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ANALYSIS OF HUGHES AM-1 AUTOMATIC MARKING SYSTEM.(U)  
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# ANALYSIS OF HUGHES AM-1 AUTOMATIC MARKING SYSTEM

*KENNETH W. SHEDD, CAPTAIN, USAF  
DIRECTORATE OF EQUIPMENT ENGINEERING  
CLOTHING DIVISION*

SEPTEMBER 1977

TECHNICAL REPORT ASD-TR-77-66  
Final Report for Period October 1976 – February 1977

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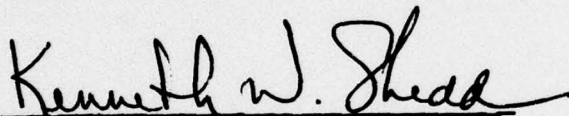
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KENNETH W. SHEDD, Captain, USAF  
Project Engineer

**FOR THE COMMANDER**



JACK H. ROSS  
Chief, Clothing Division  
Directorate of Equipment Engineering

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purchase at this time prohibitive. Periodic reviews should be made to evaluate declining system costs and increasing pattern production schedules to determine if the purchase of the AM-1 System is warranted.

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FOREWORD

This study was accomplished in response to a request from the Deputy for Engineering, ASD. Capt Kenneth W. Shedd, USAF was the project officer. The study was conducted during the period October 76 and February 77.

## TABLE OF CONTENTS

SECTION		PAGE
I	INTRODUCTION	1
II	FACTUAL DATA	3
	SOURCES OF INFORMATION	3
	HUGHES AM-1 SYSTEM	3
	MANUAL PATTERN PRODUCTION	5
	COSTS AND VARIABLES	6
III	CONCLUSIONS	13
IV	RECOMMENDATIONS	15
	APPENDIX: REPORT OF TRAVEL TO MANUFACTURER AND USERS OF AM-1 AUTOMATIC MARKING SYSTEM	23

LIST OF ILLUSTRATIONS

TABLE		PAGE
I	AM-1 SYSTEM COST	12
FIGURE		
1.	MONTHLY MAINTENANCE COSTS	16
2.	YEARLY MAINTENANCE COSTS	17
3.	MONTHLY PERSONNEL COSTS	18
4.	YEARLY PERSONNEL COSTS	19
5.	PATTERN PRODUCTION TIME (WAC UNIFORM JACKET)	20
6.	PACKAGE COMPLETION TIME (WAC UNIFORM JACKET)	20
7.	11 YEAR COST PROJECTION	21

## SECTION I

### INTRODUCTION

Pattern construction in the garment industry has been accomplished by hand since clothing was first developed. Methods have changed and improvements have occurred, but the work of the pattern maker has basically remained a manual operation. The ability to accurately adjust pattern sizes for various body dimensions and develop standards for clothing manufacturers has earned the pattern maker a position envied by many and attained by few. For it is his ability to convert ideas and visions into workable concepts that makes the pattern maker so unique.

With the invention of the computer, man has been able to relieve his workload to some extent and devote more time to creative thinking. The computer has enabled man to solve complex mathematical problems in seconds rather than months, control large industries with fewer personnel, predict the future with remarkable accuracy, and even reach the stars. It was inevitable that the new computer technology would be applied to the clothing industry. Computers are now utilized to program production schedules, keep accurate inventories, and ensure quality control. Now the computer and the pattern maker are working together to produce quality garments at less expense and in less time.

It is this joining of computers and pattern makers which prompted this report. Since the computer industry now offers a system which can grade and produce patterns with a great time savings, is it

economically advantageous for the Air Force to purchase this system  
to produce patterns or continue to accomplish the task by hand?

## SECTION II

### FACTUAL DATA AND DISCUSSION

#### SOURCES OF INFORMATION

The primary source of information for this study is the Trip Report, TDY Order No. TA-29830 dated 4 November 76 (Appendix). The report contains facts on the Hughes AM-1 Automatic Marking System. This system was observed at Hughes Aircraft Company, Baltimore, Maryland. Utilization of the basic system was also observed at the Defense Personnel Support Center, Philadelphia, Pennsylvania, and U.S. Army Clothing Facility, Natick, Massachusetts. Although the systems varied, they were basically the same (manufactured by Hughes) with only minor modifications. Information concerning manual pattern production time was obtained from pattern designers and compared for similarity. All information was solicited separately without any reference being made to other estimates. Data on GS-9 and GS-11 pay scale was obtained from Federal Employees Almanac 1975.

When evaluating all information, it must be remembered that some variables such as time to complete a set of patterns, inflation, maintenance costs, total costs, and personnel costs are the best approximations based on known facts and projected trends.

#### HUGHES AM-1 SYSTEM

The AM-1 System was designed to utilize several components controlled by a computer to produce either a marker pattern or individual pattern pieces. The operation and a list of components of the AM-1 System are contained in the Appendix.

The Hughes System employs a marker/plotter to construct a marker pattern which is then placed over the desired layers of fabric on a cutting table. This pattern is then used as a guide to cut individual pieces for a garment. However, the marker/plotter may be replaced by a Gerber plotter/cutter. This device is similar to the marker/plotter except it is a cutter and a plotter in one. This feature makes it the more desirable piece of equipment. It is therefore recommended that the Gerber plotter/cutter, in conjunction with the Hughes System, would be the best option. For most purposes, pattern pieces are the desired end product. Furthermore, the Gerber plotter/cutter is less expensive than the marker/plotter.

Operation of the AM-1 System (with Gerber plotter/cutter), is not difficult, and the training program lasts approximately two weeks. The closest training center is Cincinnati, Ohio. The cost of the training program is part of the total cost figures for the entire system.

Purchase of the system would require the hiring of two additional personnel. It is possible to function with only one operator, but this would result in excessive system down-time due to leave, illness, etc. It is also possible to cross train operators presently in the Clothing Division, but this is not recommended since each person is a specialist in his own field. Time devoted to the operation of the system would of course be at the expense of the operator's particular trade. Also conflicts with the Civil Service hiring practices may occur.

Although it is not absolutely necessary that the operators have a basic background in garment construction, it is definitely an asset. A working-knowledge of fabric construction, grading practices, and clothing design enables the operator to integrate and understand both machine and end-product quickly and better. Qualifications such as these are usually possessed only by a college graduate. This higher education would require a starting level of a GS-5 (college recruit) and an average grade level of a GS-9, on which level the study is based; however, the U.S. Army Natick Labs has two GS-11's assigned to operate the AM-1.

The cost for the system is based on the 1974 cost figures (Appendix) adjusted for 6% inflation. Only total cost will be addressed, which includes all hardware, software, training, delivery, and setup. Maintenance and personnel costs will be discussed separately.

#### MANUAL PATTERN PRODUCTION

There are presently two pattern makers assigned to the Clothing Division. Their functions are separate with one working on women's wear and the other on men's wear. Pattern production by hand is a time-consuming process which is dependent on variables such as style, number of sizes, and pattern parts per garment. Thus the need for two personnel to conduct simultaneous pattern production is a requirement. It should be pointed out that even with the AM-1 System, pattern makers are still required to produce basic patterns to be digitized and also to develop grading rules; therefore, there would be no personnel cuts.

As mentioned earlier, pattern makers are highly skilled individuals. Because of this, their average pay will be figured on a GS-11 average. Of course, there will be some starting at a higher salary and some at a lower figure, but on the whole a GS-11 is the average grade level.

#### COSTS AND VARIABLES

In order to project the cost relationship between computer versus manual pattern production, some ground rules must be established. They are:

##### AM-1 System

1. AM-1 System cost is based on 1974 purchase price with Gerber plotter/cutter. Cost is adjusted to 1977 for 6% annual inflation and projected for 5 years at the same inflation rate.
2. Maintenance fee is based on 1976 figure quoted by Hughes and projected for a 6% annual inflation rate and compared with the maintenance costs (for 6 years) being paid by Natick Laboratories for their system.
3. Personnel costs, other than those included in the total acquisition cost, will be for two GS-9 system operators and a 3% cost-of-living adjustment per year.
4. Down time or nonproductive time will be addressed but figures will be estimates with no supporting data.
5. Information on time and cost to produce patterns for a WAC Uniform Jacket was obtained from Mr. Bill Amico, Clothing Designer, and Mr. Norbert Rodil, Textile Technologist, at Natick Laboratories.

6. Items considered to be noncritical, such as facility, floor space, utilities, and materials will not be considered here.

Manual Pattern Production

1. Cost is based on salaries of two pattern makers, GS-11. Total salary figures are used because both will be paid even though only one project is considered.
2. Overtime, sick leave, and annual leave will not be discussed here.
3. Time for completion of a project will be total effective time from completion of initial base pattern to completion of entire sized and graded pattern set. Total effective time is actual working time plus break time, meal time, and normal delays.
4. Information on time to produce patterns for a Woman's Security Police Jacket was obtained from Mr. Domenico Bruno, Pattern Designer, ASD/ENEU. This time was compared with time estimates from Natick Laboratories for a similar project. These separate estimates were remarkably close and were therefore judged to be accurate.
5. Items considered to be noncritical, such as facility, floor space, utilities, and materials, will not be considered here.

When comparing the AM-1 System versus manual pattern production, probably the most important factor to consider is cost. An investment of any kind is expected to return some type of dividend, either through reduced cost, or a reduction in time to complete an assigned task. At a cost of \$295,372, the AM-1 System is definitely a major investment

(Table 1). The monthly maintenance charge, which escalates from year to year, also represents a sizable expenditure. With the addition of two system operators, personnel costs will increase correspondingly. These factors compared with manual production costs are the first items for consideration.

The initial cost figures for the AM-1 System (Table 1) were compiled from the purchase figures of the same system by Natick Laboratories in 1974. With a three-year projection at 6% inflation, the final figure of \$295,372 would be the expected acquisition price in 1977 (Table 1). This price includes all hardware, software, and installation.

The monthly maintenance figures (Table 1) are based on the figures quoted by Hughes. They have been projected for five years at an annual 6% inflation rate also. Total yearly cost is adjacent to monthly figures for annual comparison. These costs are plotted against manual maintenance costs (Figures 1 and 2) to show increasing trends only; maintenance costs for manual production will be zero.

Personnel costs (Figures 3 and 4) are also plotted for monthly and annual rates, corrected for an estimated 3% cost of living adjustment. Here again, two system operators are compared against two pattern designers. However, even if the AM-1 System is purchased, personnel costs will be cumulative, since both system operators and pattern makers will be necessary. When using Figures 3 and 4, or anytime personnel costs of the AM-1 System are considered, the totals of both the AM-1 System and manual production must be added.

Pattern production time, Figure 5, shows the months for completion of a standard uniform jacket. The project was conducted at Natick Laboratories in the fall of 1976. The item was a WAC Uniform Jacket consisting of 44 sizes and a total of 968 pattern pieces. The time to complete the entire set of patterns was 15 days by computer. The time to complete the job manually (7-1/2 months) was an estimate based on prior uniform jackets of similar design. When comparing the time figures, the AM-1 figure does not include the time required to program the computer with grade rules. This figure will vary, but on the average approximately two weeks is required to establish the program. The same grade rules may be used from other programs providing that the parameters are the same. The manual figures were computed from the time the basic pattern was completed and grading and sizing began. With the AM-1 System, there is a resulting time saving of approximately seven months over manual pattern production.

When evaluating the time differential between the AM-1 System and manual production, there is another variable which should be considered. Anytime a garment is approved for manufacture, it must be accompanied by a set of specifications which are compiled by a clothing designer. These specifications contain the necessary information, standards, drawings, and publications which are used to construct a garment. Usually both the patterns and specifications are developed simultaneously. However, for one reason or another, the specifications may require more time than usual to complete, usually due to the requirement to achieve coordination with other DOD services. When taken in conjunction with

manual pattern production, this additional time may not cause any problems due to the length of completion time for the patterns themselves. This delay, of course, depends on whether there will be major changes which may require alterations to the patterns. In other words, manual pattern production and specification development can normally be accomplished within the same time span. With the relatively short pattern production time with the AM-1 System, there will be a delay in package completion time (both patterns and specifications) that does not normally occur with the manual system. Even though the AM-1 System produces patterns in a short time frame, the specifications must still be done by hand. Delays in the development of specifications, which may not affect manual pattern production, will most probably extend the package completion time with the AM-1 System. Although the patterns may be ready in 15 days (Figure 5), the specifications may require four to six months to complete. This in effect would extend the package completion time by that same amount. It is therefore evident that even though the AM-1 System can decrease actual pattern production time from more than seven months to 15 days, outside factors such as specification development will delay the entire package completion time. It is therefore estimated that the use of the AM-1 System would reduce the actual package completion time for a set of patterns by 50% (Figure 6).

In order to visualize the cost differential between the AM-1 System and manual pattern production data, Figure 7, was projected for 11 years to compare the total costs of the two means of production.

The purchase price of the AM-1 System is distributed for a 10-year period and is combined with the operator and maintenance costs. The manual production method consists only of personnel costs, as previously stated. The cost differential is in excess of \$70,000 for the first year to more than \$90,000 in the tenth year. This differential consists of the additional personnel costs and the escalating maintenance fee for the AM-1 System. At the eleven-year point, the purchase price of the AM-1 System has been paid off, which deletes approximately \$30,000 from the annual expense. Even though the initial cost of the equipment has been technically reduced to zero at the eleven-year point, the continuing personnel and maintenance costs for the AM-1 System will be more than \$60,000 above the cost of manual pattern production. The differential between the two will continue to increase from year to year due to the projected escalating maintenance fee. The personnel costs will increase also but they will be at the same rate of 3%.

TABLE I. AM-1 SYSTEM COSTS

Item	* Dollar (\$), Month/Year						
	1974	1977	1978	1979	1980	1981	
AM-1, New Installed	248,000	295,372					
AM-1, Maintenance Cost		1,350/16,200	1,431/17,172	1,517/18,202	1,608/19,294	1,704/20,452	
AM-1, Personnel Cost (2 Operators)		2,140/25,682	2,204/26,452	2,271/27,246	2,339/28,063	2,409/28,905	
Clothing Designer (Patterns), 2 Manual Pattern Design		2,580/30,962	2,658/31,891	2,737/32,848	2,819/33,833	2,904/34,848	

\* System and maintenance costs adjusted for 6% annual inflation.  
Personnel costs adjusted for 3% cost of living increase each year.

### SECTION III

#### CONCLUSIONS

There is no doubt that the AM-1 System is a remarkable piece of equipment. Its capability to quickly and accurately produce patterns is almost unlimited. It is a tireless worker, unencumbered by the worries and limitations which affect human beings. Work projects are conducted without lunch breaks or sick leave. Completed pattern packages are precise to 1/64 of an inch. Once a project is started it will work for 24 hours a day if necessary to complete its task. It requires no sleep, and asks for no holidays. In the realm of the computer age, it seems to be the perfect answer to the clothing designers dream.

Yet, as one realizes, there are limitations to this seemingly "perfect" system. In its basic form, the AM-1 System is a machine. It consists of wires, bulbs, and metal. It cannot think; it cannot improvise; it cannot imagine. While its capabilities are far reaching, they are all dependent on human factors. It cannot exceed design limitations and parameters which are contained in its computer program. When compared with the ability of the human brain to incorporate dissimilar factors and varying conditions, the AM-1 System seems quite primitive.

In order for any system of this type to be acquired, it must, of course, offer some advantage to the user over manual production. In addition, it must reflect some kind of return or dividend as well as a cost effectiveness.

As seen in Figure 6, the AM-1 System can reduce pattern package completion time by approximately 50%. On the surface, this time saving seems to be a strong selling point. It would be if there were sufficient volume or workload to warrant the reduced production time. The Clothing Division, considering its Air Force mission, designs and develops clothing items for use primarily by the Air Force. On the whole, the impact of clothing trends, fads, and current styles have very little or no impact on the military. Basic clothing designs are utilized from year to year with only minor alterations. Even the newly developed items are designed within certain parameters that are within established military concepts. Therefore, the workload within the Clothing Division is small when compared with commercial clothing manufacturerers. Fewer complete pattern packages are required. On the average there are eight items produced or altered annually which require pattern packages. If minor changes are required on an item a whole new set of patterns may not be required; only patterns for those portions of the item affected may be produced. On the other hand a change of fabric, say 100% cotton to durable press (polyester/cotton) would require a complete set of new patterns.

It can, therefore, be perceived that a decrease in production time would result in nonproductive personnel time and lost system-usage due to a relatively small workload. Although pattern production time would be greatly reduced, the total cost per package set or item would be greatly increased. This factor is of prime importance when dealing with a system as expensive as the AM-1.

RECOMMENDATIONS

The purchase of the AM-1 System to produce patterns for the Clothing Division is not recommended at this time for the following reasons:

1. High initial cost.
2. Yearly increasing maintenance fees.
3. Increased personnel costs.
4. Low projected system utilization.

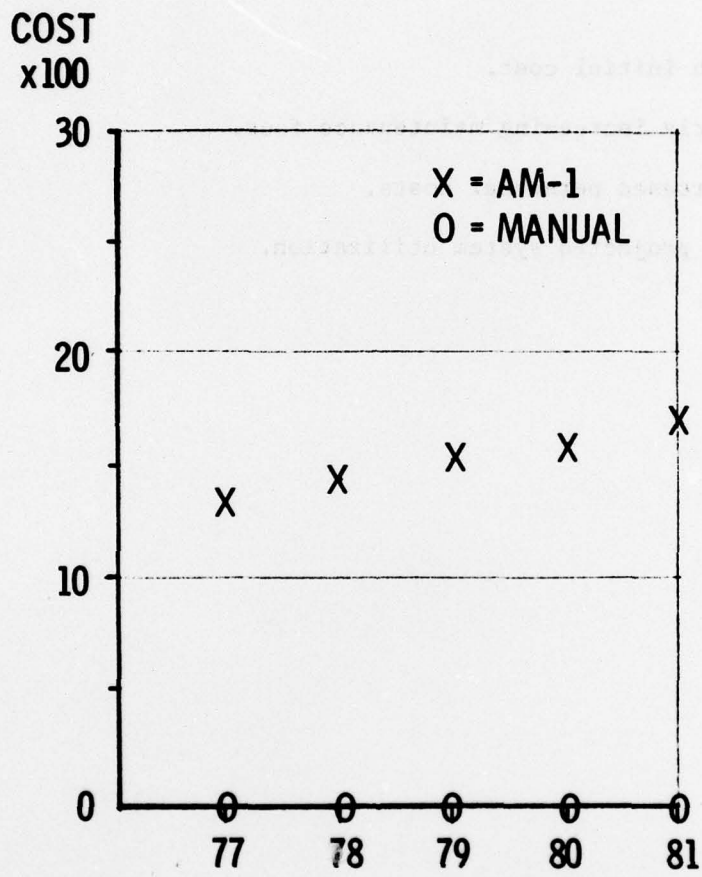


FIGURE 1 MONTHLY MAINTENANCE COSTS

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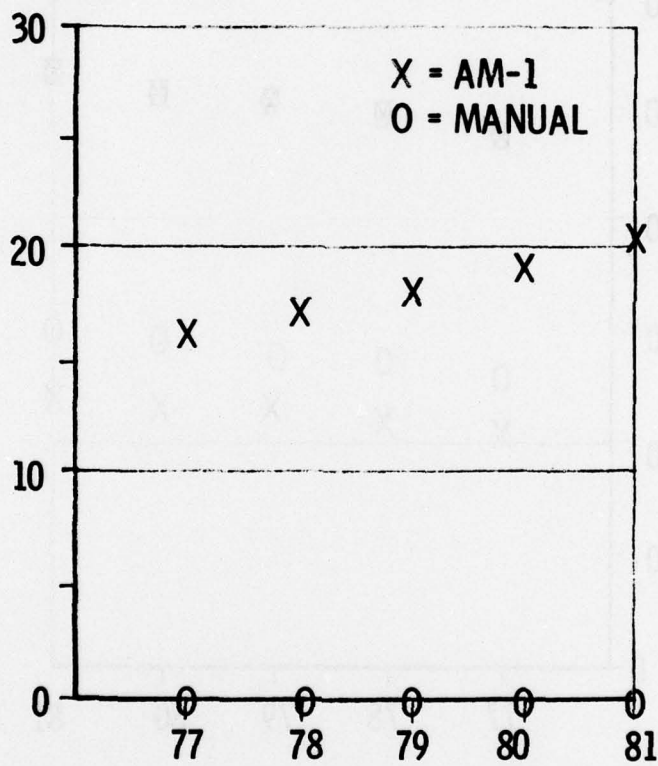


FIGURE 2 YEARLY MAINTENANCE COSTS

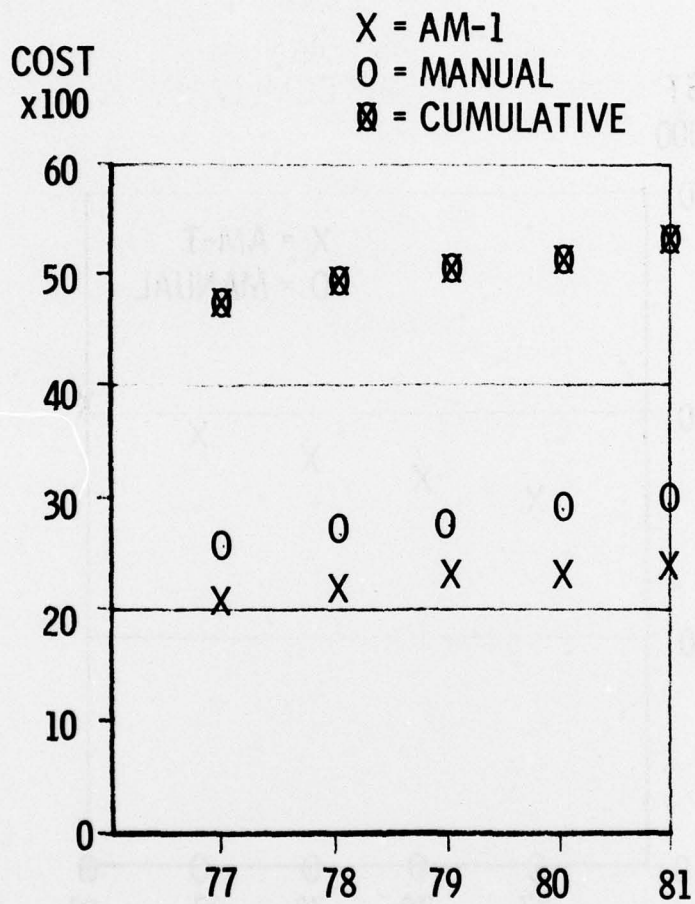


FIGURE 3 MONTHLY PERSONNEL COSTS

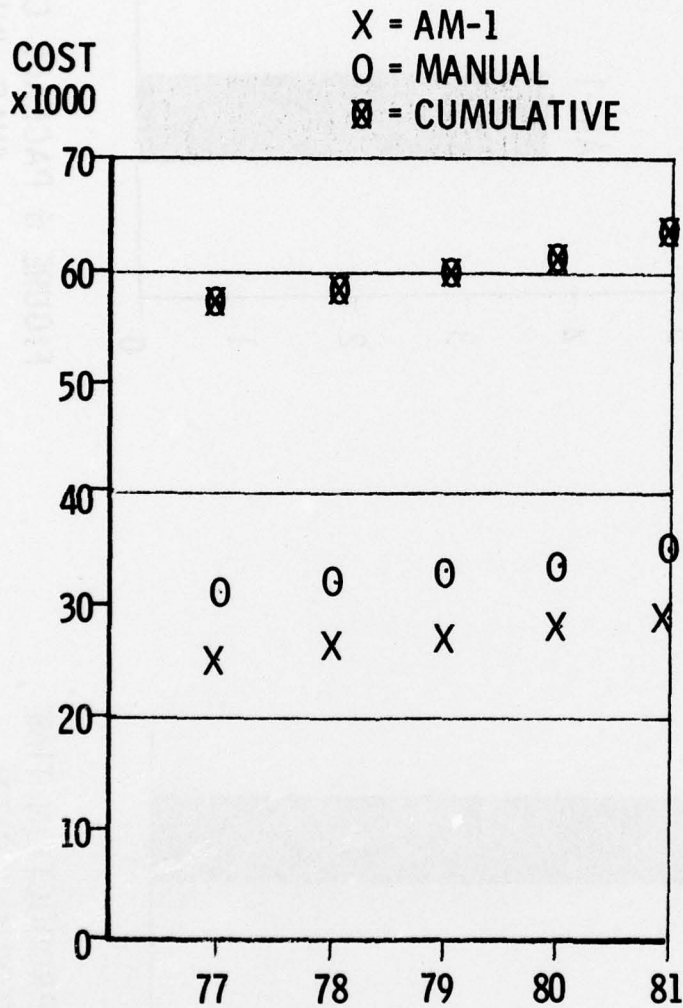


FIGURE 4 YEARLY PERSONNEL COSTS

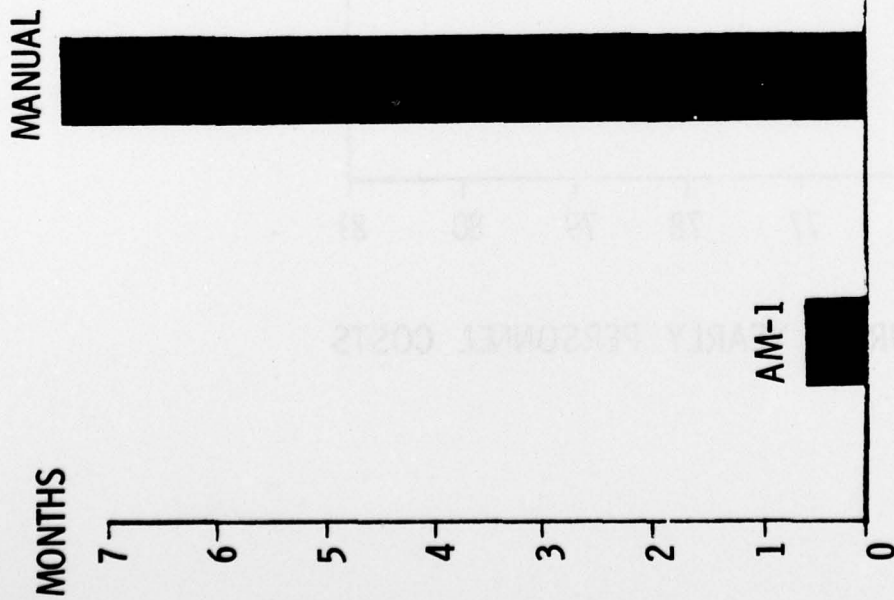


FIGURE 5 PATTERN PRODUCTION TIME  
(WAC UNIFORM JACKET)

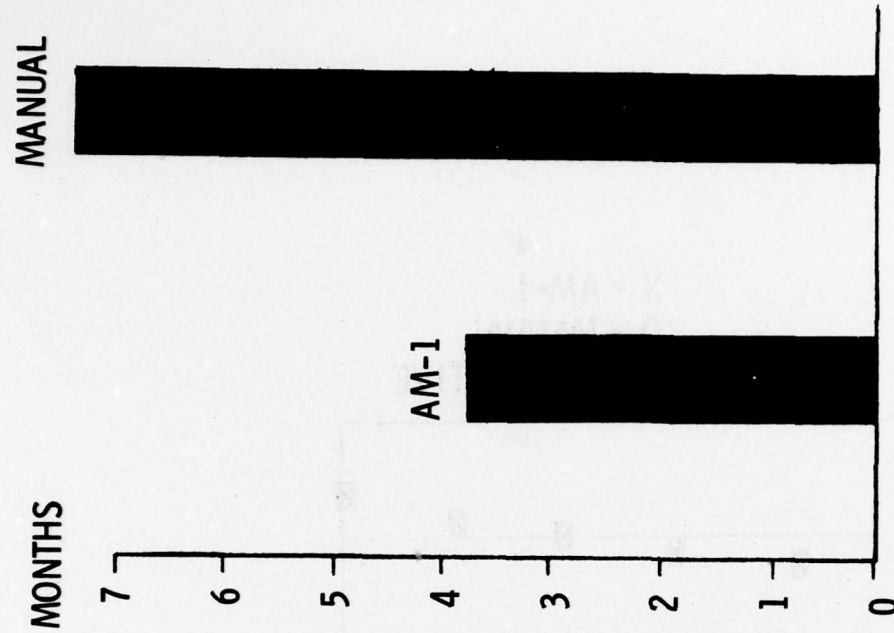


FIGURE 6 PACKAGE COMPLETION TIME\*  
(WAC UNIFORM JACKET)

\* PACKAGE COMPLETION TIME INCLUDES  
TIME TO PRODUCE PATTERNS AND  
SPECIFICATIONS

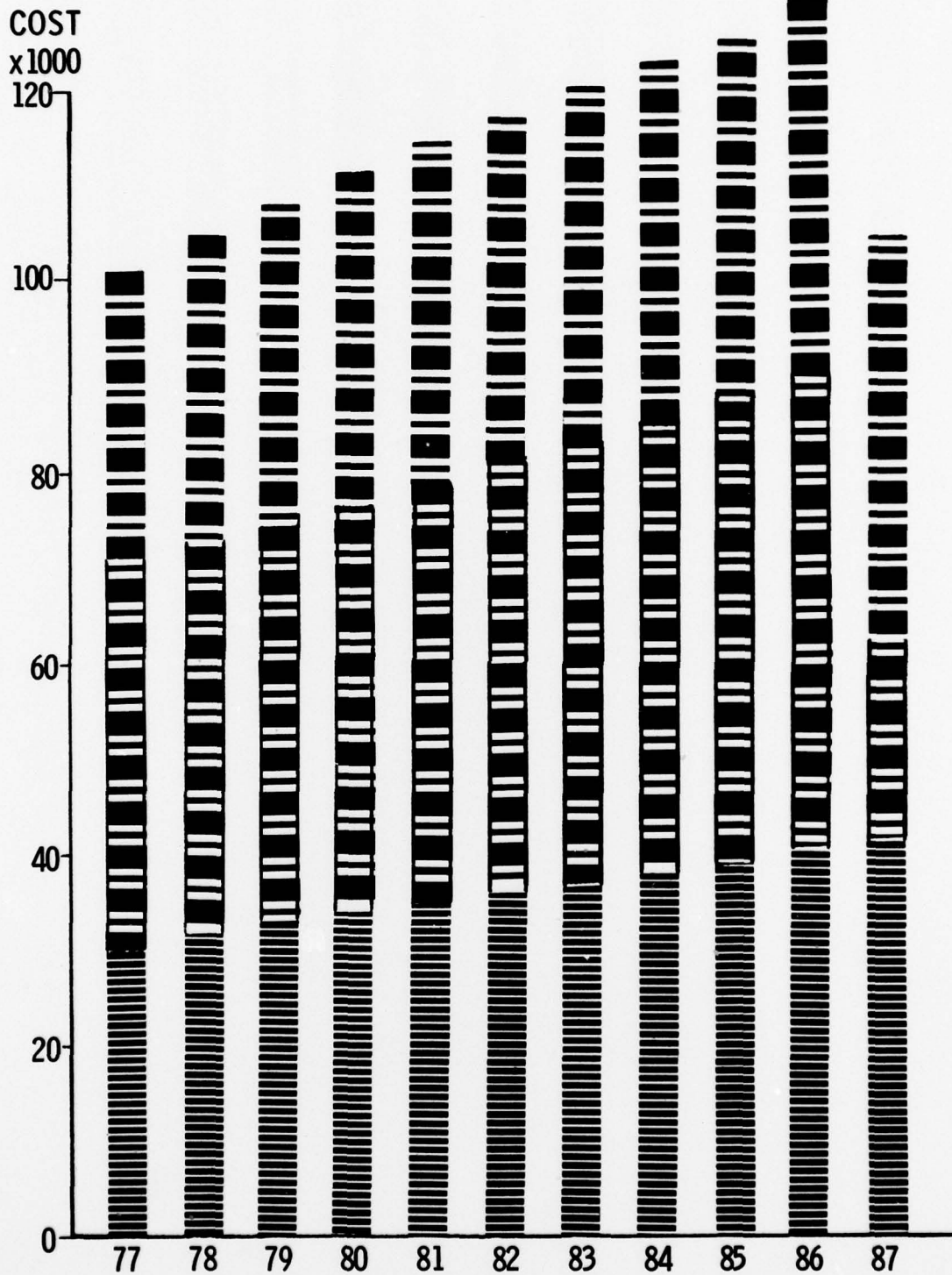


FIGURE 7 11 YEAR COST PROJECTION

AM-1

MANUAL

APPENDIX

AM-1 System Evaluation  
Trip Report

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ENEU (Capt Kenneth W. Shedd/53271)

TDY Order No. TA-29830 dtd 4 Nov 76, To observe operation of automated design system and evaluate possible use/purchase by Air Force.

ENEZ

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IN TURN

1. Activity and Place Visited:

Hughes Aircraft Company, Baltimore MD  
Defense Personnel Support Center, Philadelphia PA  
U.S. Army Clothing Facility, Natick MA

2. Travel Information: Departed 8 Nov 76  
Returned 11 Nov 76  
VIA Commercial Air R/T.

3. Purpose of Trip: To observe operation of automated design system and evaluate possible use/purchase by Air Force.

4. Names of Persons Contacted:

Hughes Aircraft Company:

Joseph A. Primavera, Sales Manager, Apparel Graphics Systems  
Dan Grube, Sales Representative  
Charles Ezrine, Design System Operator

Defense Personnel Support Center:

Colonel Cobb, Director of Mfg.  
Bob Hampton, QA Specialist (Quality Assurance)  
Joe Evangelista, QA Specialist  
Vic Cetroni, Chief of Design  
Armon Mastrangelo, Asst Designer

U.S. Army Clothing Facility:

Norbert Rodil, Textile Technologist, Clothing Branch  
Bill Amico, Clothing Designer

5. Factual Data:

a. Hughes Aircraft Company - Upon arriving at Hughes Aircraft, Mr. Primavera and Mr. Grube presented a briefing on the AM-1 Automatic Marking System. This system employs a mini-computer which stores information from a digitizer (converts basic pattern shapes into computer language). This information is also displayed on a visual monitor for marker making and pattern check. A teleprinter console enables the operator to instruct various elements of the system and print management information. The final element of the system is a marker plotter which draws full-size production markers, individual pattern markers, nested sets or miniature markers.

Mr. Ezrine then conducted a demonstration of the AM-1 System and pointed-out many of its features. A basic pattern part is placed on the digitizer and the pattern is traced with an electronic cursor. The computer receives the information, and a graphic display of the pattern appears on a monitor, as well as being stored in the computer. The operation is simple and the computer language is learned without the necessity of computer knowledge. Operators have been trained in two weeks with only a high school education. From this point the computer will command the marker plotter to grade and size the pattern to the desires of the operator and produce a marker which can then be used to cut the pattern pieces.

The entire process can be accomplished in a few seconds to a few minutes depending on results and number of markers desired. The display unit and associated computer has great flexibility and can be used for a variety of functions from changing minor details and alterations to automatically constructing a visual marker arrangement of pattern pieces and determining percentage of cloth utilization.

The system consists of modules and purchase may be of one or more component parts. The AM-1 System is also compatible with the Gerber plotter/pattern cutter and cloth cutting machine.

Cost of the entire AM-1 System is approximately \$297,000 of which the plotter is the most expensive at \$100,000. A monthly maintenance charge of \$1,350 is also available, otherwise a \$32/hour+charge is assessed when required. The closest maintenance facility is Cincinnati, Ohio.

(1) I asked Mr. Primavera about the possibility of having a computer terminal and video display installed at ENEU and tied-in to a main computer and pattern maker. He said that it was of course possible but the expense would exceed the cost of the entire system by

itself. Coordination would be a problem since the main computer would have to be programmed, and all information would have to be known by the operators. This in itself would entail a great amount of time and added expense. Even if the operation were completed without any major problems, the final pattern package would have to be sent to ENEU for final verification or approval. If errors were found, the whole process would have to be repeated. The problems in such a set-up are many, such as electrical transmission, atmospheric conditions, and dropped connections, just to name a few, any of which would cause a delay. In the worse cases, the computer program could be erased and thus the time to reprogram the computer would result in lost machine time and extra expense.

Mr. Primavera or one of his associates is available to visit the Clothing Division at WPAFB and make an assessment of the feasibility of purchasing the AM-1 System.

b. DPSC - Due to the shortage of personnel, only a tour of the Clothing Design and cutting areas was accomplished. Although time and personnel were limited, an observation of the automated design system was possible. It is similar though older than the system at Hughes. It has the ability to accomplish all functions of the newer system except it requires the use of computer cards prior to the information being transferred to a tape or disk system. The stored information is then available for display or to drive the marker plotter. There was no machinery for the production of patterns.

Conversation with Col Cobb indicated that he felt the system was not really justified for use at DPSC. He stated that if he had been the Director prior to the purchase of system, he would have been against its procurement. With the additional time available, which was not anticipated, several coordination functions between DPSC and ASD/ENEU were discussed and noted for future reference.

c. U.S. Army Research & Development Center (Natick) - The AM-1 System was also in use at Natick; however the system was complimented by a plotter/cutter, Gerber 22. The complete system was the same, as far as operation, to the systems at Hughes and DPSC. The Gerber 22 allowed for simultaneous marker making and pattern cutting or either could be accomplished separately by substituting an ink pen or pattern knife. The Natick system has been in operation since June 1974 and has for the most part been quite reliable. However there have been some associated software problems in the last few months which have not been corrected, but utilization of the equipment has remained in the vicinity of 92%. Mr. Rodil was extremely helpful and willing to provide data on any subject requested - particularly the possible use of the Natick equipment by ASD/ENEU to produce patterns and also the cost breakdown of their system.

A test sample of the WAC Uniform Jacket was utilized to predict time/cost figures. The complete set of patterns for the WAC Jacket was comprised of 44 sizes and a total of 968 pattern pieces. The time of completion of the entire set of patterns was approximately 2-1/2 weeks. (This sample was chosen due to the fact that it represents a medium of sizes and pattern parts. It was also selected because there were no interruptions and the package was worked-on from beginning to completion without any outside interference). The breakdown is as follows:

Time Required: 15 Days	Cost
Salaries (Two Operators):	\$1,920.00
System Usage and Overhead:	<u>2,000.00</u>
Total	\$3,920.00

OR

\$32.50/Hour  
\$ 4.05/Pattern Piece

Although Natick is available to perform pattern production by computer, it should be kept in mind that several factors such as system availability, workload, conflicting projects, and target completion dates will be major, uncontrollable factors as will the exact cost.

Prior to the purchase of the Hughes AM-1 System, five major electronic firms submitted their bids for comparable equipment. All bids were more expensive than Hughes and were judged to be either less efficient or not entirely suitable for Natick's purposes. Following is a copy of the total cost for the Natick system:

A. Hardware

1. Computer - Hewlett - Packard 2100	\$ 33,388
2. Teleprinter, Texas Instruments	1,300
3. Display System Imlac PDS-4	16,400
21" Monitor:	1,350
Data Tablet:	2,550
4. Digitizer Bendix Graphscan with Texas Instruments Teleprinter	12,725
5. Plotting System, Gerber 22	1,300
Plotter Cutter:	35,900
Controller	25,500
6. Enclosures, Systems Furniture	<u>1,336</u>
Sub Total	\$134,749
General & Administrative Cost	<u>39,751</u>
Total	\$174,500

B. Software	\$45,000
C. System Integration	10,500
D. Warranty	10,000
E. Training	5,000
F. Freight	<u>3,000</u>
	\$247,500

**ADDITIONAL FACTS:**

Maintenance cost was graduated from \$9,000 in the second year to \$13,152 in the sixth year; 14 days to install, check out and perform acceptance test requires approximately 460 sq ft.

1 Year Warranty (Parts and Labor)

**6. Conclusions:**

a. The Hughes AM-1 Automatic Marking System and Gerber Marker-Plotter provide users with the versatility needed to design and make patterns quickly and efficiently.

b. The system is available but at a relatively high cost. Since basic pattern designers are still required in addition to the Hughes system, there would be no monetary savings in that area. Since at least one additional and possibly two operators would be needed to operate the system, there would actually be an increase in personnel costs.

c. Natick Laboratories have the capability to produce computer patterns, but the cost is high and a reliable completion date cannot be firmly established.

**7. Recommendations:**

a. Due to the high initial investment, escalating maintenance fee, and projected usage, it is not feasible at this time to purchase the AM-1 System.

b. Patterns should be continued to be manually produced at ENEU with only necessary or short notice work done by Natick or other contractors.

c. A cost analysis of computer v.s. manual pattern production will follow.

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