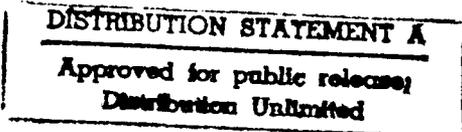
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Defense Logistics Agency
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This document is Part I of three parts, each of which will be published separately.

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This report compares the costs and productivity relationships between the traditional bundle system method of apparel production with the new production method referred to as the Unit Production System (UPS). In the former system large bundles (quantities) are completed at each operational stage before the entire bundle is transferred to the next operation. In the latter system, individual units progress from operation-to-operation in single file order as in a mass-production line.

A manufacturer that was using a bundle system switched over to a UPS. Data critical to an analysis of the two systems was collected prior to and after the changeover and then was critically analyzed. Analysis revealed that with the UPS installation weekly output increased by 9.6%; the number of workers decreased by 10.3%; production time per unit decreased by 17.3%; and, unit production costs decreased by 12.3%.

All parameters of the UPS installation are discussed.

Apparel, Bundle System, Cost, Garment, Production, Unit
Production System

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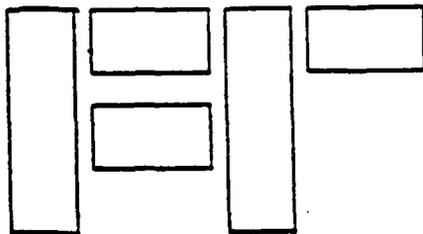
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P A R T I

COMPARISON OF COST AND PRODUCTION BETWEEN A
TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

Fashion Institute of Technology



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ADVANCED APPAREL MANUFACTURING TECHNOLOGY

FASHION INSTITUTE OF TECHNOLOGY

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**COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM
AND A UNIT PRODUCTION SYSTEM INSTALLATION**

FINAL TECHNICAL REPORT A008

**Josef Korngruen
Project Leader**

January, 1992

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DEFENSE LOGISTICS AGENCY
CAMERON STATION
ALEXANDRIA, VA 22304-6100**

COMPARISON OF COST AND PRODUCTION
 BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
 A UNIT PRODUCTION SYSTEM INSTALLATION

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TABLE OF CONTENTS

	<u>PAGE</u>
ACKNOWLEDGEMENTS	ii
TABLE OF CONTENTS	iii
INTRODUCTION	1
GARMENT INDUSTRY HISTORY	1
UNIT PRODUCTION SYSTEMS HISTORY	2
RESEARCH PROJECT HISTORY	4
SUBJECT COMPANY PROFILE	5
PROJECT GOALS	7
PROJECT PERSONNEL	7
PHASE I - THE PROGRESSIVE BUNDLE SYSTEM ANALYSIS	8
Direct Costs Associated With the Bundle System	10
Indirect Costs Associated With the Bundle System	10
Flow Chart of the Bundle System Paper Work	11
Cost of Work-in-Process	11
Labor Turnover During the First Three Months of 1990	12
Cost of Employee Replacement and Training	12
Spreadsheet for Data Collection	13
Analysis of Other Cost Items	14
Labor Operation Analysis	15
Selection and Cost of the Unit Production System	16
Selection of the Unit Production System	16
Unit Production System Costs	18
Preparation for the Installation of UPS	19
PHASE II	22
PHASE III	25
DATA ANALYSIS	27
Weekly Production Data	27
Work-in-Process Inventory	30
Manufacturing Overhead	31
Payback and Return on Capital Investment Analysis	31

COMPARISON OF COST AND PRODUCTION
 BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
 A UNIT PRODUCTION SYSTEM INSTALLATION

<u>Table of Contents (Cont.)</u>	<u>Page</u>
CONCLUSION	34
EXHIBITS	
Exhibit 1 - Marine Corps Dress Coat as a Percentage of Weekly Department Output	36
Exhibit 2 - Agreement of Cooperation for Cost Benefit Analysis of a Modular UPS Installation	37
Exhibit 3 - Plant Layout	39
Exhibit 4 - Spreadsheet Row Headings	40
Exhibit 5A- Weekly Data Required	41
Exhibit 5B- Cost Factors	42
Exhibit 6A- Average Weekly Assembly Cost per Unit for Phase I	43
Exhibit 6B- Average Weekly Assembly Cost per Unit for Phase I and III	44
Exhibit 7 - Blue and Red Marine Dress Coat as a Percentage of Weekly Department Output	45
Exhibit 8A- Customer Needs Analysis	46
Exhibit 8B- Quick Quote Estimated Annual Savings	47
Exhibit 9A- Supervisor's Daily Start-Up Routine	48
Exhibit 9B- Supervisor's Guidelines	49
Exhibit 10- Preventive Maintenance Program	50
Exhibit 11- Work-in-Process Inventory	51
Exhibit 12- Ippoliti Incorporated Weekly Data Unit Production System Analysis	52

INTRODUCTION

The purpose of this study was to analyze the impact of the adoption of a Unit Production System (UPS) on a multi-product tailored garment production facility. It was felt that data from such a study would provide manufacturers of military dress uniforms with guidelines which would assist them in the decision making process relative to the installation of a Unit Production System. The installation of a Unit Production System calls for major commitments of capital and management effort, both of which have to be carefully planned. Therefore, guidelines based on experience can be very helpful.

Even though the case study reported here describes a successful integration of a UPS, this does not mean that this is the only way to go. Every company has its own culture and should carefully investigate all aspects of and alternatives to such an acquisition. Nevertheless, this investigator strongly believes that a UPS is a viable production tool and should not be rejected out of hand merely because of its cost and complexity. The garment industry in the United States, both military and civilian, is very competitive and in order to stay in business it is important that each company investigate the potential applicability of new production tools such as Unit Production Systems.

GARMENT INDUSTRY HISTORY

The garment industry in the United States during the last 130 years of has undergone several cyclic changes in its production systems. The needs of the War Between the States brought the factory system to the industry. Uniforms were mass produced in an organized manner in plants comparable in size to today's average size garment factory. However, due to the vast influx of immigrants during the last part of the 19th century and the beginning of this century, labor was both plentiful and cheap. As a result, garment production plants degenerated to the now infamous "sweatshops". This period also witnessed the beginning of the home workshops where the production of garments became a family affair. These home workshops were really the forerunners of what are now modular production teams.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

The demands of World War I brought larger factory organizations into prominence and they have remained the dominant force within the industry ever since. The overall needs created by World War I substantially reduced the garment producers' available labor pool and in order to cope they had to reorganize their facilities and systems. This reorganization brought the progressive bundle system to the apparel industry and along with it came the piece-work incentive system. Since then the bundle system, in a variety of versions, has been and most likely will continue to be in the years to come, an integral part of the sewn products industry.

During the 1920's and 1930's, dress and coat manufacturers distributed small bundles of garments to their workers and each operator made the whole garment. Such companies had very few special machines, usually only a blindstitch machine, buttonhole, and perhaps a buttonsewing machine. All other sewing was done on single needle lockstitchers. This approach to production reflected the industry's reaction to the economic conditions of the period and could also be thought of as an early version of Quick Response.

The demands of World War II also placed a huge burden on the garment industry. Due to the war-induced labor shortage companies had to become more efficient in order to meet their production requirements. Therefore, it was during this period that we saw an influx of early mechanized equipment. Cam-guided automatic profile stitchers and thread-break detectors were some of the devices that gained wide acceptance. But, in spite of the obvious need to improve the methods and systems of production, the various segments of the apparel industry stayed with whole and semi-section garment construction until the latter part of the 1950's.

UNIT PRODUCTION SYSTEMS HISTORY

The first Unit Production System, as we know it, was developed about 1965 by the Eton Manufacturing Company of Sweden. The concept was not new - for many years overhead conveyors have been used in other industries to transport work pieces from station to station in a fixed sequence. What made the Eton System different was that one could very quickly, via a mechanical keypad, reprogram the sequencing of each work station. This allowed for rapid routing changes in the transportation sequence of garment parts. The flow of the work could now be set according to the sequencing requirements of each style and each would move through its production cycle without any work-moving labor cost. This system effectively eliminated the need for bundle-handling labor.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

This investigator had his first brush with Eton's Unit Production System in 1970. Lion of Troy, a shirt producer in Troy, NY had a six station experimental system set up in its plant. Lion and their neighbor Cluett, Peabody & Co. Inc., were jointly evaluating this "new" production method. This was twenty-one years ago when American shirt companies had little foreign competition and, therefore, had little economic impetus to invest in unproven systems. At that time neither Lion or Cluett wanted to be pioneers. Besides, their attention was concentrated on automatic shirt pocket-setting machines which were moving into their industry at that time.

Since 1970, the Unit Production System has evolved into a very sophisticated, computer-controlled production system. Of the five systems available in the U.S. only three companies, Eton, Gerber Garment Technology, and INA have any level of market acceptance in this country. Investronica has only sold one system in the U.S. so far and Jice has not sold any here as yet. Each of the companies has a different approach to handling the garment parts and to reading and recording production information. However, there is no intention in this report to evaluate the systems or compare their relative features. Each garment manufacturing company's production requirements have their own particular structure and the various Unit Production Systems have to be evaluated within the framework of that structure. Today, all the systems can rearrange the input data into many formats which will give their users the option of a vast array of reports of which only a few will be used. Although each system manager has his/her unique data requirements, these are usually supplied by less than six reports. It should also be noted that the three domestically accepted Unit Production Systems also allow their users to transfer raw payroll data to a compatible payroll system.

On the whole, Unit Production Systems have gained a far greater acceptance in Europe than they have in the United States. While we have not been able to obtain accurate sales figures, it is believed that there are between 300 and 400 UPS installations in the United States and that these systems have an average of 40 work stations each. This means that less than 2% of the U.S. apparel production work force is served by Unit Production Systems. This percentage was arrived at by assuming that there are 350 UPS operations with an average of 40 stations each and that the sewn products industry has about a 750,000 to 800,000 member production work force. One can list many reasons for this low level of acceptance, but this investigator has come to believe that the heavy demands the installation of the systems place on management and their commitment to the system and the large outlay of capital which are necessary are the major deterrents to wider domestic industry acceptance.

RESEARCH PROJECT HISTORY

This project was proposed to the Defense Logistics Agency (DLA) because it was evident to the staff of the Fashion Institute of Technology's Advanced Apparel Manufacturing Technology Demonstration Center (F.I.T./AAMTD) that UPS production methods have a definite place among the garment industry production systems. However, in order to prove out the UPS potential it was necessary to obtain hard facts and figures for verification. It was decided that the best approach to obtaining the needed facts and figures would be through a case study which tracks an actual UPS installation from the purchasing decision through at least six months of normal usage. The F.I.T./AAMTD Center then had to find a garment manufacturer with the right combination of factors which would make it a suitable subject for such a study:

1. The company had to have an active progressive bundle system and be in the early stages of planning the purchase and installation of a Unit Production System.
2. The company management had to be willing to share proprietary production and cost information, in the formats needed, with the AAMTD researchers for their analysis.
3. The company had to have an adequate product mix which was sufficiently complex to warrant a system of at least 70 work stations, possible more.
4. Visits to the production facility by the AAMTD researchers should be able to be accomplished without lengthy travel or an overnight stay.
5. The company's management, staff, and production work force had to be easily accessible to the project researchers.

The short term research and development project was awarded to the F.I.T./AAMTD Center in August 1989. It was scheduled to be completed by May 1, 1991, or within 20 months. Ippoliti Incorporated, a coalition member of our center, agreed to be the subject company for this study. The company is located in Philadelphia, PA. and manufactures a mix of tailored dress uniforms for various military services and civilian organizations. In August of 1989, the company's plans were to move to a new production facility in the spring of 1990 and, at that time, they intended to install a UPS for the facility. (Unfortunately, completion of the building was delayed by several months and they were not able to start operating their new facility until September 1990.)

Ippoliti's cooperation with the F.I.T./AAMTD research team proved to be very good. The company assigned several staff members to the collection of the necessary data and they also assigned a liaison person to work with us. This will be explained in greater detail in the next section of this report where we will profile the company and describe the arrangements for the cooperative efforts of the participants.

The outcome of this research effort proved to be beneficial for both groups: Ippoliti Incorporated learned a great deal about their manufacturing operation which they did not previously know; and, our team obtained the hard data required to complete the project and was enabled to show that with the proper effort and in the proper environment, substantial production and cost gains can be obtained with the use of a Unit Production System in a complicated garment production facility.

SUBJECT COMPANY PROFILE

One of the requirements of this research project was that we had to find a company that met the criteria listed in the previous section. Ippoliti Incorporated, a member of the F.I.T./AAMTD coalition of manufacturers, fit the mandated profile very well. The company is located in Philadelphia, PA. which is a two-hour trip from the F.I.T./AAMTD Center, and its management was very willing to cooperate with us on this project. What made Ippoliti Incorporated a very good subject for this case study is its structure and corporate culture. Like most successful organizations, it is led by a management that has a strong, long term commitment to the company and its customers. It is also sufficiently progressive in its thinking that it will willingly try out or experiment with new production equipment.

Ippoliti Incorporated is a family run and owned manufacturer of military and civilian organization dress uniforms and a small amount of made-to-order men's tailored clothing. At the start of this project the company was located in an old and run down building on Broad Street in Philadelphia, PA. There they rented 1-1/2 floors, 40,000 square feet on the second floor and 20,000 square feet on the upper floor. All the production work was accomplished on the larger second floor, and final checking by the Government inspectors was done on the upper or third floor. Offices were on both floors, split in a similar manner, production offices on the second floor and corporate offices on the third floor.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

The company was started by the grandfather of present president, Nick Ippoliti Jr., and has been located in Philadelphia, PA since its inception. There were about 170 factory employees on the payroll at the start of this project. However, during the term of the project the number of employees in the plant rose to 210 due to an expanded product line which was made possible by the move to the new production facility.

The management structure of this manufacturing company is quite simple: Nick Ippoliti Jr. is the CEO, and Louis Curcio is the vice president of manufacturing; each department, cutting, pants shop, and coat shop, has a supervisor and one or more assistant supervisors. The coat department, which is the subject of this study, has three assistant supervisors, one for each of the subassembly, assembly, and finish press sections. In addition, the company also has a person in charge of quality control who answers directly to the president.

Mr. Curcio was the company-appointed liaison person for this project and he provided the project team with easy access to and permitted them to work extensively with the coat department personnel. The Quality Control Manager supplied us with weekly reports which were used to determine to what extent, if any, the use of a Unit Production System has any effect on product quality.

The company's controller, the person in charge of the office personnel, and a member of his staff were responsible for the regular flow of pertinent data to the project team.

The primary product in the Ippoliti plant during the production data collection periods was the blue and red Marine Corps dress coat which represented between 80% and 100% of the coat department's weekly output (See Exhibit 1, Marine Corps Dress Coat as a Percentage of Weekly Department Output). This was an unexpected plus for our research effort because it reduced the number of data variables. The Marine Corps dress coat, with its 150-plus subassembly and assembly operations, is one of most complicated tailored military garments to manufacture. At the start of this project the company used a traditional bundle system, which is often referred to as a progressive bundle system, in their plant. The bundle tickets were bar-coded and read with a wand. The combination of 15-unit bundles and the large number of operations per coat created a large work-in-process backlog. In the fall of 1989 the average was a six week backlog.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

Even though the company made extensive use of computers, their application was heavily tilted toward accounting, order processing, and payroll. The availability of production and cost data was very limited, a condition which was rectified soon after the start of the project.

On the whole, looking back over the data collection periods, the relationships between the two groups, Ippoliti Inc. and F.I.T./AAMTD, proved to be very good. This quality of cooperation continued to exist in spite of occasional conflicts of priorities; Ippoliti had to get products shipped and billed, and the F.I.T./AAMTD group needed a timely flow of data. Judging by the end results we must say that Ippoliti Incorporated met every aspect of our agreement. (See Exhibit 2, Agreement of Cooperation for Cost Benefits Analysis of a Modular UPS Installation.)

PROJECT GOALS

This report is not intended to be a how-to manual, but rather it is an informational study for the military-uniform-producing industry of the experiences an F.I.T./AAMTD Coalition member company had when it switched from a traditional progressive bundle system to a Unit Production System and what the results were from such a switch. The description of the steps that were followed and the results that were achieved should be of great help to those manufacturers that are considering the installation of a Unit Production System. Such companies can examine the information within the context of their own production systems and thereby avoid as many pitfalls as possible.

PROJECT PERSONNEL

The investigatory work for the first phase of this project was performed by the author of this report who, alone, represented F.I.T./AAMTD.

The Ippoliti Incorporated project team was composed of three main members and several support staff members. The three principal team members were Nick Ippoliti, Jr., the president and the driving force behind the company's effort to modernize; Louis Curcio, the company's vice president of manufacturing; and, Olaf Langer, then a recent graduate of the Philadelphia College of Textiles and Science, who was brought in four months after the start of the

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

project. While Mr. Langer was inexperienced, he was most anxious to learn and made every effort to assemble the needed data. The support staff members supplied the weekly production output information and other financial data.

PHASE I - THE PROGRESSIVE BUNDLE SYSTEM ANALYSIS

This phase took seven and one-half months to complete; six weeks longer than planned. This delay was due to many factors. The F.I.T. team had to establish what data it needed and how much of it could be extracted from the business systems used by Ippoliti Incorporated. For those items that could not be directly extracted from the existing systems, the subject company had to reformat parts of its production data systems and set up a manual collection method for the work-in-process data. It took several weeks more than was planned to put this data collection system into place. Additionally, the amount of time Ippoliti Incorporated needed to start supplying the required data was also underestimated.

Besides the activities related directly to the generation and collection of data at the subject company opportunities were taken in the early months of the project to visit plants that were already using one or more UPS loops. This investigator interviewed the plant managers and floor supervisors of these plants to learn how they engineered their transitions to UPS; what training they felt was required to ensure efficient equipment operation; and, how well the systems became integrated into the manufacturing operation.

The author also conducted several telephone interviews in addition to visiting two of the three domestic UPS vendors. Both visited vendors were very helpful and supportive. The third vendor, reached by telephone, supplied the author with only limited information as to how its product operates and the kind of data it supplies. The collected vendor information provided the author with a much better understanding of the several U.S.-distributed systems.

Each company that uses a progressive bundle system has evolved its own unique approach as to how the bundles should be handled. There are many influencing factors that determine the size of each bundle and how it moves from work station to work station. These factors range from rate of production and bundle weight to physical operating space which, incidentally, also influences how a bundle is transported, whether it be in hampers, totes, or tied bundles.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

Ippoliti Incorporated had found it best to keep bundles tied in lots of fifteen, a quantity that was considered manageable. Each bundle was assigned four production tickets:

1. Subassembly for preparatory work
2. First assembly which covers the coat shell
3. Second assembly which covers the balance of the assembly
4. Finishing work which covers hand sewing and finish pressing. Here the control was changed to a separate ticket for each coat.

The dress coat bundles became quite heavy and cumbersome to handle as the garments moved through the assembly section. Therefore, after the second assembly when the sleeves and lining were in the coat, it was found best to have each garment move through the finishing section as a separate unit with its own ticket. Even though preparing the bundles for the various sections created extra handling, the separate coat ticket system was instituted to make sure that all the parts were properly matched. However, extra handling was costly and it also afforded opportunities for mistakes. Another factor that influenced the bundle size was that the coat shop averaged a daily output of 220 units. Any increase in bundle size would also increase the work-in-process inventory and lengthen the throughput time. Therefore, for this company, a fifteen piece bundle was the optimum size.

The use of the progressive bundle system was discontinued in the assembly department after the Unit Production System was put on line. All components of a coat are now matched once and travel as a unit on a carrier. This eliminates most of what used to be the bundle preparatory work. The one preparatory operation which is still necessary has become part of the UPS loading operation.

The physical flow or movement of bundles was not always as clear as the operation sequence may have led one to assume. Sometimes bundles were subjected to backtracking in order to perform some preparatory work which was not part of the normal operation sequence. Other times the bundle leapfrogged some operations to keep some worker busy and than was backtracked. The bundle-moving work was accomplished by one of several floor workers who performed a mix of tasks. These tasks were usually not assigned to any one person, but were performed on an as-needed basis. Parts matching, for example, was normally one of these less visible and unnoted operations which usually evolved from the efforts to increase the sewing operators' output. Ippoliti Incorporated considered these support operations to be part of their indirect labor costs.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

To prepare for the UPS installation, the operation sequence had to be charted for the vendor. This chart also created a reference tool for use when the system went on line to see if the same sequence needed to be maintained. Any sequence deviations impact total cost and pay back.

Since the UPS was only to be used in the assembly section of the coat production line, the operations flow chart which was prepared (Exhibit 3) shows only that group of operations that was to be fed by the UPS loops.

Under the progressive bundle system the complete coat assembly required 61 operations. Under the UPS this number was reduced to 52 operations. To achieve the planned output and balance, the new system consisted of three loops with a combined total of 81 service rails.

DIRECT COSTS ASSOCIATED WITH THE BUNDLE SYSTEM

This was one of the harder costs to segregate because it was composed of many small segments. The company used three bundle tickets during the assembly cycle; two for assembly, and one for finishing. The actual bundle ticket that was being used was the pressure sensitive bar coded type, and its net cost per coat was \$0.73 in the fall of 1989. However, this was only the physical ticket expense, the other costs derived from ticket preparation, preparing bundles for assembly, and payroll preparation. The combination of these segments added an additional 8.5 percent to each coat's direct labor assembly cost. When the UPS went on line, 43% of these cost were eliminated, which translates into a significant part of the projected cost savings. The reduction in cost comes from the elimination of three sections of the bundle ticket, (only the subassembly part of the ticket is needed now); the coats only have to be bundled once and loaded onto the UPS once; and, time cards for the workers on UPS are eliminated because the system automatically records the opening and closing of work stations.

INDIRECT COSTS ASSOCIATED WITH THE BUNDLE SYSTEM

The assembly and finishing departments had two full-time floor persons moving bundles through the plant. The cost of those two workers was easily determined. What was harder to identify was the percentage of the time the two department supervisors and other people in the department spent to move bundles along. It took several visits and careful observations to reach a valid cost

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

figure of \$1 per coat. This may seem to be a high cost, but this movement cost did cover 61 operations. The elimination of these floor people would reduce that cost which, on an annual basis, would greatly add to the cost savings.

FLOW CHART OF THE BUNDLE SYSTEM PAPER WORK

Ippoliti Incorporated is classified according to the Standard Industrial Codes (SIC), as a medium sized company within the garment industry. It's clerical staff perform a combination of jobs. Therefore, the paper flow is simple.

- a) A production order is generated by the sales office and given to the production office clerk.
- b) The production office clerk inputs the order and generates a cutting order and all the necessary bundle tickets.
- c) The production manager reviews the cutting order and assigns it a time slot for production.
- d) After the order is put into work the stubs of the bundle tickets are eventually fed back to the production clerk, collated, and at the beginning of each week the clerk prepares the payroll data from the stubs.

It was found that the production clerk spent three full days a week, or 66 percent of her time, performing the combination of work which was related to the bundle system. In the spring of 1990 it was not too clear what impact any reduction in the production clerk's workload would have. However, since moving into the new building all the office functions are now being performed in one central location. Thus, it was easily seen that the production clerk's work was greatly reduced and could easily be dealt with by assigning other tasks to her job description.

COST OF WORK-IN-PROCESS

For Phase I of this project, the progressive bundle system work-in-process inventory averaged out to be a 29-day backlog of work. This translated into a substantial cash outlay to cover the direct labor and overhead costs. If the company had been producing civilian products and had had to pay for the fabric in their inventory, that cash outlay would have been considerably greater. As it was, it represented at least a 14- to 15-day payroll. We estimated that payroll level by simply dividing the 29 day work-in-process backlog in half. Considering the 12% cost of money in 1989, that cash outlay represented a sizeable investment. In the spring of 1991, with the installation of the UPS the average work-

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

in-process inventory was down to an 18-day backlog and constituted a great reduction from when the progressive bundle system was in use. The payroll capital tied up in work-in-process inventory was reduced by at least as great a percentage. Although the cost of money was lower in the spring and summer of 1991 than it was in 1989, Ippoliti's labor costs were higher. However, the assembly department's through-put time via the UPS is now far shorter than it was when the progressive bundle system was in use, therefore, the cost of labor tied up in that section is now far less than it was before.

LABOR TURNOVER DURING THE FIRST THREE MONTHS OF 1990

During the last quarter of 1989 and the first quarter of 1990, Ippoliti Incorporated hired 38 new employees and lost 29 for a net gain of nine workers. Nevertheless, this represents a large and costly labor turnover of 30 percent on an annual basis. Since a labor turnover of this magnitude would have a very negative effect on the operation of the UPS, this subject was discussed quite extensively with Ippoliti's production and personnel managers who told this investigator that usually only about 20 percent of their new hires stay with the company longer than two weeks. Of those that stay longer, only about half of them become long-term employees and stay with the company at least one year. This illustrated the often taken position of investigators that the numbers must be properly analyzed or else they can be very misleading.

COST OF EMPLOYEE REPLACEMENT AND TRAINING

Hiring and training costs are higher than most companies realize. For example, as we saw, Ippoliti hired 38 employees for the coat assembly department. Even if these people are experienced sewing machine operators and pressers, it is unlikely that they have had much experience with uniform coats. Consequently, it is reasonable to assume that their average efficiency level during the training period would be in the 60 to 65 percent range, as based on observations and general experience. Using the 65% figure, and a base of \$6.00 per hour, this means a make-up pay of \$84.00 (40 hrs x 35% x \$6.00) per week. Using the two-week trial period as a minimum, the direct labor cost of training was at least \$6384.00 for the 38 new workers. Unfortunately, this was not the total cost. There are also fringes and overhead costs which more than double that amount. Also not included are the costs of repairing or replacing damaged garments that the new employees may have created.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

The cost of the training effort is much harder to determine since companies the size of Ippoliti Incorporated do not have formal programs. The administration of the training function usually falls on the department supervisor. He or she has to fit that responsibility in with all their other daily work.

There is little doubt that the cost of replacing workers on the UPS line is higher than it was with the progressive bundle system in use. Line balancing is more demanding and skills have to be more consistent. This in turn means more selective hiring and more intensive training. However, several of the UPS users who were interviewed did claim that the installation of such systems has had a positive effect on labor turnover. To a large extent this also held true for Ippoliti Incorporated - they had a very low labor turnover during Phase III of this project. Of course, not all of the positive effects can be credited to use of the UPS; being in a new and air conditioned building also had it's impact.

SPREADSHEET FOR DATA COLLECTION

The chart, Spreadsheet Row Headings, Exhibit 4, lists the headings of each row, which are self explanatory. Because of the delay in the completion of the new building we collected six months' data for Phase I instead of three months' data as originally planned. This enabled us to compare a similar quantity of data with the Phase III data of this project. Together, the data gave us good insights into what had been occurring in the assembly department during each phase. It also enabled us to spot and ask for explanations whenever there was a major deviation from the norm. And, it also showed us how quickly the coat assembly department, with the use of the UPS, reached and surpassed the rate of output of the old progressive bundle system.

The six items on the chart, Weekly Data Required, Exhibit 5A, are the cost data that Ippoliti Incorporated was asked to supply on a weekly basis. It took several weeks for them to reformat their computer system so that they could easily extract the data, but when done, the significant numbers on the spreadsheet were plotted on a graph, see Exhibit 6A, Average Weekly Coat Assembly Cost for Phase I. The Phase I spreadsheet data and the graph brought some interesting information to light which Ippoliti Incorporated was not aware of: a unit cost increase close to the end of the month. This increase apparently occurred because the company wanted to increase shipments and invoicing at that time, and to do so it's employees were required to work overtime. Since the graph made this cost increase obvious Ippoliti subsequently tried to smooth out the flow of production.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

There is a very large spike in the graph, Exhibit 6A, during Phase I which records a major company problem at the beginning of 1990. During the 1989 Christmas to New Year's shutdown a sprinkler pipe burst in the building where the company leased two floors. Ippoliti Incorporated suffered extensive damage to it's work-in-process and finished garments. It took time and money to sort everything out and to get things into order again before normal production could be resumed. This extra expense created an obvious aberration on the graph.

A comparable spreadsheet and graph was constructed for Phase III of this project and the graph was superimposed over the Phase I graph. See Exhibit 6B, Average Weekly Cost for Phases I and III. Since the cost information provided by Ippoliti Incorporated is proprietary, the cost figures are only representative of the actual costs.

ANALYSIS OF OTHER COST ITEMS

The six items in Exhibit 5B, Cost Factors, have a direct impact on the UPS's payback period. Although none of these items are part of the weekly data collection requirement, this does not make them any less important. Below is a review of these items.

1. Costs related to the bundle system have been discussed above.
2. The subject of work-in-process inventory costs has also been discussed before.
3. The acquisition cost of the UPS will be touched on in several of the following sections of this report and is specifically discussed in the section on cost analysis.
4. For the investigation of the direct labor operation costs it was found best to restrict ourselves to the data derived from the production of the blue and red Marine Corps dress coat. This was Ippoliti's main product during both the progressive bundle system and the Unit Production System control periods; see Exhibit 7, Blue and Red Marine Dress Coat as a Percentage of Weekly Department Output. Other products did not have a significant impact upon the per unit cost of the company's output. With this fact in mind, the available data allowed this investigator to establish an accurate ratio of the

rate of efficiency in the assembly department. At the end of Phase III this rate was recalculated and the two rates were compared. Any increase of efficiency would have enhanced the effect of and reduced the payback period of the UPS. The actual results proved there was no change in work force efficiency.

5. The repair rates are expressed in percentages. It was hoped that on the UPS line any garment defects would be more visible to the workers in the assembly and finishing departments since their attention would be concentrated on the garments they were working on at the time. This type of information was not recorded until the investigator requested it for this project. It became one of the unplanned benefits of the UPS. The production manager now examines the statistical information generated by the repair and rejection data collection system and has started to correct the problems at their sources. This eliminates some of the costly reworking of completed garments.
6. The present manufacturing overhead rate for Ippoliti Incorporated is well within range of the rates of other companies of the same type and size. As expected, it increased when the company moved to its new facility and purchased the UPS. The percentage of that increase and its causes will be explained in the analysis section of this report.

LABOR OPERATION ANALYSIS

Besides collecting the data, this investigator took time studies of the assembly and finishing operations during Phase I when the progressive bundle system was in use. The same operations were also studied during the last three months of Phase III. The studies of each operation were then compared to see the effect the UPS had on the elemental structure of the operations. This comparison pointed out that the structure of each operation only changed when there was an upgrade in equipment. What did change greatly was the preparatory work and the handling of the work piece before and after the assembling was done. There is no longer any need to arrange the work pieces for sewing, turning, or pressing. The work surfaces now only hold the parts being worked on, everything else is off the tables. Disposing of a work piece and getting another is now a single motion in the same direction, as opposed to having to dispose to the right and getting the next part from the left. Also, there are no bundle tickets to pull out of and replace into plastic envelopes.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

The net effect was a reduction of 18.2% in the Standard Allowed Minutes (S.A.M.) total when the results of the two sets of time studies were compared. This result was confirmed by the weekly production data we collected during Phases I and III. The actual time used per coat during both six month periods was averaged and we found the Phase III average actual production time was 17.2% lower than the Phase I average actual production time.

SELECTION AND COST OF THE UNIT PRODUCTION SYSTEM

Before we can discuss the data collected during Phase II we must deal with the selection and costs related to the Unit Production System.

SELECTION OF THE UNIT PRODUCTION SYSTEM

Ippoliti Incorporated started to investigate the features of two Unit Production Systems at the time that the proposal for this project was written, which was March 1989. The company's UPS selection team established a list of ten criteria, each of which was rated on a scale of one to ten. Naturally, the UPS with the highest rating would be the one that would be purchased. The ten criteria were:

1. Cost
2. Hardware Flexibility
3. Computer Controls
4. Software Abilities
5. Ease of Installation and Maintenance
6. Demonstration and Hands-On Usage
7. Equipment Complexity
8. Vendor Reputation
9. System Reputation
10. System Reliability

In the final analysis, only two systems were considered and compared. They were the Gerber Garment Mover and the Eton System. Nick Ippoliti and Louis Curcio visited plants where those system were in use and the home offices of both companies. However, no decisions were made until after the 1989 Bobbin Show. By that time this project had been funded and this investigator sat in as an observer during several of the purchase negotiating sessions.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

Ippoliti Incorporated's decision was to purchase an 82-station Eton System composed of three loops and two bridges. However, before the final paperwork was completed Ippoliti accepted an Eton proposal to perform an industrial engineering study of the plant operations which included a plant layout, a product operations sequence analysis, and a payback analysis. The cost of this work was \$5,000, which would be absorbed into the final purchase price if the company agreed to purchase the system. Nick Ippoliti signed the purchase agreement at the end of October 1989.

This investigator feels that the criteria list that Ippoliti Incorporated used is a good starting point in the selection process. However, there is a lot of subjectivity connected with it; not everything is hard and fast. Each person involved in a UPS selection process has different priorities and a personal agenda, and what is important to one company may be insignificant to another. Often it may be advisable to use an outside, impartial observer or consultant to help choose a system and to develop the data the vendor will need in order to construct a valid proposal. Exhibits 8A and 8B are typical forms used by UPS vendors to establish potential customer needs.

Ippoliti Incorporated's choice of the Eton System was based on both subjective and objective reasoning. This investigator feels it would be unfair to the other Unit Production System vendors to list the reasons behind that decision. The features of one system may be more suitable to a particular company than the features of another system, no system is likely to fill all of a company's requirements. A selection process of this type has to be preceded by an analysis of the company's own resources and needs. This should be done with many factors in mind, some of which are:

1. Company's staff and technical resources
2. Physical production facilities
3. Product type and mix
4. Required daily output
5. Company's data acquisition needs
6. Company's future plans

UNIT PRODUCTION SYSTEM COSTS

The total acquisition cost of a Unit Production System is composed of many initial cost segments and also some continuing costs. While the purchase price of a system is the largest segment of the final expenditure, the other costs are hardly negligible and could easily add 15% to system cost. That percentage does not include the cost of the money that a company will use to purchase the UPS, which, in Ippoliti's case, was a 10.8% bank loan.

The total dollar amount used by Ippoliti Incorporated for the payback analysis was composed of the following segments:

1. The net cost of the Eton System, which included:
 - A. The previously noted Industrial Engineering study
 - B. System hardware
 - C. Freight in
 - D. System installation
 - E. The training staff for two three-day management and supervisors training sessions prior to System installation
 - F. Eton System's project supervisor and an installation specialist, on site for three weeks after System start-up, to continue the training of supervisors, operators, and maintenance staff, and to ensure proper functioning of the System
 - G. Eton System's UPS programmer, on site for two weeks after computer control start-up, to train operating staff and ensure proper functioning of the System.
2. System selection costs also includes traveling to the vendors' headquarters and to several sites where the UPS under consideration was in operation. Travel also included the 1989 visit to the Bobbin Show which was considered necessary by Nick Ippoliti in order to make the final decision.
3. Computer system to operate the Eton System, which was purchased separately. (The vendor allowed a credit for not supplying the computer and printer.)
4. Interest cost for the loan used to purchase the Eton System. In this case it was a five-year loan at 10.8%.
5. Salaries earned and expenses employees incurred while attending training sessions.
6. Cost of installation of necessary power, steam, vacuum and compressed-air lines.
7. Cost of the loss of production during the start-up period. (This proved to be far less than expected because of the way the change-over was phased in.)

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

Besides these listed major cost items there are a number of small items such as redesigning forms, changing office procedures to deal with new data flow, and spare parts inventory space needed to maintain the UPS, that should also be considered.

PREPARATION FOR THE INSTALLATION OF UPS

The preparation for the installation of the Unit Production System literally has to start right after a company decides to acquire such a system. That effort can be summed-up in four words; planning, training, preparing, and communicating. This investigator quickly became aware of the fact that these activities have to be reviewed and updated on a regular basis and have to be maintained on a continuing basis after the UPS is operational. Unit Production Systems rarely allow more than a twenty-minute window for the correction of a problem, whether it be a machine breakdown, absenteeism, a product-part shortage, or any other one of the many problems that might arise on a line. Ippoliti's management reviewed and updated these four activities periodically, as necessary, and were able to make the transition from the progressive bundle system to the UPS quite smoothly.

The planning of the physical positioning of the UPS was started in the summer of 1989 and was finalized with the architects of the new building that fall. One of the problems encountered was, for example, the assignment of space for the finish pressing area as close as possible to the boiler and vacuum. To maintain a high rate of efficiency, the steam and vacuum lines must be kept as short as possible. This meant that the gas lines would have to be brought to the selected location within the building site. Since the finish pressing area was served by one of the UPS loops, it also had to be located near the coat assembly loops. However, from finish pressing the coat moves to final examination, which is also the Government inspectors' location. This in turn, determines the location of the packing and shipping area which must be near the loading dock. Needless to say, all this complicated planning had to be completed before the building foundation could be laid.

By February 1990, the company started the review of their work force. Attendance records were checked and skill levels were examined to determine who would be good candidates for working on the UPS and who could be crosstrained in several sewing or pressing operation skills. In Ippoliti's case this was not much of a problem; over the years the company had built a reliable and

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

skilled work force which served it well. Also, as far as cross training was concerned, the company's product mix had always required that sewing operators and pressers be able to switch back and forth between several types of dress coats and overcoats, and this, in itself eased any crosstraining efforts that might have been required.

Late in March 1990, Eton System's project manager met with Ippoliti's management and supervisors to plan the final configuration of the UPS. Mistakes and misunderstandings were avoided by also involving the floor supervisors in this process; everyone had an opportunity for input and knew what to expect when the installation was completed.

Now the actual move and the layout of each work station had to be planned. To reduce the time loss to a minimum it was planned to move the sewing and pressing departments into the new building over four successive weekends, starting with the 1990 Labor Day Weekend. During July and August, the company prepared sufficient work-in-process to cover potential problems in the start up. The first section to move was the finish pressing department. It was the most difficult part of the move; all the presses had to be disconnected, moved from one building to the other, and then reconnected. Of course, all the coats ready for pressing also had to be moved, placed on hangers and UPS carriers, and be ready for start-up. By starting the move at the pressing and finishing section, the last segment of the assembly process, the work-in-process would only have to be moved once. The next to last segment of the assembly process is the joining of the lining to shell, and that was the section that was moved next. The other sections were moved in a similar rotation, thereby maintaining a constant forward work-in-process motion.

The pressing department was the only section that experienced a problem during the move, and it was not UPS-related. The new boiler kept shutting down and it took two days to find and correct the defect. The balance of the move went smoothly and by the fourth week of September 1990, the UPS was fully functional.

When switching to a UPS, the training of the workers who are going to be served by the system is usually not much of a problem. The actual work to be done rarely changes radically. What does change is the manner in which the operators get the parts and the manner in which they dispose of the completed workpiece. This means dealing with a new workplace layout, learning new motions, and developing a new rhythm. Another thing that people working on a UPS have to learn is how to input into and extract information from

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

the terminals that are now at each work station. Ippoliti had very little problem with either of these. The transfer to the UPS was achieved in four weekly groups consisting of 15 to 20 workers each, and the training of groups of that size was easily accomplished by the joint efforts of Eton System's and Ippoliti's own staff.

The training of how to manage the Unit Production System has to be, and was, far more formal. Management had to learn what data had to be prepared for input into the UPS, and how to balance the system. Floor and UPS loop supervisors had learn to recognize what the various screen displays meant and how to respond to the information that was being given to them. Ippoliti's management group was given two initial training sessions and then training was continued during the first three weeks of UPS operation. It was repeated again when the UPS computer system was installed.

As Ippoliti's management rapidly found out, it is most important to have all the style data ready before the UPS can be programmed and balanced. The minimum data requirements are:

1. Style information
2. Standard Allowed Minutes (S.A.M.) for each operation
3. Operation codes for each operation
4. Machine or operation listing for each workstation
5. Operations listings and sequences for each style
6. Employee numbers and skill levels

This information has to be analyzed before one can balance the flow of work. Very few operations in the assembly of a dress uniform take equally long to complete or are in 1:2 or 1:3 ratios. Therefore, some operations might have to be broken up and others combined in order to create the needed work flow. In Ippoliti's plant there are several operations where it is necessary for an operator to float between two workstations, and there is one case where the operator floats between three workstations. These workers have become very proficient in juggling their tasks. However, all this did not happen without the proper preparation.

Good communications between all parties are vital to the successful start-up and running of a UPS. When Nick Ippoliti finalized the decision to purchase the UPS he let all the employees know that this was going to happen. This allowed lots of time for questions and for the alleviation of misconceptions about the UPS. Illustrations of the system were posted on the bulletin board, as were building progress reports. Staff meetings were held regularly to deal with the concerns that arose from time to time. This flow

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

of information greatly helped to smooth the transition from the progressive bundle system to the Unit Production System. All employees were very cooperative on the UPS start-up day, a day that is usually quite stressful.

PHASE II

While phase II of the project officially ran from September 4 through November 3, 1990, there were several important events that had to take place before we could start to collect data for this phase. These events were the installation of the UPS and staff training for the operation of the system. The Eton System installation was started at the end of July 1990, and took two weeks to complete. This gave the electricians and plumbers enough time to finish their work. Eton's installation team consisted of a project manager and two technicians. They were assisted by the mechanic Ippoliti Incorporated assigned to maintain the system.

At the time Nick Ippoliti signed the purchase agreement, Eton requested that a maintenance person be assigned to keep the UPS properly maintained. That maintenance person was given several days of training in Eton's home office and was then asked to assist with the system's installation which was some very good additional training and hands-on experience.

Eton System advises the users of their UPS to have their supervisors follow a daily start-up routine (Exhibit 9A) and also provides them with some guidelines to be followed throughout the day (Exhibit 9B). Eton also recommends that users of their UPS have the assigned mechanic follow a preventive maintenance program (Exhibit 10). This maintenance philosophy worked well in Ippoliti's case; no system breakdowns occurred during the first year of use although they did have to replace a small number of circuit boards and some other small parts. It was also noted that the garment carriers tend to break easily. In a recent interview with Ippoliti's Vice President of Manufacturing this investigator was told that the company follows a regular preventative maintenance program and that this work is usually performed on Saturdays.

Eton Systems started their on-site system training one week before the start-up of the Unit Production System. The actual training was performed by Eton's project manager who was assisted by a technician, both of whom stayed on-site through the end of the third week of operation. The Eton System staff made sure that the system was functioning properly and made the work station adjustments which normally are needed during the start-up of a UPS.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

The first segment of the training process was theoretical, it involved the work station commands, the programming of the system, and how to set up the data collection method. One must remember that Eton Systems start-up method is somewhat different from that of other UPS vendors because the Eton UPS was a mechanical system that evolved into a computer controlled system. Therefore, Eton feels it is best to initially operate their UPS for three to six months under the control of their proprietary Electronic Logic Control (ELC). In Ippoliti's case it was a three months operation of the ELC before the control computer was installed during the first week of December 1990.

During the three months between the start-up and the installation of the control computer the operation of the UPS was supervised by three persons, one for each loop. The sewing loops were composed of about 23 workers each, and the finishing and pressing loop had about 15 workers. The loop supervisors were drawn from Ippoliti's existing staff and, in reality, they each performed a dual function: they made sure that the work flowed smoothly, and they attended to quality problems. One of the supervisors recorded each worker's output every two hours to ensure that everything was balanced and that no bottlenecks were developing. The supervisory terminal of the Eton ELC allows one to read each worker's output for that day which gives the company the total daily production results. The UPS also requires the services of a person to load and unload the system. At Ippoliti that person is one of the two bundle system floor service people. After the control computer was installed in December 1990, the staffing was reduced to one person supervising the sewing section and another person supervising the finishing and pressing section.

Originally the plan was to physically move the assembly department sewing section into the new building over three weekends. The move, however, was accomplished in two weekends. In spite of the usual problems one normally encounters during such a move, the transfer to the UPS went smoothly. The workers adapted quickly and had no trouble learning the new carrier unloading and loading motions. By the end of the first month everyone had settled down to a normal routine.

Not everything, however, was trouble free. Some difficulties did arise which impacted the operations of the Unit Production System. The first problem was the new pressing steam boiler; it broke down several times during the first month. When coats cannot be pressed the system backs up very rapidly. The second problem was the work-in-process. The company miscalculated the required level of work-in-process and reduced it below the proper balance. The

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

miscalculation occurred because the company did not factor in the increased output attained with the use of the UPS, which meant that the assembly department had to work very tightly and without any buffer for several days. This hand-to-mouth situation created a very stressful situation, and small problems such as a minor quality problem, a machine breakdown, or an employee absence or lateness could upset the flow of work. It took two weeks for the company to correct the work-in-process level and they have had no problems with it since. As a matter of fact, the switch to the UPS has had a very positive impact on the company's work-in-process; it is now, on the average, 33% lower than when the bundle system was in use in the assembly section, and the company's output is greater. The changes in the work-in-process are shown in Exhibit 11.

Two other situations, one positive and one negative, arose in early October 1990. The negative situation involved the company's main sleeve setter who claimed that the operation took longer on the UPS than it did previously. The operator claimed that handling was harder and that it took longer to remove the coat from the carrier and to rehang it. Time studies proved something else, the handling part was actually faster, but the sewing cycle took longer now. (What had not been mentioned before is that Ippoliti had suspended their incentive system until such time as they felt that the integration of the UPS was complete.) The matter was settled when the operator and the Union representative were assured that the incentive system would be re-instituted.

The second situation concerned the finishing operations in the production of the Marine Corps Dress Coat, a lengthy hand sewing operation. When the work was fed to these sewers via the UPS their production increased an average of 12%. This increase could not be explained away by the elimination of the bundle ticket and bundle handling time since that was less than 2% of the total operation time. The only conclusion possible was that this group of five workers subconsciously decided that they would themselves fulfill the needs of the increased output because they did not want anyone else to join their group.

Phase II of this project was considered complete at the end of October 1990. By that time everyone had become accustomed to the UPS and its operation was going quite smoothly.

PHASE III

This six-month phase was the second data collection period of the project. As in Phase I, we collected weekly production data and posted it to the spreadsheet previously discussed. The information we required covered the same areas in both phases. By coincidence, the time periods of Phases I and III fell into the same part of the calendar year, just one year apart; Phase I ran from October 1989 through March 1990; Phase III ran from November 1990 through April 1991. Therefore, we did not have to concern ourselves about how different seasons impacted productivity, absenteeism, etc., and it also made it unnecessary for us to compensate for such production-affecting periods as the Thanksgiving and Christmas to New Year's Day shut downs, and other vacation periods.

As noted, the control computer system was installed early in December 1990. An Eton System programmer installed it and remained on-site for two weeks to train Ippoliti's staff and to eliminate any bugs that might arise. The timing of the computer installation created a problem in January 1991 that no one could have foreseen. Normally, when a company installs a computer system it will input data to it as rapidly as possible. Ippoliti did not do that because at the time of installation they were only running one style garment on the UPS, the blue and red Marine Corps Dress Coat. Therefore, they entered only the data relating to that garment. Such an approach is quite understandable, it requires a great deal of concentration and time, neither of which is ever in ample supply, to prepare the data for the type of garments Ippoliti Incorporated produces. The simplest garment has at least forty operations and each style needs, at a minimum, the input of the following information:

1. Style information;
2. Standard Allowed Minutes for each operation;
3. Operation codes for each operation;
4. Machine or operation listing for each work station;
5. Operation listing and sequence for each style; and,
6. Employee numbers and skill levels.

The information pertaining to items 1 through 5 have to be entered only once but can be edited at any time. Item 6 has to be entered for each production run. Therefore, Ippoliti Incorporated thought it would be best for them to prepare and input the information for each style at the same time as the first cutting order was issued for a particular style.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

Item numbers 2, 4, and 5 are interrelated as they affect the balancing of the system: one has to consider whether operations have to be combined or broken apart and how many work stations are needed for a particular operation in order to achieve the proper system balance. Then one has to examine each work station and operator skill so that the various garment operations are routed to the proper work station.

The problem Ippoliti Incorporated encountered as they entered additional style data into the system was that some carriers were being misdirected. Those carriers simply did not follow the routes to which they were assigned. Naturally, when the system supervisor became aware of the problem he tried to make the needed corrections. However, the problem was compounded unintentionally by some of the workers on the UPS who, in their efforts to obtain or enter information into their station terminal, made mistakes

which misdirected some carriers to the wrong stations. It took several weeks to sort this all out, but after that the misdirection of garment carriers was reduced to only a once- or twice-a-day occurrence.

After operating the UPS under computer control for about three weeks, management felt that it was no longer necessary to have a supervisor for each loop. The data generated by the system and the oversight offered by the screen displays made the supervisory function much more efficient. Because of this the company reassigned one of the two assistant supervisors. This led to an examination of the entire supervisory structure within the subassembly and assembly department and, after skills were matched to needs, there was a realignment of all supervisory duties. These changes were not made arbitrarily, they were the result of regular meetings of management representatives, supervisors and production personnel which, during the first few months of UPS operation were held on a daily basis. Many other subjects related to production were discussed at those meetings and those discussions led to changes in in-process inspection procedures and to work-in-process buffers between the subassembly and assembly departments.

The company had some other problems which were not caused by the UPS but which impacted the production data collection for the assembly department. When Ippoliti moved to the new building, tasks were added to the computer system which overloaded it from time to time. To deal with this they established data priorities which resulted in our data being generated only when time was available. They solved some of the computer problems and were able to bring our data up-to-date by the end of Phase III.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

Early in 1991, Ippoliti took an order for a small quantity of overcoats which were to be assembled with use of the UPS, and it was the production of this order which emphasized the need for proper planning and preparation. Since the quantity was small, little thought was given to what would occur after the overcoats were loaded onto the UPS. The length of the coats created problems at certain work stations because the height of the UPS at these stations was not appropriate for this product and required some minor adjustments. This brought home the vendor's message that one has to think about how the stations and the system must be properly set up for a smooth operation. Workplace changes are not hard to make, they just require some preplanning.

Phase III of this project ran well, aside from the lapses in the data flow we encountered few problems or unusual situations. During last February and March time studies were made of all the operations being performed on the UPS. These studies were then compared with the studies made during Phase I when the assembly department was using the bundle system to determine any changes in the department's rate of efficiency and any changes in individual operations. The findings will be discussed in detail in the next section.

DATA ANALYSIS

WEEKLY PRODUCTION DATA

The bulk of the information we collected during Phases I and III was derived from weekly data sheets (Exhibit 12) which were created in response to our request for certain cost and departmental data. Even though this information was gathered on a weekly basis it could not be extracted from the data flow at the time we started this project. Ippoliti had to reformat some of their computer programs to generate this data.

The weekly data sheets recorded the following information:

1. The number of employees at work in the sub-assembly and assembly departments. (The numbers fluctuated very little during both control periods).
2. The number of employees working at standard rates gave us insight into the effectiveness of the incentive rate system which, during Phase I, affected a number of operations.
3. The total payroll for each department served to give us the average hourly rate per departmental employee and the average direct cost per unit produced in each department.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

4. **Total labor hours per department** gave us the average time required to produce one garment. That information also was used to calculate the departmental rate of efficiency.
5. The intention for collecting the **total weekly make-up data** was to see if there was any correlation between make-up and the production time per garment, departmental efficiencies, and the time studies. We found that the make-up data was inconclusive because the incentive rates had not been properly maintained and most of them were inappropriate for the operations where they were applied.
6. The **units produced** showed the total weekly output for the departments, which was broken down by quantity per style in the comments section. This information was used to check if there was a direct relationship between the percentage of Marine dress coats produced and the average time needed per unit or the total weekly output. It was found that there were no correlations between the data, from which we deduced that many of Ippoliti's products have similar labor contents.
7. The **work-in-process inventories** had to be assembled manually and were given to us only on a monthly basis. The Phase I and Phase III quantities, and their relationships, were plotted on a time versus quantity graph, Exhibit 11. It is obvious that work-in-process is dramatically reduced by use of the UPS.

We wanted one more piece of cost information, the **weekly variable indirect costs of the assembly department**. However, when we discussed this with Louis Curcio we found that they varied very little from week to week. Under the progressive bundle system the costs consisted of two floor people and close to 50% of the department supervisor's and assistant supervisor's time. Switching to the UPS substantially reduced these costs; they now include only the person who loads and unloads the system, and the sewing loops' supervisor. The pressing loop supervisor is the same person who supervised the pressing section under the bundle system, therefore, there is no change there. The department supervisor and assistant supervisor now do what they are supposed to do, which is supervise and make sure that quality is maintained. This reduction in variable indirect costs was factored into the direct labor cost per unit and is reflected in the net gains achieved.

The weekly information derived from the production data sheets was entered into a spreadsheet and that data was then processed into the information we wanted:

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

1. Average department hours worked per week
2. Average number of members in the department work force
3. Average cost per unit
4. Average minutes per unit
5. Average hourly rate per employee per week
6. Average weekly assembly time per unit as a percentage of average total unit production time
7. Weekly Marine Corps Dress Coat production as a percentage of weekly departmental coat production.

We used the same spreadsheets for Phases I and III and compared the 26 week averages of the two periods. The results of this comparison are:

1. Average weekly output increased by 9.6%
2. Average number of workers within the assembly department decreased by 10.3%
3. Average weekly hours worked within the assembly department decreased by 2.7%
4. Actual average time per unit decreased by 17.3%
5. Actual average cost per unit decreased by 12.3%

The decrease in the actual cost per unit reflects the cost reduction in real or present dollars, not in constant dollars, which explain why there is a difference in the magnitude of the decreases in average time and average cost. This was due to a Union-negotiated pay increase which averaged 5.7% in the assembly department. If we had made the cost comparison between the two phases in constant dollars then the average assembly and finishing time reduction would have been equal to the average cost decrease.

One of the major concerns in any production organization is its rate of efficiency which is defined as a change, in percentage, from what is considered to be "normal performance". The accuracy of the normal performance standard is dependent on the skill and industry experience of the person establishing it. In spite of all the training and tools that are available for taking time studies, one still must factor some subjective judgements into the final operations standard. For the producers of highly repetitive products, such as shirts or work wear, these standards have become very refined and accurate and it is not unusual for these types of garment producers to operate at rates of 100%, or better. However, for a garment manufacturer such as Ippoliti Incorporated, the rate of efficiency is rarely greater than 80%. The product mix and fabric variability is great and the company must factor allowances into their standards to compensate for those variations, a common practice of tailored garment producers.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

We became aware that there were some problems with Ippoliti's work standards when we examined them in the fall of 1989, and therefore we decided to take time studies of all the assembly and finishing operations. The Phase I set was taken in January and February of 1990 and the Phase III set was taken exactly one year later. We totaled all the operations' Standard Allowed Minutes for each Phase and then compared them. As expected, the total time required to assemble and finish press a Marine Corps Dress Coat in Phase III had decreased by 18.2% from Phase I, pretty much in line with the charges in the actual departmental performance of 17.3%. The 0.9% difference can easily be rationalized to be due to a variety of factors such as absenteeism, level of work load, different operators, and minor inaccuracies in the time studies.

WORK-IN-PROCESS INVENTORY

Work-in-process inventory is a cost item that every garment manufacturer tries to reduce. The cost of money (prime rate plus two percent) is two percent lower now, in the fall of 1991, than it was in the fall of 1989, but it still is a major expense item.

The first accurate work-in-process data was received early in January of 1990 and that data flow continued through the next four months. The data showed that Ippoliti Incorporated had an average work-in-process backlog of 29 days. When this is translated into working capital required, at a 12% cost of money, it becomes a cost factor that cannot be ignored. We started to track the work-in-process inventory for Phase III early in November of 1990 and continued through April 1991. During that period the average backlog was 18 days. This meant that the adoption of the UPS reduced the backlog by 38%. However, the actual difference in numerical units in the work-in-process inventory is somewhat smaller; it is a 33% reduction from the average quantity maintained in the spring of 1990. Exhibit 11 shows the actual numerical relationships of the two control periods. The quantities are representative but the relationships are actual.

The reason for the difference in the above percentages is that the weekly departmental output increased by 9.6% with a 10.3% smaller work force. The reduction in the work-in-process inventory created another cost reduction, but one that is more difficult to extract. The entire reduction in the work-in-process inventory occurred in the assembly and finishing department where the through-put time has been reduced to only four days from the previous 14 day through-put time. However, that department, because of its skill

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

requirements, has a higher labor cost rate than the subassembly department. Therefore, a reduction in the work-in-process inventory cost skewed toward the subassembly department lowers the amount of working capital tied up by that inventory by a percentage that is greater than the 33% shown above.

MANUFACTURING OVERHEAD

Overhead costs are an expense that manufacturing companies must control very carefully. Excessive manufacturing and administrative overhead expenses can put a great deal of pressure on profits. Manufacturing companies massage their individual costs in a variety of ways in order to determine the final product labor cost. The method we used to determine the basic product labor cost was to add manufacturing overhead expenses to direct costs. We considered the combined costs to be the actual labor cost of a garment. In turn, to arrive at the actual labor cost reduction used for the payback analysis we added the appropriate amount of overhead to the cost reduction to calculate the actual dollars saved.

In Ippoliti's case, both administrative and manufacturing types of overhead had to increase because of the cost of the new building and the new equipment that was purchased. Between December 1989 and April 1991, the manufacturing overhead rose 21%. For our calculations we used the 1991 cost because that was the period in which the direct labor cost reductions took effect.

It is important to point out that Ippoliti Incorporated operated the UPS at 80% to 85% of capacity during the year. If the company had had the available work to operate the system at 100% it could have done so without having to increase any of the costs that make up manufacturing overhead other than those that involve direct labor. This would have lowered the 21% increase in manufacturing overhead to only a 5.5% increase. Of course, it would have also reduced the payback period which will be explained in the next section.

PAYBACK AND RETURN ON CAPITAL INVESTMENT ANALYSIS

The length of the payback period and the rate of return on capital invested are financial measurements which will tell the investing company whether the investment has been successful. In short, has it paid off?

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

The payback analysis tells an investor how long it takes to recoup the investment. There are a variety of methods which one could use to obtain this information. The three most used methods are:

1. **Straight Payback** - this method compares the actual final depreciable cost of the purchased equipment with the net periodic savings obtained with use of that equipment. The length of time for accumulated sums of the two to become equal is the time span of the payback period.
2. **Internal Rate of Return** - this method takes into account the time-value of money. For this method one ascertains the rate which would make the sum of the annual discounted values of the yearly savings equal to the present cost of the project. If that rate is greater than the rate the company considers to be acceptable then the investment is worthwhile.
3. **Net Present Value Analysis** - this method also applies the time value of money. However, in this case one uses the cost of capital at the time the investment is made. The premise is that the value of money diminishes by the compounded periodic cost of capital. The payback period is determined by finding the point in time when the sum of the discounted cash flow from the gains of the investment equals the original investment.

We cannot really say which is the best method even though financial people claim that the third method offers the most realistic financial picture. The final choice belongs to the company comptroller or accountant. To offer a valid analysis this investigator felt that it would be best to use all three methods. Although some companies include equipment depreciation in their calculations, we did not do so because we decided to base our calculations only on before-tax gains. Each state has a different business tax structure, therefore, we felt that by bringing taxes into the picture we might distort the final results. Depreciation is used for tax purposes only and only affects after-tax earnings. It diminishes the asset value of the investment on an annual basis while, at the same time, it adds an annual expense equal to that depreciation. In short, on the basis of gross earnings, one equals the other without any net effect. For all three methods, and for calculation of the return on capital invested (ROCI), we used an equipment life of seven years and a zero salvage value. We are aware that the UPS has a longer life than that but for the sake of consistency we used the allowable depreciation period for the payback calculations although we did not include depreciation in them. If included, depreciation will usually shorten the payback time.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

The components of total original investment, as explained in the section on Unit Production System Costs, are:

1. Cost of the Unit Production System
2. System selection cost
3. Computer dedicated to the Unit Production System
4. Interest cost of the bank loan
5. Training expenses
6. System installation costs
7. System start-up costs

We calculated the gains achieved by using the UPS by the following equation:

$(CRU \times ADO) \times (1 + MFGOH) = \text{Net Production Cost Gain}$
CRU is the Cost Reduction per Unit
ADO is the Annual Departmental Output
MFGOH is the Manufacturing Overhead for that department

To the Net Production Cost Gain we added the annual reduction in bundling and bundle ticket costs. Because we decided to be on the conservative side with our analysis, we based our results on those two major gains. We did not use the reductions in the cost of working capital due to the decrease in work-in-process inventory. This investigator feels that this gain is a cushion for some of the hidden costs which a company might incur when it switches to a UPS.

To arrive at the final payback data we reduced the projected annual gains by the projected annual costs generated by purchasing and using the UPS. In this case the projected annual costs are composed of the interest charges of the loan used to purchase the UPS and the annual maintenance cost of the UPS. The yearly interest cost is a declining amount and is the sum of the monthly charges. The maintenance cost is based on the percentage of time spent by the person charged with care of the UPS and the projected annual cost of replacement parts. With respect to the cost of replacement parts, we factored in an annual 5% inflation factor. The subtraction of the net annual cost from the gross gains gave us the net projected annual departmental gain. Using the above information we arrived at the following results:

Method 1 - Straight Payback	20.7 months
Method 2 - Internal Rate of Return	63%
Method 3 - Net Present Value Analysis	21.3 months

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

There is a fourth result that is usually of interest to financial managers and that is the Return On Capital Invested (ROCI). It is the product of the average annual savings divided by total original investment. In this case the ROIC is 65%. Again, we must point out that all results are based on before-tax totals and on the seven year allowable depreciation period.

We could easily enhance the already acceptable results by projecting even greater returns through increased sales in response to the greater output capacity. For example, the output could easily be increased beyond the 85% of capacity at which the department is now operating, however, that would only be wishful thinking and little would be gained by doing that. Nevertheless, we did look at what would happen if the assembly department was to operate at 100% of capacity and we obtained these results:

Method 1 - Straight Payback	19 months
Method 2 - Internal Rate of Return	68.5%
Method 3 - Net Present Value Analysis	19.6 months
ROCI - Return on Capital Invested	66.8%

The above exercise shows that under the ideal condition of a plant operating at 100% of capacity certain gains can be achieved. However, the assumption here is that only the output increases and everything else, including the cost of sales, remains constant.

This assumption presents many "ifs", something this investigator is not very comfortable with. We would rather stay with numbers that we can substantiate.

To verify that our actual results are correct we had them audited by an accountant who is familiar with capital investment. That person verified the results and stated that we followed accepted accounting procedures.

CONCLUSION

This research project/case study took several months longer to complete than we anticipated, but the results were very gratifying. They prove that, given the right environment and proper managerial commitment, a Unit Production System can be successfully integrated into a multi-product tailored garment plant.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

The garments which Ippoliti assembles on it's Unit Production System range between 40 and 52 assembly and pressing operations per unit. In spite of this complexity the company is, after a year of use, very satisfied with the results of the UPS.

It is interesting to note that at the time this report is being written Ippoliti Incorporated has undertaken the rearrangement of some of the UPS work stations in order to gain even better results. This only proves that production methods in the garment industry cannot remain static. To be competitive, companies must periodically analyze their systems and adjust them when the need arises. The key here is that attention must be paid to the productive methods and companies must stay aware of when there is a need to make changes.

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

EXHIBIT 1

Marine Corps Dress Coat as a Percentage of Weekly Department Output

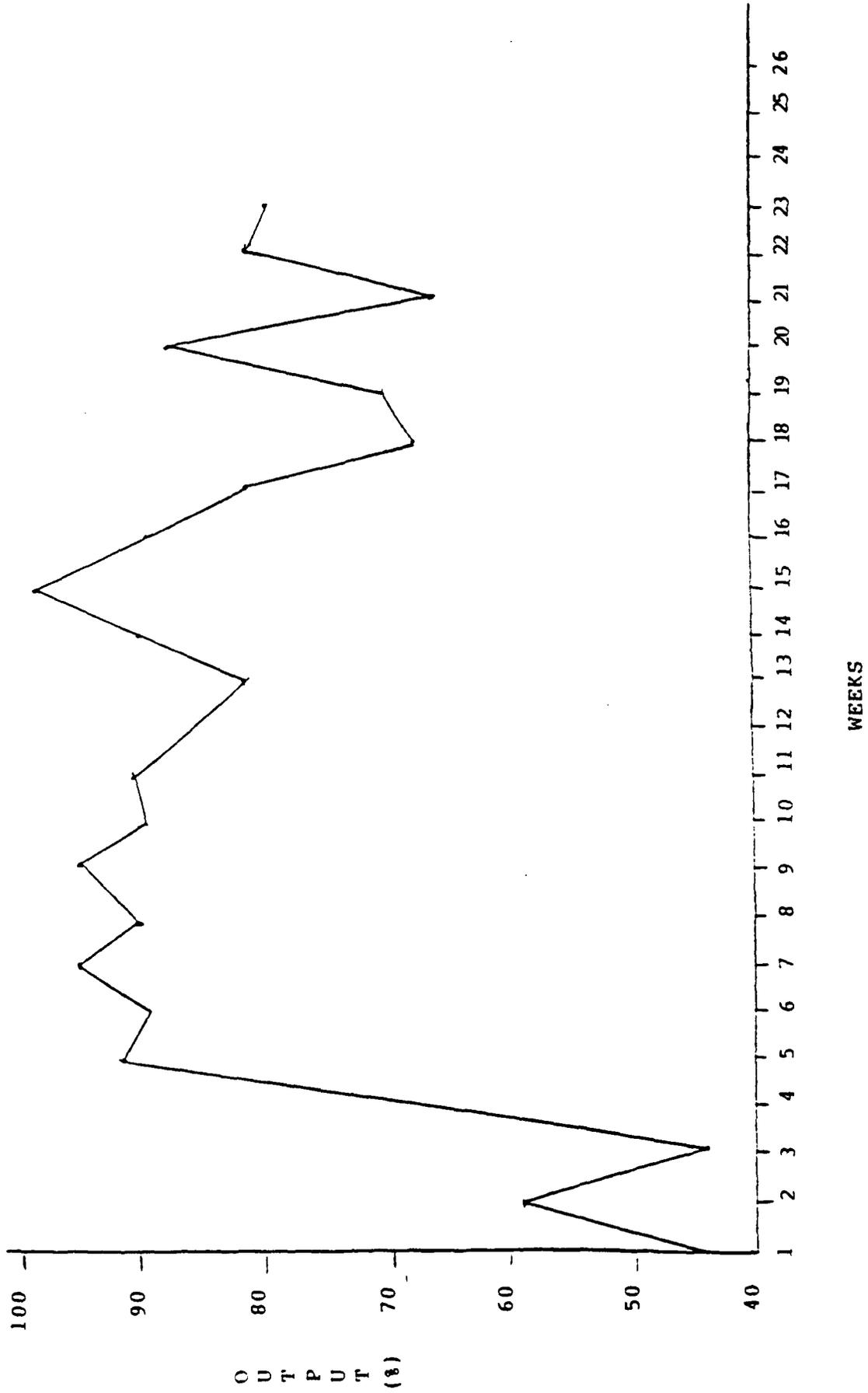


EXHIBIT 2

December 6, 1991

AGREEMENT OF COOPERATION FOR
COST BENEFIT ANALYSIS OF
A MODULAR UPS INSTALLATION

Ippoliti Incorporated, with offices at Broad & Carpenter Streets, Philadelphia, PA 19147, agrees to participate with the Advanced Apparel Manufacturing Technology Demonstration Center of the Educational Foundation for the Fashion Industries (hereafter referred to as AAMTD), located at 227 West 27 Street, New York, NY 10001, in a comparison of cost and production data between a traditional bundle system and that of a unit production system. This is a short-term research effort funded by the Defense Logistics Agency of the United States Department of Defense (contract #DLA900-87-D-0016-0003), a copy of which, including the approved technical proposal, is attached and made a part of this agreement.

To complete this research effort it will be necessary for both Ippoliti Incorporated and AAMTD to each supply certain inputs and accomplish certain tasks. Below is a listing of what each group agrees to supply and accomplish. Since this is to be a cooperative effort, and, because of its nature, will cover new ground, it is not possible to totally define each task. It is understood and agreed that adjustments will have to be made, both groups consenting, as the project progresses. However, the goals of this research effort have been defined and both groups agree to make every effort to achieve those goals within the time frame established by the governing DLA contract.

The primary aim of this research effort is to bring into focus the impact of the unit production system on costs and production methods. To do so will require Ippoliti Incorporated to supply or provide the following to the AAMTD team:

- 1) All the necessary production data relating to output quantities, operation times, production flows, etc.;
- 2) Pertinent and applicable overhead cost data;
- 3) AAMTD research team access to the production floor for the purposes of observation and analysis;

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

- 4) Faculty-supervised FIT students access to approved areas of the plant; and,
- 5) Assistance in collecting data.

The AAMTD team will supply or provide the following:

- 1) Collation and organization of the collected data for analysis;
- 2) All the analytical work necessary to the research effort; and,
- 3) Preparation and writing of the preliminary, final, and other reports, including the editing of the reports for publication.

The AAMTD team will make sure that no information will be disclosed or published which Ippoliti Incorporated considers to be proprietary. However, as required in the DLA contract, production efficiency data will become public information at the conclusion of the project. These data will be expressed in percentages, minutes, hours, etc., and will not disclose Ippoliti Incorporated's compensation rates, overhead costs, and/or other proprietary dollars and cents information.

This agreement between Ippoliti Incorporated and AAMTD is for services only. This agreement does not cover equipment, garments, or any other hard or soft goods to be purchased, leased, or transferred. Also, no other agreements or contracts written or verbal, are in force between the parties at the time of signing of this agreement.

Henry A. Seesselberg, Date
Director

FOR IPPOLITI INCORPORATED

Date

COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

EXHIBIT 4
SPREADSHEET ROW HEADINGS

Assembly Section

Total Section Employment
Employment on Standard
Percent of Total
Total Hours Worked by Department
Section Payroll
Section Make-Up Pay
Percent of Total
Average Hours Per Week
Average Assembly Cost Per Unit
Average Hourly Rate
Weekly Output
Total Units Produced
Percentage of Output Per Style

EXHIBIT 5A
WEEKLY DATA REQUIRED

1. Number of employees on incentive in the subassembly and assembly sections.
2. Total direct labor payroll for the subassembly and assembly sections.
3. Total hours worked by each of those sections.
4. Make up pay in Dollars for those that are on incentive in those sections.
5. Weekly finished coat production by style.
6. Estimated indirect labor cost for the subassembly and assembly sections.

EXHIBIT 5B
COST FACTORS

1. Costs related to the Bundle System in the subassembly area
 - a. ticket costs
 - b. bundling costs for assembling
 - c. ticket preparation costs
 - d. payroll preparation cost.

2. Work-in-process

A listing of how much work-in-process exists on a week-to-week basis.

3. Acquisition cost of unit production system

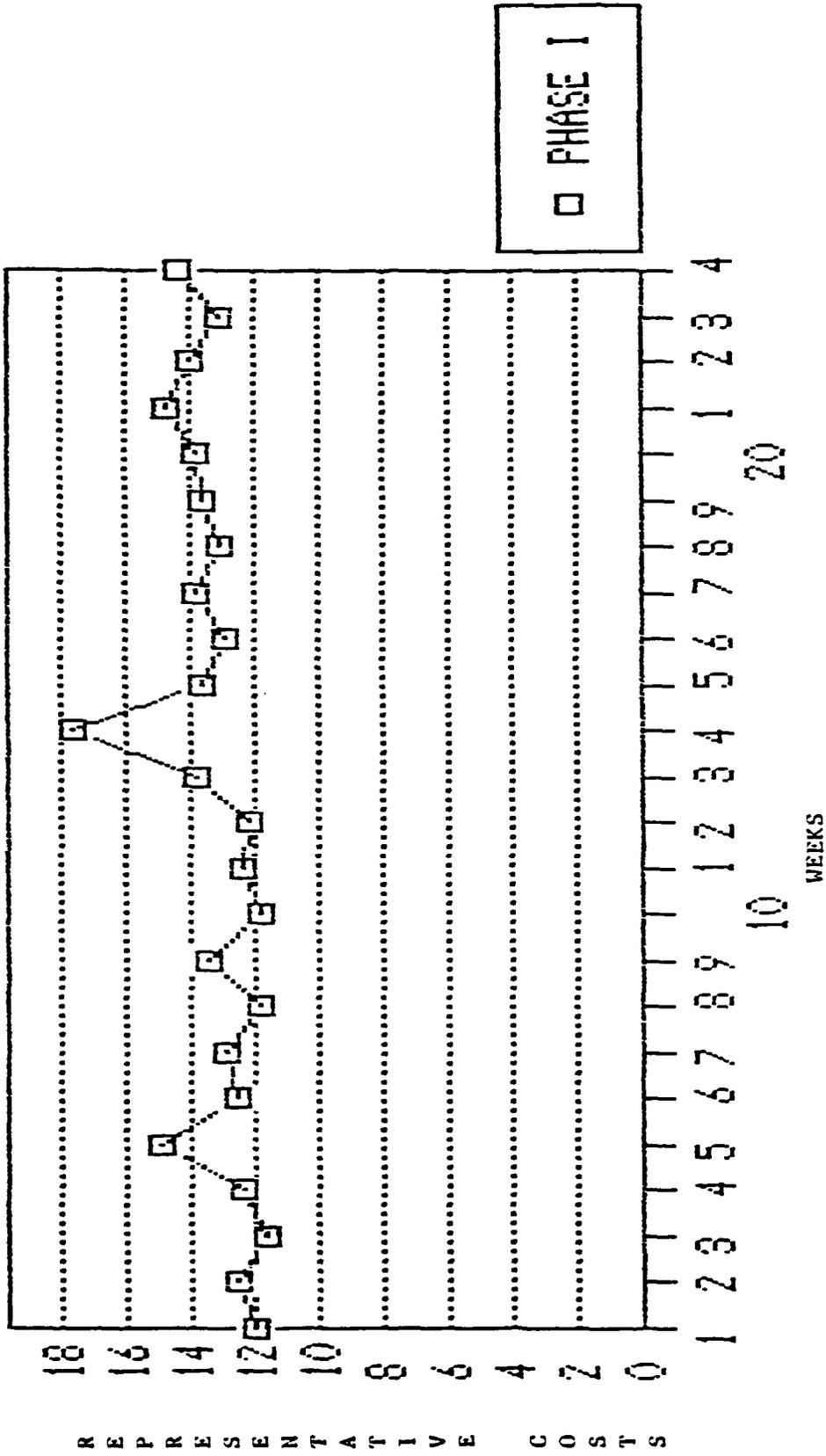
All costs incurred so far and all future costs related to the purchase of the system.

4. Direct labor operation costs for styles other than the Marine Corps Dress Coat.

5. Present repair rate related to sewing and pressing.

6. Present manufacturing overhead rate, in percent.

EXHIBIT 6A
 AVERAGE WEEKLY ASSEMBLY COST PER UNIT FOR PHASE I



COMPARISON OF COST AND PRODUCTION
 BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
 A UNIT PRODUCTION SYSTEM INSTALLATION

EXHIBIT 6B
 AVERAGE WEEKLY ASSEMBLY COST PER UNIT FOR PHASE I & III

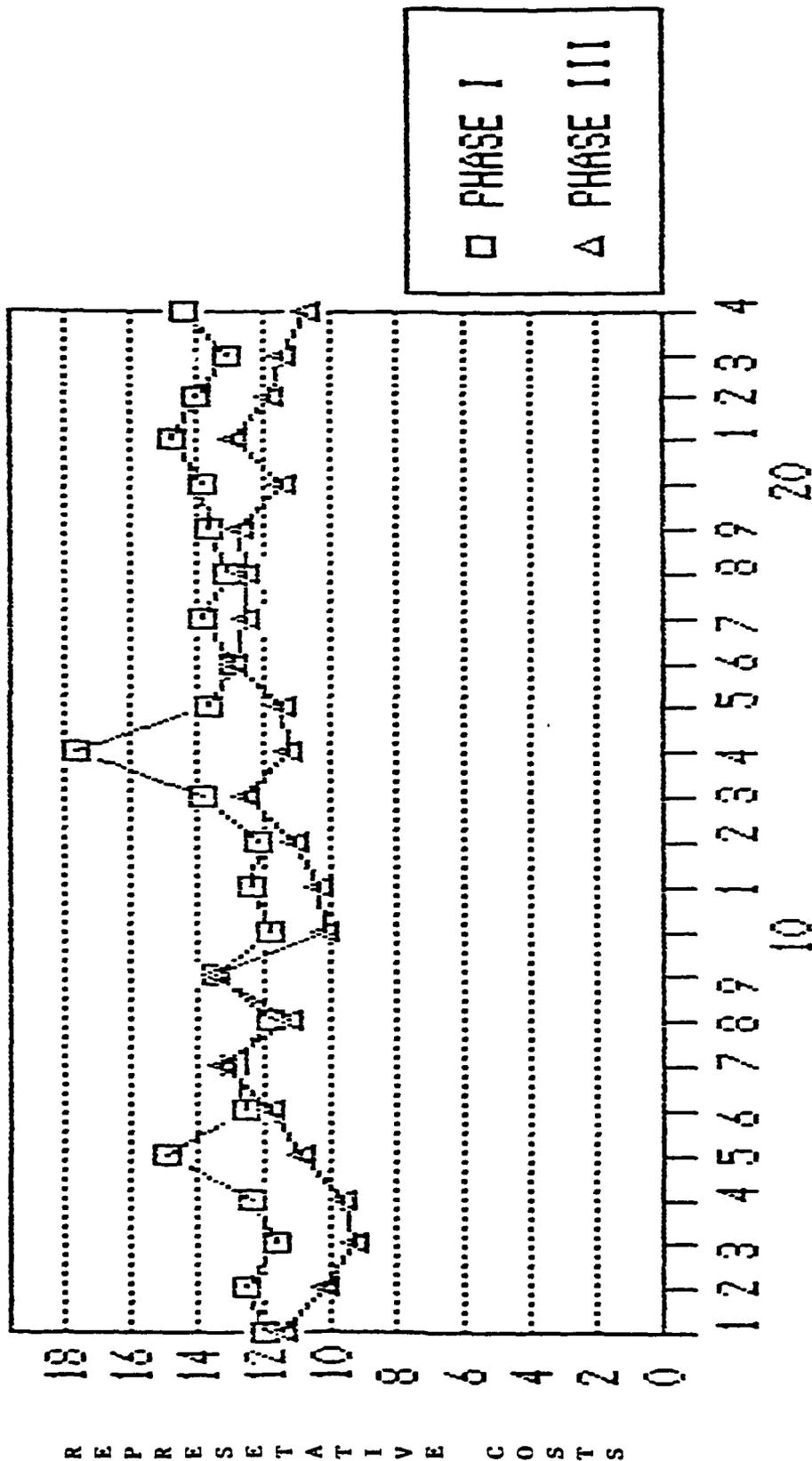
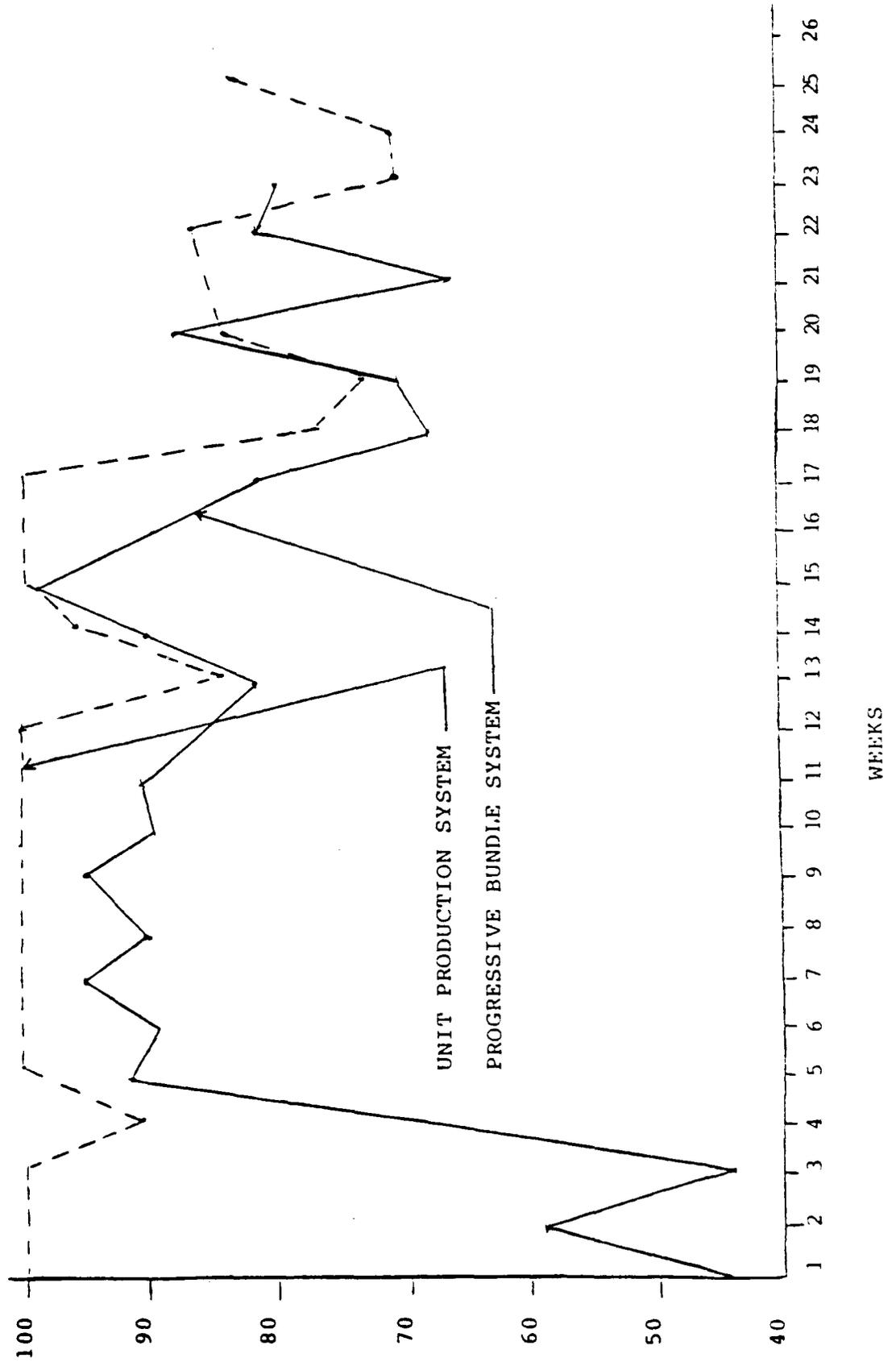


EXHIBIT 7

Blue and Red Marine Dress Coat as a Percentage of Weekly Department Output



O U T P U T (%)

COMPARISON OF COST AND PRODUCTION
 BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
 A UNIT PRODUCTION SYSTEM INSTALLATION

EXHIBIT 8A
 CUSTOMER NEEDS ANALYSIS

DATE: _____ PROJECT: _____ SALESMAN: _____

CUSTOMER NAME: _____

PRODUCT: _____ TOTAL AVERAGE SAM'S: _____

PRODUCTION VOLUME: _____/DAY FRINGE BENEFIT RATE: _____%

PRODUCTION GOAL: _____ UNITS/_____ WIP COST _____ (Labor/Materials)

OPERATORS AVAIL FOR ETON: _____ HRS/DAY: _____ MIN/DAY: _____

PLANT EFFICIENCY: _____% DAYS/YEAR: _____

AVERAGE PAY: _____/HR OPT: YES _____ NO _____

INVENTORY/DAYS

ATTACHMENTS

CUT WORK _____

OPERATIONS LIST _____

PARTS _____

(This is mandatory)

ASSEMBLY _____

SKETCH _____

FINISH _____

SAMPLE _____
 (If possible)

PRESENT STAFF: (INDIRECT)

_____ Payroll & Office Staff @ \$ _____/hr

_____ Supervisors @ \$ _____/hr

_____ Line Servers @ \$ _____/hr

PRESENT MATERIAL HANDLING/REPAIR COSTS:

Present bundle handling _____ (based on SAM/garment)

Cost of 2nd's repairs: Cost per reject: \$ _____
 Present Level: _____%

EXHIBIT 8B

QUICK QUOTE
 ESTIMATED ANNUAL SAVINGS

DATE: _____ PROJECT: _____
 COMPANY: _____ PRODUCT: _____

- (1) Present data for assembling & finishing _____ % of operations
- Present Direct Labor Cost: \$ _____/Unit ÷ \$/MIN = _____ (SAM'S)
 Average Hourly Pay: \$ _____/Hour ÷ 60 = _____ (\$/MIN)
 Present Production Level: _____/Day
 Present Staff: _____/Operators
 Hours Worked: _____/Min/Day _____ Hrs/Day
- (2) Proposed Direct Labor Cost: \$ _____/Unit, _____ % Reduction _____ (SAM)
 Proposed Production Level: _____ Day _____ % Increase
 Proposed Staff: _____ Operators
- (3) Indirect Labor Reductions: \$ _____
 Supervisor: _____ person @ \$ _____/Hr
 Line Servers: _____ person @ \$ _____/Hr
 Payroll: _____ person @ \$ _____/Hr
- (4) WIP Reduction Value: \$ _____
 Present: _____/Units
 Proposed: _____/Units-1 day throughput on UPS
 Product Value: _____/Unit _____ % Interest Rate

* _____ 2002 OPT workstations, configured as _____ production line(s) are required. This includes loading and spare stations, plus thirty percent (30%) extra input buffer.

<u>ITEM/CATEGORY</u>	<u>ESTIMATE ANNUAL SAVINGS</u>
Direct Labor	\$ _____
Indirect Labor	\$ _____
Fringe Benefits (_____ %)	\$ _____
Quality Improvement	\$ _____
WIP Interest Savings	\$ _____
TOTAL ANNUAL SAVINGS	\$ _____
Eton System Net Investment	\$ _____
Estimated WIP Reduction (One Time)	\$ _____
ESTIMATED NET INVESTMENT	\$ _____

ESTIMATED RETURN ON INVESTMENT _____ YEARS

EXHIBIT 9A

SUPERVISORS'
DAILY START-UP ROUTINE

1. BE IN SECTION A LITTLE BEFORE STARTING TIME.
2. GREET ARRIVING EMPLOYEES.
3. DETERMINE ABSENTEES AND MAKE APPROPRIATE MOVES FOR BEST PRODUCTION BENEFITS.
4. TALK TO EACH PERSON RETURNING FROM AN ABSENCE.
5. THIRTY MINUTES AFTER STARTING TIME, TAKE PRODUCTION COUNTS TO GET FEEL FOR THE DAY'S PRODUCTION.
6. ONE HOUR AFTER STARTING TIME, TAKE PRODUCTION COUNTS AGAIN, REVIEW THESE NUMBERS AND MAKE APPROPRIATE MOVES.
7. AT ONE HOUR INTERVALS DURING THE DAY, TAKE PRODUCTION COUNTS.
8. THE FOLLOWING ITEMS MUST BE PERFORMED AT EACH WORKSTATION TWICE EACH DAY, ONCE DURING THE MORNING HOURS AND ONCE AFTER LUNCH.
 - a. CHECK BAR CODE HEADLINE READERS AND FIN COUNTERS.
 - b. CHECK FOR CORRECT CLAMP NUMBER AND CORRECT ADDRESS IN THE KEYPAD. IF THERE IS AN ERROR WITH CLAMP NUMBER, CHECK CHAIN SPECS AND WORKPOSITION SETTING. ENTER A DOT AND F8 AND THE CHAIN SPEC SETTINGS WILL APPEAR. CHECK AND/OR CORRECT. THEN ENTER ANOTHER F8 AND THE WORKPOSITION WILL APPEAR. IF THE RECEIVING WORKSTATION ADDRESS SETTING IS INCORRECT, ENTER NEW ADDRESS AND F7.
 - c. CHECK THE FIFO. IF THE FIFO IS INCORRECT, PHYSICALLY REMOVE ALL CLAMPS FROM THE FIFO AND CLEAR THE ELC BY ENTERING 907F4.
 - d. CHECK THE BARCODE READER STABILIZER.
 - e. CHECK THE AMOUNT OF WORK IN THE WORKSTATION. TEN TO FIFTEEN MINUTES WORK SHOULD BE AVAILABLE IN EACH WORKSTATION.
 - f. CHECK THE OPERATION METHOD BEING USED.
 - g. CHECK THE QUALITY OF THE WORK BEING PRODUCED.
 - h. CHECK FOR ANY REPAIRS NEEDING TO BE COMPLETED.
 - i. CHECK FOR PARTS OF THE GARMENT LYING AROUND THE WORKSTATION.
 - j. CHECK FOR THREAD CONES IMPROPERLY STORED.
 - k. CHECK GENERAL CLEANLINESS OF WORKSTATION.
 - l. FOLLOW-UP WITH LOW EARNING OPERATORS.

EXHIBIT 9B
SUPERVISOR'S GUIDELINES

- * Never fill stations past the center red pole.
- * Never remove clamps from a station FIFO (between the barcode reader and the headliner) without first deleting the clamp. 903.CLAMP NUMBER F4
- * Never use both rails on a double rail station unless you are sorting styles or colors. They are NOT to be used to store extra work, except in certain designated cases.
- * Never allow operators to press their black advance button OVER and OVER and OVER! It will mess up their FIFO at their station. If they have done so, you will need to check and correct their FIFO.
- * Never re-address work to another station because one is full without investigating first.
- * Never tell operators about the unlock command.
- * Completely handle one problem before moving on to another.
- * Ask for help when needed.

EXHIBIT 10
PREVENTIVE MAINTENANCE PROGRAM

TWICE A DAY

1. CHECK HEADLINE BAR CODE READERS AND FIN COUNTERS.
2. CHECK FIFO'S, CHAIN SPECS, WORK POSITIONS.

ONCE A DAY

1. CHECK FOR BROKEN FINS AND REPLACE.
2. REPAIR BROKEN HANGERS. ALL BROKEN HANGERS SHOULD BE REPLACED ON A RACK, NOT THROWN IN BOXES.
3. CLEAN BAR CODE READER EYES.

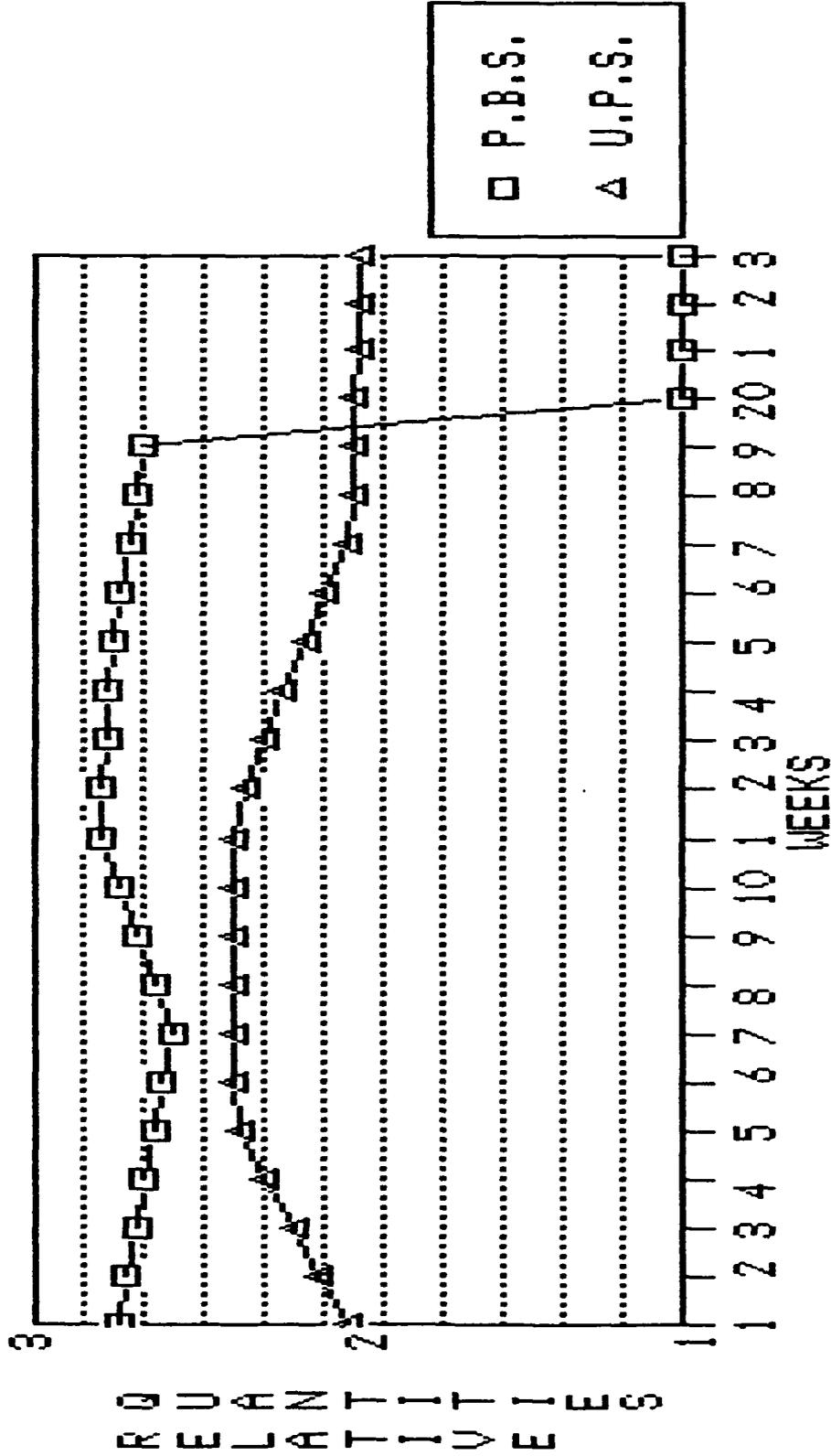
ONCE A WEEK

1. CHECK AIR ADJUSTMENT AND CYLINDER AT EACH STATION.
2. CHECK INPUTS AND OUTPUTS AT EACH STATION.
3. CHECK ADJUSTMENTS ON LOADING AND UNLOADING BOXES.
4. CHECK LOADING CATCH ADJUSTMENTS.
5. CHECK PARTS INVENTORY AND UPDATE.
6. CHECK ALIGNMENT OF ALL SUPPORT PROFILE.

ONCE A MONTH

1. CLEAN SYSTEM - HEADLINER - LOADING RAILS - UNLOADING RAILS
2. RUN HEADLINER WITH DOORS OFF TO CLEAN DRIVE BAND AND TAKE GEARS OFF MOTOR AND LET SET OVERNIGHT TO GIVE DRIVE BAND A CHANCE TO EQUALIZE BETWEEN MOTORS.

EXHIBIT # 11
 WORK-IN-PROCESS INVENTORY



COMPARISON OF COST AND PRODUCTION
BETWEEN A TRADITIONAL BUNDLE SYSTEM AND
A UNIT PRODUCTION SYSTEM INSTALLATION

EXHIBIT 12

IPPOLITI INCORPORATED

WEEKLY DATA

UNIT PRODUCTION SYSTEM ANALYSIS

Week ending _____ Units Produced _____ WIP _____

	Total Emp	# Emp on STD	Total Payroll	Total Hours	Total Make-Up
Sub Assembly					
Assembly					
Total					

COMMENTS:

Submitted By _____ Date _____