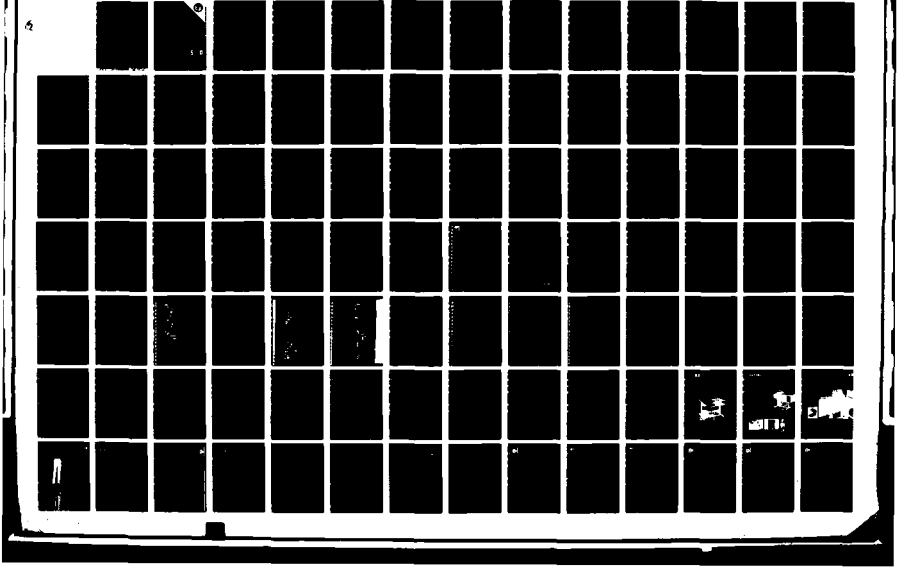
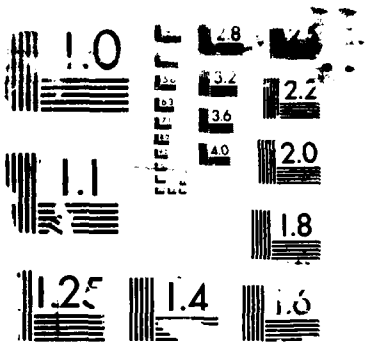
AD-A189 120 MANUFACTURING TECHNOLOGY FOR APPAREL AUTOMATION PHASE 1 1/2
2 AND 3 ACTIVITY(U) NORTH CAROLINA STATE UNIV AT
RALEIGH SCHOOL OF TEXTILES E M MCPHERSON 15 OCT 87
UNCLASSIFIED NCSU/DLA-87/2 F/G 15/5 NL





RESOLUTION TEST CHART

Report: NCSU/DLA-87/2 CDRL A004

MANUFACTURING TECHNOLOGY FOR APPAREL AUTOMATION

Phase I, II and III Activity

Edwin M. McPherson
North Carolina State University
School of Textiles
Box 8301
Raleigh, NC 27695-8301

15 October 1987

Interim Report for Third Quarter 1987

Contract DLA900-87-C-0509 (July - October)

Prepared for
Defense Logistics Agency
Production Management Support Office
DLA-PR Cameron Station
Alexandria, VA

Report: NCSU/DLA-87/2 CDRL A004

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TABLE OF CONTENTS

PREFACE

The monthly interim reports are summarized in this semiannual report. Activity to date has included work performed by

Dr. J. R. Canada
Ms. Carol Carrere
Dr. T. G. Clapp
Dr. H. Hamouda
Ms. Karen Hersey
Dr. T. J. Little
Mr. E. M. McPherson
Dr. W. K. Walsh

As well as other staff and graduate students as needed.

SUMMARY

NCSU has specified design concepts for apparel material handling units for the purpose of reducing the labor content in the production of apparel or military sewn products. The design concepts were offered to existing equipment producers for bid on all or part of the equipment units. The modules specified include pickup and placement devices, orienting and alignment devices, equipment feeding devices and, finally, dispose or stacking devices. Wherever practical, existing commercially proven equipment is to be utilized or modified to satisfy systems requirements. Bids have been received and evaluated.

Flexibility in equipment is sought through the use of programmable computers or computer chips. The selection of a vendor to produce all or elements of the system has been guided by the vendor's demonstrated capability to produce original equipment at market value costs. Commercially viable equipment must generate operating cost savings which will recapture the equipment investment within a reasonable time span. If the modules developed do not do this, then the apparel industry will not buy the units. A primary constraint in this project is the requirement that the modules be an attractive investment for apparel manufacturers. Only one vendor stayed within these bounds.

At the time of this interim report, a contractor has been selected and an award has be made. The industrial review board has met twice (18 August 1987 and 5 October 1987) for the purpose of reviewing progress. A contract between ARK, Inc. and NCSU has been completed.

Parallel activity to vendor selection includes studies on the assembly of garments and definition of flexibility within an apparel context. A preliminary report on flexibility is included in this interim report. Current activity is proceeding on schedule.

INTRODUCTION

1.0 Under the contract signed by DESC 12/16/86 and received by the NCSU School of Textiles 1/2/87, agreed to activity has been divided into five phases, of which the first four are to be immediately undertaken by NCSU within the base period. There are:

1.1 Phase I, Project Management. Provide, in accordance with paragraph 3.1 of the Statement of Work (SOW), North Carolina State University's Technical Proposal, Manufacturing Technology for Apparel Automation, April 86.

Project management shifts in its requirements between phases. After setting up the initial Management Master Plan (see appended chart for current progress), there are basic Department of Defense accounting, reporting and review activities which apply to all phases. North Carolina State University has put in place reporting and accounting controls at the outset to conform with these regulations. Monitoring and managing the project becomes more complex after the vendor is selected. Working with the vendor will require field reviews by appropriate NCSU or IRB staff or by consultants as problems arise. From time to time, it is anticipated that reliable students may work on the vendor premises to check progress and assist where appropriate.

1.2 Phase II, Establishment of Garment Subassemblies. Provide, in accordance with paragraph 3.2 of the SOW, Attachment 1, Section C, North Carolina State University's Technical Proposal, Manufacturing Technology for Apparel Automation, April 1986.

A requirement for extending use of the modularized work station to as broad a base as seems reasonable is one of the tasks outlined in the DLA objectives. This requires further investigations of operation sequences and assembly parts in both military and civilian apparel. In one sense this activity is a market survey to determine potential users of work station groups. A new survey of present active government apparel contractors is being formulated. Manipulation of this data base should provide insight into future areas for automation as well as a basis for establishing the rules of flexiblity within an apparel environment.

1.3 Phase III, Recommend a Set of Modularized Work Unit Groups. Provide, in accordance with paragraph 3.3 of the SOW, Attachment 1, Section C, North Carolina State University's Technical Proposal, Manufacturing Technology for Apparel Automation, April 1986.

There are several inventor/entrepreneurs as well as a number of small to medium equipment firms which have been evaluated to determine which individuals or firms are able to bring modularized equipment into practical use at a reasonable price. This analysis involves not only prior history of reliability but also such other items as financial stability, employed manpower, the skills of the firms' manpower, and the shop equipment. The result of this analysis has led to the selection of ARK, Inc. as the vendor.

1.4 Phase IV, Design, Construction and Testing of Modularized Work Unit Groups. Provide, in accordance with paragraph 3.4 of the SOW, Attachment 1, Section C, North Carolina State University's Technical Proposal, Manufacturing Technology for Apparel Automation, April 1986.

NCSU is planning to provide for a staff presence to assist and work with the vendor or subcontractor. As an example, graduate students from the School of Engineering may be utilized in preparing drawings for small firms which lack adequate staff. The activity here will be largely that of monitoring progress against pre-established bench marks.

PROGRESS BY PHASES (16 July - 15 October, 1987)

PHASE I PROJECT MANAGEMENT

Activity progress from 2 January - 15 October 1987 is marked off on the MMP activity chart in Appendix I. The DD Form 1473 report documentation page will be prepared by DLA and will be forewarded to ONRR and DESC.

Project management activity for this period includes two industrial review board meetings. The summary of the 18 August 1987 meeting held at NCSU is included as Appendix II. This meeting reviewed vendor proposals received by NCSU to that date and established the fact that the "best and final bid" from vendors was due 21 August 1987. The second IRB meeting 5 October 1987 was held in Atlanta at the Sunbrand headquarters. (See Appendix III) This meeting covered the final bid selection, introduced the selected vendor (ARK, Inc.) to the IRB and solicited open discussion with the vendor on his proposed approach. Data submitted in this report includes:

MMP	Appendix I
IRB Meeting 18 August 1987	Appendix II
IRB Meeting Blessing Letter 19 August 1987	Appendix III
IRB Meeting 5 October 1987	Appendix IV
Best and Final Offer ARK	Appendix V
Best and Final Offer Singer	Appendix VI
Correction to Best and Final Offer Singer	Appendix VII

Offer Acknowledgement	Appendix VIII
Offer Evaluation T. G. Clapp, H. Hamouda	Appendix IX
Exploratory Study Flexibility/Modularity In Automated Apparel Manufacturing Systems - John R. Canada	Appendix X
Subcontract Agreement For Technical Services Between NCSU and ARK, Inc.	Appendix XI

Per DLA request prior submissions and attachments as included in NCSU/DLA - 87/1 report of 15 July 1987 follow. Data included in report 1 as:

Preliminary equipment specifications	Appendix III
Singer/TechStyle Proposal	Appendix IV
Cole Associates Proposal (ARK, Inc.)	Appendix V
Daily News Record article (3/9/87)	Appendix VI
Daily News Record article (3/13/87)	Appendix VIII
Proposal Review questions (Singer and TechStyle)	Appendix VIII
Singer Trip Report - T. Clapp	Appendix IX
Singer Trip Report - H. Hamouda	Appendix X
Proposal Review questions - ARK, Inc.	Appendix XI
ARK Trip Report - T. Clapp	Appendix XII
ARK Trip Report - H. Hamouda	Appendix XIII
ARK Proposal Clarification	Appendix XIV
Style Number and Style Description	Appendix XV
Operation Description	Appendix XVI
Styles in each operation	Appendix XVII
Percent Contribution of an Operation	Appendix XVIII

The current three month period has completed the vendor selection phase. The project is now entering the vendor overview period which will extend from 2 October 1987 up to 1 March 1989 for a maximum of eighteen months.

PHASE II DATA BASE

Since the 15 July 1987 report, Dr. J. R. Canada has completed a preliminary exploration of defining flexibility in an apparel environment. The purpose of this exploration was to establish the nature of a research project in this area. (See Appendix for report) He establishes the areas in which further study might be directed, probably utilizing students.

NCSU is transfering a TI990 computer from industrial engineering to apparel. The addition of this system will more than double the data base capacity. The data base will be arrayed in a varie;ty of sequences for analytical purposes.

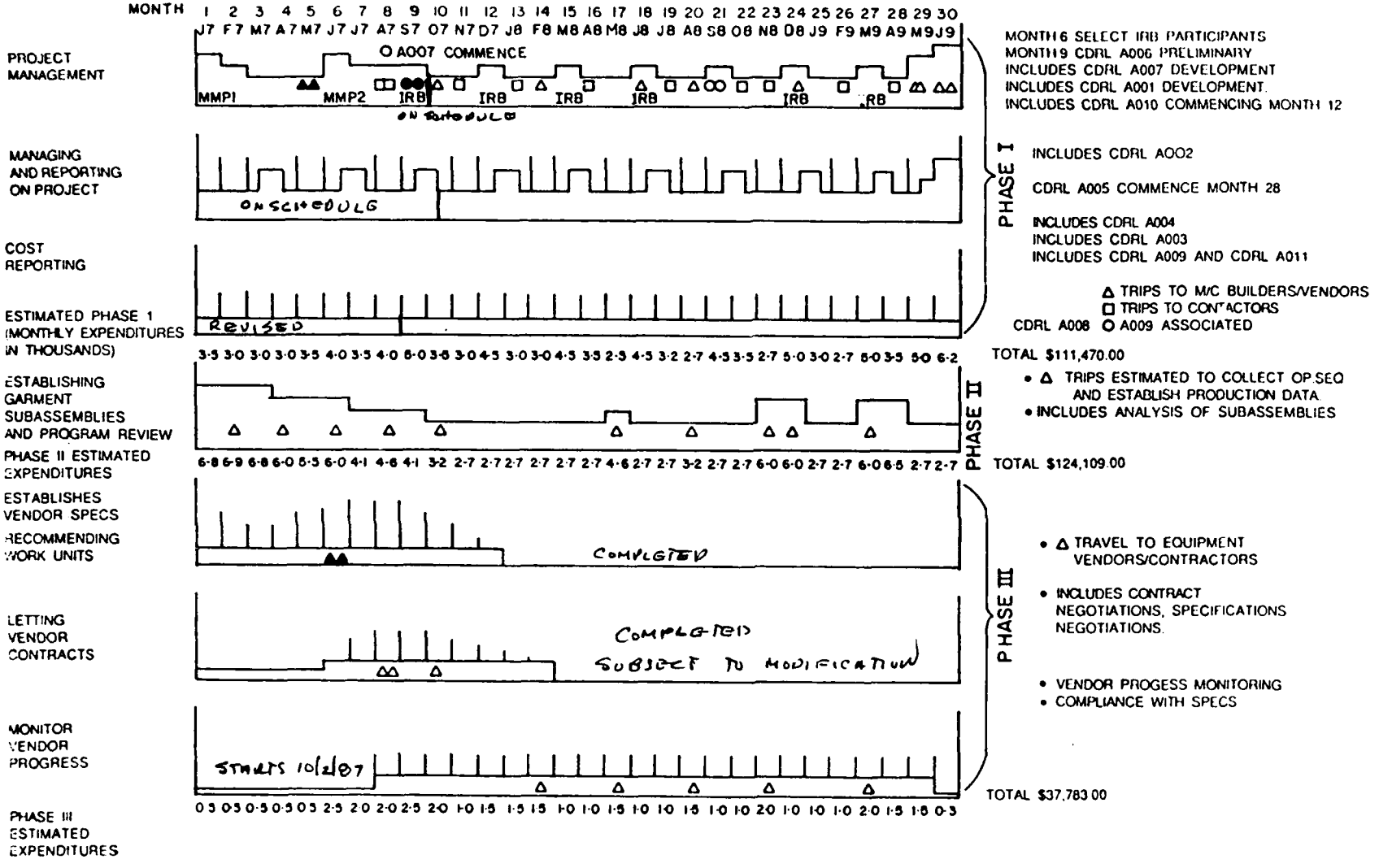
PHASE III RECOMMEND/SPECIFY A WORK UNIT GROUP

As covered in Phase I of this report a contract has been signed by ARK, Inc. and NCSU to produce a work unit. This basically completes Phase III. Although there will be some minor additional activity associated with the contract.

PHASE IV MONITOR THE CONTRACTOR

This phase began with the 5 October 1987 meeting in Atlanta. Check point dates are in the process of being clarified.

DLA 900-87-C-0509 PROPOSAL NO. 86-0849 NCSU-SCHOOL OF TEXTILES JUNE 1987



MONTH 6 SELECT IRB PARTICIPANTS
MONTH 9 CDRL A006 PRELIMINARY
INCLUDES CDRL A007 DEVELOPMENT
INCLUDES CDRL A001 DEVELOPMENT.
INCLUDES CDRL A010 COMMENCING MONTH 12

INCLUDES CDRL A002

CDRL A005 COMMENCE MONTH 28

INCLUDES CDRL A004
INCLUDES CDRL A003
INCLUDES CDRL A009 AND CDRL A011

△ TRIPS TO M/C BUILDERS/VENDORS
□ TRIPS TO CONTRACTORS
CDRL A008 O A009 ASSOCIATED

TOTAL $111,470.00

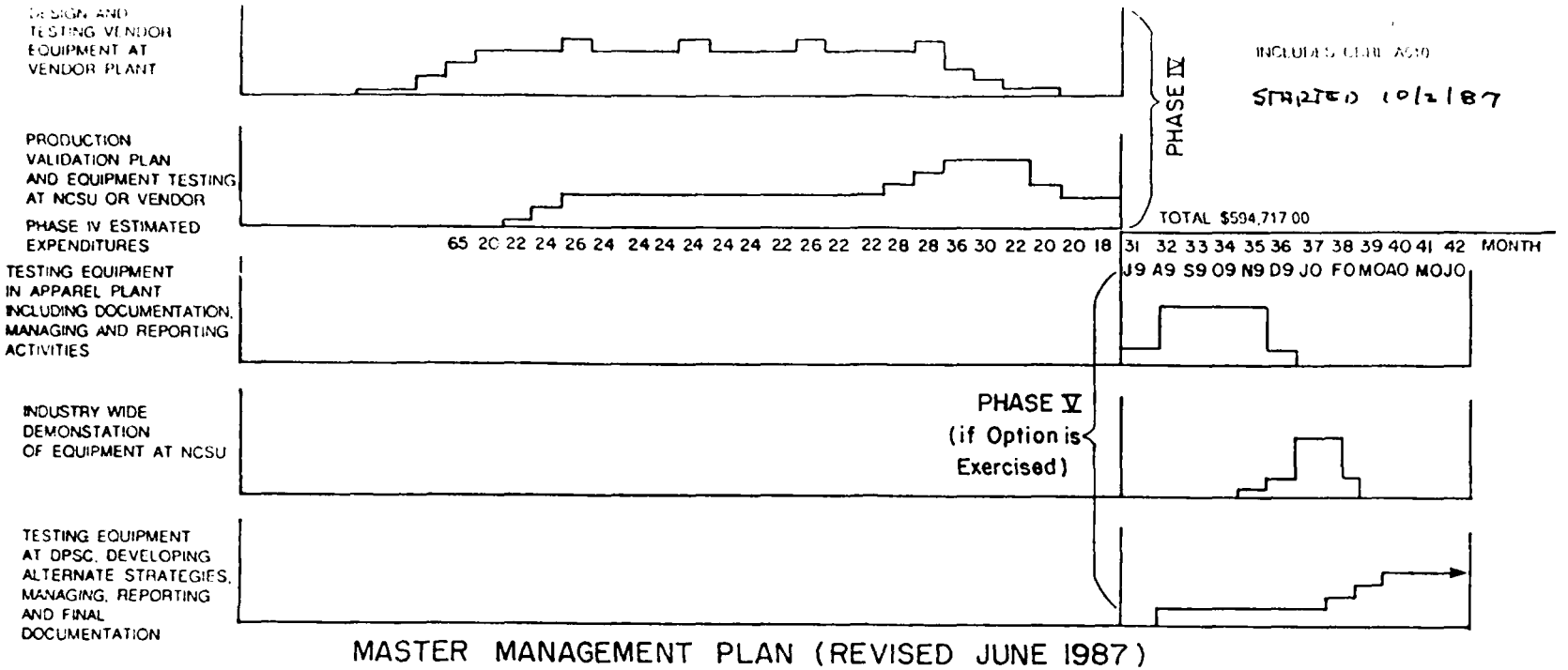
- △ TRIPS ESTIMATED TO COLLECT OP SEQ AND ESTABLISH PRODUCTION DATA.
- INCLUDES ANALYSIS OF SUBASSEMBLIES

TOTAL $124,109.00

- △ TRAVEL TO EQUIPMENT VENDORS/CONTRACTORS
- INCLUDES CONTRACT NEGOTIATIONS, SPECIFICATIONS NEGOTIATIONS.
- VENDOR PROGESS MONITORING
- COMPLIANCE WITH SPECS

TOTAL $37,783.00

APPENDIX I PAGE 1



MASTER MANAGEMENT PLAN (REVISED JUNE 1987)

INDUSTRIAL REVIEW BOARD

MEETING OF AUGUST 18, 1987

ATTENDING FROM INDUSTRY

Hubert Blessing	Levi Straus
Manny Gaetan	Bobbin
Don Moffitt	DPSC
John Nicholson	Tennessee Apparel
Don O'Brien	DLA
Joe Off	$(TC)^2$
Ernst Schraymayer	Jet Sew
Max Tripp	Sun Brand

ABSENT

David Adcock	Allwear Manufacturing
John Wilcox	KSA

ATTENDING FROM NORTH CAROLINA STATE UNIVERSITY

Carol Carrere
Tim G. Clapp
Hechmi Hamouda
Trevor Little
Ed McPherson

ABSENT

John Canada
Karen Hersey
Gerry Isley
W. K. Walsh

CONTENTS

APPENDIX II

Don O'Brien

The meeting was opened with Don O'Brien as the first speaker. He reviewed the origins of the Defense Logistics Agency's Manufacturing technology for Apparel Automation Project. DLA is seeking to develop commercially feasible equipment which can be converted from civilian to military use (or vice versa) in the event of war. The United States sewing operator base has been eroded by imports. The Department of Defense does not want to be dependent upon overseas apparel sources in event of war. DLA staff has expressed some concern that the proposed module might not be flexible enough for multiple use. He feels that the IRB may be able to assist the equipment producer in developing alternate uses for the equipment. He expressed a desire for further marketing surveys and welcomes ideas on how the proposed project can be exploded into other productive areas. He explained that NCSU has a contract with DLA rather than a grant. The contract is to produce viable equipment.

E MCP

McPherson presented a contract overview that included a calendar of events as follows: Proposal submitted to DLA April 1986, cost proposal audited July/August 1986 during which time several amendments were made which reduce original proposal estimate from $1,300,079 to $1,189,163. The amended proposal was approved 12/12/86 and was received at the textile school 12/29/86. The project is broken into seven phases of whic' five are funded.

PHASE I Project Management includes: MMP, reports, IRB, and related expenses $111,470.

PHASE II Development of specifications of garment subassemblies which can be candidates for equipment configurations. $124,109.

PHASE III Recommend a work cell and prepare an equipment specification. Includes advertising for vendors, mailing of specifications, review of specs. with vendor; analysis of replies and

recommending a vendor. Since vendors were to file their "best and final" offers by 5:00pm 8/21/87, the IRB was asked not divulge costs and evaluations until after the deadline. $37,783.

PHASE IV Construction and testing of a modularized work unit capable of being reconfigured to accomodate at least two assembly sequences. This activity includes drawing, regular progress reviews. Initially the work was to be completed in twelve months but has since been extended to eighteen months, $594,717.

PHASE V Reporting costs included above. The currently funded project totals $868,079.00. The next two phases are an option period valued at $321,064 and are to be initiated by a DLA progress review.

PHASE VI Project management six months extension $54,767.

PHASE VII Demonstration on contractors and defense department premises. Each demonstration to be under plant operating conditions for periods of three months. $266,297.00

McPherson then outlined the coming topics with Tim Clapp to speak on evaluation, T. J. Little on MMP, and Carol Carrere on subassembly data. Progress dates since the contract completion are:

ITEM	COMPLETION DATE
Specifications	4/3/87
Vendor Answers	5/15/37
Visit Vendors	6/87
Completed Review	6/15/87
Requested Time Extension	6/19/87
Received Approved Time Extension	6/19/87
Mailed Notice of Extension and request for "Best and Final" Bid	8/13/87
Final Bid Due by 5:00 pm	8/21/87

Dr. Tim Clapp (NOTE: This is taken from a tape recording and contains the usual incomplete statements. Some voice identification may be in error.)

TC - I want to talk about the specification that was written and also the evaluation of the proposals that we received. On the specification Ed and Don have prefaced what I plan to say in that we wanted to design or develop a systems specification to combine 3 parts. We want this to be a success. Ed did not go into what the 3 parts were and I will start it; I am not the apparel expert so Ed will have to help me out as well as Trevor. The project or the work cell would be to take a front pants pocket, military pants pocket, that have a facing and a bearer, take the parts from the cut stacks, assuming face to face cut, and some people do not cut face to face but a lot of the military contractors do and that is the more difficult way to handle the cut stacks. But take the cut stacks, face to face, separate the individual plys and then sew the facing and the barrier on the pocket and then the final operation would be to fold and bag the pocket. So that's the brief outline of the work cell system - take the parts, cut face to face, and produce a bagged pocket to military specks. Which is something of a problem on its own - the people say that military specks are never used and I'll let ... when you take pockets apart and look at them, they are not all done exactly the same. OK. So that's the problem so our bid to develop specifications and use the DOD specifications for combat trouser uniform front pockets to work out system specifications. Now, what were we thinking about when we were writing the specifications? OK. As I mentioned earlier, flexibility is a prime concern. What do we mean by flexibility? How do we define flexibility? John Canada, in Industrial Engineering, is working on defining flexibility for us; but in a practical sense, if this work cell system were to go into a military contractors plant, 1) you would like for it to be able to manufacture all the sizes of the different

military pockets, and 2) you would also like for it to be able to make civilian pockets of similar styles. So it should have the flexibility to make a range of sizes and also be able to very quickly and efficiently switch from military to civilian pockets for making civilian apparel so that you wouldn't be limited to just this particular style of pocket as -

Manny Gaetan - Do you accept questions in the process? TC - "Yes"

Gaetan - So, therefore, you are not only talking about the shape of different kinds of fabrics that civilian would handle - TC - That's right - Now, when we are talking about material -

Gaetan - You have more uniformity of fabrics in military than you have in civilian -

TC - That's right. Now one of the considerations in terms of flexibility that, that material properties, now I am speaking generally here, and if I say something wrong please correct me - but generally speaking, the military contractor that makes the pants generally works in a, I am going to say a narrow fabrics range as oppossed to - they do woven pants, they may make work pants and they wont use knits and real light, so there is a range we feel like they should be able to work in from flexibility of materials also.

McPherson - Let me add one thing here - one of the projects we have is to find out what fabrics present pickers can pick up successfully. That's a separate project, though.

Gaetan - My point is that you might be increasing the cost of the project by perhaps $70,000 by requiring it to handle a wide spectrum of fabrics for civilians that would not be required for the military.

TC - That's true. If we expected that the feeder bottom of the sewing machine separaters to separate knit fabrics or sheer fabrics that would be very unreasonable. By the same token, though, thinking long-term from a general concept, we would like to design, this is talking about the feeder module as an

example, we would like to design the feeder module so that, let's say this feeder module, instead of going to produce military pockets, let's say we wanted to use it in a completely different operation, we wanted to see this feeder module to a knitwear company. OK. The goal would be that the basic module would be the same, the picking mechanism would be different. It may be a vacuum instead of a needle, or it may be an adhesive, but the basic hardware is the same so that would make it more affordable to the, no, I wouldn't really call it mass production, but to be able to take the basic unit and modify the feeding or picking head. But we don't expect, in this project, that the supplier would supply three entirely different picking devices for this project. We don't expect that this project in order to be a success must be able to do knit fabrics or very sheer fabrics and also the military fabrics.

Interrupter - I think this is an interesting point here because the actual pocket bag itself, whether it is civilian or military, falls within fairly reasonable ranges. The big concern, I think, is what these facings and bearers are going to be like, but there is an advantage in that they are small pieces and so we are actually picking and placing these smaller pieces and that is going to be a challenge, I agree, and that's where the most variations will come

(Several muffled voices - cannot distinguish what they are saying -)

Max Tripp - where did you go with this, are you directing this toward military garments basically or it is going to be for commercial and military or nopefully to do both?

TC - Well, I guess Don could address that better than I could but we would like for all apparel manufacturers to want to buy the equipment and if minor modifications were needed for particular manufacturers, let's say they weren't producing military garments but they were producing other garments that had different fabric properties that either the pickers would be changed or the modules, the basic modules would be the same so we would like for civilian manufacturers to go with that that they would be interested in it also.

John Nicholson - Well, I can understand that. We have been making dress trousers for the military for 30 some years and we make the Marine Corps, the Air Force, the Army, the Navy. All have some few minor differences, but we have also made the battle dress trousers which is different in shape and size but we don't do commercial work but very, very seldom, and you won't find many government contractors that jump back and forth between commercial and military. So basically your thrust is either military or commercial so that we don't need to have a machine that will do both of them. If we are going to do military then that is what we would look at and the commercial guy, I guess, would look at the commercial.

Don O'Brien - If I could just address that for a second. One of the rationales for the program that we are pursuing is we want to be able to bring online a wide variety of contractors in a very short period of time if there were some kind of national emergency or something like that. So the requirement in the statement of work is to produce a military and a civilian type of garment and the rationale here is within the context of what Tim was saying about changing out the feeder and optional pickers is that we would want as much commonality between commercial and military contractors as possible so that the commercial contractors could very easily pick up government work without massive change overs.

Joe Off - That is true, we have made the Levis, we've made big commercial manufacturers and it is basically the same operation. We wouldn't have any problem, not to my knowledge, ... highly styled items you might get into some problems on the volume items you are looking at here but basically the same ...

Don O'Brien - Well, I guess the other point I want to make is that, and I was a little concerned about this, is that the final parts that were selected represented something that was a compromise, Ed can feel free to correct me, but between something that was doable and something that was representative of a technical challenge. It was a balance of all the constraints that would be put on a project but I don't really hope that the project is not perceived as only a pocket machine or a pocket capability but a broader range of capability that would have similar size parts, let's say, within some geometric constraint on handling the material. So that, the pocket was selected because it was a real part and it demonstrated the new technical achievement but it is not specifically a pocket machine, it is supposed to be a more general purpose machine and . . . .

McPherson - Let me talk a little bit about the principle. The principle we are trying to demonstrate here is we have lots of machines right now that can put one piece against another piece and sew. But they haven't gone to three. Now, we are looking at an area here of about two feet by two feet that we are going to assemble something on and the basis I look at this is, with minor modifications of the programs, we can run the arms and the pickers, we should be able, in that same area, assemble other types of things either by modifying the program or by modifying the pickers. But what we are looking at is an area of assembly which allows us to do more than is being done now. We are trying to make it as inexpensive as possible, because if we don't make it inexpensive, nobody is going to buy it.

Hubert Blessing - Gentleman (with strong accent - Unable to understand. NOTE: Separate recap is being made)

McPherson - This is nothing but equipment capable of expansion. What you do is start checking pocket alternatives as well as other places it can be used. But that is really what we are after. OK, Tim, we have busted you up a bit -

TC - That's all right. We have touched on modularity which is basically developing units and we have been using the feeder unit as our example. We have the registration units and other units in there but modularity in terms of having uniform electronics, being able to connect mechanically to take these modular units and reconfigure them, not on a daily basis like "I need this feeder module over here tomorrow". That's not really what we are looking at in terms of flexibility but being able to take that feeder module and, instead of feeding bearers or facings, be able to feed another small part. So, you are still working with the basic module but you may change the feeding head or the picker device. So, it is working towards commonality of a basic system and if we could, long term from the university perspective and thinking years down the road in quick response and flexibility, it would be nice to be able to have the designer design the garment and once that two-dimensional pattern is in the marker maker, that information could be used to communicate to the manufacturing floor, take that information to make flexible change. That's long-term but we do that sort of thing at the university - we think in those terms. And commonality of the electronic controls to be able to send that information down with that ability to change is very important there. Retail calls ... chance of success. We wanted to do something that we had a high chance of success. We don't want this to be a failure, Ed doesn't - he doesn't want to go off into retirement being a failure with this contract. I am sure Don doesn't

want to be a failure either so I guess that was one of the considerations with taking small parts and with taking this pocket assembly. Also, using as much existing technology as possible, in developing this work cell, it is critical in making it a success. In retail calls, using existing technology is also critical here. In minimizing the retail calls so that the apparel manufacturer can justify purchasing this system and acceptance by the apparel manufacturers. I don't know if the total bottom line is cost, but I know it is very important. It is also quality aspects and in the specifications we want to produce the parts that are of equal if not greater quality than can be produced by hand.

OK. Now I want to address the question about whether it is a prototype or a production machine. We specified that once the system was built, an initial prototype would be done at the facility where its manufactured and then the succeeding step would be to go into a production operation and actually run extensive production testing (McPherson - It may take 3 months to test it) so it would go through a fairly extensive production testing.

As far as the design of the system, I was trying to describe the problems more than anything else and our goals that we would like to accomplish in the system. We specifically did not spell out how we wanted it designed and we left this up to the creativity of the vendors making the proposals. We may have wanted to do something like that but we specifically did not say that this module would have to be connected to this module and and we didn't define the modules. We basically said a feeder module, a registration module, very general. So it was left up to the vendor in the proposal to configure these modules in the way he felt was the most appropriate.

In order to assure the widest publicity possible for potential project bidders, two articles were published in the Daily News Record. Calls were received expressing interest in the specification together with sample pockets

were sent to these nine firms. These firms - I have got AMF down twice, it was sent to Richmond and to Joe Off in Texas, so these were sent out. To May 15, which was our deadline, two proposals has been received. The proposals were submitted by -

Manny Gaetan - Excuse me - Is this in the handouts?

TC - It's not in mine.

Manny Gaetan - I want to make a list of the -

TC - Oh, OK, excuse me -- I can give you a copy, they will be included in the minutes (McPherson - we will read them to you in a minute)

Manny Gaetan - Oh, I'm through - I'm sorry.

TC - OK, I'm sorry. Proposals were submitted by Singer Sewing in concert with TexStyles Incorporated, and also a proposal was submitted by ARK Incorporated. Now AMF requested an extension in time involved for proposal completion and advised us that they could not complete the work cell in under 2 years. Our initial time specification was one year and that has been extended now to 18 months. Singer Sewing have in concert with TexStyle Incorporated in the quotation made a proposal. In the proposal TexStyles Inc. is listed as the primary subcontractor in the proposal. There was some collaboration between TexStyles Inc. and Singer Sewing and I will address that in a little more detail in a minute. ARK Inc., the small firm that produces machinery for apparel and Textile-related companies, is a sister corporation to Cole and Associates. Cole and Associates are primarily consultants for the apparel and related companies. Cole and Associates and ARK Inc. provide, I guess, total services to apparel and textile-related companies. Cole and Associates is more the industrial engineering branch and ARK Inc. is the machinery side of the -

McPherson - ARC Inc. was formerly Apparel Research Kellwood and Bill

Cole bought that when he left Kellwood - it's about 25 years old and they have built special purpose machines for years.

TC - The bids were reviewed by our staff at NCSU and plant visits were scheduled. Dr. Hamouda and I visited Singer and ARK to evaluate the facilities and ask technical questions pertaining to each proposal. I had previously visited TexStyles, the TexStyles facilities, so I was familiar with their facilities and technical staff there.

At this time, I would like to describe the conceptual design of each of the proposals. I feel that once we look at the conceptual design then we will be able to compare the two.

... Now I want to, I guess, reiterate what Ed had said earlier, the contract has not been let yet. So I guess confidentiality is (McPherson - yes, we would appreciate if nobody discusses anything that you hear here today - until after the 21st). This is the Singer/TexStyles conceptual design of the combat trouser work segment. Let me try to go through the system, or the work cell, and you can get a very good idea of the conceptual design.(NOTE: Used a slide and a pointer here). We have basically, three feeder modules, this feeds the pocket, the barrier and the facing and each of the feeder modules has in series with it, a flipper module, which is assuming you have a face to face cut. The flipper module there is to flip every other part. If you were not cutting face to face you would not even need this module. Then there is the registration module to register the part so that you know where it is located, transport it into a combiner module that combines the pocket and the barrier so at this point the barrier and the pocket are orientated and registered on top of each other, transferred through a sewing module. The sewing module would sew the barrier onto the pocket. This is transferred to another registration module and at this point the low facing bundles are separated, flipped as necessary, registered, and combined with the pocket which already has the barrier sewed onto it. At

this point, the third part it is registered and placed on the pocket. The pocket is then moved into the next sewing module which sews the facing, sews this part onto the pocket and then it is transported to a folding and bagging operation which is not shown here. The proposal that was submitted, basically submitted in terms of two options. One, this option and the additional option would have a folder and a bagger to bag the pocket and then to stack it. So, in this area there would be a folder and a bagger and then the stacker. Any questions, generally, about the conceptual drawing?

? You said one of your interests was to use known technology - does any of this require new frontiers of technology?

TC - Well, it is hard to answer that - particularly for me because of our visit to Singer. When we visited Singer, Dr. Hamouda and I visited the facilities and our primary goal was to evaluate the facilities and ask technical questions about the conceptual design. As to those questions, how much of this is commercial or production proven equipment? I think one of the specific questions I asked was "If you had to assemble this system today, how much of the assembly drawings and equipment drawings, these type drawings, could you provide?" If there was one of these systems that was already, let's say they had bought a feeder module from a company, or let's say a bagger, let's say they bought a commercial bagger, well they could provide those drawings, that was a general question. The first question I asked Singer, though, was I knew it was a joint proposal, my first question was who has prime responsibility or accountability for the project? And Jim Lower, who many of you know is no longer with Singer, was our prime contact at Singer and at our visit he stated that Singer had prime responsibility for the contract and that TexStyle Inc., as stated in the proposal, was a primary subcontractor to be used to assist in the development of the system. So, I began to ask some general technical questions to the best of my ability. One question I asked was, we will use the feeder as an example, why are the feeders round? It seems like it takes up a lot of floor

space. I am just asking a basic question. Singer responded, well, we don't know if we are going to use round feeders, we will probably use a belt feeder. And I said, OK, what about the transfer devices or the cloth separation devices, Singer has several devices - we really don't know which, you know, we really haven't decided on what device we are going to use. They assured us that whatever they supplied would meet the specifications. Yes sir -

Off - I just wanted to ask - for example, if you are going to put it in the round, you already have it stacked, why are you going to stack it manually instead of picking from the cartridge if it is already stacked?

McPherson - That is what we basically have -

Off - Right - but the question I asked you is because this concept looks very similar to a prototype two years ago at the Bobbin Show under the Georgia Tech contract.

TC - Exactly.

Off - So, this leads me to believe there is a considerable amount of work that has already been done in this area.

Blessing - Of course, we are all aware of that from a technology point of view, I don't want to call it it's ??? but shortly thereafter, here is my reasoning - you combine two pieces, all right, subsequent to each one - let me explain - you culminate any kind of ?? you have ??? what you do you feed one piece ??? and you take the second piece which you want to lead when you pick it up since in time and time phase they are 180 degrees apart so you have plenty of time to get a fast ??? (cannot understand but every few words). So if you ask me do I see anything new in technology, I see nothing what is not at least 10 years old. (NOTE: This is being retyped separately)

Off - Tim, while you were at Singer, did you see any other piece of equipment?

TC - OK, in the morning, we went to the $(TC)^2$ facility at Fairfield, I guess the $(TC)^2$ machine is being developed for commercial application.

Off - Well, let me be a little bit more specific - Did you see any piece of equipment that was working in that operation.

TC - I don't know - At the Bobbin Show did you - they had a pocket -

McP - You didn't see it at Singer?

TC - Yes I did, (lots of overlapping voices) we didn't see this at Singer, but in other words, we saw a pocket machine that was, it was basically a jeans pocket, they were putting the facing on the pocket at Singer and they demonstrated it at the Bobbin Show, I don't know if it was last year or the year before.

Off - Last year.

TC - OK, It's one complete unit and they had, I think, two large robots hooked to it, one to combine the pieces, it may have been one to combine and the other one to move it through the sewing unit.

Off - They put the facings on, putting the watchpocket on, bagging it and finishing it all in one machine with two heads - You saw that?

TC - That's right - we did see that - OK.

McP - That machine isn't what they proposed.

Off - I realize that, that's where I am headed, I just wanted to make sure they had seen this piece of equipment -

TC - Yes, we did see it and I did ask the question how much, if I wanted to buy this machine, how much would it cost and they said around $250,000

Off - Good deal -

TC - OK, Now, but here is the other point that you bringing up that is very important. When we look at this conceptual design that was proposed to us, there is virtually no or very little Singer technology. This is primarily a design by TexStyles which is very similar to the Bobbin Show prototype. When I was at TexStyles visiting their facilities, this was a little over a year ago, I saw the basic system they showed at the Bobbin Show in 1984. I was told at that time it was prepared to run at the Bobbin Show and had not been

run since. Now, that was a year and a half ago, OK, so I don't know if it has been pursued since then and I am not sure if it has been in extensive production/testing or not, but when I was there I did not see it, was not able to see it run.

Nicholson - I have a question - Someone earlier said something about this concept of assembly had to be able to use hand cut goods and I think this is critical to this whole program. Go back 40 years ago to my first operation I was testing methods on and the standards which set cutting standard composites with Kurt Salmon, and we basically are doing the operation the same as we did then except new machinery for some and so forth but it is one of our toughest operations in our company to train and maintain the quality workmanship and right now we are looking at dye cutting of pockets and getting a more accurate cutting on the facings because those girls are constantly moving those facings up and down the pocket to make it come together properly, and I think that if it is important to have anything like this succeed *you are going* to have to have a more accurate cutting that we have been able to do and most people can do with hand cutting, you are going to have to have dye cutting, you are going to have to have automated cutting of some sorts. I think it is critical that it is not going to be hand cut to be successful in my opinion.

Gaetan - Tim, could I ask a question here? When are you going to have a standard. What is the variation in those cut pockets, is it plus or minus 16, plus or minus 8, just the dimensions.

Nicholson - Well, we say you should hold it within an eighth, but unfortunately they don't. If they cut that pocket manually it can vary up to a quarter or a half.

? - There you go - Yes Sir.

(Overlapping voices) - Gentleman (with strong accent - cannot understand.)

? Military is a straight pocket - (overlapping voices again.)

Gentleman (with strong accent again.)

McPherson - Why don't you move along to the others -

TC - Ok, the last point I want to make about this before I move along is it is a series operation and generally speaking, in a series operation, any module failure will reduce the whole system's efficiency. Hubert, would you agree with that, and in the proposal they propose that this system will work at 95 per cent efficiency at a production rate of 3,500 pairs per day or 7,000 pockets per day.

And now I want to talk about -

? - Thirty-five hundred pair a day bagged pockets

TC - yes, bagged pockets - one every four seconds. That was quoted in the statement of proposals.

Now, ARK Inc. conceptual design is not as drawn to scale it is more conceptual as - they have a different approach. Their approach is, first thing they want to do is turn in the modular parts, ok, because they are going to do the initial cloth separation - take the cut parts - use a turning system to separate right from left and this turning device system will be used for all the parts - any small parts that need to be turned right and left will be run on this system. The next system is a serger which would search the facings and the barriers. Th specification for this is if you don't serge? you have to fold. Is that right?

McPherson - The specifications say that you can either serge or fold.

TC - They prefer serging because folding is more difficult to accomplish.

Blessing - Why not top stitch, makes a much better quality garment than serging?

McPherson - We would probably be able to get better quality. The stitch makes a much nicer garment but right now we are meeting the DOD specifications -

O'Brien - does not allow it -

McP - DOD doesn't allow it - that doesn't mean that a lot of people don't do it -

Tripp - Serging operation, 503 type stitching - - you are talking 406 or a (Accent again).

Mumbled voices -

TC - The serger is a separate design system that would serge most any small part. It would serge the facings and the barriers without any reprogramming or any modification. Now, both of these systems run at a much higher speed than what we will call the assembly system - the combining of the facing and the pocket - and they have been separated, they can still be monitored by the controller and they can be placed in a work cell type of operation with all of these units around the controller, but in the design they felt like it would be better for several reasons to separate these out. One is the productivity of these two machines is much higher than this machine, also that added flexibility this turning divider could be in the cutting room - it does not have to be with the work cell - the serger, if you were serging other small parts, it may be with the other sergers in the plant - also, they were very concerned about system efficiency. That these modules would be - would not effective - as you add sewing modules, that was their prime concern that if you put sewing modules in series you really reduce the overall efficiency of the system. That's why they have presented an alternate method of the assembly which basically the assembly system is you have three feeder modules which feed into a registration unit. The registration unit - well is the combining unit and this is the registration unit that registers the orientation to it so they know where the pocket is located. Let's move into the sewing system - let me get my notes here - OK the sewing system - these two sewing modules are something like a Pfaff 438 lock stitch. Their philosophy is to, the more you have to move the pocket material, the more chance you have for having problems so they are going to move the pocket into position and then clamp the pocket and then sew around the facing and the barrier. They are holding the pocket stationary and moving the sewing machine. They will use an

Omni directional 301 stitch. This is what they are - you know more about that than I do. Now, the next step would be to combine the barrier with the facing on the pocket, again registered and a simpler sewing operation, sewing module as this one, say the Pfaff 438 lock stitch machine, now they continued with a folder that would fold the pocket and then a bagger and a staffer. Their alternative method, which they feel would be better from an overall efficiency point of view, is to separate this out again so that you don't have three sewing systems in series and bag the pocket with a similar system. Now all of these units will have the same basic electronic control modules, independent controllers. These can run independently or in conjunction with a controller. Now all of these units will have the same basic electronic control modules, independent controllers. These can run independently or in conjunction with a controller. In other words, if you wanted all of these machines in one physical location with one operator primarily as a tender, you could do that, or if you wanted to move the right and left part separation to the cutting room or the small parts serger to another place in the plant, you could do that also.

Off - Your bobbin machinery requires, that is your lock stitch requires a bobbin - by changing it to 401 stitch is a way so they would not have to change the bobbin, OK -

(Mumbled voices -)

? How does he get from one unit to the next one?

TC - OK, the operator would physically move the finished stack from one operation to another -

Blessing - In other words, move the stocks

TC - Stacks, right, bundles, now their operation procedure is basically to do a stack of rights and a stack of lefts, or bundles, almost in a bundle concept for each cut. I guess he would separate rights and lefts and that bundle of rights would go into the bundles of lefts would go into the system.

Blessing - (cannot understand.)

(Several mumbled voices -)

Blessing - There is a lot to be said for setting up right and left assembly of pants panels.

TC - I think he -

(Accent) - NO - ???

Schamayr - In the fact that you have an operator handling bundles raises the question, in this ARK proposal - in the first Singer/Textiles there is one pocket every four seconds, how many people in that one cell?

TC - One

Schamayr - One person - how about in this one? One person also. What is the output?

TC - they are very pragmatic, they say between two to four thousand pair of pockets per day, per shift, excuse me, two thousand to four thousand pair per shift.

Gaetan - Two thousand to four thousand (Right) when you say they are very pragmatic, does that imply the other is not?

TC and McPherson talking at the same time -

TC - they gave a range, they can't say, they would not say that this machine would produce 3 thousand pairs a day

Other mumbled voices -

McP - we specified that whatever the proposal stated had to have a minimum of 2 thousand pair - so they meant the minimum - they said they would do that but they wouldn't tell us exactly how much more

Mumbled voices again -

TC - Production is important from the stand point of return on investment, and also the higher the proven speed of the system the more you ask for the system -

Tripp - Set up and the cost.

TC - OK, that's my next slide -

O'Brien - Let me ask one question - did he ever address what the

controller

McP - The controller keeps track of thread breaks, everything - it meets defense department specifications

O'Brien - Well, that goes without saying, I was just wondering -

McP - Keeps track of everything going down - of anything going wrong -

O'Brien - OK, go ahead -

Off - Excuse me, there are simple controllers on the market that can do all this so right off the shelf packages right now so I would -(Overlapping talking)

TC - Let me address that controller question briefly. We did address that and they said that they would go with a microprocesser system that would be more of a monitor than a controller. It would monitor these units and alert the operator to the problems and also it would be a controller in a sense of working with these sewing modules - let's take for example you had, well the different sizes, OK, when you change sizes you would have to change the path of the sewing head so those programs would be programmed in the controller so the operator would see her ticket size 12 and she would go to the computer and set up that size 12 right panels are coming down the line and she would, the microprocesser, those programs would control that numerical control sewing -

Moffit - When you make those pockets on this machine you've got to alternate the rights and lefts in sequence - correct?

TC - No. He is going to do it in bundles, well sequence in terms of he is going to send say a bundle of rights then a bundle of lefts to the same lots.

Moffitt - Is the other one doing the same thing or alternating one and one?

TC - The other one, based on that proposal, is one right, one left, one right, one left, because as you take them off the stacks and there's circular feeders you are going to be picking up a right facing and a left facing, right pocket, left pocket. Yes sir -

TC - OK, I guess the point I want to make with both systems is they can do right and left so if you want to have this system just do right, you could

just feed right or with both systems, they both have that flexibility.

Nicholson - Just remember, if you go with the military, you don't have to worry too much about shaping, when you get into civilian goods you start getting into shaping and when you start splitting bundles like that you really have to watch your shaping or you are in really big trouble.

(Several overlapping voices -)

IC - any other questions - OK - compared to Ed, if I am running over my time allotment, I'll stop - I am just about finished. OK, we try to do a comparison between the Singer/TexStyles proposal and the ARK proposal - flexibility, yes for both of them, it's a hard thing to say yes its definitely flexible until it's built so both proposals get the yes in flexibility, modularity, yes; electronic control, yes; facilities in visiting the Singer built facilities and the TexStyles facilities - each facility in itself is capable of producing the proposed equipment. The ARK facilities, their philosophy is to use subcontractors, they have, basically, a small facility where they assemble the complete machine and they subcontract out like their electronic controls, a lot of their machining, they have prototyping capabilities, if they need to make a modification they have the machines, the lathes, the drill presses and things of this nature to assemble machinery and make minor modifications. I was concerned about that - they are located in Shelbyville, Tennessee, I said what else is around Shelbyville and they provided a list of subcontractors that they normally use that are very close to the Huntsville space center and there are a lot of high tech operations around there. John, you could probably speak to that in that area, so

Nicholson - I think, also, with the auto engineering development center they have access to and they have some very sophisticated tool and dye makers, machine shops that serve all this area that have extremely competent people running this -

TC - and at our meeting with ARK, Inc., the electronics subcontractor was there and prepared to meet with us so he was very knowledgeable on the systems, he presented a lot of options, controls that we might consider so we feel confident about the subcontractor. We also looked at a machine ARK had just finished putting together - a finished production machine - and we were able to look at the subcontractor work first hand-at their machining, welding, electronics, wiring, and things of this nature. So, very good -

(Several voices at the same time -)

TC - I will address that, I knew that would be an important point - we feel like all parties are capably competent, ARK provided a list of machinery they have provided that is in production a wide range and we know Singer has a track record also and TexStyles, Inc., produced production machinery also -

Gaetan - They produced equipment - my question is, what kind of automatic equipment? There is a big difference when you jump from plain piece of equipment where an operator feeds it and to a fully automatic piece of equipment. Has ... (cannot understand)

McP - ARK has - ARK has built automatic equipment ranging from assembly of tents through home furnishings to hosiery -

Tripp - I believe they have also produced equipment that has been manufactured by their suppliers to the industry that are in commercial use today.

McP - Well in, they are represented by some of these equipment firms.

Tripp - And not just one, by several.

Gaetan - TexStyles - automatic Sheet Hemmer

McP - and Singer has produced some of these - the question being introduced in automatic piece of equipment

? - I think it is going to boil down to, in my opinion, is the, if remember be at ?? evaluating proposals, it gets to the point of ... price is the soundness of the proposal, you have a tough job because the proposals have different

proposals. We have here a man who is very competent in the area and ... and if he can divorce himself from what he knows, ... evaluate two concepts, otherwise we are going to have to subpoena ?? and have him ?? every 2.6 seconds -

? - I don't think that's sufficient information ... I think the Singer proposal ... pretty unrealistic - I don't many things ... it is only supposed to be sketchy, the second one is very sketchy, so you can imagine a lot of things and maybe it is fantastic, but - I don't know. The second proposal is so sketchy I can visualize the whole machine, all of us can, but I don't know if we visualize the same thing.

? - How much of the concept ... (several garbled voices - Accent again -)

TC - I think the answer to the question - there was a concept. Now, Singer's response to what specific equipment will be used is not really a deciding factor or a major factor because we are talking about concept. If we go back to the sketch, the concept is what is important - the series concept, the feeder, registration, and how they do it, not as the technical part of a circular feeder - they could produce this machine - if they got the contract they could produce this machine. In talking with Singer, what they plan to do was once the contract was let, assuming they got the contract, then they would sit down with North Carolina State University and DLA and other officials and hammer out some more of the details. Yes sir -

? - My concern, is that what we saw from ARK in concept appears very solid but when you translate that concept into something that looks more tangible, maybe either more cumbersome more simpler than what Singer proposed - so we don't know

McP - then there - he didn't put the whole written response up -

? - Who's he -

McP - Tim, - the proposal response in the case of ARK detailed the machine they are proposing to use and the sequence of operation, that was in

writing, not in drawings, whereas the other proposal put up drawings and didn't tell what was going to be in it.

?... the expense of writing.

McP - Yes - it is very possible he knows how he is going to make this thing work -

? - If I had to make a judgment right now, it would be the ARK proposal because there isn't enough to pick apart -

TC - that is a very valid point. Ed is correct in that ARK had much more written details and Singer/Texstyles had much more graphic details. And so we -

TJL -I think that we should probably add that we got our meeting out of line by about one week, that's essentially, and at the planning of this first IRB meeting we were at that stage going back two months, six weeks, something like that, we anticipated we would share with you the entire proposals and all the details, but as Ed said earlier, the bids actually don't close until Friday and we don't feel it is really fair to give you the full thing ... absolutely available

McP - They will be available as soon as we get a closing

TJL - So just hold it now until 5 o'clock Friday - thereafter you can have carte blanche to all the details, but I think it is -

(Mumbled voices - Accent again -)

McP - I feel comfortable with the procedure he has outlined and that basically as he has it, he has check points, when things are going to be done, what ... have to be made, what drawings have to be done, etc., he has set himself up a program of objectives, now that doesn't mean he won't miss something. We set a program of objectives, too, and we are already a year behind.

? - I have a question I would like to ask - was it your intention with this group to serve as an evaluation committee on these proposals?

McP - No it was our intention for this group to monitor and evaluate the progress and correct any errors that they see occur.

? - So therefore, we are not going to be involved in any evaluation of these proposals.

McP - No, your viewpoints are definitely welcome, please don't misunderstand me. The purpose of the review board is to review the progress, be sure that we are not straying, that we are not wasting money, that we are not going off the deep end.

TJL - I think that you should also add that the technology is going to be visible -

McP - Yes, it is going to be visible, it is going to be practical - we can cut the thing off at any time -

Gaetan - What recourse do you have if they start missing dates or if the equipment is not as practical?

McP - Requiring performance Bond

TJL - That comes under the contract letting procedure through N. C. State the successful bidder ...

(Accent again -)

McP - Progress payments. We will review to determine if they have met their target that has been set and we will make payment - So we have a test, we have to get all our money back, we have progress payments based on review, we got objectives that will be set as to what is to be ready when

Gaetan - In what you described was the narrative of the ARK proposal you said you had check points, when to submit reports, bills and so forth and so on, that sounds to me a little administrative rather than technical, what kind of equipment, what stage, what kind of sensors, what kind of picking device, is that addressed fully there or just administrative when ...

McP - he mentions specific sewing equipment

TJL - Stitch times, methods of registration and sensors and things like that -

TC - There is more detail and justification of concept. He, Ark Inc.,

describes the reason for having the turning device separate, the reason for the concept and that was very important to me in that when we visited ARK they basically justified their concept based on their experience with manufacturing people.

McP - They also provided us with the location of the turning device that he's built. It is running and has been running for 4 years and thinks this....

TC - For example, ... both systems one operator would be required with a skill level, I put average, from a standpoint of being a computer programmer, productivity 3,500 pair a day 7,000 pockets per day, ARK has between 2 and 4 thousand pairs per day for 8,000 pockets per day. Existing technology, now, the reason why I put a question mark here is that Singer's comment was that we don't know what feeder unit we will use, we don't know what devices we are going to use, they basically said that the sewing modules and registation unit that had been developed by Textiles look very promising and other equipment may or may not be used. So, I didn't get a definitive or a very good answer on how much would be new developed or how much was existing. To contrast that with ARK, they estimated 60 to 80 per cent of the equipment is already available. They have built a turning/divide machine the closed loop serger is a new machine.

McP - that a new device -

TC - That's the new - OK - they specified the sewing systems that were used and they would buy a commercial bagger so they estimated, in their opinion, that 60 to 80 per cent would be existing technology. Completion time 15 to 17 months. Now the Singer proposal stated that they would complete it in 12 months without the bagger. With the bagger option it would be another 3 to 5 months with the bagger addition so that was part of what we were specifying so their completion time was actually 15 to 17 months. ARK, Inc. was 16 to 18.

Don Moffitt - could have the ultimate responsibility as far as Singer and TexStyles - who is actually going to build and deliver the piece of equipment -

TC - OK, the question that I asked when we visited Singer, Jim Lower, who was the Vice President at that time, stated very clearly, and Dr. Hamouda can support me on this, they had prime responsibility and accountability -

McP - They didn't say where they would do it -

TC - Now they, as far as where they were going to be built, they said they would build it at the place that would be best suited - as an example, they said if Piedmont, South Carolina was physically closer for us to go to TexStyles to check on the manufacturing, it could be there. Or, if TexStyles were going to produce the sewing modules and the registration modules, they may be built there, other parts would be built at the Singer facility. So they were very flexible in meeting with us in deciding where it would be built. So, I don't have any concern about, location really wasn't a concern there. Singer, as far as prime responsibility, they would have prime responsibility to see that the contract got done - finished ... specification. Yes sir -

Nicholson - What is the total completed cost package of this contract? The equipment side?

TC - continuing with the comparison - I have the manufacturing costs - the cost of the manufacturing, to make the system - not to sell it but to make the system - is estimated at $165,000 plus

McP - That's the production model -

TC - Yes, that's the production model, not the prototype. They estimate if you were going to sell it to the apparel manufacturer, that on production equipment, where you are going to make more than one, it would be $165,000 and the plus is an addition to the bagger, they basically quoted or estimated that it would be $165,000 for the sewing system and the bagger would be in addition -

? - How much more?

TC - Well, their - OK, I estimate - they quote the bagger at retail being $70,000, now their markup on $165,000 to $250,000, I added another $70,000 to get up to $320,000, that includes the bagger, they said the bagger option would be $70,000 at retail and they are marking it up 51% so this figure, if you included the bagger, in my estimation would be $211,000 to manufacture. So they said they would retail it at $320,000 -

(Accent) -???

TC - OK, their economic justification for this was very important, their economic justification was two-shift operation, high productivity for a two-year payback. OK, for -

(Accent - ???, many mumbled voices)

TC - I am just restating their proposal presented in their economic justification. ARK estimated that they were trying to produce the system, the production system for between $40,000 and $60,000 and the question mark here, for the retail cost, they said whatever the market will bear. If their production is high and they can sell it for $100,000 or $150,000, if they can get a one-year payback on it, then that is what they would charge at retail.

Nicholson - So they don't know what it would be at retail -

TC - It depends on the production and justification. The proposal being, now I had these numbers in and Ed said we'd better take them out because the contract hasn't been let, but Singer is substantially higher and if Ed wants to elaborate any more - you can - that's all I am going to say about it -

McP - I just want to say one thing, their bid was more money when we have for the whole job - Their bid was for more money than we received from the government for the whole job

? - More than a million dollars -

McP - I didn't say that -

TC - Ed - you will have to qualify that -

McP - What we have received to date - which means all phases including this meeting -

(Accent - ???)

McP - It is a practical number -

(Accent - ???)

Nicholson - As I recall - and it's been a long time - but I think the production rate on that and the way we are sewing is probably about 500 per day, so if you are talking about 3,000 you are talking about 6 and you have to have one attendant for this so you are eliminating 5 operators at $200 a week that's not enough to pay out.

T H E E N D!

Tape Ran Out But 95% is Included

Specifications Considerations

- Flexibility
- Modularity
- Chance of Success
- Retail Cost
- Acceptance by Apparel Manufacturer

LEVI STRAUSS	UNION SPECIAL
TEXNOLOGY SYSTEMS	AMF
SINGER SEWING	JET SEW
TECHSTYLE	ARK, INC.

Proposals Submitted by :

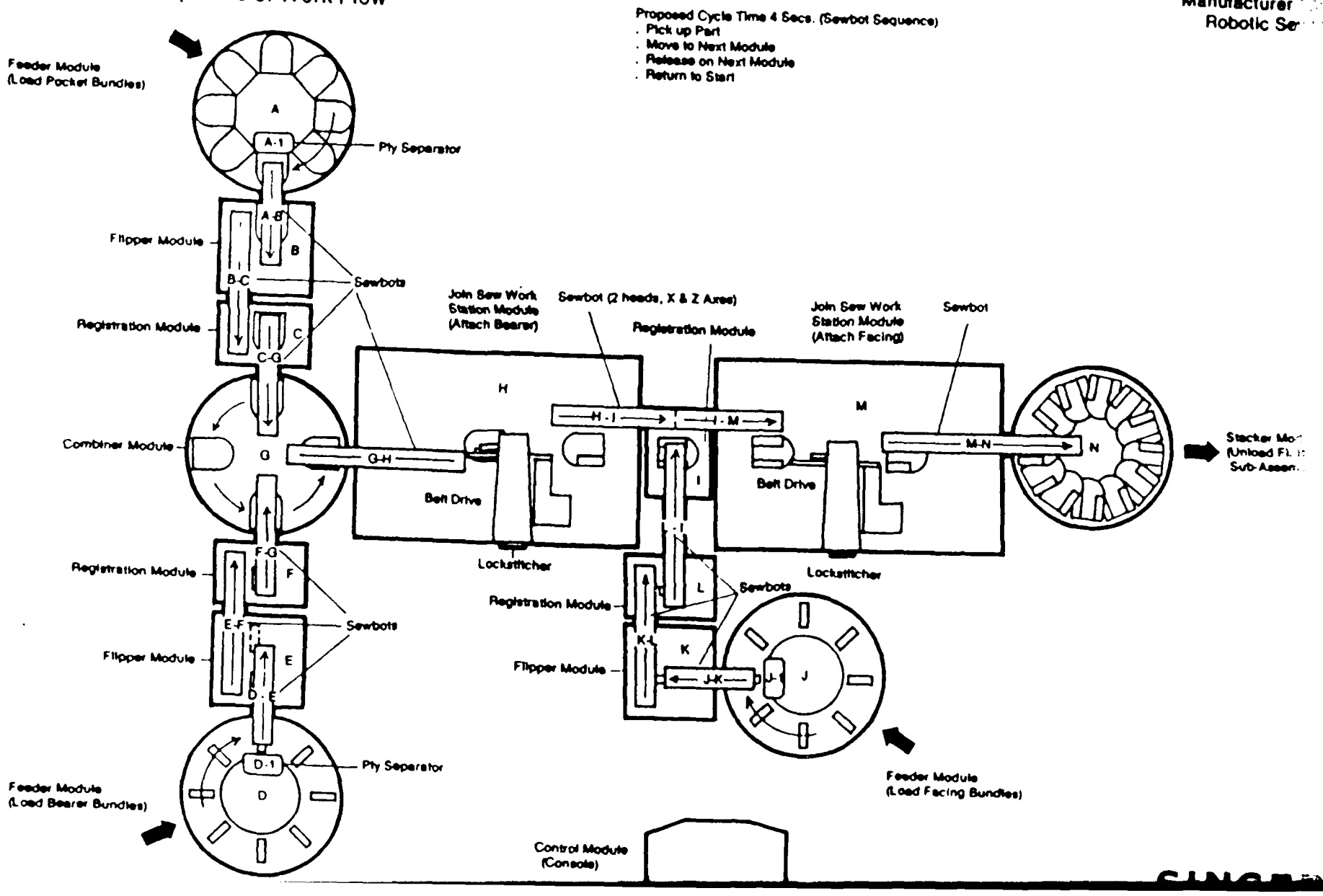
- Singer Sewing
  " in concert with TechStyle , Inc. "

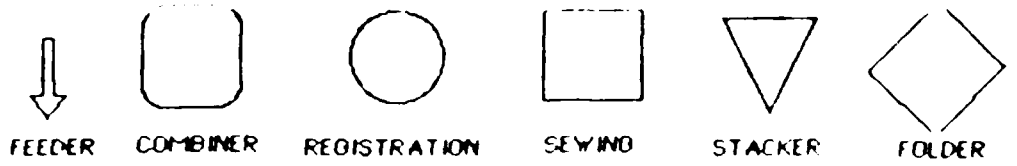
- ARK , Inc.

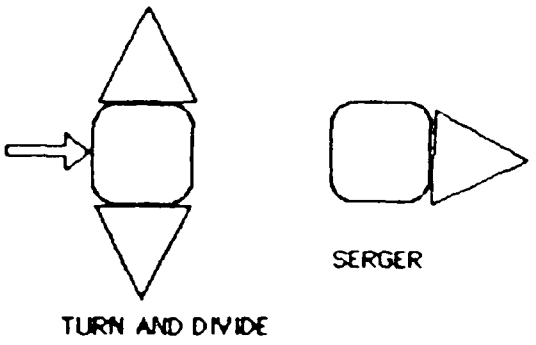
COMBAT TROUSER UNIFORM FRONT POCKET WORK CELL

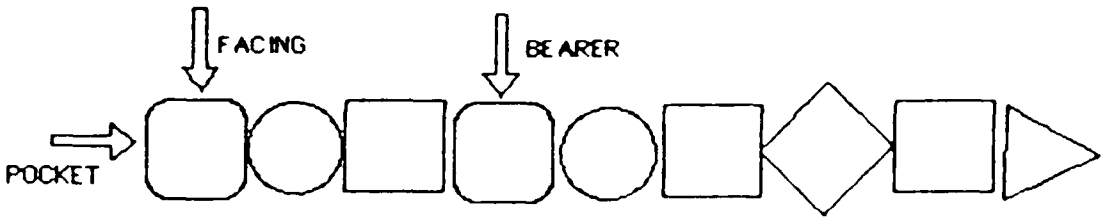
Exhibit 2 (Plan View) - Configuration of Modules and Sequence of Work Flow

Manufacturer
Robotic Se

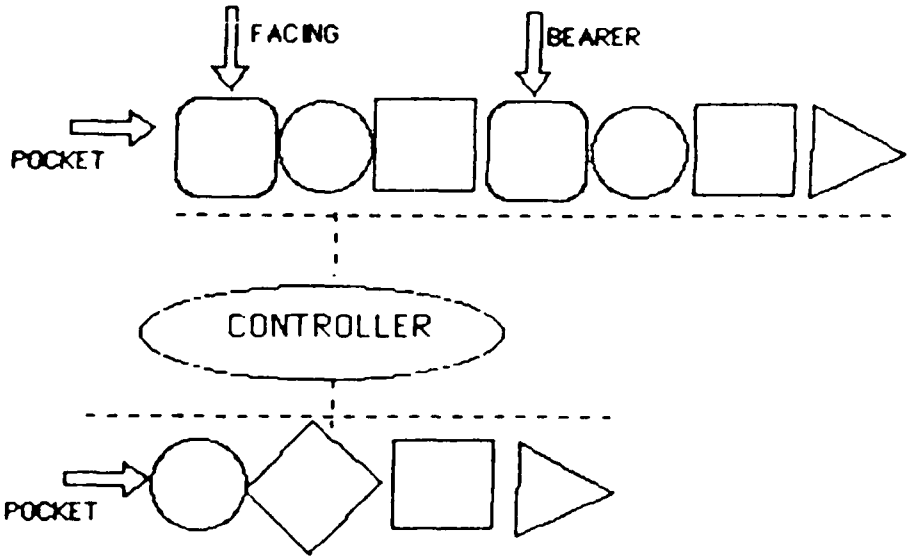








ALTERNATIVE METHOD



ARK INC.

CONCEPTUAL DRAWING OF
MODULAR POCKET SYSTEM

Proposal Comparison

	Singer	ARK
Flexibility	yes	yes
Modularity	yes	yes
Electronic Control	yes	yes
Facilities	yes	yes
Technical Competence	yes	yes
Personnel (operators)	1	1
skill level	AVE	AVE
Productivity (pockets/day)	7000	4000 - 8000
Existing Technology	?	60 - 80 %
Completion Time (mo.)	15 - 17	16 - 18

PROPOSAL COMPARISON

	SINGER	ARK
MANUFACTURING COST	$165K +	$40-60K
RETAIL COST	$320K	?
PROPOSAL BID	(Singer substantially higher)	
CONCEPTUAL DESIGN		+
CHANCE of SUCCESS		+

IRB Meeting Raleigh - August 18, 1987

Comments by Hubert Blessing during Dr. T. Clapp's presentation.

Singer's Bid

The operator has only 2 hands and many operations would be redundant if 3 parts could be assembled/handled.

I don't regard the pocket as a 3 part assembly but the operation is a lucrative one .... we should examine operations and abolish those that are unnecessary. [NCSU is building an operations sequence data base].

From technology viewpoint - when combining two pieces - subsequent to each piece being registered you accummulate tolerances that exist - this is not the way to (assemble garments)... One piece should be fed virtually at random and its position defined. The second piece should be read as it is picked up since in time and time phase they are 180° apart this provides enough time for a fast cycle. Why register? If you read that piece and then come back with the transfer device orienting the "hand" (so that it is geometrically correct to the hand), the piece can be placed on top of the other piece without accummulation of error and saving 25-35% of the hardware and floor space.

If you ask me if I see anything new in technology (here)....I see nothing that is not at least 10 years old. Suggest you visit Williamson Dickie and review the AEL system which is over 10 years old

...One problem when chosing a pocket (and we close a few pockets every year)... one should be aware of the reference notch on the closed pocket by which you hang the pocket - this notch is the criteria for subsequent assembly. This (notch) is important in a pair of jeans because of the front pockets' (construction)....the notch is more important than any other part. All the rest of the pocket is irrelevant and therefore cannot precut this notch (learned that the hard way) - better to establish

that notch for a given spec. dimension from the top of the pocket and wherever you want to close the pocket...that notch has to be on the machine and if you die-cut or hand-cut it is really irrelevant. (My) philosophy is one that likes that die clicked pocket for uniformity but if the machine relies on die cut pockets - forget it! Materials are not uniform and sew differently. The notch is used for subsequent assembly and I would insist that the notch is generated on the machine to a specified dimension...then the cutting accuracy is no longer critical. What you will be doing is accummulating tolerances and you cannot recognize that notch at a reasonable cost in its location. You are therefore likely to add up (in extreme case) 3 or 4 tolerances. Want to keep this in mind (during equipment design and development).

ARK Inc.

Does the topstitch not give a better pocket? Or use 401 with less unravelling than just serging? -[Ed McPherson - this may be put in later... now want to meet the product specs.]

How does ARK get from one unit/machine to the next? -[Tim Clapp...operator moves bundle...stack of lefts then rights]

Why does ARK not split (the system) between the two lockstitch machines and take the bearer or the facing and put them with the bagger which will give higher efficiency? Then the System as a whole would be more efficient if the break was between the two lockstitch machines.

...indifferent which two modules can be joined together referring to the lower diagram of ARK (already forgotten about the top one).

If you treat it subsequently in a manual fashion when hanging the pocket it is irrelevant whether or not, you split the left and right (pockets into stacks). One is better off having them split because as you get into more complex assemblies...visualize trousers being assembled by

sewing left and right tubes and attach the fly and waistband last. That way you can hold the product two dimensional as late as feasible thus minimizing $ investment in machinery. Looking down the road,...better off having them separate.

Discussion - Comparison

Tough to make a decision...can only go by track record or impression of people who are going to head up the project.

(In the RFP) how much of the concept did you ask for and how much did you ask for the concept to be spelled out? If you only asked for the concept the bottom half of the ARK concept is far superior to anything else you have shown. Do they have to be more specific than they have shown... (that's Ernsts' question.)

If Ed McPherson feels conmfortable with the detailed mechnanisms/descriptions from ARK, I personally would give best marks to the last proposal of ARK (even though I would have a different split in the concept system).

Taking $18,000 - 20,000 per operator base pay Singers' does not pay back on a three shift operation.

ARK's economic justification is reasonable with respect to cost of equipment.

I visualize that $40,000 - 60,000 is a reasonable number for such a machine and if you ever want to retail it cannot cost more than that. This is a credible cost to me with the mark up depending on the numbers of machines built.

1ST IRB Meeting: NCSU-DLA Project
NCSU Raleigh, NC
18 August 1987

Presentation Summary: Subassembly Data base
By: Carol G. Carrere
NCSU Apparel Research Assistant

An ongoing effort over the past 2 years has yielded a database representing operation sequences for construction of a full range of styles of apparel products. Contributions of styles have been received from private industry as well as government sources including the DPSC, DuPont and [TC]², among others. Efforts to enter the information in such a way as to mask the source are ongoing; the information will then be available for future U.S. Apparel Industry research efforts. Verification of the database entries began in late spring and is ongoing. Methods were developed to transfer the original rigid data format, as contained within the Leadtec [Apparel Production System] software, to ASCII format for introduction into a relational database manager system known as Knowledgeman. Some additional programming was required for the transfer in USCD Pascal. The 3.5 megabyte data file transfer presented a challenge. Manpower resources included a Computer Science undergraduate and an Apparel graduate student in addition to myself.

Sorting of the database represented the cutting of new ground; new information was obtainable as the flexibility of database entries was increased. An effort to verify the product types represented by the database, heretofore obtained through manual extraction, yielded the distribution shown in Figure 1. Currently the database contains 326 styles grouped into seven general product catagories representative of men's, women's, and children's apparel.

Examples of the types of information available through new sorts of the original database include the following:

(1) Listing of Styles; database content description,
(2) Sort by operation description; provides range of SAM's for a given operation,
(3) Sort by # Styles using each operation; provides insight into depth of data base for a given operation, and
(4) Sort by operation showing % contribution of that operation to a style; depicts the importance of any single operation to the labor content of a group of styles and provides a means for determining the impact of change on a style's cost.

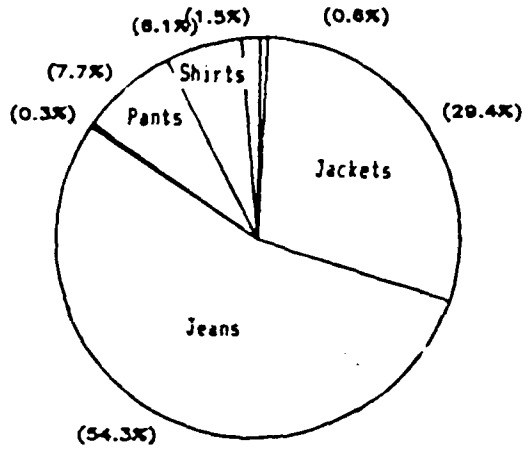
Future direction for use of the database includes identification and characterization of product subassembly operations suitable for flexible automation.

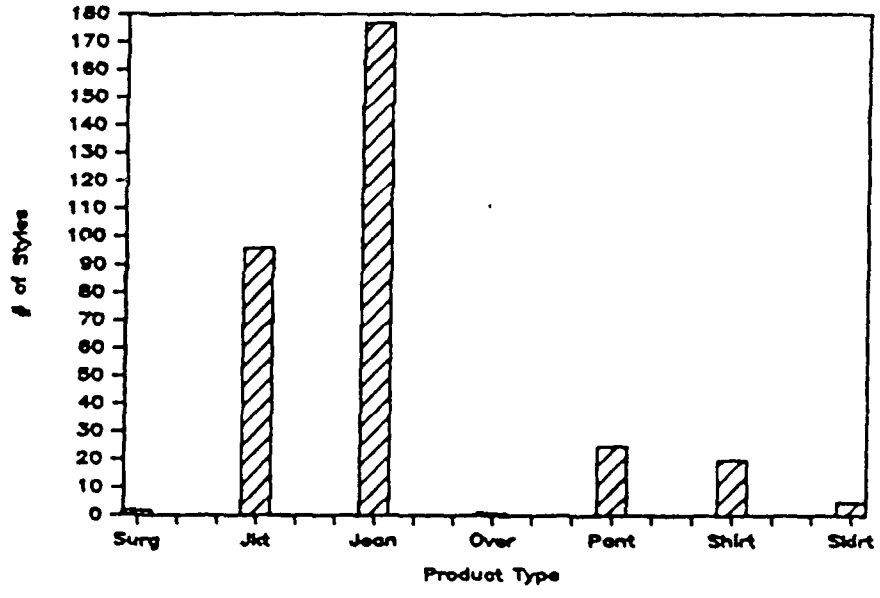
cc: E. McPherson
T. Little

DISTRIBUTION OF STYLES BY PRODUCT TYPE

SUMMARY: [by Product Type]

Surgical	2	0.6%
Jackets	96	29.4%
Jeans	177	54.3%
Overalls	1	0.3%
Pants	25	7.7%
Shirts	20	6.1%
Skirts	5	1.5%
	326	





DSPC
Durab.+
[TC]²

FIGURE 1.

STYLE # & STYLE DESCR

1	110-50XX	[redacted] PANTS
2	110-56XX	TYPE IV WORK PANTS
3	118-2041	LAUNDRY PANT--D/C
4	118-37XX	BEDFORD CORD PANT - COMMERCIAL
5	118-70XX	WORK PANT
6	118-95XX	[redacted] UNIFORM PANT
7	118-9803	[redacted] FLARE
8	12345	DAN
9	200-0041	MENS [redacted] - ZIPPER FLY
10	200-0141	MENS [redacted] SLIM - ZIPPER FLY
11	200-0241	MENS JEAN - BUTTON FLY
12	200-0341	MENS BOOT CUT [redacted]
13	200-10XX	MENS [redacted] BOOT CUT [redacted]
14	200-12XX	MENS [redacted] BOOT CUT [redacted]
15	200-14XX	MENS CORD BOOT CUT [redacted] D/IPR
16	200-15XX	STRAIGHT LEG [redacted] - CORDUROY
17	200-19XX	MENS BOOT CUT [redacted]
18	200-20XX	STRAIGHT LEG [redacted] - TWILL
19	200-21XX	[redacted] BOOT CUT FLARE
20	200-7041	MENS BOOT CUT [redacted] - WASHED
21	200-7241	MENS [redacted] - WASHED
22	200-7341	MENS SLIM [redacted] - WASHED
23	201-0541	[redacted] BOOT CUT [redacted]
24	201-0745	MENS BOOT CUT [redacted]
25	201-0941	MENS BOOT CUT FLARE
26	201-23XX	BOOT CUT [redacted]
27	201-24XX	BOOT CUT FLARE - STRETCH DENIM
28	202-0341	WIDE [redacted] FLARE
29	202-0441	WIDE [redacted] FLARE/WASHED [redacted]
30	202-0449	WIDE [redacted] FLARE
31	202-0941	MENS STRETCH DENIM [redacted] FLARE
32	202-15XX	[redacted] FLARE - CORDUROY
33	202-16XX	[redacted] WIDE [redacted] - BEDFORD CORD
34	203-0341	YOUTHS BOOT CUT [redacted] BOYCONST
35	203-10XX	YOUTHS BOOT CUT [redacted]
36	203-12XX	YOUTHS BOOT CUT [redacted] PRES
37	203-14XX	BOOT CUT [redacted] (BOYS CONST.)
38	205-0341	BOYS BOOT CUT [redacted] BOYCONST
39	205-10XX	BOYS BOOT CUT [redacted]
40	205-12XX	BOYS [redacted] BOOT CUT [redacted]
41	205-14XX	BOYS CORDUROY BOOT CUT [redacted]
42	220-0041	RIDER JACKET - DENIM
43	220-10XX	RIDER JACKET - CURED
44	220-1216	MENS WESTERN JACKET
45	220-19XX	[redacted] JACKET - ROUGH HIDE
46	220-7041	[redacted] JACKET - WASHED
47	223-0041	[redacted] JACKET - BOYS/YOUTH
48	224-1916	LADIES [redacted] - ROUGH HIDE
49	225-46XX	UNIT [redacted] JACKET
50	240-0041	BOYS [redacted]
51	240-7041	BOYS [redacted] WASHED 240-0041
52	240-9849	BOYS BOOT CUT [redacted]
53	240-9969	BOYS BOOT CUT [redacted]
54	241-0041	YOUTHS [redacted]
55	241-7041	YOUTH [redacted] WASHED 241-0041
56	241-9849	YOUTH BOOT CUT [redacted]
57	241-9969	YOUTH BOOT CUT [redacted]
58	242-0029	BOYS BOOT CUT [redacted]

APPENDIX XV

1807-0101-00-L-OMJ	85-06-24	16.9380		DOUBLEFOLD GARMENT AND BAG
1807-0101-00-L-OWJ	85-07-03	16.9380		DOUBLEFOLD GARMENT AND BAG
1807-0101-00-L-OYJ	85-07-02	16.9380		DOUBLEFOLD GARMENT AND BAG
1807-0101-00-L-AMJ	85-06-25	16.7220		DOUBLEFOLD GARMENT AND BAG
1807-0101-00-L-AYJ	85-07-01	16.7220		DOUBLEFOLD GARMENT AND BAG
2100-0102-00-W-OMC	86-01-21	36.0000	U851300-Z	DRAW BACK ARMHOLE
2060-0203-00-W-OMC	86-01-21	4.0000	EAGLECOMPO	EAGLE LINING FACING
2060-0203-0A-W-OMC	86-01-23	21.0000	EAGLECOMPO	EAGLE LINING FACING
0114-0104-00-B-OMC	85-09-20	22.1000	LH515	EDGESTITCH AND PLEAT BREAST POCKET
0117-0104-00-B-OMC	85-09-20	58.9000	251-11	EDGESTITCH AND PLEAT LOWER POCKET
1901-0207-00-R-WRS	85-10-16	12.0000	251-2	EDGESTITCH COLLAR
1903-0205-00-W-OMC	86-01-23	32.0000	PFAFF483	EDGESTITCH COLLAR
0311-1102-00-L-OMC	85-08-07	47.0340	LOCK ST	EDGESTITCH FRONT - REDUCED RPM
0311-1101-00-L-OMC	85-08-06	42.6360	LOCK ST	EDGESTITCH FRONTS
0311-1101-00-L-OWC	85-07-31	42.6360	LOCK ST	EDGESTITCH FRONTS
0311-1101-00-L-OYC	85-08-07	42.6360	LOCK ST	EDGESTITCH FRONTS
0311-6001-00-L-OMC	85-08-03	47.7720	LOCK ST	EDGESTITCH FRONTS (EXTRA POINTING OUT)
0311-6001-00-L-OWC	85-08-01	47.7720	LOCK ST	EDGESTITCH FRONTS (EXTRA POINTING OUT)
0311-6001-00-L-OYC	85-08-06	47.7720	LOCK ST	EDGESTITCH FRONTS (EXTRA POINTING OUT)
0311-6001-00-L-AMC	85-08-06	47.9520	LOCK ST	EDGESTITCH FRONTS (EXTRA POINTING OUT)
0311-6001-00-L-AYC	85-08-06	47.9520	LOCK ST	EDGESTITCH FRONTS (EXTRA POINTING OUT)
0201-0601-00-P-OMJ	85-09-19	20.9000	61900	EDGESTITCH LEFT FLY
1803-0503-00-T-MRS	85-10-22	20.0000		EXAMINE
1803-0903-00-R-WRS	85-10-15	52.2000		EXAMINE & BRICK
1803-0903-00-W-MRS	86-01-14	13.8000	HAND	EXAMINE AND BRICK
1803-0903-0A-W-MRS	86-01-15	3.0000	HAND	EXAMINE AND BRICK
1803-0903-0A-W-MSS	86-01-15	3.0000	HAND	EXAMINE AND BRICK
1803-0503-00-D-MRS	85-09-20	0.5466	FORMASTER	EXAMINE FOLDED SHIRT
1803-0503-0A-D-MRS	85-09-20	0.5016	FORMASTER	EXAMINE FOLDED SHIRT
0114-0101-00-B-OMC	85-09-20	16.4000	REECE 101	EYELET BREAST POCKET
0117-0101-00-B-OMC	85-09-20	31.2000	REECE 101	EYELET LOWER POCKET
0106-0102-00-G-OCP	85-09-27	36.4000	281-3	FACE AND CLOSE FRONT POCKET
0403-0701-00-L-OWP	85-06-17	53.2740	LOCK ST	FACE AND WELT HIP POCKET W/FOLDER
0401-0200-00-G-OCP	85-09-27	24.4000	281-3	FACE BACK POCKET
0402-0701-00-G-OCS	85-09-19	28.5000	6800 2 MD3	FACE BACK POCKETS
0402-0701-00-X-OCP	86-01-08	25.0000	PFAFF 463	FACE BACK POCKETS
0402-0701-00-X-OCS	86-01-07	25.0000	PFAFF 463	FACE BACK POCKETS
1212-0712-00-X-OCP	86-01-08	37.0000	PFAFF463	FACE EXTENSION END
1212-0712-00-X-OCS	86-01-08	37.0000	PFAFF463	FACE EXTENSION END
0103-0202-00-I-OCS	85-09-19	5.3000	241-12	FACE FONT POCKET
0103-0202-00-W-OCP	86-01-24	8.0000	PFAFF463	FACE FONT POCKET
0103-0202-00-X-OCP	86-01-08	8.0000	PFAFF463	FACE FONT POCKET
0103-0202-00-X-OCS	86-01-07	8.0000	PFAFF463	FACE FONT POCKET
0103-0201-00-C-OWP	85-09-18	30.0600		FACE FRONT POCKET
0103-0201-00-C-OYS	85-09-19	30.0600		FACE FRONT POCKET 1/4 TOP SINGLE
0103-0203-00-E-OWP	85-09-23	52.8000	281	FACE FRONT POCKETS
0103-0201-00-G-OCS	85-09-19	11.1000	RIMOLDI680	FACE FRONT POCKETS
0301-0113-00-Y-WSS	86-06-16	39.3000	SNGER251-6	FACE FRONT POCKETS
0402-0701-00-C-OWP	85-09-18	19.6800		FACE HIP POCKET
[illegible]				[illegible]

(2)

'STYLES IN EACH OPERA

SAM = SAM FOR THAT OPERATION

AC1-2000	0 00000	MENS
AC2-2000	0 00000	MENS

DATE 06/17/87
OPERATION 0000-0001-00-H-MSS DESCRIPTION: CUTTING

STYLE NUMBER	SAM	STYLE DESCRIPTION
ASE-4000	0 00000	MEN
ASE-4001	0 00000	MEN

DATE 06/17/87
OPERATION 0000-0001-00-L-OMJ DESCRIPTION: CUTTING

STYLE NUMBER	SAM/100	STYLE DESCRIPTION
200-0041	89 14200	MENS [redacted] - ZIPPER FLY
200-0141	89 14200	MENS [redacted] SLIM - ZIPPER FLY
200-0241	89 14200	MENS JEAN - BUTTON FLY
200-0341	89 14200	MENS BOOT CUT RIDER
200-20XX	89 14200	STRAIGHT LEG RIDER - TWILL
200-7041	89 14200	MENS BOOT CUT RIDER - WASHED
200-7241	89 14200	MENS [redacted] - WASHED
200-7341	89 14200	MENS SLIM [redacted] - WASHED
201-0541	89 14200	LP BOOT CUT [redacted]
201-0941	89 14200	MENS BOOT CUT FLARE
202-0341	89 14200	WIDE [redacted] FLARE
202-0441	89 14200	WIDE [redacted] FLARE
202-0449	89 14200	WIDE [redacted] FLARE
209-0241	89 14200	[redacted] MENS CUT JEAN [redacted]
209-1109	89 14200	[redacted] FLARE [redacted]
400-0041	89 14200	[redacted] JEAN
400-0341	89 14200	[redacted] STRAIGHT LEG - WASHED
411-0241	89 14200	[redacted] FLARE
411-1044	89 14200	WIDE STRIDER - CHAMBRAY
411-2041	89 14200	[redacted] FLARE - WASHED
411-3141	89 14200	[redacted] SUPER BELL

DATE 06/17/87
OPERATION 0000-0001-00-D-MRS DESCRIPTION: CUTTING

STYLE NUMBER	SAM/100	STYLE DESCRIPTION
AC1-2000	0 00000	MENS'S REGULAR DRESS SHIRT
AC2-2000	0 00000	MENS'S REGULAR DRESS SHIRT

DATE 06/17/87
OPERATION 0000-0001-00-H-MSS DESCRIPTION: CUTTING

STYLE NUMBER	SAM/100	STYLE DESCRIPTION
ASE-4000	0 00000	MEN'S SPORT SHIRT
ASE-4001	0 00000	MEN'S SPORT SHIRT

DATE 06/17/87
OPERATION 0000-0001-00-L-OMJ DESCRIPTION: CUTTING

STYLE NUMBER	SAM/100	STYLE DESCRIPTION
200-0041	89 14200	MENS [redacted] - ZIPPER FLY
200-0141	89 14200	MENS [redacted] SLIM - ZIPPER FLY
200-0241	89 14200	MENS JEAN - BUTTON FLY
200-0341	89 14200	MENS BOOT CUT [redacted]
200-20XX	89 14200	STRAIGHT LEG [redacted] - TWILL
200-7041	89 14200	MENS BOOT CUT [redacted] - WASHED
200-7241	89 14200	MENS [redacted] - WASHED
200-7341	89 14200	MENS SLIM [redacted] - WASHED
201-0541	89 14200	[redacted] BOOT CUT [redacted]
201-0941	89 14200	MENS BOOT CUT FLARE
202-0341	89 14200	WIDE [redacted] FLARE
202-0441	89 14200	WIDE [redacted] FLARE/WASHED [redacted]
202-0449	89 14200	WIDE [redacted] FLARE
209-0241	89 14200	[redacted] MENS CUT JEAN LOT [redacted]
209-1109	89 14200	[redacted] FLARE LOT [redacted]
400-0041	89 14200	[redacted] JEAN
400-0341	89 14200	[redacted] STRAIGHT LEG - WASHED
411-0241	89 14200	[redacted] FLARE
411-1044	89 14200	WIDE [redacted] - CHAMBRAY
411-2041	89 14200	[redacted] FLARE - WASHED
411-3141	89 14200	[redacted] SUPER BELL
411-3941	89 14200	WIDE [redacted] - WASHED DENIM
411-4041	89 14200	CANADIAN BIG BELL 14 OZ DENIM
411-4049	89 14200	WIDE [redacted] WASHED [redacted]
411-4941	89 14200	[redacted] [redacted] JEAN CANADA DENIM
411-4949	89 14200	[redacted] [redacted] JEAN WASHED DENIM
411-5041	89 14200	[redacted] SUPER BELL - WASHED
413-5049	89 14200	MENS [redacted] - WASHED [redacted]

DATE 06/17/87
OPERATION 0000-0001-00-L-OMJ DESCRIPTION CUTTING

STYLE NUMBER	SAM/100	STYLE DESCRIPTION

APPENDIX XVII

OF AN OPERATION TO A STYLE BASED ON

SAM OP / SAM TL X100

411-4041	1614.33600	42	3.207	CANADIAN BIG BELL 14 OZ DENIM
411-4049	1631.04000	42	3.174	WIDE [redacted] WASHED 411-4041
411-4941	1547.18400	40	3.346	[redacted] JEAN CANADA DENIM
411-4949	1749.78600	43	2.959	[redacted] JEAN WASHED DENIM
411-5841	1644.57000	42	3.148	[redacted] SUPER BELL - WASHED
413-5049	1656.28800	44	3.126	MENS [redacted] - WASHED [redacted]
418-3941	1694.23200	41	3.056	[redacted] STRIP JEAN-WASHED 140ZDEN
418-6041	1654.22400	41	3.130	[redacted] STRIP JEAN-REVERSE140ZDEN
418-6541	1684.63800	41	3.073	[redacted] STRIP JEAN-WASHED REV DEN
418-9441	1654.22400	41	3.130	[redacted] STRIP JEAN - 14 OZ DENIM

DATE: 07/09/87 SAM: 51.7740
OPERATION: 0108-0101-00-L-0WJ DESCRIPTION: SET SCOOP FRT PKT

STYLE NUMBER	SAM TOTAL	OPS	% OF STYLE	STYLE DESCRIPTION
260-2641	1631.17200	42	3.174	LADIES WESTERN STRETCH DENIM
261-0541	1668.61800	43	3.103	LADIES WESTERN SCOOP FRT JEAN
300-1141	1425.04800	37	3.633	[redacted] SCOOP POCKET JEAN LADIES
300-19XX	1662.73800	40	3.114	[redacted] JEAN LADIES

DATE: 07/09/87 SAM: 51.4260
OPERATION: 0108-0101-00-L-0WP DESCRIPTION: SET SCOOP FRT PKT

STYLE NUMBER	SAM TOTAL	OPS	% OF STYLE	STYLE DESCRIPTION
118-9803	1611.11400	44	3.192	PHILLIPS [redacted] FLARE

DATE: 07/09/87 SAM: 51.7740
OPERATION: 0108-0101-00-L-0YJ DESCRIPTION: SET SCOOP FRT PKT

STYLE NUMBER	SAM TOTAL	OPS	% OF STYLE	STYLE DESCRIPTION
203-0341	1403.54200	42	3.637	YOUTHS BOOT CUT [redacted] BOYCONST
205-0341	1418.54400	42	3.650	BOYS BOOT CUT [redacted] BOYCONST
240-0041	1335.67800	40	3.876	BOYS [redacted]
240-7041	1498.24800	43	3.456	BOYS [redacted] WASHED [redacted]
241-0041	1302.58800	40	3.975	YOUTHS [redacted]
241-7041	1503.24600	43	3.444	YOUTH [redacted] WASHED [redacted]
242-0541	1547.05200	44	3.347	BOYS BOOT CUT [redacted]
242-0629	1662.71400	49	3.114	BOYS BOOT CUT [redacted] -NAPSUITING
242-0749	1592.78400	49	3.251	BOYS BOOT CUT [redacted] NAPSUITING
242-5041	1396.41000	41	3.708	BOYS HUSKY BOOT CUT [redacted]
242-7341	1519.11000	43	3.408	BOYS BOOT CUT [redacted] WASHED
243-0541	1737.24600	47	2.980	YOUTH BOOT CUT [redacted] FLARE [redacted]
243-0629	1622.84400	47	3.190	YOUTH BOOT CUT [redacted] -NAP SUIT
243-0749	1622.84400	47	3.190	YOUTH BOOT CUT [redacted] -NAP SUIT
243-5041	1401.40800	41	3.694	YOUTH HUSKY BOOT CUT [redacted]
243-7341	1503.24600	43	3.444	YOUTHS BOOT CUT [redacted] WASHED
244-0041	1234.27200	40	4.195	HUSKY [redacted]
420-0041	1576.09200	42	3.285	BOYS [redacted] STRAIGHT LEG [redacted] WAS
420-02XX	1420.77600	39	3.644	BOYS [redacted] FLARE
420-0341	1607.70000	42	3.220	BOYS [redacted] STRAIG LEG WASH MENS
420-2041	1592.38800	42	3.251	BOYS [redacted] FLARE WASH MENSCONST
420-4041	1429.04400	40	3.623	WIDE [redacted] BOYS 140Z DEN MEN
420-4049	1602.69600	43	3.230	WIDE [redacted] BOYS WASH [redacted] MEN

421-6041	1611.82800	41	3.212	BOYS [redacted] STRIP JEAN REVERSE DEN
421-8041	1632.52800	42	3.171	BOYS [redacted] STRIP JEAN-BRUSHED DEN
421-8049	1662.94200	42	3.113	BOYS [redacted] STRIP JEAN-WASHBRSHDEN
423-0041	1584.87000	42	3.267	STUDENT [redacted] STRAITLEG [redacted] WAS
423-02XX	1420.01400	39	3.646	STUDENTS [redacted] FLARE
423-0341	1616.47800	42	3.203	YOUTH [redacted] STRAIT LEG WASH MEN
423-2041	1590.79200	42	3.255	STUDENT [redacted] FLARE WASHENSCONST
423-4041	1440.69600	40	3.594	WIDE [redacted] STUDENT 140ZDENMEN
423-4049	1611.47400	43	3.213	WIDE [redacted] STUDENT WASH [redacted]
424-6041	1631.17200	41	3.174	STUDENTS [redacted] STRIP REVERSE DEN
519-12XX	1619.70000	43	3.197	[redacted] YOUTHS STRAIGHT LEG

DATE: 07/09/87 SAM: 51.4260
OPERATION: 0108-0101-00-L-0MJ DESCRIPTION: SET SCOOP FRT PKT

Master Management Plan (MMP) Trevor Little

Part of the project requirement during the proposal writing phase was the development of a Master Management Plan. The attached Chart F shows the MMP anticipated at the time of proposal submission divided according to project phase and allocation of professional man days.

NCSU has been operating and managing the project according to this Chart F until the proposals discussed were opened and evaluated. At that time it was necessary to modify the original Chart F for two reasons -

1. Proposals from potential vendors required more than the one year allocated (in Chart F) for design and testing vendor equipment
2. CDRL items, proposed travel, IRB activities and estimated cost expenditures needed to be added together with the contract number.

Maintaining the original contract cost, the DLA was requested to approve an extension of the contract time allowing 18 months for equipment design and testing. This contract extension was approved on August 7.

The revised MMP is attached to the minutes for completeness even though it was made available to attenders at the IRB meeting. For the duration of the project NCSU will be following according to the MMP and IRB participants can obtain a more complete overview of the entire activities.

Since best and final offers are due on Friday, NCSU would appreciate that the MMP be kept confidential until next week.

CHART F

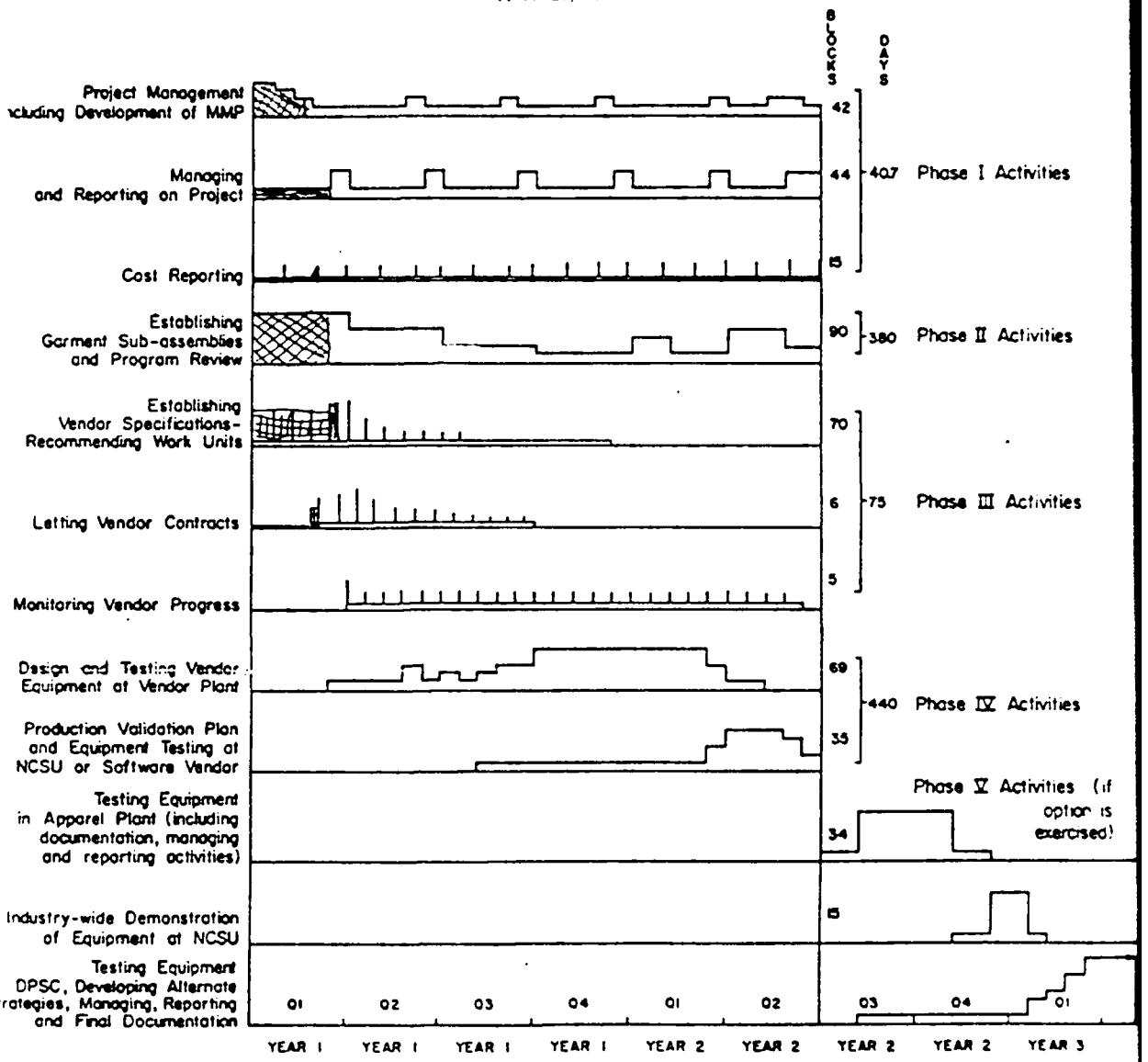
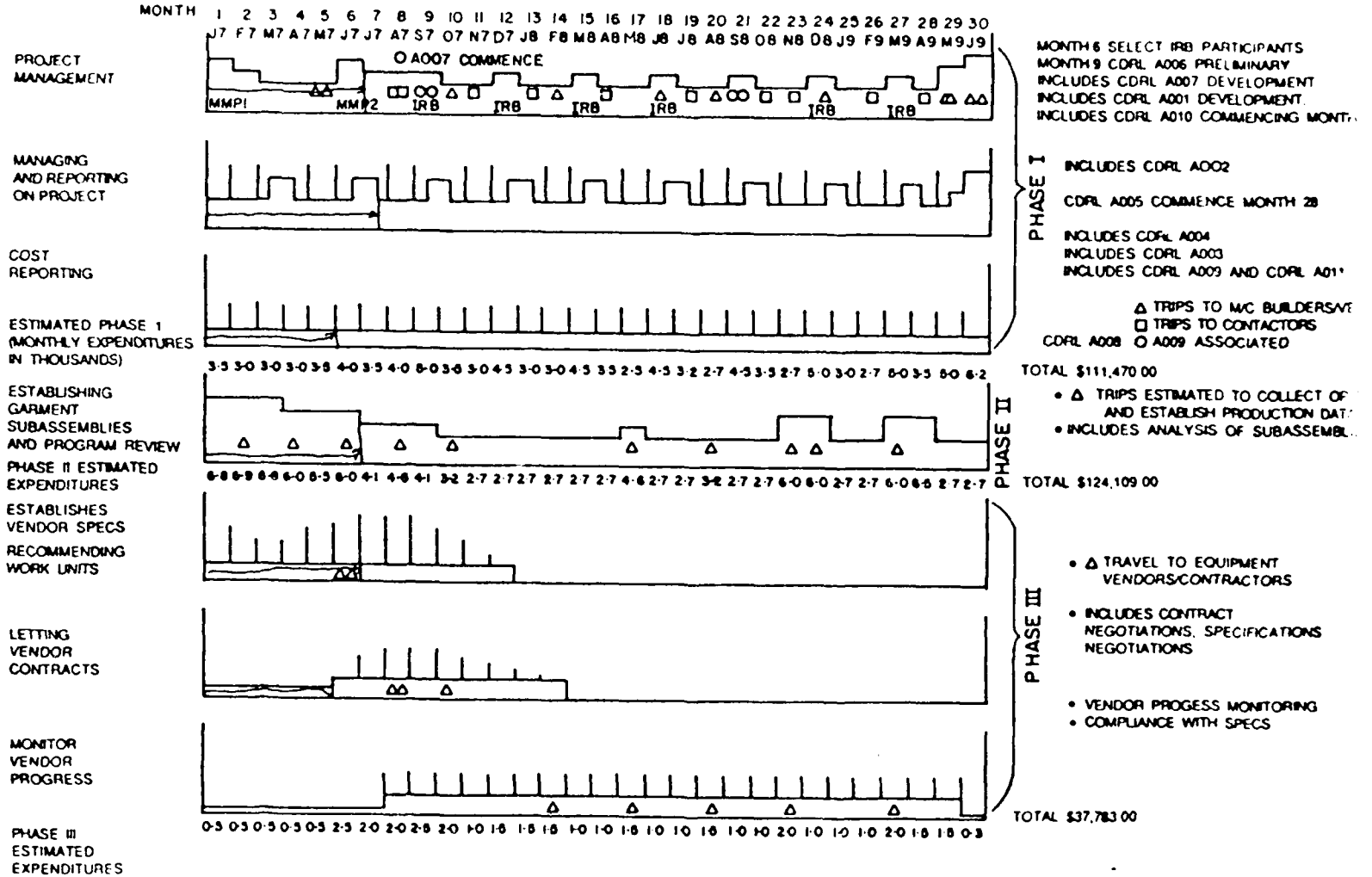


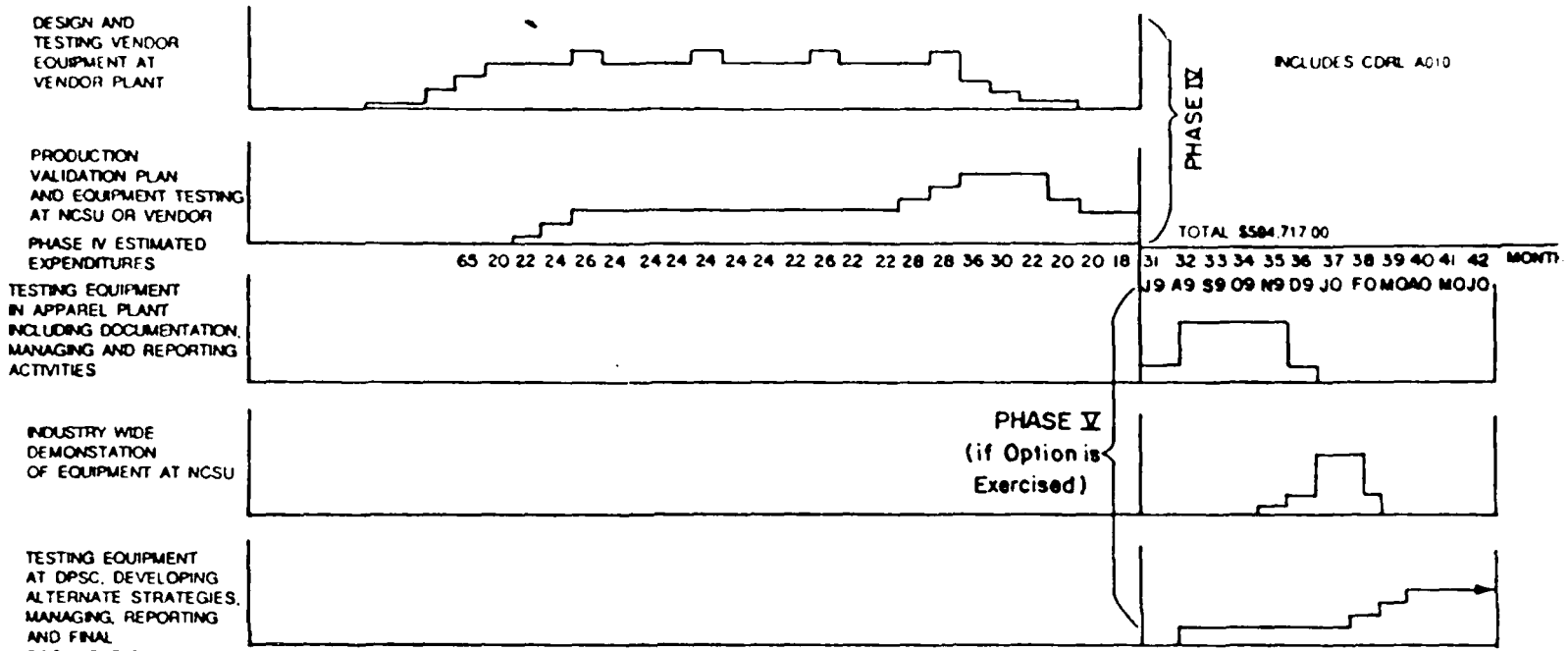
CHART F: Time Phased Activity for Project (estimated)
(This will be subject to change during development of MMP.)

APPENDIX I

DLA 900-87-C-0509 PROPOSAL NO. 86-0849 NCSU-SCHOOL OF TEXTILES JUNE 1987



APPENDIX IV



MASTER MANAGEMENT PLAN (REVISED JUNE 1987)

August 19, 1987

Professor Ed McPherson
North Carolina State University
Department of Textile Management and Technology
Box 8301
Raleigh, North Carolina 27695-8301

Dear Ed:

On the flight home, I started analyzing and digesting what I learned at our meeting yesterday and following are my conclusions.

It is frustrating to see that very few people or companies in the United States are involved in automatic garment manufacture. It is frightening.

In an effort to promote good citizenship (since the whole project is being paid with tax dollars), I must tell you we spent a lot of money learning this operation and came to the conclusion it should be split apart. I cannot help but state you should insist that ARC, really your only valid contender, break all three operations apart individually to provide a buffer between each sewing operation. I therefore will disclose to you what we learned some 15 years ago in constructing such a machine, and at the same time, this may afford a sensible solution for the transfer from machine to machine.

Our first version, which we called F-14, produced exactly the product you are talking about. However, since our quantity in slacks was infinitely smaller than in jeans, we decided to devise a version for jeans front pocket production. We actually built and operated this machine, which we called DF-13. Due to all the operations in line without a buffer, we never could achieve more than 50% efficiency even though we manned the machine with two instead of one operator to respond better to machine interference. We subsequently scuttled the machine and took a new approach which I am not at liberty to explain to you. Obviously, the conclusion would be to have stand alone individual models. Under separate cover, I am forwarding renderings of the two machines so you can better comprehend what I am trying to tell you. Please do not make copies of these renderings since I would not appreciate the biggest folly of my life printed in the newspapers or magazines. However, if they would be helpful in discussions with you vendor, please feel free to show it to them so they better comprehend and cooperate.

APPENDIX III

We also discussed that you would send me a printout of your file which statistically evaluates operations incrementally as used in the construction of a pair of slacks, jeans or other garments for that matter. Please forward such a copy to me so I can give it some thought and comment on it. Since I will not have the time to look at the entire garment industry, I would like to confine it to construction of jeans and slacks. If you are unable to run such a sort on your file at this time, I could run the sort myself, but I think it would be a worthwhile effort to complete such a file sort as it may help the entire United States apparel industry. Of course, I would delete the names from where you obtained the information.

I am also enclosing the travel payment forms for reimbursement. Incidentally, reimbursement should be made to Levi Strauss & Co., not me. Thank you.

Best regards,

Hubert Blessing
Director, Research & Development

HB:sr
Attachments

SINGER

August 19, 1987

Mr. Edwin McPherson
School of Textiles
North Carolina State University
P. O. Box 8301
Raleigh, NC 27695-8301

Dear Mr. McPherson:

We are pleased to re-submit our bid as a best and final offer, as enclosed, in response to the bid solicitation of March 3, 1987, for the combat trouser uniform front pocket work cell system.

We have also enclosed video, as listed below, to demonstrate technologies which we have recently developed which can help support this project:

Equipment	Technology
Jeans Front Pocket System	Pick-up and parts transfer
Boxer Short System	Pick-up, ply separate, ply sensing, turnover and feed three plys for registration and sew.
Pocket Facer/Bagger	Folding and guiding multiple plys.
$(TC)^2$	Commercialization of conveyance systems, vision interface and software capability.

You will note that although individual module function and development remain similar in concept to that in our initial proposal the amount of equipment in our revised proposal has been substantially reduced to more closely approximate North Carolina State specifications. Further, you will note that the Singer content has increased by taking advantage of our newly developed technologies and, at the same time, we are utilizing proven technologies developed by Techstyle, Inc. If at some future date there were increased productivity requirements, the work cell as now proposed will have the flexibility to be reconfigured with additional modules to improve cycle time without additional development cost.

IRB - SUNBRAND OCTOBER 5, 1987

PRESENT

Don O'Brien
Ed McPherson
Max Tripp
Manuel Gaetan
John Nicholson
Hechmi Hamouda
Joe Off
Ernst Schramayer
Don Moffitt
Trevor Little
Karen Hersey

Ed McPherson opened the meeting at 8:00 am.
- 2 qualified bids were received on the project with Bill Cole of ARK Inc. being the successful bidder.

Don O'Brien reviewed the important points in the statement of work.
- Equipment must be an attractive investment for the apparel producer.

- Flexibility is the 2nd key requirement with the changeover from civilian to military apparel being critical.

- Definition of flexibility sizes and styles within same class of garment. Any further suggestions on definition of flexibility would be appreciated.

- Modules needed to assemble machine which are integrable to complete the work cell.

- Test the equipment in lab (NCSU) and in an other facility to be determined at this stage of the project.

- Equipment should being demonstrated assemblying military than change to civilian apparel in the same class of garment.

M. Gaetan

(TC)^2 established a price point that producers would pay for equipment. what is target $ on this procurement?

Ed

This is described in equipment specification in the $40K - 60K based on 2 year ROI single shift operation.

Don O'Brien

- Need to look down the road at the interconnectability of modules.

- 3 other contracts awarded FIT, Clemson and G. Tech/Southern Tech. for Demonstration Centers.

APPENDIX IV

- Hope can co-ordinate all the efforts DLA is funding and encouraged IRB member to feel free to contribute through the IRB or otherwise.

Karen Hersey

NCSU has put together a credible sub-contract for ARK Inc. Arrangement that allows ARK Inc. to have limited rights to its invention. NCSU will have rights for education. Ideas and intellectual property belong to NCSU and ARK, the physical m/c will belong to the government.

FAR's - [Federal Acquisition Requirements] incorporated in the ARK contract.

ONR - Office of Naval Research handles all contracts with eduational institutions.

Don O'Brien

The project will be viewed as a failure it DLA acquires the machine for its own facility --- would rather see the equipment sold on a commercial basis.

M. Gaetan

1225 dozen/week at 4 sec. cycle. How many companies have that volume?

Ed. Mc.

150 firms approx had that volume of products. (3 years ago).

Joe Off

172 is the average # of employee per plant manufacturing trousers. 206 plants employ 50 or more people.

Don O'Brien

- modules emphasize more that pockets
- **specific study what the market is?**
-- 3 pieces put together in this equipment.

M. Gaetan

I was involved in study for market penetration for $(TC)^2$ technology for suit coats.

Ernst Schramayer

In general , for the apparel industry, a machine must be so productive that the flexibility is lost. For example, a machine to hem cuffs and short sleeves was too expensive. The machine was split up into separate machines operating at peak performance. (40 cuffs/minute with 1/16" gap)

Ernst Schramayer

Some of the equipment may be better in centralized cutting but cutting is now being decentralized in parts of the industry.

Joe Off

In general, as number of threads goes up, effieciency goes down for apparel equipment.

Don O'Brien

The computing bidder (Singer) offered a tranfer line with a buffer in between machines. Is there something in between independent modules and interdependent modules? Little research has been done on **level of flexibility** needed for the apparel industry.

John Nicholson

?Specifications - How flexible is Natick with respect to specifications and standards? (25 - 30K dress pants military/week.) BDU is sufficiently different from dress pants.

Don O'Brien

If you will show Services another way to assemble apparel, they will adopt if properly positioned to the appropriate function within DOD.

Introduction Bill Cole

Hechmi Hamouda

... reviewed the bids and the evaluation process, handout attached.

Ed Mc.

Another bid was received from singer with changed drawings - 180° different with respect to drawings. $ still substantially higher than ARK.

Bill Cole

Described the concepts proposed by ARK Inc.

- modular in concept but run parallel operations - **turn and divide module**
- separating into lefts and rights - what if splice?
- Pocketing ... is there a right and wrong side? If so need to recognize face side.
- use the turn and divide in cutting room.

Pocket Facings

Compare serge and sewn down to fold and sew down equipment works better if no folder.

- Pick-up and separate - will need some work. The remainng technology exists today for attaching facings.

Max Tripp

Is 401 acceptable?

Bill Cole

A Spec. change would be needed to use 401 stitch.

M. Gaetan

Will there be special instructions to spreaders with respect to splices?

Bill Cole

Some companies ---- paper mark the splices.

M. Tripp

Spreading without defect removal trend is being observed in many industry sectors.

Bill Cole

A generic purpose serger is illustrated as a stand alone module. **Top and bottom proposals.** The major difference is that in the lower figure the bagger is shown as a separate module, to improve efficiency of the system.

- will need pick up and ply separating
- will need to select pocket bagging unit. The pocket corner is important and none of existing baggers sense off pocket.

Ernst Schramayer

Commented on letter from Tim Clapp proposing placing a Clupicker to IBM Robot. He discouraged Clapp's approach saying that to attach an end effector to a Robot will probably fail and there is a need to look at the complete system for pick and place.

Ed. Mc.

Commented that Tim clapp's approach was to take number of devices and establish range of fabrics it will handle successfully.

Bill Cole

The next steps will include:

- Gantt chart for entire process
- board work will be started as soon as possible
- cutting metal will be 2 months away.

Drawing

ARK Inc. will be doing some drawings NCSU needs to know to what extent ARK drawings will define the equipment - drawings will be available for NCSU.

John Canada's report on flexibility will be in the next quarterly.

- flexibility, modularity and universality need to be addressed.

M. Gaetan

What are the merits of commonality? The cost benefits of using/addressing commonality with respect to shape(s) for military apparel should be established and common shapes recommended. Responding - Don O'Brien said that active groups are looking into the problem and he will find out status.

J. Nicholson said that they have made definite recommendations.

Don O'Brien will start something on shape and look at the commonality between DOD and civilian apparel. For this project, the variation in the shapes and sizes is to some extent being handled by building in the flexibility into the equipment.

E. Schramayer

Shapes not the most critical in his opinion, the construction is the most critical?

Joe Off

There are basically 3 ways to make a pocket
1) Fold/stitch
2) cover stitch
3) serge and sew

I question the commercially of option 3). When equipment comes and is successful it does tend to standardize the operation. When a machine does something well and is preferred it makes the m/c even more successful. In considering the longer term commercial viability of the procurement we should go back and fold and sew down. Although this goes against Bill Cole's approach we should pursue quality. Imports fold and sew down and that is the challenge we have. Biesler - has technology to fold straight edges.

How to Proceed!

1) An addendum needed from Bill Cole

2) Don O'Brien noted the IRB's recommendation that for the m/c to be commercially viable, need to fold and sew down, have 3 months approx. to resolve and ARK Inc. can begin work an the turn and divide module. Dress slacks will be targeted.

Don O'Brien will

1) Modify the SOW to include dress slacks as an option.

2) approach Nattick for a straight edge on facings.

3) provide cut stack of pocketing and facing to conduct a test on pick-up devices.

Bill Cole will go ahead with turn as divide and look at cost to put on a Biesler folder or H. Rovin's folder system.

Japanese small parts serger is available as per Joe Off.

John Nicholson plans to test the final product the IRB is welcome to visit anytime.

The next meeting of the IRB is scheduled for Monday, January 11 at 9:00 am in Shelbyville, TN at ARK Inc.

Work Cell Specifications

For

Combat Trouser Front Pocket

RESULTS OF

PROPOSAL EVALUATION

Dr. Hechmi Hamouda

Dr. Timothy Clapp

Specifications Considerations:

- Flexibility
- Modularity
- Chance of Success
- Retail Cost
- Acceptance by Apparel Manufacturer

Interested Bidders:

- AMF (2)
- Ark, Inc.
- Jet Sew
- Levi Strauss
- Singer Sewing
- Techstyle
- Texnology Systems
- Union Special

Proposals Submitted By:

- Singer Sewing (Jointly with Techstyle, Inc.)
- Ark, Inc.

Results of Proposals Evaluation:

	Singer	Ark
Flexibility	Yes	Yes
Modularity	Yes	Yes
Electric Control	Yes	Yes
Facilities	Yes	Yes
Technical Competence	Yes	Yes
Personnel (Operators)	1	1
(Skill Level)	Avg	Avg
Productivity (Pocket/Day)	7000	4000-8000
(Pair/Day)	3500	2000-4000
Existing Technology	?	60 - 80%
Completion Time (Months)	15 - 17	16 - 18

Proposals Comparison:

	Singer	Ark
Manufacturing Cost	$165K +	$40 - 60K
Retail Cost	$320K	?
Proposal Bid	*	
Conceptual Design		+
Chance of Success		+

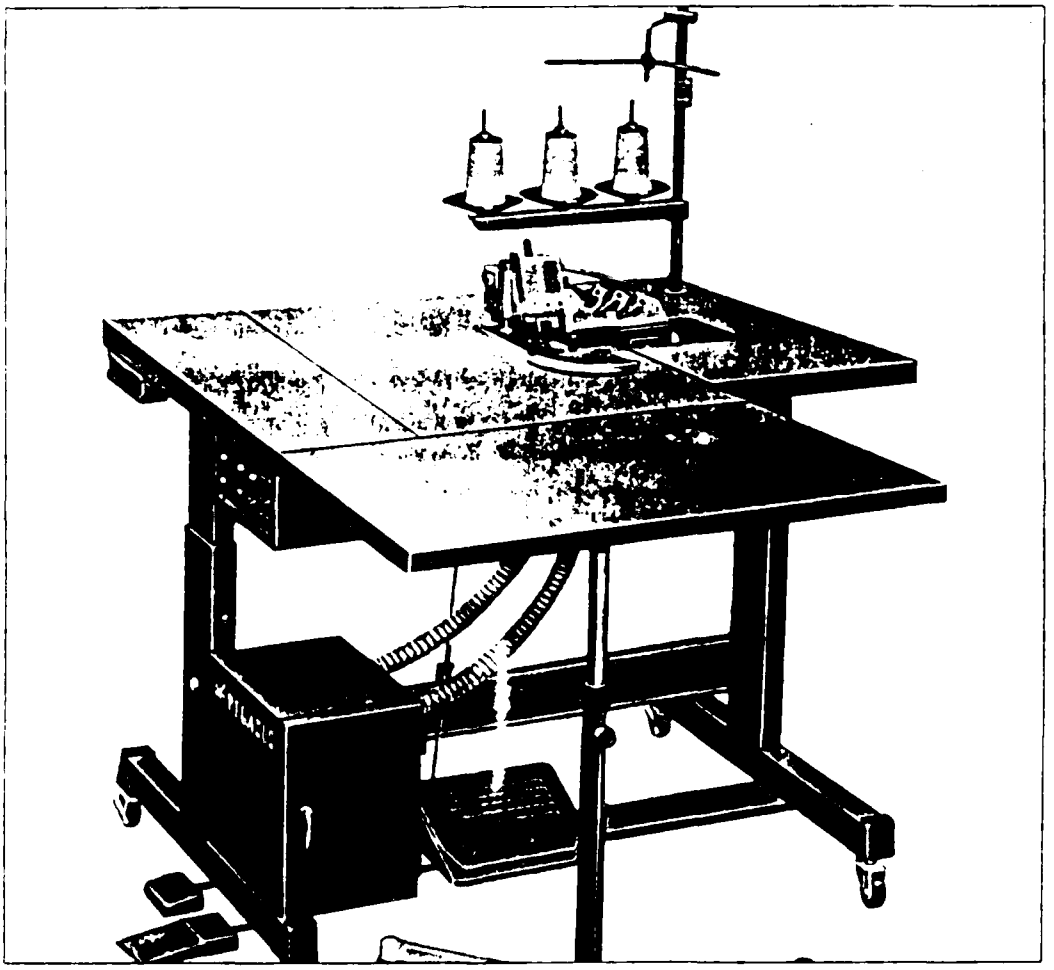
* Singer Substantially Higher

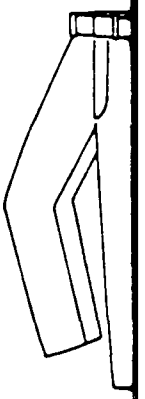
8

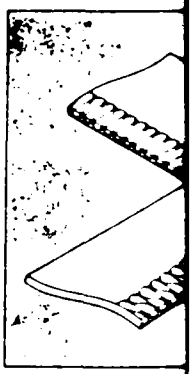
LS-301

1	3	3.2	3·4·5·6	1～3	6	6,000

● Stitch Length Adjustment……Push button ● Diff. Feed Adjustment……Lever







■ 小物用サージングユニット
■ スラックスの前立やブラウスの見返しなど、小物パーツのサージング。
■ 小物パーツのサージングが手離しで行なえます。オペレータはミシンが稼動している間に、次のパーツの準備ができ、オーバーラップ作業が行なえるので大変能率的です。
また、補助テーブルを取付けることにより、通常のサージングもできます。スイッチを切替えると、単体専用ロックミシンとしても使えるので、幅広く活用できます。

■ Small parts serging unit
■ For serging on small pieces such as the fronts of slacks or the facings of blouses.
■ Enables "hands-off" serging of small pieces to be performed. Since the operator can be preparing the next piece while the machine is serging, the unit offers great improvements in efficiency.
■ Furthermore, by simply fitting an auxiliary table it can also be used for normal serging operations. By just flicking a switch, the machine can also be used as a stand alone overedger, so it can be used for a wide range of applications.

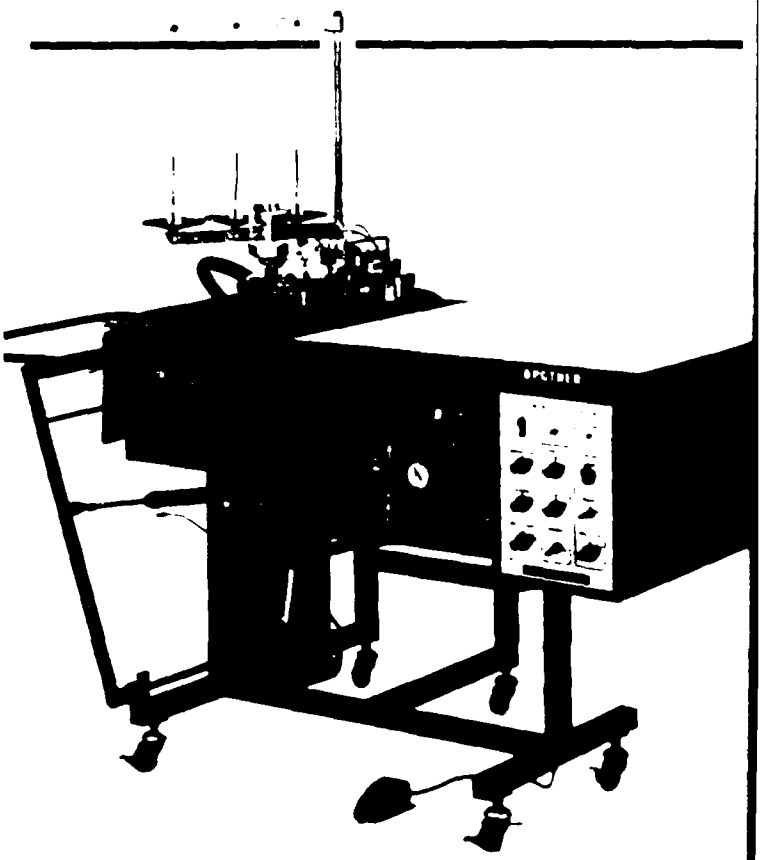
■ 小衣物縫邊機
■ 實際便利的前餘部分或女襯衫的部品的縫邊。
■ 能不用手工便進行小衣物部品的作業員在轉動縫機後便能進行下個準備，因此能有高的事能。
此外另裝上補助板便能變爲一般的包縫換開關倘能使用於立式作業用此活用範圍相當寬廣。

BAS-101

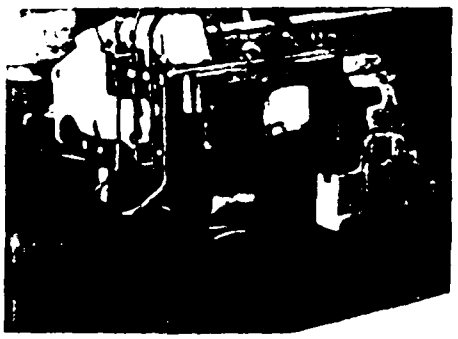
自動サージング機〈超高速オーバーロックミシン付〉
AUTOMATIC SERGING MACHINE

日本サージングマシンBAS-101は、高性能サーボモーターやフォトセンサーを採用、エアスムージング装置・切り替え式スタッカーなど数多くの特長を備えた最新鋭機です。シンプルなシーツから、厚物までの素材の変化、パターン変更に対応でき、布をセットするだけでサージングから糸切り、積み重ねまで、すべてを自動的に行ないます。熟練・未熟練を問わず、高い生産性と省力化、品質の均一化をお約束します。

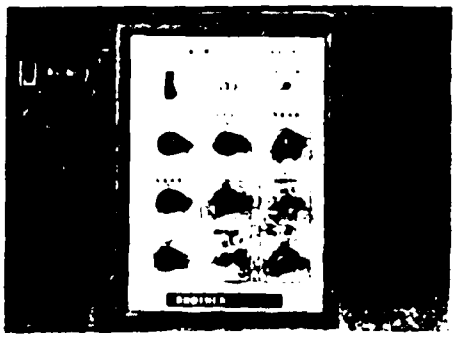
BAS-101 is the latest automatic serging machine featuring a number of advanced mechanisms and functions such as high performance servo motor, photo-sensor, air smoothing mechanism and changeover stacker. Wide range of fabrics from thin material as georgett to thick material, and change of patterns can be dealt with immediately. BAS-101 carries out from serging to thread cutting and stacking automatically, by just setting the fabric. BAS-101 is the key for the labor saving and uniform quality, allowing even an unexperienced operator to achieve high productivity.



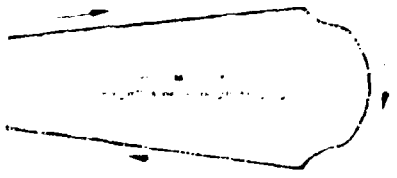
適用品目 APPLICATIONS



サーボモータコントロール

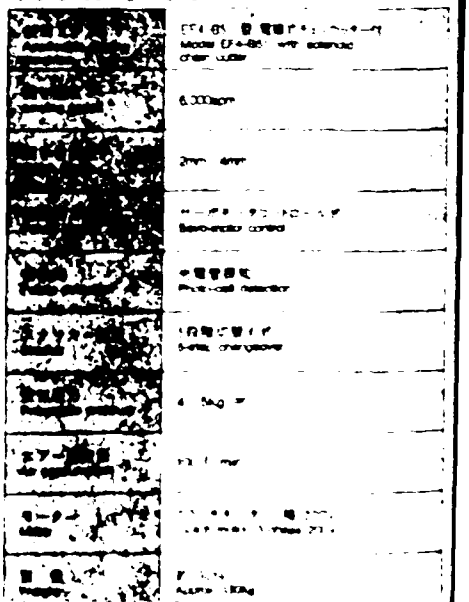


コントロールボックス CONTROL BOX



Servo motor Control

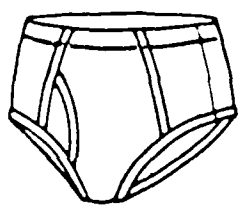
仕様 SPECIFICATIONS

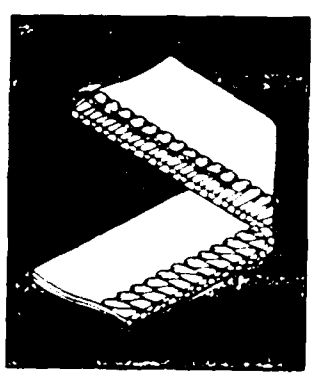


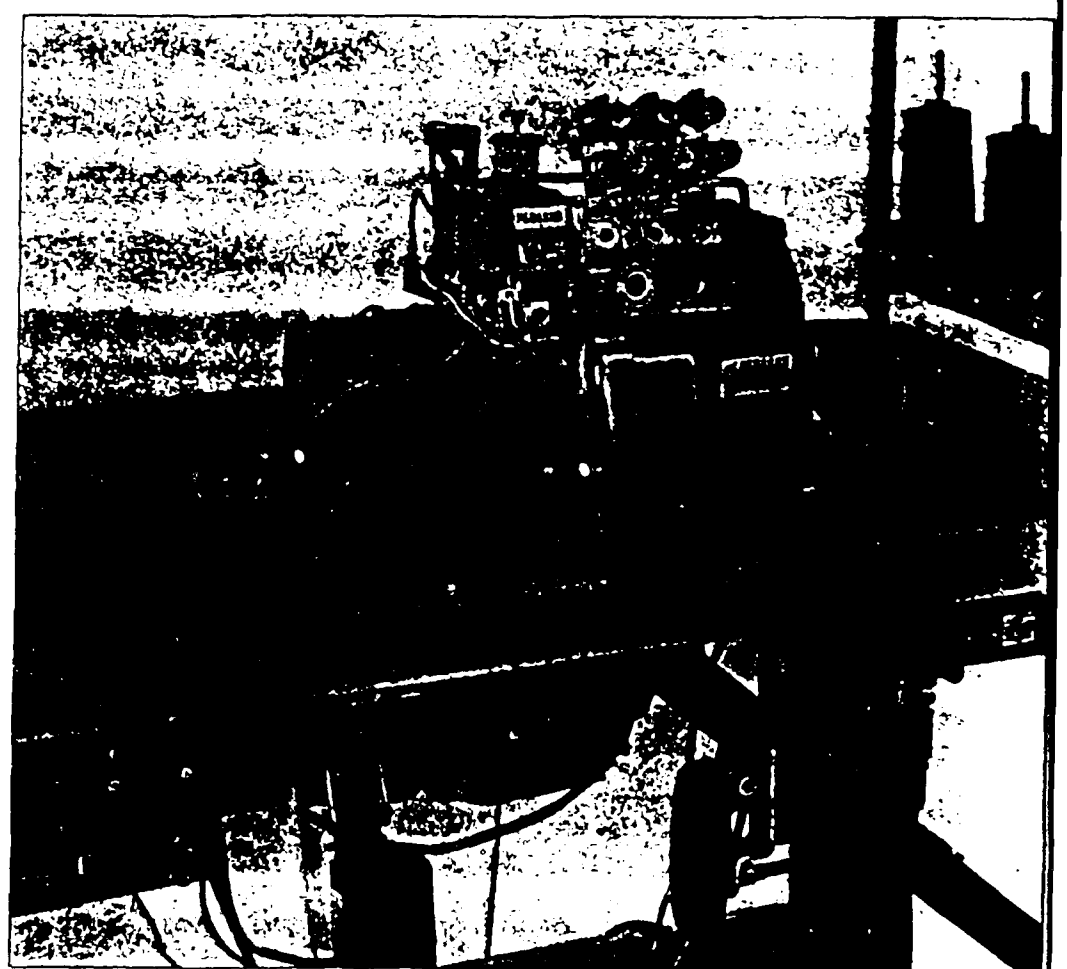
BL-200

1	3	3.8	—	3·4·5·6	0.7～2	5	8,000

● Stitch Length Adj.……Push button ● Diff. Feed Adj.……Lever with micro-adjustment







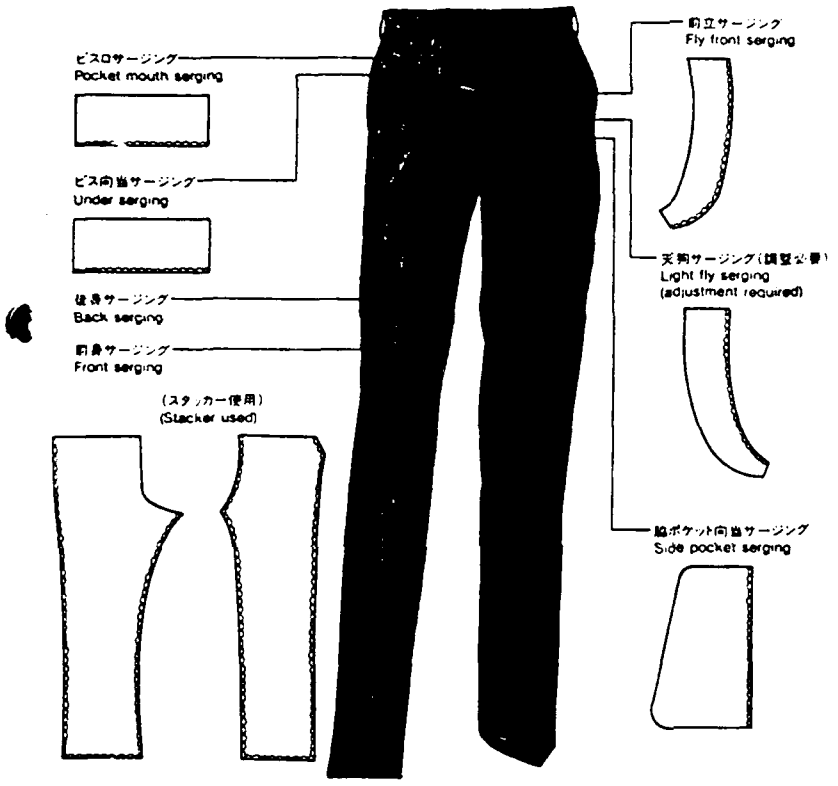
■1本針自動バックタッカー
■ニットシャツの袖下縫や脇縫など止め縫の必要な地縫工程。
■ほつれ止めのために、縫い始めにカラ環をシームの中に包み込むバックタック縫が自動的に行なえる自動バックタックユニットです。
従来オペレータはバックタックするためにカラ環を手前に引き戻す動作が必要でしたが、BL-200では、地縫と同じ動作だけでバックタックが行なえます。

■ 1-needle, automatic backlatcher.
■ For plain seaming operations such as sleeve and side closing knit jersey, etc, where a backlatch operation is required.
■ An automatic backlatch unit which performs backlatching automatically at the start of the seam and prevents it from fraying.
■ Normally, the operator has to pull the thread chain forwards in order to do backlatching. This unit, however, makes that operation unnecessary and allows backlatching to be performed in exactly the same way as plain seaming.

■單針式自動套縫機
■適用於編織襯衫的袖下縫或腰縫等需要套縫的直縫工程。
■爲了防止接縫解開在開始縫時便自動的進行套縫的自動套縫機。
以往作業員在進行套縫時需將線拉往前側，此機種不需此動作能像直縫一樣來進行套縫。

BAS

紳士スラックス/MEN'S SLACKS

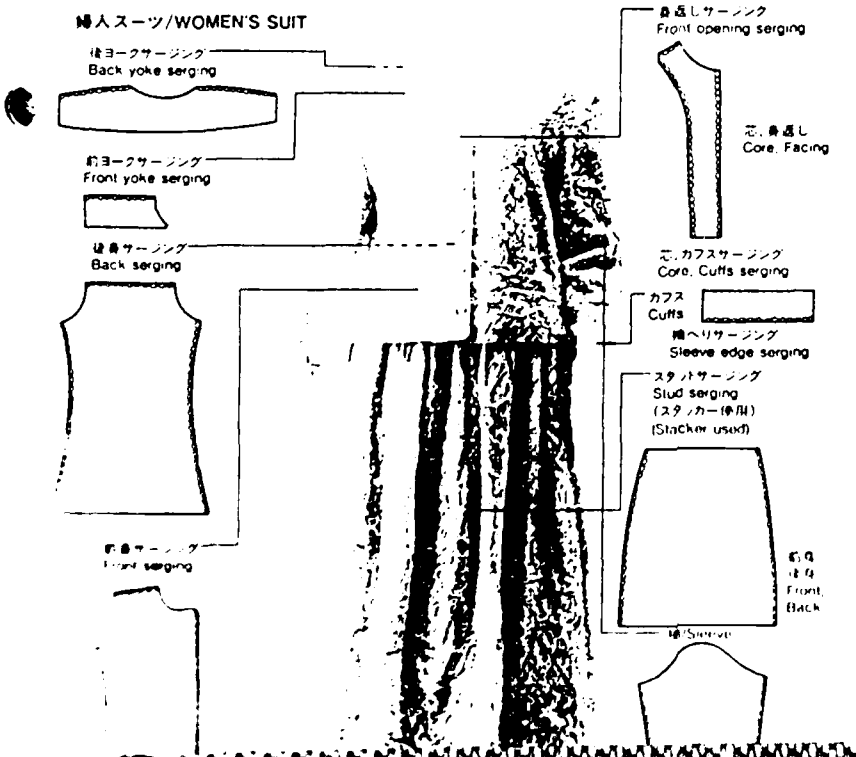


工程No. Process No.	作業内容 Operation	標準時間 Standard time		低減率 Reduction ratio
		EF4-B511	BAS-101	
P4	脇ポケット向当サージング Side Pocket hiding serging	14	10	28.5
P11	前立サージング Fly front serging	8	6	25.0
P19	天狗サージング Light fly serging	9	6	33.3
P32	ピスロロ当サージング Pocket mouth serging	14	10	28.5
P33	ピス向当サージング Under serging	14	10	28.5
F1	前身サージング Front serging	68	46	32.3
B1	後身サージング Back serging	56	38	32.1
	縫製工程計 Total sewing sec.	183	125	31.7

素材：パワーストレッチ
ポリエステル 55%
毛 40%
ポリウレタン 5%
1着当縫製時間 2.172秒
縫製比 84%
縫製比＝オーバーロック縫製時間 / 1着当縫製時間

Material: Power stretch
Polyester 55%
Wool 40%
Polyurethane 5%
Total processing time per piece 2.172sec
Sewing time ratio 84%
Sewing time ratio = Overlock processing time / Total processing time per piece

婦人スーツ/WOMEN'S SUIT



工程No. Process No.	作業内容 Operation	標準時間 Standard time		低減率 Reduction ratio
		EF4-B511	BAS-101	
P4	身返しサージング Facing serging	44	20	54.5
P8	前ヨークサージング Front yoke serging	18	10	44.4
P9	後ヨークサージング Back yoke serging	17	11	35.3
P4	カフスサージング Cuffs serging	11	7	36.4
P5	袖ヘリサージング Sleeve edge serging	47	29	38.3
F1	前身サージング Front serging	67	37	44.8
B1	後身サージング Back serging	91	55	39.6
	縫製工程計 Total sewing sec.			
SF1	前身 Front serging	11	9	18.2
SB1	後身 Back serging	11	10	9.1
	縫製工程計 Total sewing sec.			
	縫製工程計 Total sewing sec.	313	193	

ARK, Incorporated

P.O. Box 636 Shelbyville, Tn. 37160 615/684-4737

August 18, 1987

Mr. Edwin McPherson
School of Textiles
North Carolina State University
P.O. Box 8301
Raleigh, N.C. 27695-8301

Dear Mr. McPherson:

This is in reply to Dean William K. Walsh's letter of August 13, 1987 regarding an amendment to the prime contract extending the fabrication and completion dates for the "Combat Trouser Uniform Front Pocket Work Cell System".

We note that Item 6. in the original bid "Time Requirement" has been modified as follows:

> Preliminary construction should be completed by April 4, 1988.
> Operating modules must be completed by March 4, 1989.

We are pleased to rebid our proposal originally dated May 15, 1987. Our quotation is $393,000 for the complete project as described. Terms are 10% advance deposit with the contract and regular monthly progress payments over the ensuing term of the contract. Each progress payment will be justified using DOD cost accounting standards.

Thank you again for the opportunity to quote.

Sincerely,

ARK, INCORPORATED

W. R. Cole, Jr., P.E.
President

WRC/jc

APPENDIX J

Proposal for

COMBAT TROUSER UNIFORM FRONT POCKET WORK CELL SYSTEM

(Best and Final Offer)

Submitted to:

North Carolina State University
School of Textiles

August 19, 1987

SINGER

Manufacturer Applied Robotic Sewing

North Carolina State University
School of Textiles

Business Office
Box 8301, Raleigh, N C. 27695-8301
Tel (919) 737-3077

August 21, 1987

ATTESTED

This proposal was received 8-21-87 and was opened after 5 o'clock 8-21-87.

We are notarizing each page as evidence no proposed cost of development was included.

E. M. Pherson

Tim Clapp

Notary Public
My commission expires 10-23-89

SINGER

NORTH AMERICAN SEWING PRODUCTS DIVISION

August 19, 1987

Mr. Edwin McPherson
School of Textiles
North Carolina State University
P. O. Box 8301
Raleigh, NC 27695-8301

Dear Mr. McPherson:

We are pleased to re-submit our bid as a best and final offer, as enclosed, in response to the bid solicitation of March 3, 1987, for the combat trouser uniform front pocket work cell system.

We have also enclosed video, as listed below, to demonstrate technologies which we have recently developed which can help support this project:

Equipment	Technology
Jeans Front Pocket System	Pick-up and parts transfer
Boxer Short System	Pick-up, ply separate, ply sensing, turnover and feed three plys for registration and sew.
Pocket Facer/Bagger	Folding and guiding multiple plys.
$(TC)^2$	Commercialization of conveyance systems, vision interface and software capability.

You will note that although individual module function and development remain similar in concept to that in our initial proposal the amount of equipment in our revised proposal has been substantially reduced to more closely approximate North Carolina State specifications. Further, you will note that the Singer content has increased by taking advantage of our newly developed technologies and, at the same time, we are utilizing proven technologies developed by Techstyle, Inc. If at some future date there were increased productivity requirements, the work cell as now proposed will have the flexibility to be reconfigured with additional modules to improve cycle time without additional development cost.

Again, we appreciate your consideration of our bid and hope that with what we have presented, you will conclude that we are the most qualified to successfully complete this challenging program.

Sincerely yours,

Vince Vento (m)

Vince Vento, Vice President
Robotic Systems

VV/el/1.24
cc: W. Current
S. Kind
H. Rovin
G. Sansone

August 19, 1987

Professor Ed McPherson
North Carolina State University
Department of Textile Management and Technology
Box 8301
Raleigh, North Carolina 27695-8301

Dear Ed:

On the flight home, I started analyzing and digesting what I learned at our meeting yesterday and following are my conclusions.

It is frustrating to see that very few people or companies in the United States are involved in automatic garment manufacture. It is frightening.

In an effort to promote good citizenship (since the whole project is being paid with tax dollars), I must tell you we spent a lot of money learning this operation and came to the conclusion it should be split apart. I cannot help but state you should insist that ARC, really your only valid contender, break all three operations apart individually to provide a buffer between each sewing operation. I therefore will disclose to you what we learned some 15 years ago in constructing such a machine, and at the same time, this may afford a sensible solution for the transfer from machine to machine.

Our first version, which we called F-14, produced exactly the product you are talking about. However, since our quantity in slacks was infinitely smaller than in jeans, we decided to devise a version for jeans front pocket production. We actually built and operated this machine, which we called DF-13. Due to all the operations in line without a buffer, we never could achieve more than 50% efficiency even though we manned the machine with two instead of one operator to respond better to machine interference. We subsequently scuttled the machine and took a new approach which I am not at liberty to explain to you. Obviously, the conclusion would be to have stand alone individual models. Under separate cover, I am forwarding renderings of the two machines so you can better comprehend what I am trying to tell you. Please do not make copies of these renderings since I would not appreciate the biggest folly of my life printed in the newspapers or magazines. However, if they would be helpful in discussions with you vendor, please feel free to show it to them so they better comprehend and cooperate.

We also discussed that you would send me a printout of your file which statistically evaluates operations incrementally as used in the construction of a pair of slacks, jeans or other garments for that matter. Please forward such a copy to me so I can give it some thought and comment on it. Since I will not have the time to look at the entire garment industry, I would like to confine it to construction of jeans and slacks. If you are unable to run such a sort on your file at this time, I could run the sort myself, but I think it would be a worthwhile effort to complete such a file sort as it may help the entire United States apparel industry. Of course, I would delete the names from where you obtained the information.

I am also enclosing the travel payment forms for reimbursement. Incidentally, reimbursement should be made to Levi Strauss & Co., not me. Thank you.

Best regards,

Hubert Blessing
Director, Research & Development

HB:sr
Attachments

Manufacturer Appli
Robotic Systems

TABLE OF CONTENTS

SINGER

I. BID OVERVIEW

The Singer Sewing Company in concert with its primary sub-contractor, Techstyle, Inc. is pleased to re-submit their bid in response to the request for a best and final offer received from North Carolina State University on August 14, 1987.

The system proposed in the best and final offer has been modified from the system proposed by Singer on May 15, 1987 to more closely address the requirements of the Preliminary Equipment Specification issued by North Carolina State University on March 7, 1987 as modified by the August 13, 1987 request for best and final offer.

The system embodied in the proposal takes further advantage of the cycle time allowed in the specification to reduce the number and complexity of modules and thereby more closely approach the production cost target identified in the specification. It is recognized that this significantly reduced cost to the user will allow the system to be affordable to a broader range of contractors and thereby increase its value to the program sponsor. The program outlined herein for completion of the development effort also takes full advantage of the program schedule expansion provided in the August 12th, 1987 letter. This program extension allows time for fuller examination of alternate concepts and for evaluation of candidate approaches thereby reducing program risk and allowing for a more effectively executed design.

In selecting Singer Sewing Company and Techstyle, Inc., the customer can be confident of being teamed with the industry leaders in the field of sewn product automation. Singer's efforts in this area are well known, starting with full automation of automotive trim and textile products, and leading into development of modular automation systems based on $(TC)^2$ technology for the apparel industry. Efforts in this area have led to Singer's development of a system that fully automates the production of a complete jeans front pocket assembly, as well as equipment capable of simultaneously and with full automation, sewing the three panels that form a pair of men's boxer shorts. Experience in both of these areas in particular is directly applicable to the task of joining the three parts that form the combat trouser front pocket. In addition, Singer Sewing Company has the financial and human resources needed to carry out a program of this magnitude. Techstyle is known to have developed a concept demonstration model directed towards full automation of the trouser pocket assembly process and has in fact produced a number of systems currently being employed in semi-automatic sub-assembly of the trouser pocket.

Singer is confident that the experience of these two companies can be combined to provide the most effective solutions to the automation of trouser assembly and is committed to directing the resources of these companies towards that end.

II. BIDDER QUALIFICATIONS

A. SINGER SEWING COMPANY

Singer Sewing is a worldwide leader in the manufacturing and marketing of consumer and industrial sewing equipment Singer is the acknowledged leader in robotic sewing technology with the application of in-line production and pre-production robotic systems with leading U S. manufacturers of automotive trim (General Motors, Ford, Chrysler, etc.), textile products (Collins & Aikman, Burlington, J P. Stevens, etc) and apparel (Union Underwear, Lee Company, etc.).

In addition to the Singer Sewing Company's considerable experience and current capabilities in the field of total system garment automation, Singer is the key commercialization and product application resource of the Textile Clothing Technology Corporation $(TC)^2$ which provides additional access to leading edge robotic and material handling technology equipment. Singer Sewing and $(TC)^2$ have a particular interest in a strong working relationship with North Carolina State University and hope that acceptance of this bid will forge an additional link in that relationship.

B. TECHSTYLE, INC.

TechStyle, Inc. has been in business since 1970, designing and developing specialized machinery for the textile and apparel industries. TechStyle and its Company President, Mr. Herman Rovin have long been recognized as a particularly creative and cost effective resource in the development of soft goods material handling and sewing equipment systems.

TechStyle developed and presented the first "Sewbotic Work Cell" system for trouser and jean pocket sewing in the form of a working proof of concept system at the 1984 Bobbin Show in Atlanta, Georgia. This proof of concept system was developed for the U.S. Department of Commerce (Contract No. 99-26-0 '1-69-30). TechStyle, Inc. was sub-contracted by the Georgia Institute of Technology to engineer, design and build the appropriate hardware. The work cell concept and module description which is profiled in North Carolina State University's preliminary equipment specifications closely approximates the proof of concept hardware which still resides at TechStyle's facility in Piedmont, South Carolina.

In summary, Singer Sewing is confident of our combined abilities to complete the proposed system development and to complete the obligation within the time period and budget level proposed.

III. PROJECT APPROACH OVERVIEW

Manufacturer Appli
Robotic Systems

The work cell, which is detailed in the following section, is made up of three loading systems, one unloading system and one sewing system. Two robots work together to pick-up plys after they have been separated, delivered and registered from the loading system, and then maintain positional control of the parts to and through the sewing operation. After the bearer and facing have been properly joined to the pocket lining, the finished assembly is stacked on the unloading system in the order which parts were introduced. The operation sequence for the two robots is as follows:

Robot 1

- Pick-up bearer
- Move to pocket
- Pick-up pocket
- Move to sew
- Hold through sew & trim
- Move to combiner/holding table
- Return to start
- Return to start

Robot 2

- Pick-up facing
- Move to pocket/bearer assembly
- Pick-up pocket/bearer assembly
- Move to sew
- Hold through sew & trim
- Move to stacker
- Release finished assembly

IV. PROPOSED UNIFORM FRONT POCKET SYSTEM APPROACH

(SYSTEMS ILLUSTRATED IN EXHIBITS 1-2)

Manufacturer Applic
Robotic Systems

The proposed work cell shall consist of the following modules:

1. Three Feeder Modules (includes pick-up, ply separation and transfer devise) - These units will accept input product (1 for pocket, 1 for facings and 1 for bearers) and will be capable of reliable, repeatable, ply separation and feeding. The feeder modules will incorporate indexing conveyors each having the capacity to hold a minimum of four bundles, elevator platforms to lift the stacks to a constant height for pick-up and transfer arms capable of taking individual plys directly from the cut stacks of material and reliably placing them on the registration module. For bundles cut face to face, the pick-up and ply separation device will have the ability to alternately turn face down plys over during transfer to the registration module.

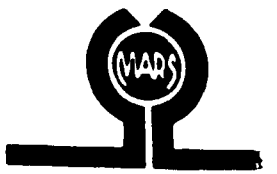
2. Three Registration Modules - These units will register each of the three pieces of cloth individually and in justaposition to each other and will accurately orient them to a fixed starting position.

3. One Combiner Module - This unit will provide a surface with a means to accurately hold the bearer and pocket lining assembly in the position in which it will be released by the first robot to await pick-up by the second robot.

4. One Sewing Module - This unit will sew bearer and facing to the pocket lining. It will incorporate a means of guiding, controlling and folding under the edge to be sewn on both the bearer and the facing while sewing them to the pocket lining and afterwards trimming the thread.

5. One Stacker Module - This unit, similar to the feeder module, will accept the finished assemblies from the robot after the second sewing operation. When the complete bundle is restacked. It will convey the finished bundle out of the loading position so that the next bundle can be restacked. The conveyor will have the capacity to hold a minimum of four finished bundles to await manual unloading. The stacker conveyor can also be programmed to layer the assemblies in a way that they may be fed to future automation equipment.

IV. PROPOSED UNIFORM FRONT POCKET SYSTEM APPROACH (Con't)



Manufacturer Applie Robotic Systems

6. Two Robots - These units will pick-up plys from the registration modules, introduce them to the sewing module, hold them during sewing and release them in an accurate position. Both robots will have a vertical "Z" motion capability for picking-up or placing parts down. The units will also have both a longitudinal "X" motion capability and a transverse "Y" axis capability for moving a part to a precise location as a particular application requires. The X & Y axes will be servo-controlled and remotely programmable. The operation sequence for each of the two robot is as follows:

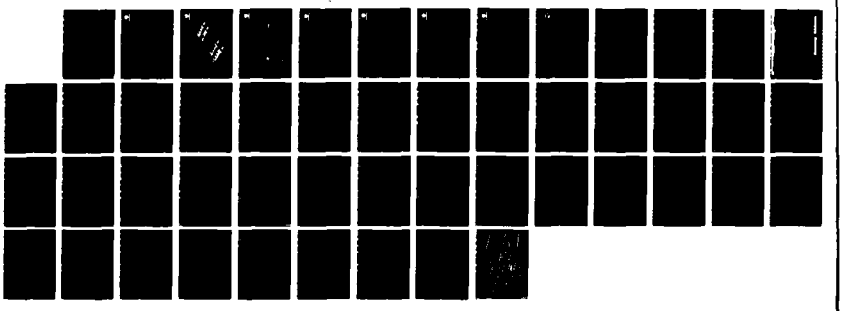
Robot 1 - Sew Bearer to Pocket Lining	Robot 2 - Sew Facing to Pocket Lining
Pick-up bearer	Pick-up facing
Move to pocket lining	Move to pocket assembly on holding table
Pick-up pocket lining	Pick-up pocket assembly
Hold during sew and trim	Move to sew
Move to combiner/holding module	Hold during sew and trim
Release part on holding table	Move to stacking location
Return to start	Release finished assembly
	Return to start

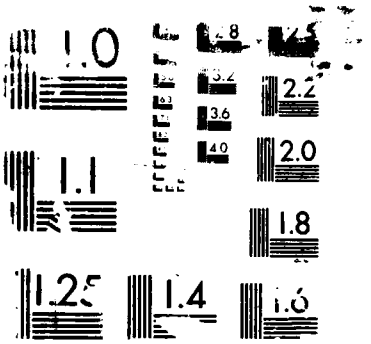
7. Control Module (Console) - This unit will be comprised of microprocessor computer - controls which will direct and monitor the operational status of each of the six modules. In addition, the control module will be capable of programming each of the individual modules and the total system to respond to changes in product size, style or type of material.

Military bearers and facings will be attached to the pocket by folding under the sewn edge and joining them with a [illegible] stitch. Civilian pocket facings and welts will also be attached in a similar manner.

The system will occupy a space approximately six feet by eleven feet not including the control console.

AD-A189 120 MANUFACTURING TECHNOLOGY FOR APPAREL AUTOMATION PHASE 1 2/2
2 AND 3 ACTIVITY(U) NORTH CAROLINA STATE UNIV AT
RALEIGH SCHOOL OF TEXTILES E M MCPHERSON 15 OCT 87
UNCLASSIFIED NCSU/DLA-87/2 F/G 15/5 NL

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IV. PROPOSED UNIFORM FRONT POCKET SYSTEM APPROACH

Manufacturer Applic
Robotic Systems

The complete cell will occupy approximately 225 square feet including the computer-control console. Each module will be controllable either independently or as a coordinated sector of the total work cell. All modules will be free standing and mounted on retractable casters but can be joined together mechanically to form a rigid integral structure. In addition, all the modules will be electronically linked to a main control processor. The hardware will conform to the codes outlined in North Carolina State University's preliminary specificatons. The power requirements for the Work Cell are estimated as follows:

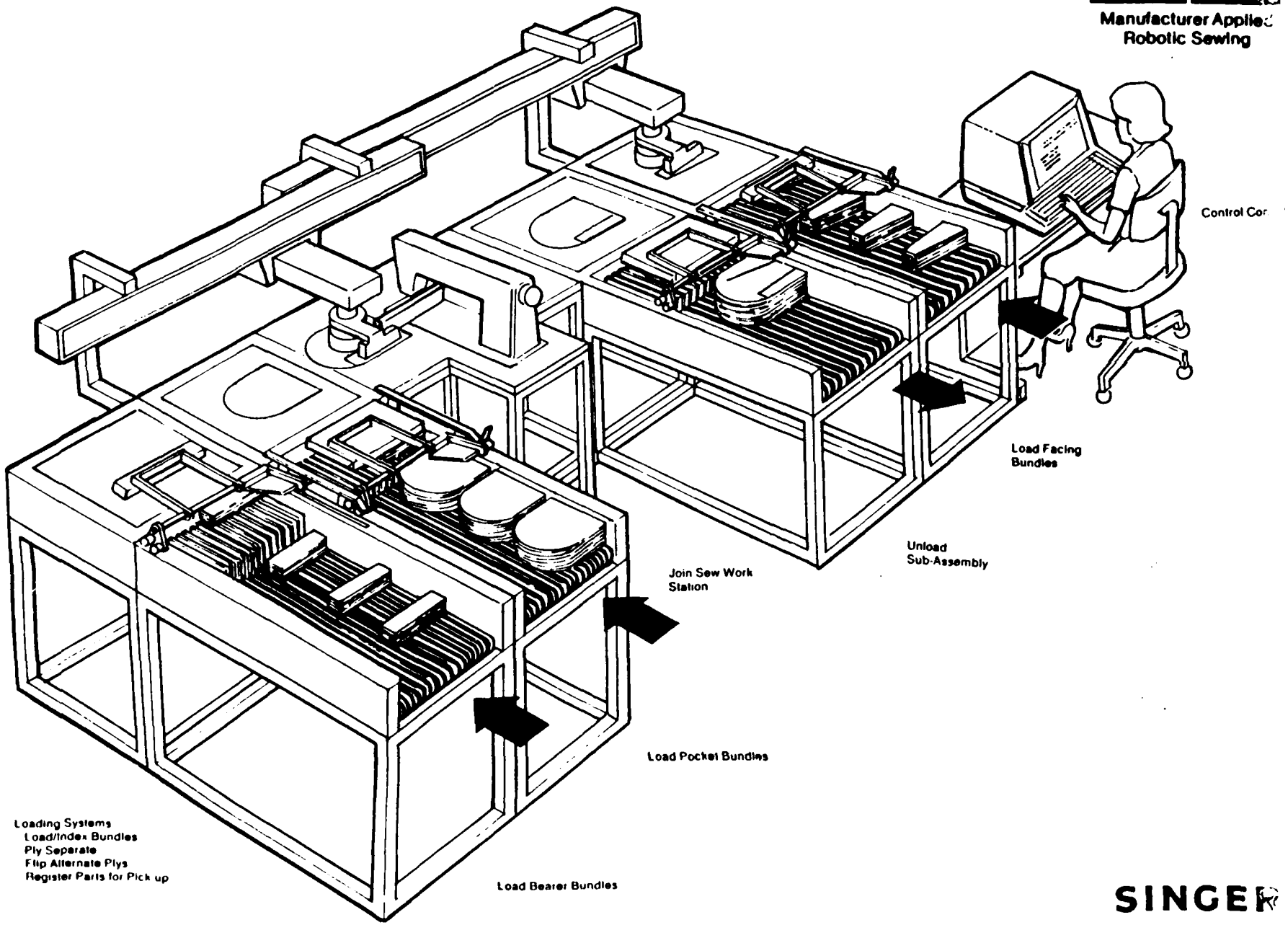
- 220V AC @ 3-10A, 50-60HZ
- 90 PSI air @ 8-10 CFM
- Vacuum--unable to specify at this time

SINGER

COMBAT TROUSER UNIFORM FRONT POCKET WORK CELL

Exhibit 1 (Perspective) - System Overview

Manufacturer Applied Robotic Sewing



SINGER

COMBAT TROUSER UNIFORM FRONT POCKET WORK CELL

Exhibit 2 (Plan View) - Configuration of Modules and Sequence of Work Flow

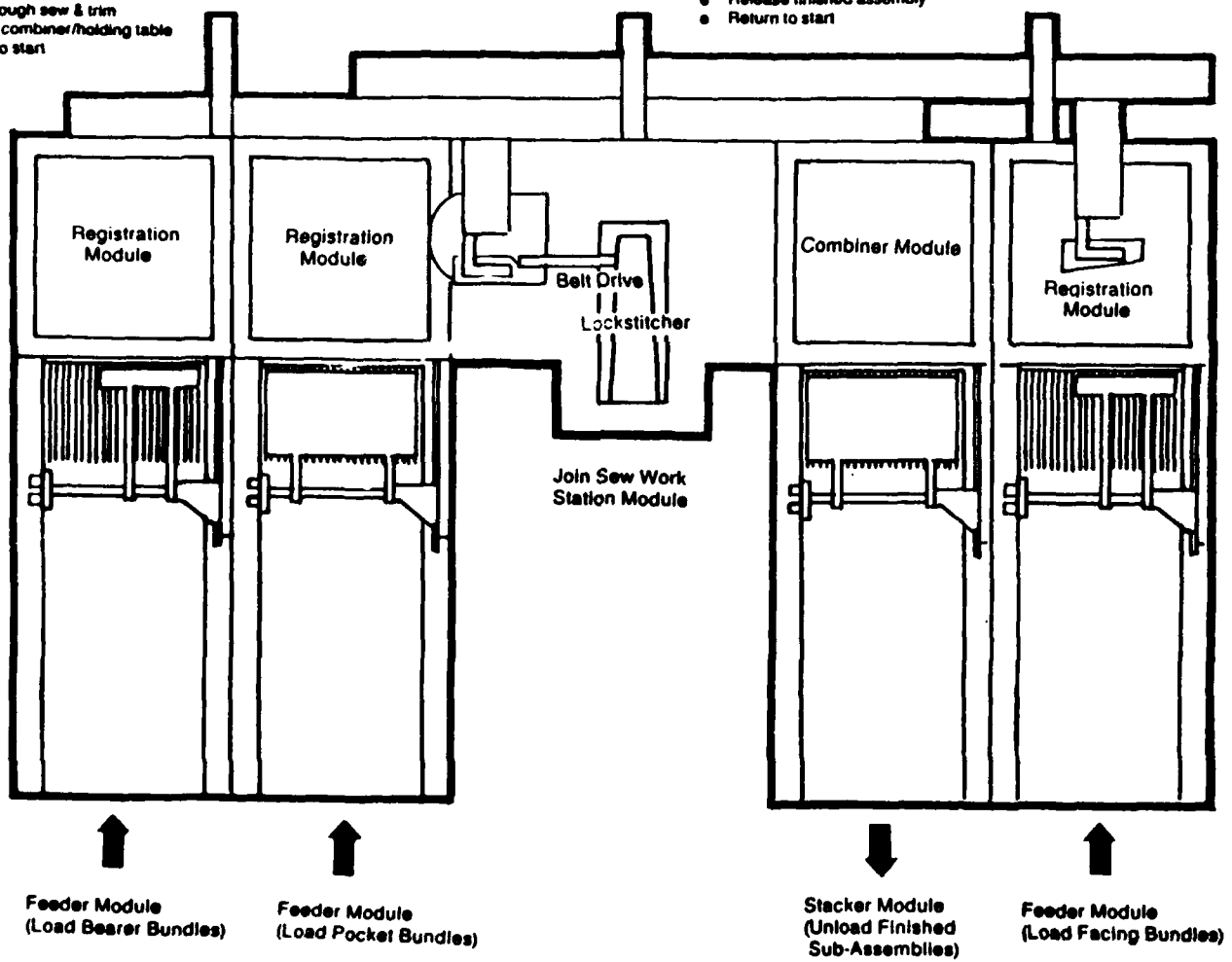
Manufacturer Applied Robotic Sewing

Robot 1

- Pick-up bearer
- Move to pocket
- Pick-up pocket
- Move to sew
- Hold through sew & trim
- Move to combiner/holding table
- Return to start

Robot 2

- Pick-up facing
- Move to pocket/bearer assembly
- Pick-up pocket/bearer assembly
- Move to sew
- Hold through sew & trim
- Move to stacker
- Release finished assembly
- Return to start



Note Control Console not shown

SINGER

V. SYSTEM FEATURES

Manufacturer Applied Robotic Systems

- The proposed work cell will be capable of producing faced only front pockets for uniform combat trousers. It will accommodate all sizes.
- The proposed work cell will be capable of producing faced only front pockets for civilian slacks, dress pants and work pants. It will accommodate all sizes.
- The proposed work cell will produce faced only front pockets for all sizes of civilian pockets falling within the "on-seam" or "casual seams" of dress slacks. (Note: Work pants front pockets fall under the category of 'on-seam' pockets consisting of either one or two facings. Uniform dress trouser front pockets also fall in the 'on-seam' category).
- The proposed work cell will be capable of joining other two or three picce assemblies but may require:
  1. Program changing
  2. And/or mechanical change of work stations if different sewing heads are to be used
- The entire work cell will be designed in a manner such as to maintain at least a 95% uptime level.
- All feeders and stackers will be similar in construction.
- All registration modules will be similar in construction.
- Both robots will be identical in construction less those axes that are not required.
- Both robots will be capable of having their end-effectors quickly replaced.
- Cutting of pockets may be hand cut, die-cut or cut by automated cutting systems such as the "Gerber-Cutter". The accuracy of cut parts will of course be better and more conducive to automated assembly if die-cut or Gerber-cut. Tolerance requirements will be established between Singer Sewing/TechStyle and North Carolina State University.
- Cutting may be face-to-face or all face up. The integrity of 'shade-match' and/or piece marking will be maintained. The integrity of right side-wrong side (such as the camouflaged surfaces of military pockets, facings and bearings) will be maintained.

VI. PRODUCTION COST/PRODUCTIVITY TARGET

The entire pocket facing system, after a suitable production phase-in period, will be capable of being sold in production quantities for approximately $45,000. Cost reduction efforts will be carried out during this period with the objective of more closely approaching the target price range of $25,000 - $40,000 as stated in the North Carolina State preliminary equipment specification.

Initial production price estimates for the various system modules are tabulated as follows:

Module	Cost Each Module	No. of Modules	Total System Cost
Feeder Modules	$ 1633	3	$ 4900
Registration Modules	1667	3	5000
Sewing Module	11667	1	11670
Combiner Module	300	1	300
Stacker Module	1633	1	1633
Robot	6667	2	13300
Control Module	8333	1	8500
		12	$45303

Throughput of the system is easily compatible with the 14-second cycle time requirement specified and is targeted to exceed that specification by as much as 40%. Compliance with this goal would increase throughput to 2800 pockets per day. Throughput is enhanced by sharing the complete operation between two control robots thereby allowing operations to proceed in parallel.

VII. SYSTEM DEVELOPMENT SCHEDULING

Manufacturer Applied Robotic Systems

Below is an overview of the total system development schedule:

- September 1987 - Program go-ahead
- December 1987 - Complete preliminary definition of design & conduct initial product design approach review.
- March 1988 - Construct/evaluate proof of concept models and complete product design.
- April 1988 - Initiate procurement
- June 1988 - Begin assembly of key modules.
- September 1988 - Integration and test of modules
- December 1988 - Integrate components into a complete system.
- March 1989 - Complete testing and deliver for factory test.

We would establish detailed milestones consistent with the above for funding flow and to assure the close interface and involvement of key North Carolina State program managers.

SINGER

Manufacturer Applie.
Robotic Systems

IV. PROPOSED UNIFORM FRONT POCKET SYSTEM APPROACH

The complete cell will occupy approximately 225 square feet including the computer-control console. Each module will be controllable either independently or as a coordinated sector of the total work cell. All modules will be free standing and mounted on retractable casters but can be joined together mechanically to form a rigid integral structure. In addition, all the modules will be electronically linked to a main control processor. The hardware will conform to the codes outlined in North Carolina State University's preliminary specificatons. The power requirements for the Work Cell are estimated as follows:

- 220V AC @ 3-10A, 50-60HZ
- 90 PSI air @ 8-10 CFM
- Vacuum--unable to specify at this time

North Carolina State University
School of Textiles

Department of Textile Management and Technology
Box 8301, Raleigh, NC 27695-8301
Tel (919) 737-3442

August 28, 1987

Mr. Dan Gearing/DLA-PR
Defense Logistics Agency
Cameron Station
Alexandria, VA 22304-6100

Dear Mr. Gearing:

Enclosed is the late supplement to the Singer Proposal table 8, which was opened by Bill Walsh on Thursday, August 27, 1987.

Sincerely,

Edwin M. McPherson
Associate Professor
Textile Mgmt & Technology

APPENDIX VII

SINGER

NORTH AMERICAN SEWING PRODUCTS DIVISION

August 25, 1987

Mr. Edwin McPherson
School of Textiles
North Carolina State University
P. O. Box 8301
Raleigh, NC 27695-8301

Dear Mr. McPherson:

It has come to our attention that Section VIII had been inadvertently left out of our best and final offer which was sent to you last week.

Based on my discussion with Mr. William K. Walsh on this date, I am enclosing a complete copy of our bid for your review, plus two copies of Section VIII which should be added to the last page of our proposal that was mailed to you on August 20th.

Sincerely,

Vince Vento (VV)

Vince Vento, Vice President
Robotics Systems

VV:mb 1/1.80

VIII. SYSTEM DEVELOPMENT COST

The system development costs tabulated below reflect the effort required to complete the design and concept evaluation work involved in the development of each module, as well as the fabrication and testing costs associated with the building of the first system. The cost of the program effort involved in program management, customer and sub-contractor liaison and in support of installation in the user's facility is also included in the summary. Documentation to be provided as part of this effort will include installation drawings, performance specifications, operating instructions, maintenance instructions and spare parts lists. Proposal drawings, design analysis and test reports will be provided as part of the design review process.

Design	$200,000
Fabrication and Test of 1st System	280,000
Program Support	90,000
	$590,000

North Carolina State University
School of Textiles

Office of the Dean
Box 8301, Raleigh 27695-8301
Tel (919) 737-3057

September 4, 1987

Mr. Vince Vento
Vice President
Singer Robotic Systems
135 Raritan Center Parkway
P. O. Box 1909
Edison, NJ 08818-1909

Dear Mr. Vento:

It is with regret that North Carolina State University must advise you that you are not the successful bidder for the "Combat Trouser Uniform Front Pocket Work Cell System Specification" (March 3, 1987). Your "Final and Best Offer" has been subjected to committee analysis and has been found to be deficient in meeting several items in the specifications. In addition, your bid cost was higher than that of the successful bidder.

Your efforts in preparing your two proposals are appreciated and certainly do contribute to our knowledge of your capabilities. You may be certain that you will receive high consideration for any further apparel equipment development projects that North Carolina State University undertakes.

Sincerely,

E. M. McPherson

EMM:geb

bc: Mr. Ralph Holland
Mr. Dan Gearing
Dean R. A. Barnhardt
Dr. F. D. Hart
Ms. Karen Hersey
Ms. Linda Jackson
Dr. W. K. Walsh
Mr. E. M. McPherson
Dr. H. Hamouda
Dr. T. J. Little
Dr. T. Clapp
Mr. E. Sikoski

APPENDIX VIII

E. McPherson

P 439 937 895

RECEIPT FOR CERTIFIED MAIL

NO INSURANCE COVERAGE PROVIDED
NOT FOR INTERNATIONAL MAIL

(See Reverse)

Sent to Mr. Vince Vento	
Street and No. Singer Robotic Systems 135 Raritan Pkwy	
P.O. State and ZIP Code PO 1909, Edison NJ 08818-1909	
Postage	$ 22
Certified Fee	75
Special Delivery Fee	
Restricted Delivery Fee	
Return Receipt showing to whom and Date Delivered	70
Return Receipt showing to whom Date, and Address of Delivery	
TOTAL Postage and Fees	$1.67
Postmark or Date SEP 1987	

* U.S.G.P.O. 1985-480-794

PS Form 3800, June 1985

RALEIGH NC CITY STATION SEP 1987 USPS

Fold at line over top of envelope to the right of the return address

P 439 937 897

RECEIPT FOR CERTIFIED MAIL

NO INSURANCE COVERAGE PROVIDED
NOT FOR INTERNATIONAL MAIL

(See Reverse)

Sent to Mr. B.H Cole Ark, Inc	
Street and No. PO 636 109 Hay St.	
P.O. State and ZIP Code Shelbyville NC 37160	
Postage	$ 22
Certified Fee	75
Special Delivery Fee	
Restricted Delivery Fee	
Return Receipt showing to whom and Date Delivered	70
Return Receipt showing to whom Date, and Address of Delivery	
TOTAL Postage and Fees	$1.67
Postmark or Date SEP 1987	

* U.S.G.P.O. 1985-480-794

PS Form 3800, June 1985

RALEIGH NC CITY STATION SEP 1987 USPS

Fold at line over top of envelope to the right of the return address

North Carolina State University
School of Textiles

Office of the Dean
Box 8301, Raleigh 27695-8301
Tel (919) 737-3057

September 4, 1987

Mr. Bill Cole
Ark, Inc.
P. O. Box 636
109 Hay Street
Shelbyville, TN 37160

Dear Mr. Cole:

It is with pleasure that North Carolina State University can advise you of your successful bid for the "Combat Trouser Uniform Front Pocket Work Cell System Specification" (March 3, 1987). Committee evaluation of your proposed work has found it to be in conformity with the specifications. In addition, you are the low bidder.

A contract is in preparation by North Carolina State University for your signature. It should be ready for review on the 7th or 8th of this month. Please advise us if you wish it mailed to you for review prior to a meeting here or if you would prefer reviewing the contract here.

Congratulations upon your successful bid!

Sincerely,

E. M. McPherson

EMM:geb

bc: Mr. Ralph Holland
Mr. Dan Gearing
Dean R. A. Barnhardt
Dr. F. D. Hart
Ms. Karen Hersey
Ms. Linda Jackson
Dr. W. K. Walsh
Mr. E. M. McPherson
Dr. H. Hamouda
Dr. T. J. Little
Dr. T. Clapp
Mr. E. Sikoski

APPENDIX IX

MEMORANDUM August 31, 1987

TO: Ed McPherson

FROM: T. G. Clapp TGC

SUBJECT: Technical Summary and Comparison of Final Proposals (submission date 8/21/1987) to Construct a Combat Trouser Uniform Front Pocket Work Cell System

As stated in my travel reports, dated June 8, 1987 and June 11, 1987, Singer Sewing Company and ARK, Inc. have the experience, technical resources, and facilities to develop and construct the work cell system.

ARK, Inc. did not revise their original proposal; therefore, the technical review in my travel report, dated June 11, 1987, needs no modification. Singer Sewing Company revised their original proposal and is summarized below. The cost sheet was not included the revised bid submitted 8/21/1987.

Singer's revised proposal reduces number and complexity of modules to more closely approach the production cost target identified in the specification. The system consists of three feeder modules, three registration modules, one combiner module, one sewing module, one stacker module, two transfer modules, and one control module.

The feeder module is designed to feed stacks of parts cut face-to-face or all face up, separate and turn individual parts, and transfer the part to the registration module. A registration module is used to register each part. One transfer module or robot is dedicated to combining the bearer and pocket, hold assembly during sew and trim, and move assembly to a combiner/holding module. The bearer/pocket assembly is then transferred to the combiner module. The second robot places the facing on the bearer/pocket assembly, holds the assembly during sewing, and moves the facing/bearer/pocket assembly back to the combiner module. The three part assembly is then transferred to a stacker module.

The proposed design minimizes the number of sewing modules and the material handling by the operator. Similarity between different modules is achieved where possible, such as the feeder and stacker modules. Much of the technology in this design is not new. The performance goal of this system is estimated at 2800 pockets per day at 95% uptime.

The revised Singer proposal and the ARK proposal are compared based on technical considerations, conceptual design, and proposed bid. Each bidder has the necessary qualifications to complete the proposed task. These qualifications include experience, technical competence, technical resources, and facility resources.

APPENDIX IX

Each bidder presented a modular conceptual design and described modular flexibility to some degree. Operator and maintenance skill levels are similar in each proposal. The conceptual design proposed by ARK is recommended for the following reasons:

1) The productivity of the ARK system is 4000 - 8000 pockets per shift versus an upper goal of 2800 pockets per shift by the Singer system.

2) The ARK system will perform three more types of operations than Singer. These operations include small parts serging, pocket folding, and pocket bagging. The small parts serger module, the folding module, and the bagging module will enhance the similarity and modularity of apparel processes. The fold and bag sequence is an additional assembly operation in the work cell system. The small parts serger will have the flexibility to serge different parts with no modifications.

3) The ARK proposal bid is $393,000. The revised Singer proposal bid is $590,000. (Note: The cost sheet containing the Singer bid was recieved after the 8/21/1987 deadline.) The bid difference is $197,000.

The objectives set forth by the Defense Logistic Agency are best met by the proposal submitted by ARK, Inc. for the reasons stated above.

cc: Dean Barnhardt
Dean Hart
Dr. Walsh
Dr. Little
Dr. Hamouda
Karen Hersey
Linda Jackson
Earl Pulliam

Exploratory Study On Meaning and Measurement of Flexibility/Modularity in Automated Apparel Manufacturing Systems (AAMS)

for Defense Logistics Agency Contract 900-87-C-0509

for

School of Textiles, NCSU

by

John R. Canada
Industrial Engineering, NCSU

August 26, 1987

APPENDIX X

Exploratory Study or Meaning and Measurement of Flexibility/Modularity in Automated Apparel Manufacturing Systems (AAMS)

for Defense Logistics Agency Contract 900-87-C-0509

by

John R. Canada

Prologue, Caveats, and Promises

This initial draft briefly reflects interim results of approximately two weeks effort by John R. Canada to (1) become familiar with on-going apparel manufacturing automation programs, particularly as backed by (TC)2 and DLA; (2) explore existing concepts and apparent needs re flexibility/modularity; and (3) tentativity structure approach(es) for further studies to aid in full definition and pragmatic measurement of flexibility/modularity.

This report is intentionally brief, but can be enhanced as deemed needed for reporting to DLA and for working with Textiles and/or Industrial Engineering graduate students on specific projects involving in-depth categorization and measurements. John R. Canada will be available to work with students, particularly on use of multi-attribute decision analysis methodologies to provide specific quantification of flexibility/modularity (hopefully together with other important attributes) to help evaluate what are the most appropriate levels of automated apparel manufacturing systems (AAMS) for selected circumstances.

Charge, Approach, and Resources

The original charge given to the author approximately July 15, 1987 was to explore and hopefully prepare for future studies on

"...the meaning, definition, and evaluation of flexibility in design of automated apparel manufacturing systems"

However, more specific expectations by DLA of direct application to the presently-planned "Trouser Front Pocket" AAMS seemed to be expressed in a letter from Donald O'Brien of DLA confirming conversations between Dan Gearing and Bill Walsh on 7/9/87:

"...we stressed the importance of a good theoretical foundation for decisions regarding the appropriate level of flexibility and modularity of the apparel manufacturing system you are developing under DLA."

The most important resource has been good, knowledgeable people in School of Textiles--most notably Tim Clapp, Trevor Little and Ed McPherson. They each have been very generous with time and also helpful by articulating perspectives on the state of the art/needs and by leading the author to relevant literature--particularly proposals and reports revolving around $(TC)^2$ and DLA apparel automation programs. The author also procured approximately 15 good articles on automation flexibility; however virtually all literature found is specific to metal piece parts manufacture and very few address assembly. Plenty more articles exist; however, it is widely perceived there are none very directly applicable.

Definitions of Flexibility

A suggested good, working definition of flexibility is:

"...the ability to adapt to change(s) in any parameters, with the lower the cost and time required to change the better."

The following are the main parameters to consider in an AAMS or work cell; together with an indication of the usual range of parameter values:

Parameter	Range
1. No. of needles (for securing)	1 to 8
2. Type of stitch (for securing)	28-29 lot basic (but only 10-12 common in practice)
3. Garment type	∞
4. Folder(s), if any	Very many
5. Size	∞
6. Shape, Geometry (style)	∞
7. Material	Very many
8. Set, Placement	∞

While the above indicates that the potential combinations of parameters affecting flexibility are limitless, in practice flexibility is important only with respect to those parameters which might change within the time frame and production unit under consideration. For example, since apparel manufacturers are normally specialized by product type (trousers, shirts, etc.), flexibility of interest to them is normally within that product type. Thus the most important parameters would be limited to:

1. Size
2. Shape, geometry (style)
3. Material (type, weight, handling characteristics)

4. Type of stitch (perhaps)

For DLA, it should be recognized that a most important criterion is the overall flexibility of a given AAMS to be converted quickly from normal civilian apparel manufacture to (relatively similar) military apparel manufacture in time of surge mobilization.

Kusiak[1] recognizes that four types of flexibility should be considered in manufacturing systems, as follows:

1. Flexible Manufacturing System (FMM) flexibility, measured by the no. of parts that can be processed by the FMM.
2. Material Handling System flexibility, concerned with ability to handle different parts in a number of different routes.
3. Computer System flexibility, measured by its adaptability to the changing functions.
4. Organization flexibility, which can be considered as:

   (a) Job flexibility - mix of parts
   (b) Schedule flexibility - number of different routes along which jobs proceed.
   (c) Short-term flexibility - change over costs w/in current program.
   (d) Long-term flexibility - set-up costs due to new changes.

Much research is needed to quantify the important types of AAMS flexibility.

Definitions of Module/Modularity

Like the dictionary definition of the word "system", the word "module" can be defined as "...anything one defines it to be".

Kusiak[2] defines a flexible manufacturing module (FMM), in the

---

[1] Kusiak, Andrew, "FMS's: A Structural Approach", Int'l J. of Production Research, Vol. 23, No. 6, 1985, pp. 1057-1073.

[2] Kusiak, Op/Cit

context of usual metal parts manufacture, as:

"...A numerical (computer) control machine augmented by a parts buffer, tool changer, pallet (handling) changer, etc." He then defines progressively longer or generally more complex combinations of FMM's as flexible manufacturing cells, groups, production systems, and manufacturing lines.

The AAMA Apparel Research Committee recently articulated the following definitions:

A Modular Production Unit is a self-contained, manageable work unit of 5-17 people performing a measurable task. The operators are interchangeable among tasks within the group to the extent practical and (any) incentive compensation is based upon the team's output of first quality product.

A Work Cell is an aggregate of equipment (modular units) which, in tandem, would perform at least the following functions:

1. Feed incoming material pieces
2. Register placement locations of material
3. Combine material to be joined
4. Sew/join
5. Stack or place product for next operation

It is now the opinion of the author that the word module can be best used to describe individual pieces of equipment (or software) which might be re configured, added or deleted, to meet

changing production needs for a work cell or AAMS. This is consistent with Tim Clapp's letter of June 11, 1987 reviewing the ARK/Colt proposal for a Trouser Front Pocket AAMS in which he described the cell or system as consisting of 21 modules as follows:

5	Feeders
2	Combines
1	Tune/Divide
1	Serge
4	Stackers
3	Registrators
2	Sew (301)
1	Sew (bag)
1	Fold
1	Controller
21	Total

Note that the 21 modules are of 10 different types. It might be useful to distinguish them again from the five functions of feed, register, combine, sew/join, and stack.

Quantification/Qualification of "Appropriate Levels of Flexibility/Modularity"

Benjamin Franklin in a famous letter to his friend about 200 years ago, wrote:

> "...In the matter of so much importance wherein you ask my advice, I cannot, for lack of sufficient premises, tell you what to determine, but if you please I will tell you how..."

The author has many multi-attribute methodologies in his "how" kit, but determining what is most appropriate for what level of application will require in-depth work, probably utilizing students. A primary methodology candidate is simplified weighted

evaluation (linear scoring). That is part of an attached 1985 IIE Proceedings article, which is provided because it is readily available and indicative.

The author is very open to further consultation with Textiles faculty as well as work to better meet DLA expectations and related future research needs.

EVALUATION OF

COMPUTER-INTEGRATED MANUFACTURING SYSTEMS

John R. Canada
North Carolina State University

ABSTRACT

A systematic procedure/methodology is illustrated for evaluating prospective computer-integrated manufacturing (CIM) opportunities. The methodology includes strategic and tactical weighted evaluations as well as net present worth or accounting financial projections to facilitate making choices which best meet the firm's strategic and short-term objectives.

INTRODUCTION AND NEED

Much has been, and will continue to be, written regarding the importance of modernizing manufacturing systems to better incorporate high technology--normally characterized by the use of computers/microprocessors for product/process design, manufacturing equipment controls, and/or decision support systems.

We will loosely refer to computer-integrated manufacturing (CIM) as any computer-oriented equipment or system which aids in, or achieves, the automation of a manufacturing enterprise; and which is planned to increase, if not eventually complete, integration of the enterprise. CIM regards manufacturing as a continuous flow process. The CIMS acronym is an expression of the ultimate goal and not necessarily the approach to achieving that goal. Integration connotes the tying together of adjacent operations with each other and overall control systems.

A full CIM system very much involves product fabrication and assembly, materials handling, inventory management, and maintenance as well as other important functions such as product design, quality control, cost control, and service; and classically draws upon a common computer data base. Even with non-engineered products, the concept of integration is valid, although it applies to fewer staff functions.

Due to competitive pressures, manufacturers must plan and initiate sound steps toward CIM systems. Some decision makers advocate bold steps, but most recognize the need for phased development of resources (personnel, technological, product, financial, etc.) based on a general master plan.

Computer-based automation equipment and systems require massive capital investments. Many firms have tended to base their investment decisions on traditional discounted cash flow financial justification methodologies best suited to meet profitability criteria rather than long-term strategic goals. These traditional financial justification methodologies, when used in conjunction with high hurdle (minimum attractive) rates prevalent in today's uncertain and capital-scarce environment, often result in rejection of proposed high technology equipment and systems.

The inadequacy of such traditional justification procedures has become apparent. Much of the published literature blames the problem on the inability of traditional justification procedures to quantify and formally consider so-called intangible benefits, and other literature points out the shortcomings of contemporary and allegedly outmoded cost accounting systems, which inhibit the use of relevant, but oftentimes unconventional, measures of performance. Some authors even totally disclaim attempts to justify modern automation through traditional capital budgeting evaluation practices on the grounds that such decisions should be made primarily based on strategic considerations.

Bela Gold, in a landmark article in Harvard Business Review* said:

> "The real promise of CAM technology lies not in its use as yet another, perhaps fancier than usual machine tool located at a single point in an otherwise unchanged production process. CAM's promise lies, by contrast, in its ability to integrate adjacent operations with each other and with overall control systems. Because it offers a systematic--not a "point" capability, neither its purchase nor performance should be evaluated in the traditional way."

METHODOLOGY AND EXAMPLES

Figure 1 diagrams the suggested methodology. The analysis is based on the common procedure of considering investment projects in two categories:

(1) Opportunities, which are each independent of one another, (i.e., any number of such

*Gold, Bela, "CAM Sets New Rules for Production," Harvard Business Review, Nov-Dec 1982.

INSTITUTE OF INDUSTRIAL ENGINEERS
1985 Annual International Industrial Engineering Conference Proceedings

opportunities can be chosen within whatever constraints without affecting the prospective results of other opportunities), and

(2) Alternatives, which are mutually exclusive (i.e., at most one of the alternatives within a given opportunity group can be chosen).

For example, opportunities for a firm could be an AS/RS System for a Finished Goods Warehouse or a CIM System for a particular manufacturing plant. Within each such opportunity there probably are numerous alternatives, such as different Vendor Systems. If opportunities happen to be interdependent so that one increases or decreases the desirability of another, then combinations can be considered.

Category (Length of Decision Impact)	Examples
Strategic (long-term)	CIM Systems New Product Line
Administrative (medium-term)	Replace General Purpose Equipment
Operational (short-term)	Fixtures and Minor Equipment Discretionary Repairs

Operational decisions are shown as being made by routine decision rules. Investment opportunities in the strategic and administrative categories, because they tend to overlap, are shown to go through the same subsequent steps. They are first screened according to whether strategic objective "musts" are met. As the name implies, these "musts" are criteria or questions which must be satisfied before an opportunity would be eligible for further consideration. Examples are: "Does it maintain or advance the firm's technological capabilities?", and "Does it keep us concentrated in the _____ business?", and "Does it risk less than _____% of the firm's worth?"

Opportunity Selection (Figure 1, Block (A))

Those opportunities which pass the strategic "musts" test are then ranked and tentatively selected within whatever constraints exist according to a method called "Strategic Weighted Evaluation."

Figure 2 lists some eight example strategic attributes together with a description of potential benefits due ti CIMS for each. The use of this methodology must determine which of these or any other attributes/criteria are of significant importance to the firm, and those chosen should be as independent* of each other as possible.

*"Independent" attributes or criteria mean that evaluations of the desirability of outcomes for a given attribute is not affected by what the outcomes of any of the other attributes happen to be.

The calculation of the "Strategic Weighted Evaluation" is performed in exactly the same manner as for the "Tactical Weighted Evaluation" (to be explained in the next section)*--the only difference is that the chosen strategic attributes and their respective weights will typically differ (significantly) from the chosen tactical attributes and weights.

Alternative Selection (Figure 1, Block (B))

Next, any mutually exclusive alternatives for each tentatively accepted opportunity are considered and tentatively selected by consideration of:

(a) Non-monetary (intangible) factors; i.e., "Tactical Weighted Evaluation," and

(b) Monetary (quantifiable) factors; i.e., "Net Present Worth," within whatever constraints.

Each are explained below.

(a) Tactical Weighted Evaluation. Figure 3 is a form illustrating the identification and weighting of attributes. Note that it shows that only four tactical attributes are considered applicable (important). Typically, it is recommended that the most important of these attributes be given a weight of 100, and all other chosen attributes be given less weights according to their perceived importance relative to other attributes. Such weights are often so subjective that it is recommended that one test various combinations for "consistency of preferences" until one is satisfied the weights are reasonable.

The last column of Figure 3 shows the formula for "normalizing" the weights to total 100. This is merely a thinking convenience, as people tend to like to refer to quantitative weights as "parts of 100" or "percentages."

Figure 4 is a form illustrating the calculation of "Tactical Weighted Evaluation" for two alternatives. Note the normalized weights from Figure 3 are used. Note also that an "evaluation rating" (on a scale of 0 to 10) is made to reflect how well each alternative meets each attribute. For example, with respect to the first attribute, "CIMS Tactical Aims," alternatives P-1 and P-2 scored 7.5 and 9, respectively. These scores could have been based on some quantitative scales, or just subjective judgement with some guides--such as a 0 would be "very poor" and a 10 would be "extraordinary". Alternative P-1 rates a 9 and alternative P-1 rates somewhat less, probably "very good", with a 7.5.

The right-hand portion of Figure 4 shows the formula for computations, with the column total for each alternative being the "Weighted Evaluation" measures--which were 82 and 75, respectively. Note also that the bottom right-hand-side provides a place for entering any Monetary Measure of Merit (separately determined, such as below).

*The "weighted evaluation" methodology is known by many names, such as "simple additive weighting." For more background and examples, see Canada, J.R. and White, J.A., Capital Investment Decision Analysis for Management and Engineering, Prentice-Hall, 1980, pp. 452-55.

(b) Net Present Worth. Figure 5 shows a good easy-to-use form for calculating the Net Present Worth for an alternative project. The form provides for considering income taxes, after-tax cash flows for up to 10 years, and it also includes discount factors of 10%, 20%, or 40%. The example figures happen to be for Alternative I-B (which was also in Figure 4). For an after-tax discount factor (minimum attractive rate of return) of 20%, the Net Present Worth for that alternative is shown to be $350M in the right-hand column, next-to-bottom row.

Figure 6 shows a summary of typical study results for all mutually exclusive alternatives for four different opportunity groups in terms of both Tactical Weighted Evaluation and Net Present Worth. It also provides for information on "Resources Used" for which there may be constraints (in right-hand columns). In this case, only the investment in year 0 was shown as a constraint, and the total of that resource available was shown at the bottom of the column.

Note in Figure 6 that arrows were used to denote the best alternative for each opportunity group for Tactical Weighted Evaluation and Net Present Worth, respectively. The final choice will depend on the decision maker's preferences for Tactical Weighted Evaluation scores versus Net Present Worth. As a typical aid, Figure 7 shows the best alternative for each opportunity ranked by decreasing Tactical Weighted Evaluation. Similar ranking according to decreasing Net Present Worths can be done to facilitate thinking regarding final selections within whatever constraints. If the number of projects and tradeoff posibilities is fairly large, the final choosing can be facilitated by graphical comparisons.

Note in Figure 7 that the choices by decreasing rank are IV-B, I-A, II-B, and III-B. To live within the $250M total investment constraint, Project III-B would have to be dropped. Note, however, that Project II-B has a Net Present Worth of -$10M. One might rationally decide it is worth substituting Project III-B for Project II-B to include a Net Present Worth of $200M rather than -$10M, even though that means having a Tactical Weighted Evaluation of 70 rather than 80. With this substitution, the final choices would be Projects IV-A, I-A, and II-B with a Total Net Present Worth of $1,160M, while requiring a total investment of $225M (within the constraint).

Mutually Exclusive Combinations and Interdependent Effects (Figure 1, Block (C))

The above procedure can be supplemented to consider interdependent effects of opportunity groups. For example, suppose the acceptance of CIM at Plant I would enhance the benefits of CIM at some other plant. Or, possibly the acceptance of an AS/RS Finished Goods Warehouse would decrease the benefits of a computerized Administrative Information System. Such interactive effects can be considered through detailing out all what are called "mutually exclusive combinations" of projects under consideration and choosing the combination which has the best tradeoff of Tactical Weighted Evaluation scores and Net Present Worth. Figure 8 is an illustrative form which uses a "binary table" on left side to enumerate which alternatives are included (if 1) or not included (if 0)). That illustration shows example numbers for some 8 mutually exclusive combinations. The assumptions for quantifying the interdependent effects do not warrant discussion here. Note, for example, that mutually exclusive combination No. 33 (i.e., projects IV-B and I-A) is found to have the highest Tot. Net P.W.

Summary

Basing evaluation and justification of investments in CIMS entirely on financial measures is both inadequate and misleading. This paper has illustrated briefly a simplified system* which includes strategic as well as tactical factors together with financial measures. It is hoped this will greatly facilitate rational decisions which properly balance the strategic and short-term considerations which are so important in evaluating advanced manufacturing systems.

*Complete system is included in "Should We Automate Now?, Evaluation of Computer-Integrated Manufacturing Systems: An Applications Manual with Handy Forms," Industrial Extension Service, North Carolina State University, Raleigh, 1985, 200 pp.

ABOUT THE AUTHOR

John R. Canada is Professor of Industrial Engineering at North Carolina State University. He previously served as Associate Dean of Engineering for Extension at NCSU, and he taught at Virginia Polytechnic Institute and State University and Georgia Institute of Technology. He was also affiliated with 3M Company, Eastman Kodak Company, and Tennessee Valley Authority. In addition to many publications in engineering journals he has authored or co-authored four texts in engineering economics and decision analysis. A Fellow of AIIE, Dr. Canada received a BSIE and MSIE from Virginia Polytechnic Institute and Ph.D. from Georgia Institute of Technology.

Figure 1 Recommended Selection Process

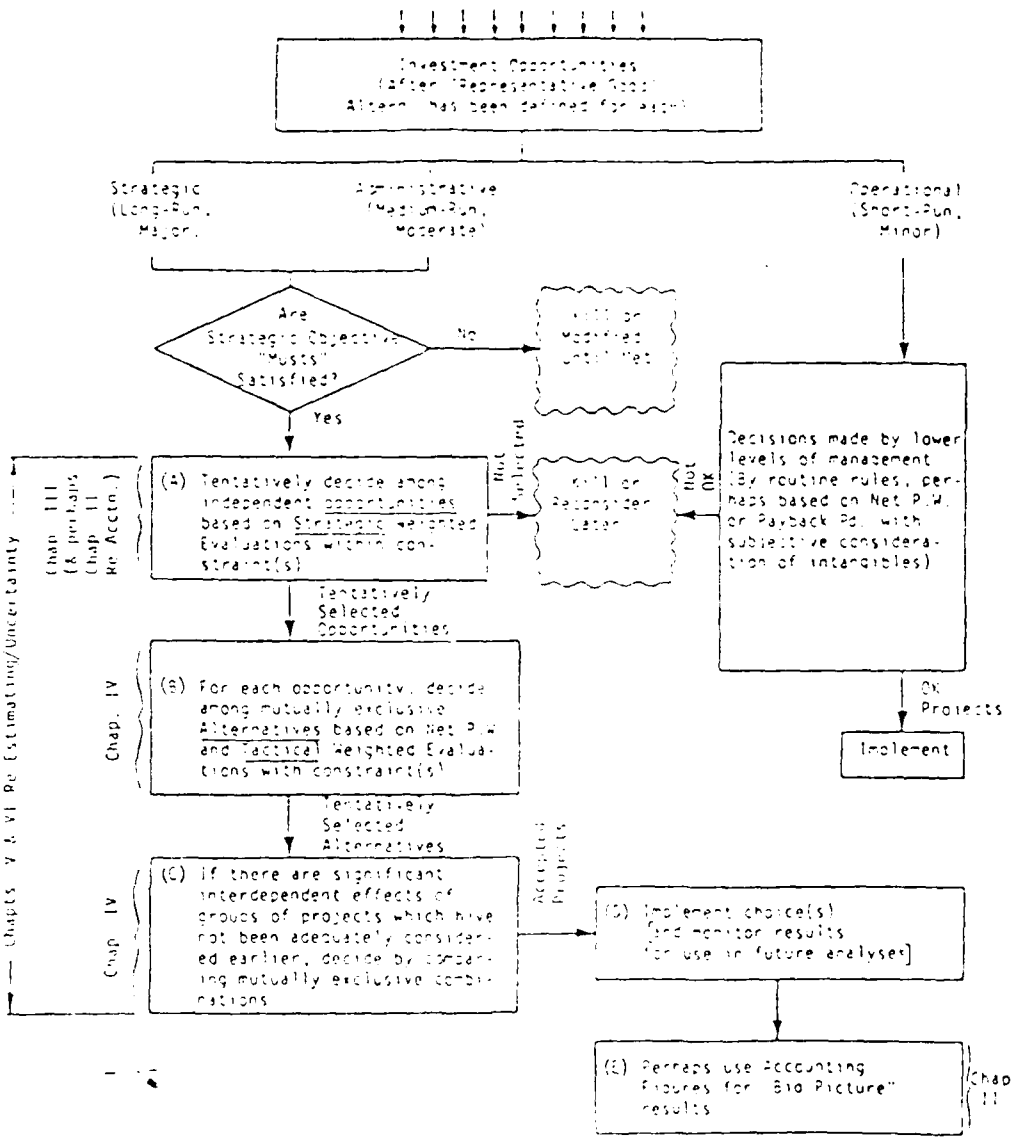


Figure 2 . Example Strategic Attributes/Criteria
(Described in Terms of Potential Benefits Which are a Function
of Extent of Implementation of CIMS)

Attribute	Potential Benefits Due to CIMS
1. Quality -	Greater consistency in manufacture and ease in testing
2. Flexibility	-Increased ability to adapt to changing customer requirements (product or volume) economically
3. Lead times -	Reduction in time to achieve product/process designs, and to manufacture/ship
4. Capacity -	Increased manufacturing thruput ability
5. Inventories -	Reduced size due to flexibility, shorter lead times and precise, fast information systems
6. Controls -	Tighter due to reliance on computer programs rather than operators for process and shop actions
7. Future options	-Created through firm's acquisition of new technological capabilities (hardware, software, and people) on which it can build
8. Long life -	Maintain capabilities and use rates of facilities due to ability to combine economics of high-volume dedicated automation with the flexibilities of job-shop production

Figure 3

Pg ___ of ___

Attributes (identification and weighting) By ___ Date ___

Sheet: ILLUSTRATION OF WEIGHTING FOR TACTICAL ATTRIBUTES

Check One ✓ Strategic Tactical

Attribute Criterion	Check if Applicable	Weight	Normalized weight (eWeight/Tot. Weight)
1. Quality			
2. Flexibility - Product			
3. Flexibility - Schedule			
4. Lead Times			
5. Capacity			
6. Inventories			
7. Controls			
8. Future Options			
9. Long Life			
10. Scrap/Rework			
11. Employee satisfaction			
12. Riskiness, LACK OF	✓	63	25
13. Serviceability/Maintainability	✓	37	15
14. Mat./Engr. Effort Avail.	✓	100	40
15. Other CIMS Has How it's Met			
16. Other PROFITABILITY EXPECTED			
17. Other RELATIONS, EMPL/PUBLIC			
18. Other PRODUCIBILITY			
19. Other CONTROLLABILITY			
20. Other COMPATIBILITY			
21. Other SERVICIBILITY	✓	50	20
22. Other			
23. Other			
24. Other			
25. Other			

Total Weight = 250 Total = 100

Comments: ___

Figure 4

Pg ___ of ___

Weighted Evaluation of Opportunities - Alternatives

By ___ Date ___

Check One ___ Strategic
_I_ Tactical

Title: ILLUSTRATION OF TACTICAL WEIGHTED EVALUATION OF ALTERNATIVES

Project Descriptions
P-1 ALT I-A
P-2 ALT I-B
P-3
P-4

Attribute/Criterion (Ref. Fig II-4)	Normalized Weight	Evaluation Rating P-1	P-2	P-3	P-4	Weight x Evaluation Rating ÷ 10 P-1	P-2	P-3	P-4
CIMS TACTICAL AIMS	40	7.5	9			30	36		
RISKINESS, LACK OF	25	8	6			20	15		
SERVICEABILITY	20	10	7.5			20	15		
MGT/ENGRG EFFORT	15	8	6			12	9		
					Total	82	75		
Monetary Measure of Merit, Like Net P.W. (If considered separately)						$300M	$250M		

Comments
Other Considerations ___

Recommended Decision/Reason(s) ___

Figure 5

Project Monetary Costs and Savings

Pg ____ of ____

By ____ Date ____

What: EXAMPLE CALC OF NET PW, ALTERN. I-B

Savings Compared to: (If not obvious in "What") No CIM, KEEP STATUS QUO

Comments: ALL NOS IN $M

Net P.W. @ 20 % = $350

Payback Pd. = ~1.7 YRS

Line	How Calc? (Lines)	YEAR 1986 0	1	2	3	4	5	Each Yr. 6-10	TOTAL
INVESTMENT, CAPITALIZED									
(1) Equipment Cost		130							
(2) Accessories & Tooling Cost		10							
(3) Other		-							
(4) Total Capital Inv.	(1) + (2) + (3)	140							
(5) Investment Tax Credit	10 % x (4)	14							
INVESTMENT, EXPENSED									
(6) Engineering		30							
(7) Installation		13							
(8) Startup		5							
(9) Other									
(10) Total Expensed Inv.	(6) + ... + (9)	48							
(11) Total All Inv. Aft. Credit	(4)+(10)-(5)	174							
OPERATING SAVINGS (COSTS)									
(12) Direct Labor Savings			50	80	100	SAME AS YR. 3	SAME AS YR. 3	150	
(13) Indirect Labor Savings			10	10	10			10	
(14) Material Savings			30	50	60			80	
(15) Maintenance Savings			10	10	10			10	
(16) Other Savings			40	50	60			88	
(17) Other Costs			(20)	(20)	(20)			(30)	
(18) Total Operating Savings	(12)+...+(17)	(48)	120	180	220			308	
ANALYSIS									
(19) Depreciation	___ x (4)	[illegible]	28	28	28			0	
(20) Net Before Tax Savings	(18)-(19)	(48)	92	152	192			308	
(21) Net After-Tax Savings	(20)x(1-.50)	(24)	46	76	96			154	
(22) Net After-Tax Cash Savings	(21)+(19)	(24)	74	104	124			154	
(23) Net After-Tax Cash Flow	(22)-(11)+(10)	(150)	74	104	124	124	124	154 x 5	1170.0
(24) Discount Factor @ 10%		1.000	.909	.826	.751	.683	.621	2.354	
(25) P.W. @ 10%	(23)x(24)	(150)	67.3	85.9	93.1	84.7	77.0	362.5	620.5
(26) Discount Factor @ 20%		1.000	.833	.694	.579	.482	.402	1.202	
(27) P.W. @ 20%	(23)x(26)	(150)	61.6	72.1	71.8	59.7	49.8	185.0	350.0
(28) Discount Factor @ 40%		1.000	.714	.510	.364	.260	.186	.379	
(29) P.W. @ 40%	(23)x(28)	(150)	52.8	53.0	45.1	32.2	23.1	58.4	114.6

Figure 9

Ordering of Opportunities/Alternatives

Pg 1 of 3

By RC Date 7/12/

Rank By: ___ Weighted Eval. ___ Net P.W. ___ Final Recom. ✓ Other

What: SUMMARY OF STIOI RESULTS --
ALTERNATIVES FOR TOP FOUR OPPORTUNITIES

(NOTE: TACTICAL W&TO EVAL NUMBERS ARE NOT NECESSARILY THE SAME AS FOR STRATEGIC W&TO EVAL.)

Ident.	Opportunity/ Alternative/Cordon Description		✓ Tactical / Strategic Weighted Evaluation	Net P.W. ($ added IN $M Amt.	Cum.)	Resources Used INVEST. $ IN $M Amt.	Funds	Amt.	Cum.
1	II-ASIES	ALT. A	85	560		100			
2	WHSE.	" B	85	660		75			
3		" C	75	340		50			
4									
5	II-CIM,	ALT. A	72	70		70			
6	PLT II	" B	90	-10		70			
7									
8	I-CIM,	ALT. A	82	300		50			
9	PLT I	" B	75	350		150			
10									
11	II-CIM,	ALT. A	65	320		80			
12	PLT III	" B	70	200		100			
13		" C	68	100		60			
14									
15									

Total Avail.: 250 Total Avail.: ( )

Comments:

Other Considerations: ARROWS "↘" AND "▲" DENOTE BEST ALTERNATIVE FOR EACH OPPORTUNITY (GROUP) FOR W&TO EVAL AND NET P.W., RESPECTIVELY

Recommended Decision/Reason(s):

Figure 7

Ordering of Opportunities/Alternatives

Pg 3 of 3

Rank By ✓ Tactical-weighted Eval. ___ Net P.W. ___ Final Recomm. ___ Other

By JRC Date 3/12/

What: RANK ORDERING BY WEIGHTED EVALUATION FOR BEST ALTERNATIVE WITHIN EACH OF TOP FOUR OPPORTUNITIES

Rank	Opportunity/ Alternative Combin. Description	Tactical Strategic Weighted Evaluation	Net P.W. (if applic.) IN $M Annl.	Cumul.	Investment YRO IN $M Annl.	Cumul.	Resources Used Annl.	Cumul.
1	II-B: AS/ES, Alt B	85	660	660	75	75		
2	I-A: CIM A-II, Alt A	82	300	960	50	125		
3	II-B: CIM A-II Alt B	80	-10	950	70	195		
4	III-B: CIM A-II, Alt B	70	200	1150	100	295		
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Total Avail (250) Total Avail. (___)

Comments

Other Considerations _____

Recommended Decision/Reason(s) INDICATED CHOICES ARE III-B, I-A, AND II-B

FIGURE 8

Pg 1 of 1

By JRC Date 3/1/-

Mutually Exclusive Combinations - Illustration of Possible Interdependent Effects for 8 Combinations with Highest Net PW in Figure IV-11

PROJ. IDENT. - DESCRIPTION

(See Figure IV-11)

PROJ. IDENT. - DESCRIPTION

	PROJECT IDENTIFICATION							IF OUTCOMES INDEPENDENT			IF OUTCOMES INTERDEPENDENT			RESOURCES USED	
	IV-A	IV-B	IV-C	II-A	II-B	I-A	I-B	TOT. NET P.W.	TACTICAL WGTD. EVAL. TOTAL	TACTICAL WGTD. EVAL. PER PROJ. $	TOT. NET P.W.*	TACTICAL WGTD. EVAL. TOTAL	TACTICAL WGTD. EVAL. PER PROJ. $	INV. YR 0, $M AMT.	AMT.
NET P.W. $M	560	660	360	70	-10	300	350								
WGTD. EVAL.	85	85	75	76	80	82	75								
RESOURCE INV. YR 0	100	75	50	70	70	50	150								
RESOURCE															
MUT. EXCL. COMB. NO.															
21	0	1	0	1	0	1	0	1,030		79.7	+200 (6) 830 -350 (3)		-3 (5) +5 (4) 81.9	195	
34	0	1	0	0	0	0	1	1,020		80	-350 (7) 670		+5 (1) 85	225	
33	0	1	0	0	0	1	0	960		83.5	960 (1)		(2) 83.5	125	
23	0	1	0	0	1	1	0	950		82.3	950 (2)		(3) 82.3	195	
17	1	0	0	1	0	1	0	930		79.7	+200 (6) 730 -350 (8)		-3 (5) +5 (6) 81.7	220	
32	1	0	0	0	0	0	1	910		80	-350 560 (4)		+5 (1) 85	250	
31	1	0	0	0	0	1	0	860		83.5	860 (5)		(5) 83.5	150	
19	1	0	0	0	1	1	0	850		79.7	850 (7)		(6) 79.7	220	

OTHER CONSIDERATIONS *Numbers in ( ) indicate rank order for the respective measures.

RECOMMENDED DECISION/REASONS

Total Avail. ($M) (250)

Total Avail. ( )

SUBCONTRACT AGREEMENT FOR TECHNICAL SERVICES

Between

NORTH CAROLINA STATE UNIVERSITY

and

ARK, INCORPORATED

Subcontract No. 860849

RESEARCH ADMINISTRATION
Date 10-5-87
Copy To: McPherson
Wilson, Wilson
Wilson, III

This Subcontract Agreement (the "Agreement") made this 2nd day of October, 1987, by and between North Carolina State University, a North Carolina non-profit educational institution ("NCSU") and ARK, INCORPORATED, a corporation organized under the laws of the State of Tennessee ("Subcontractor").

WHEREAS, NCSU has entered into Contract No. DLA900-87-C-0509 (the "Contract") with the Defense Logistics Agency ("DLA"); and,

WHEREAS, NCSU desires to subcontract and Subcontractor is willing to perform a portion of the work called for by the Contract,

NOW, THEREFORE, the parties hereto do hereby mutually agree as follows:

ARTICLE I. ENGAGEMENT

1.1 NCSU, upon the terms and conditions specified herein, hereby engages Subcontractor to perform certain technical services as further defined in an Equipment Specification entitled "COMBAT TROUSER UNIFORM FRONT POCKET WORK CELL SYSTEM SPECIFICATION" dated March 3, 1987, ("Specification") attached hereto and identified as Appendix "A." Such work shall be performed by Subcontractor in accordance with its proposal dated May 15, 1987, as submitted under letter dated August 18, 1987, and identified as Appendix "B."

1.2 Subcontractor as an independent contractor and not as an agent of NCSU shall furnish the necessary personnel, materials, services, and facilities, and otherwise do all things necessary for or incident to the performance of all tasks and duties necessary to the completion of the work contracted for hereunder.

1.3 For purposes of this subcontract NCSU has designated Mr. Edwin M. McPherson to act as its Program Manager for the purpose of providing a liaison between NCSU and the Subcontractor. From time to time under the

APPENDIX X1

provisions of this Agreement the NCSU Program Manager shall be identified as the authorized representative in carrying out the terms of this Agreement for NCSU.

ARTICLE II. STATEMENT OF WORK ("SOW")

2.1 The Subcontractor shall perform the work contracted hereunder to meet the Specification. The work shall be performed in a workmanlike manner employing the highest standards. The Subcontractor shall bear responsibiliy for all work conducted under this Subcontract whether the work is performed directly by the Subcontractor or by a lower-tier subcontractor.

2.2 Subcontractor's performance under this Subcontract shall be secured by a performance bond in the amount of $393,000.00 to be secured and purchased by NCSU prior to commencement of work.

ARTICLE III. PERIOD OF PERFORMANCE

3.1 The period of performance for this Agreement shall be in accordance with the following schedule:

(i) Construction of the initial prototype shall be completed by April 4, 1988.

(ii) The operating prototype shall be completed and ready for plant testing by March 4, 1989.

3.2 In order to ensure timely performance, the Subcontractor shall use its best efforts to adhere to a timeline which shall be prepared jointly by the parties and shall set forth bench marks to be met by the Subcontractor. In addition, NCSU shall be entitled to make periodic inspections of work progress at the Subcontractor's facilities at such time as may be mutually agreed upon but in any event no less frequent than one every six months.

3.3 Whenever Subcontractor has knowledge that any actual or potential situation is delaying or threatens to delay timely performance, the Subcontractor shall give written notice within five (5) days thereof, including all relevant information with respect thereto, to the NCSU Program Manager. The parties acknowledge that the adequacy of NCSU's performance under its Contract with DLA will be determined, in part, on the timeliness of its performance which will be directly affected by the timeliness of the Subcontractor's performance.

ARTICLE IV. BID PRICE AND PAYMENT SCHEDULE

4.1 This is a Fixed Fee Subcontract entered into on the basis of the bid price set forth in Appendix "B" in the amount of $393,000.00. Under no circumstances shall NCSU or DLA be obligated to reimburse the Subcontractor for any costs in excess of the bid price of $393,000.00 for work performed to the Specifications.

4.2 Payments shall be made to the Subcontractor in accordance with the following payment schedule:

(i) $39,300.00 (10 percent of the contract price) upon execution of this Agreement.

(ii) Monthly progress payments based on invoices submitted by the Subcontractor which shall be consistent with those applicable Cost Accounting Practices set forth in the Federal Acquisition Regulations. Such invoices shall be certified as to accuracy by an officer or other appropriate official of the Subcontractor.

(iii) After payment of 85 percent of the Fixed Fee, NCSU may withhold further payments until a non-interest bearing reserve is set aside in an amount that NCSU considers necessary to protect its interest and that of DLA. This reserve shall not exceed 15 percent of the total Fixed Fee or $100,000, whichever is less.

(iv) Final payment shall be made upon receipt from the Subcontractor of a final invoice showing evidence that the final report including necessary invention disclosures and invention reports have been submitted to NCSU and upon approval by DLA of the work performed.

(v) All invoices under this Agreement shall be submitted to:

Edwin M. McPherson
School of Textiles
North Carolina State University
Campus Box 8301
Raleigh, NC 27695-8301

All invoices shall be paid within 30 days of approval.

ARTICLE V. REPORTS

5.1 The Subcontractor shall prepare and forward to the NCSU Program Manager technical progress reports every 90 days after the Subcontract award until project completion.

5.2 Technical reports shall outline the objectives and accomplishments of the reporting period, how the system, process, technique, method used was developed, is constructed, how it works, and who to contact for additional information. Where relevant, those reports should include engineering designs and schematics, test results, process formulas, operations data and statistics, user instructions, charts and graphs and whatever else may be necessary to permit readers to successfully transition the technology for their own use. Reports should also include a sufficient amount of economic information to enable others to evaluate the economic risk of implementing the results.

ARTICLE VI. DELIVERABLES

6.1 The Subcontractor shall deliver to NCSU or its designee one prototype of the work cell system fabricated in conformance with the Specifications attached hereto as Appendix A, together with all component modules thereof, design documentation (including reports and drawings), software, and all such other information and data as may be necessary to complete the Work Statement hereunder. Such deliverables shall also include the work product and design documentation of any lower-tier subcontractor.

6.2 All equipment developed under this Subcontract shall be considered property belonging to the U. S. Government and shall be subject to FAR 52.245.5, Government Property (Cost Reimbursement, Time and Materials or Labor-Hour Contracts) (Alternate I).

ARTICLE VII. PROPRIETARY DATA

7.1 In the event that Subcontractor's performance under this Agreement requires the incorporation of Subcontractor's proprietary data, Subcontractor agrees to accept the provisions of AFSC DARS 7-2003.61c Contractor's Agreement to License and Assist Government Designated Parties to the Contract Products for Government Purposes as such provision is incorporated into this Agreement under ARTICLE XV. In addition, Subcontractor agrees to flow the clause down to lower-tier subcontractors for research and development work. In

the event of refusal of a lower-tier subcontractor to accept this clause, Subcontractor shall follow the procedures set forth in paragraph (h) for AFSC DARS 7-2003-61c substituting the NCSU Program Manager for the Contracting Officer.

7.2 To the extent it becomes necessary for NCSU employees to access the Subcontractor's proprietary data as defined in AFSC DARS 7-2003.61c, NCSU agrees to protect such data from unauthorized use or disclosure so long as it remains proprietary and within 30 days of identifying a need for such proprietary data shall enter into a mutually acceptable protective agreement covering such data. In any event, however, any such agreement shall preserve to the U. S. Government and its designees appropriate use of the data in development of the system provided for under the SOW.

ARTICLE VIII. RIGHTS IN DATA

8.1 NCSU shall acquire on behalf of the Federal Government Rights in Technical Data and Computer Software sufficient to comply with DFARS 52-227-7013 (modified) as incorporated into this Agreement under ARTICLE XV. Subcontractor shall provide the foregoing rights on its own behalf and on behalf of lower-tier subcontractors or consultants which it may employ in performance of this Agreement. NCSU shall acquire for itself and Subcontractor shall provide on its own behalf and on behalf of its lower-tier subcontractors and consultants, rights in technical data and computer software for purposes of research and education only. NCSU shall not use technical data or computer software as the basis for any commercial activity.

8.2 It is contemplated that during the course of this Agreement students and employees of NCSU may participate in certain design activities related to the SOW. Those designs developed solely by students and employees of NCSU shall be the property of NCSU subject to a royalty-free, perpetual, nonexclusive right and license granted to the Subcontractor to use such developments for purposes of carrying out the SOW. Designs developed jointly by employees and students of NCSU and employees of the Subcontractor shall be jointly owned with each party having the right to use such designs for any purpose without the obligation to account to the other.

ARTICLE IX. PATENT RIGHTS

In conformance with FAR 52.227-11 the Subcontractor as a Small Business Entity shall retain title to all inventions made by its employees during the course of this Agreement subject to those license rights reserved in FAR 52.227-11 to the United States Government. In addition, the Subcontractor shall agree to grant to NCSU a royalty-free right and license to use any such inventions for purposes of education and research.

ARTICLE X. INDEMNIFICATION

10.1 Subcontractor agrees to indemnify and hold NCSU and the U. S. Government harmless from any and all liability for injury to persons or property arising out of performance of this Agreement caused by the negligence or willful misconduct of the Subcontractor, its lower-tier subcontractors, consultants, agents or employees, including any and all expense legal or otherwise, incurred by NCSU in the defense of any claim or suit, provided, however, that Subcontractor shall not be liable for injury to persons or property caused by the negligence or willful misconduct of NCSU, its students or employees.

10.2 Subcontractor agrees to indemnify and save NCSU and the U. S. Government harmless from any costs previously paid to Subcontractor which are deemed, upon Federal government audit, to be unallowable. Subcontractor shall immediately, upon demand by NCSU and/or DLA, reimburse NCSU or DLA, as the case may be, for any such unallowable cost and other charges related thereto.

10.3 The State of North Carolina waives its sovereign immunity to the extent provided under the State Tort Claims Act. That Act permits the State, and the North Carolina State University as an agency of the State, to be sued for negligence and to pay claims in an amount up to $100,000 for bodily injury or property damage. North Carolina State University does not otherwise have the authority to enter into a hold-harmless or indemnification agreement.

ARTICLE XI. SUBCONTRACTING AND CONSULTING SERVICES

11.1 Subcontractor may enter into subcontracting or consulting agreements for the procurement of services or material under this Agreement provided that Subcontractor shall flow down all relevant provisions and INCORPORATED provisions under ARTICLE XV to allow Subcontractor and NCSU to comply with the provisions of this Agreement and the DLA Contract.

11.2 Prior to entering into any agreement affecting parts, processes, software, components or systems incorporated into the equipment developed hereunder with the owner(s) of proprietary data, copyrights or patents or with any other party that would encumber or otherwise affect the future salability of the automated apparel equipment, the Subcontractor shall submit the terms and conditions of such agreements to the NCSU Program Manager for review and approval a minimum of 45 days prior to the planned execution date of the agreement.

ARTICLE XII. ACCESS TO SUBCONTRACTOR'S FACILITIES

From time to time it may be necessary for NCSU to present to DLA demonstrations of progress in carrying out the SOW. Subcontractor agrees to make its facilities available for such purposes, upon reasonable notice, and shall cooperate with NCSU in such demonstrations to the extent necessary to enable NCSU to meet the goals of the DLA Contract.

ARTICLE XIII. TERMINATION FOR DEFAULT OR FOR CONVENIENCE

13.1 This Agreement may be terminated in whole or in part by NCSU at any time during the period of performance:

(i) Whenever Subcontractor shall default in performance of the terms of this Agreement (including in the term "default" any failure by the Subcontractor to make progress in the prosecution of the SOW which endangers proper performance) and shall fail to cure such default within a period of thirty (30) days after receipt from NCSU of a notice specifying the default;

(ii) Whenever, for any reason, DLA shall determine that termination is in the Government's interest;

(iii) In the event Subcontractor files or has filed against it any bankruptcy proceeding, receivership, or any similar action under any debtor relief laws or regulations.

13.2 Such termination shall be initiated by giving written notice to Subcontractor of intent to terminate. Upon receipt of such notice of intent to terminate, Subcontractor shall cease all work under the Agreement, place no further subcontracts or orders; terminate all applicable lower-tier subcontracts and cancel or

divert applicable commitments covering personal services; assign to NCSU as directed by the NCSU Program Manager all right, title and interest of the Subcontractor under the lower-tier subcontracts terminated in which case NCSU or the Federal government snall have the right to settle or pay any termination settlement proposal arising out of those terminations; and deliver to NCSU copies of all reports and deliverables (regardless of status of completion) generated o date of termination.

13.3 In the event of a termination as described herein, the parties shall mutually agree upon the settlement of all outstanding liabilities and termination settlement proposals arising from the termination of subcontracts.

13.4. The Subcontractor shall deliver to NCSU any information and items that, if the contract had been completed, would have been required to be furnished, including (i) materials or equipment produced, in process, or acquired for the work terminated and (ii) completed or partially completed plans, drawings, and information.

13.5 After termination, the Subcontractor shall submit a final termination settlement proposal to tne NCSU Program Manager within 6 months of the effective date of termination. If the Subcontractor fails to submit the termination settlement proposal within the time allowed, the NCSU Program Manager may determine, on the basis of information available, the amount, if any, due the Subcontractor and snall pay the amount determined.

13.6 Subject to the foregoing paragraph 13.5, the parties will agree upon the whole or any part of the amount to be paid because of the termination. This amount may include reasonable cancellation charges incurred by the Subcontractor and any reasonable loss on outstanding commitments for services that tne Subcontractor, exercising reasonable diligence, is unable to cancel or divert to other operations. All such costs claimed shall be governed by cost principles and procedures in Subpart 31.3 of the Federal Acquisition Regulation (FAR).

ARTICLE XIV. PHASE V OPTION

14.1 Upon approval of the DLA Contracting Officer, the parties hereto shall agree to proceed with Phase V of the Contract to demonstrate the modularized work unit

groups at the Defense Personnel Support Center factory in Philadelphia, PA.

14.2 Prior to proceeding with Phase V, the parties shall negotiate the cost of performance to the Subcontractor. Subcontractor shall provide NCSU with a detailed cost estimate, including Fixed Fee for performance of the following:

(i) Module shipment. The Subcontractor shall ship the prototype work unit group to the Defense Personnel Support Center factory. The Subcontractor shall include manuals for installation, operation, and maintenance, detail and assembly drawings, electrical, electronic, hydraulic and pneumatic drawings, software, interface diagrams and instructions, and any other information required to support the use of the equipment in industry.

(ii) Production validation. The Subcontractor shall install the work unit groups, integrate them with other factory operations, including materials handling and utilities users, assist in the implementation of production, test the system's ability to satisfy the production validation plan, analyze performance results and validate the results against the performance criteria used to cost justify the system.

ARTICLE XV. MISCELLANEOUS

15.1 COMPLIANCE WITH LAWS: In the performance of the Agreement, Subcontractor shall comply with all applicable laws and all rules, regulations, and determinations of governmental agencies.

15.2 INCORPORATED PROVISIONS: Subcontractor shall be bound by all applicable terms of the following clauses of the Federal Acquisition Regulation (48 CFR Chapter 1) and Department of Defense FAR Supplement (48 CFR Chapter 2) which are hereby incorporated herein by reference:

a. Federal Acquisition Regulation (48 CFR Chapter 1) clauses

1.	52.202-1	Definitions	APR 1984
2.	52.203-1	Officials Not to Benefit	APR 1984
3.	52.203-3	Gratuities	APR 1984
4.	52.203-5	Covenant Against Contingent Fees	APR 1984
5.	52.204-2	Security Requirements	APR 1984
6.	52.212-8	Priorities, Allocations and Allotments	APR 1984
7.	52.215-1	Examination of Records by Comptroller General	APR 1984
8.	52.215-2	Audit--Negotiation	APR 1984
9.	52.215-22	Price Reduction for Defective Cost or Pricing Data	APR 1984
10.	52.215-24	Subcontractor Cost or Pricing Data	APR 1985
11.	52.215-30	Facilities Capital Cost of Money	APR 1984
12.	52.215-31	Waiver of Facilities Capital Cost of Money	APR 1984
13.	52.216-7	Allowable Cost and Payment	APR 1984
14.	52.216-11	Cost Contract - No Fee	APR 1984
15.	52.219-8	Utilization of Small Business Concerns and Small Disadvantaged Business Concerns	JUN 1985
16.	52.219-9	Small Business and Small Disadvantaged Business Subcontracting Plan	APR 1984
17.	52.219-13	Utilization of Women-Owned Small Businesses	APR 1984
18.	52.220-1	Preference for Labor Surplus Area Concerns	APR 1984
19.	52.220-3	Utilization of Labor Surplus Area Concerns	APR 1984
20.	52.220-4	Labor Surplus Area Subcontracting Program	APR 1984
21.	52.222-2	Payment for Overtime Premium	APR 1984
22.	52.222-3	Convict Labor	APR 1984
23.	52.222-26	Equal Opportunity	APR 1984
24.	52.222-28	Equal Opportunity Preaward Clearance of Subcontracts	APR 1984
25.	52.222-29	Notification of Visa Denial	APR 1984
26.	52.222-25	Affirmative Action for Special Disabled and Vietnam Era Veterans	APR 1984
27.	52.222-26	Affirmative Action for Handicapped Workers	APR 1984
28.	52.223-2	Clean Air and Water	APR 1984
29.	52.224-1	Privacy Act Notification	APR 1984
30.	52.224-2	Privacy Act	APR 1984
31.	52.227-1	Authorization and Consent Alternate I	APR 1984

32.	52.227-2	Notice and Assistance Regarding Patent and Copyright Infringement	APR 1984
33.	52.227-11	Patent Rights - Retention by the Contractor (Short term) ..	APR 1984
34.	52.228-6	Insurance - Immunity from Tort Liability	APR 1984
35.	52.228-7	Insurance - Liability to Third Persons	APR 1984
36.	52.230-3	Cost Accounting Standards	APR 1984
37.	52.230-4	Administration of Cost Accounting Standards	APR 1984
38.	52.230-5	Disclosure and Consistence of Cost Accounting Practices	APR 1984
39.	52.232-9	Limitation on Withholding of Payments	APR 1984
40.	52.232-17	Interest	APR 1984
41.	52.232-22	Limitation of Funds	APR 1984
42.	52.232-23	Assignment of Claims	JAN 1986
43.	52.233-1	Disputes	APR 1984
44.	52.242-1	Notice of Intent to Disallow Costs	APR 1984
45.	52.242-10	F.O.B. Origin--Government Bills of Lading or Prepaid Postage	APR 1984
46.	52.243-2	Changes - Cost Reimbursement Alternate V	APR 1984
47.	52.243-7	Notification of Changes	APR 1984
48.	52.244-2	Subcontracts (Cost Reimbursement and Letter Contracts) -- Alternate I	APR 1985
49.	52.244-5	Competition in Subcontracting	APR 1984
50.	52.245-5	Government Property (Cost Reimbursement, Time and Material or Labor-Hour Contracts) (Alternate 1)	APR 1984
51.	52.246-25	Limitation of Liability-- Services	APR 1984
52.	52.247-1	Commercial Bill of Lading Notations (F.O.B. Origin)	APR 1984
53.	52.249-5	Termination of Convenience of the Government (Educational and Other Nonprofit Institutions)	APR 1984
54.	52.249-14	Excusable Delays	APR 1984
55.	52.251-1	Government Supply Sources	APR 1984
56.	52.233-03	Protest After Award - Alternate I	JUN 1985
57.	52.215-33	Order of Precedence	JAN 1986

b. Department of Defense FAR Supplement (48 CFR Chapter 2) clauses:

1.	52.294-7005	Oversees Distribution of Defense Subcontracts	JUN 1982
2.	52.215-7000	Pricing of Adjustments	APR 1985
3.	52.219-7000	Small Business and Small Disadvantaged Business Subcontracting Plan (Master Plans)	APR 1984
4.	52.225-7002	Qualifying Country Sources as Subcontractors	OCT 1980
5.	52.225-7006	Buy American Act. Trade Agreements Acts, and the Balance of Payments Program	APR 1985
6.	52.225-7008	Duty-Free Engry--Qualifying Country End Products and Supplies	AUG 1984
7.	52.225-7009	Preference of Certain Domestic Commodities	OCT 1980
8.	52.225-7012	Preference of Domestic Specialty Metals	OCT 1980
9.	52.227-7000	Non-Estoppel	OCT 1966
10.	52.227-7018	Restrictive Markings on Technical Data	MAR 1975
11.	52.227-7029	Identification of Technical Data	MAR 1975
12.	52.227-7030	Technical Data - Withholding of Payment	JUL 1976
13.	52.227-7031	Data Requirements	APR 1972
14.	52.227-7036	Certification of Technical Data Conformity	OCT 1985
15.	52.227-7037	Validation of Restrictive Markings on Technical Data.	OCT 1985
16.	52.231-7000	Supplemental Cost Principles	APR 1984
17.	52.233-7000	Certification of Requests for Adjustment or Relief Exceeding $100,000	FEB 1980
18.	52.242-7003	Certification of Overhead Costs	MAY 1985
19.	52.246-7000	Material Inspection and Receiving Report	DEC 1969

For purposes of interpretation of the foregoing, Subcontractor shall be substituted in place of Contractor, and where necessary for NCSU to carry out its obligations thereunder, NCSU shall be substituted for Government, DLA or its representation, including the Contracting Officer. Subcontractor shall be entitled, nevertheless, to all of the rights and privileges granted to it under the foregoing

regulations as a Small Business Entity as defined at CFR Title 13 Ch. 1-121. Subcontractor hereby acknowledges and agrees that Subcontractor has received copies of and is familiar with the foregoing provisions.

15.3 GENERAL RELATIONSHIP: Subcontractor agrees that in all matters relating to this Agreement it shall be acting as an independent contractor and shall have no right, power or authority to create any obligations, expressed or implied, on behalf of NCSU and/or the Government and shall have no authority to represent NCSU as an agent.

15.4 NOTICE: All notices and written consents required under this Agreement shall be in writing and shall be delivered personally by a nationally recognized overnight service or posted by certified mail, return receipt requested, addressed to the party set forth below or as otherwise from time to time may be designated in writing. Notices shall be deemed served upon the notice of actual receipt of the expiration of three (3) days after posting:

FOR SUBCONTRACTOR:

William R. Cole, Jr., President
Ark, Incorporated
P. O. Box 636
Shelbyville, TN 37160

FOR NCSU:

Edwin M. McPherson
School of Textiles
North Carolina State University
Campus Box 830
Raleigh, NC 27695-8301

WITH COPY TO:

Dr. Franklin D. Hart
Vice Chancellor for Research
North Carolina State University
Campus Box 7003
Raleigh, NC 27695-7003

15.5 TIME OF THE ESSENCE: Time is of the essence in connection with each and every provision of this Agreement.

15.6 MODIFICATIONS TO AGREEMENT: No modification of this Agreement shall be binding unless in writing, attached hereto, and signed by authorized representatives of both parties.

15.7 WAIVER OF RIGHTS: No waiver of any right or remedy shall be effective unless in writing and nevertneless shall not operate as a waiver of any other right or remedy or of the same right or remedy on a future occasion.

15.8 SEVERABILITY: Every provision of this Agreement is intended to be severable. If any form or provision shall be held to be illegal, invalid, or unenforceable, for any reason whatsoever, such illegality, invalidity or unenforceability shall not affect the validity of the remainder of this Agreement.

15.9 SUCCESSORS: This Agreement shall be binding upon and shall insure to the benefit of the parties, their successors and permitted assigns.

15.10 NONUSE OF NAMES: Neither party snall use the name of the other in any form of advertising or publicity without the express written consent of the other party.

15.11 APPLICABLE LAW: This Agreement and the application or interpretation thereof shall be governed and construed in accordance with the laws of the State of North Carolina.

IN WITNESS WHEREOF, the duly authorized representatives of the parties hereto have executed this Agreement on the dates shown.

FOR:	FOR:
ARK, INCORPORATED	NORTH CAROLINA STATE UNIVERSITY
By: W R Cole, Jr PE	By: [signature]
Title: President	Title: Vice Chancellor for Research
Date: October 2, 1987	Date: 10-2-87

END

DATE

FILMED

3-88

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